THE UNITED REPUBLIC OF TANZANIA

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

August, 1976

JAPAN INTERNATIONAL COOPERATION AGENCY

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INTRODUCTION

In September 1975, the Government of the United Republic of Tanzania and the Government of Japan have mutualy agreed with respect to the scope of works for the feasibility study and preliminary design of Southern Coastal Link Road and concluded it. At the same time, the Government of Japan have submitted the Inception Report which describes the concrete contents of the works to be conducted in the field survey and in Japan, together with organization and work schedule for the execution of this study.

On the basis of these scope of works and Inception Report, the field surveys were carried out from mid September to early December of 1975 including aerophotograph taking, topographic survey, regional economy and traffic survey, soil and aggregate survey, hydrological survey and survey for the existing conditions of roads and bridges by respective experts.

The results of these field surveys were described in the progress report submitted to the Government of Tanzania.

At the end of survey period, both parties have agreed and defined, as shown in CHAPTER I-1, the design criteria for this project upon mutual exchange of their comments on the draft of design criteria presented by both parties.

Then, the various data obtained in the course of field surveys were studied and analysed in Japan, and based on these results, planning and design of road and bridges, construction cost estimate, planning of construction, economic analysis and evaluations were prepared by collating with scope of works and contents of Inception Report.

These works consists of basic plan to meet the design criteria and several stage construction plans mainly for the pavement work as a necessary step for the completion of the roads. These works were proceeded with the results of discussions at the meeting held several times by the supervisory committee.

The Interim Report presented herewith describes the outline of the results of engineering and economic studies mentioned above and presents the Tanzania Government our recommendations at this stage of the studies.

CHAPTER I THE BASIC CONDITIONS FOR THE ENGINEERING PLANNING AND ECONOMIC EVALUATION

I-1 Design Criteria

The design criteria to be adopted in the studies for this project is the one which was agreed with the Tanzania Government at the time of field survey in 1975.

The contents are as follows:

SOUTHERN LINK ROAD PROJECT

DESIGN CRITERIA

1. The design of all geometrical elements of the road should follow AASHO recommendations for 2 lane Rural Highway with the following controls:-

   a) Design speeds

   Flat to rolling terrain - 100 Km/h, Max. grade - 5%
   Rolling to Hilly " - 80 Km/h, Max. grade - 6%
   Mountainous - 60 Km/h, Max. grade - 8%

   b) Pavement and shoulder widths

   Roadway - 6.5m
   Shoulders - 1.8m but can be reduced to minimum of 1.2m in deep cuts (greater than 2m)

   c) Maximum Super-elevation rate 8.0%

   d) Maximum cross fall (normal crown) - 3%

   All other elements of design should be as per AASHO. (A policy on Geometric Design of Rural Highways)

2. Bridges

   a) Loading as per BS 153, HA loading or AASHO H20 - S16 - 44 which-ever gives the worse effect.

   b) Steel to BS 4360 grade 43A or JIS equivalent. Reinforcement Steel use appropreate BS specifications or their JIS equivalent.

   c) Concrete to be dependant on locally available aggregates and cement. In special case cement other than ordinary portland cement can be specified if justified.

   d) Bridge width - 7.5m for 2 lanes carriageway

e) Footpath - 1.5m on one side for 3 main bridges, 1.0m for flood opening bridges if longer than 30m. No footpath for spans shorter than 30m

3. Construction gauges

Width - in accordance with AASHO
Height - 4.7m

4. Clearance under the girder of bridge

Main bridges - 1.2m above H.W.L.
Others - 1.0m above H.W.L.

5. Units - All measurements etc., are to be in metric units.

6. Drawings sizes - 600 x 840mm
Reports - 210 x 300mm

7. Pavement - depending on locally available materials for base and sub-base, and for surfacing use surface dressing or asphaltic concrete depending on economics strength of pavement and availability of material locally.

I-2 Construction Section

The proposed route in this project are classified into following 5 sections:

	Section	Distance (Km)
1.	Kibit - Nyamwage	36.00
2.	Nyamwage - Nangurukuru	101.15
3.	Nangurukuru - Kiranjerange	86.70
4.	Kiranjerange - Lindi	76.23
5.	Nangurukuru - Kilwa Masoko	30.38
	Total	330.46

In this project, however, planning, design and construction cost estimates for 12Km section around Rufiji River and Ruhoi River are excluded as these works were covered by the design of Rufiji River Bridge Project.

I-3 Topographic Maps Used

Since the studies as described in this report are at the preliminary stage, the planning and design of road and bridges were prepared using 1/5000 scaled topographic map. However at the following preliminary design stage, 1/2000 scaled topographic map will be used, therefore, at the final stage, the minor changes may occur in the figures indicated in the present report.

I-4 Standard elevation and co ordinates of topographic survey

The standard elevation level to be adopted in the planning and design for this project is based on the elevation used in the design of Rufiji River Bridge Project, and as to the original point for the coordinate of plan was indicated at the point of origin in Kibiti.

I-5 Premise for the economic evaluation

The economic evaluation was carried out for the 5 construction sections in the total extension of 330.5km between Kibiti and Lindi excluding 12kms section around Rufiji Bridge construction site assuming that the Rufiji Bridge is already constructed.

When the bridge will be constructed across the Ruvuma River running along the boundary with Mozombique, the traffic volume of the Southern Link Road is considered to increase at a rapid rate as this road will become an international trunk road.

Therefore economic evaluations were made by estimating future traffic volume for both cases of assuming the Ruvuma River Bridge will be constructed at the year of 1981 and will not be constructed.

CHAPTER II ROAD PLANNING

II-1 Existing Road Conditions

The existing road of 325km section from Kibiti to Lindi and 37km between Nangurukuru and Kilwa Masoko are, as shown in Table 2-1, mostly of unimproved earth road where the vehicle speed could hardly be kept at 30km/hr even in a dry season in which road conditions are relatively good. Particularly at the area where black cotton clays are distributed, the condition of road surface is very poor and the vehicles are difficult to pass. There are also many places of steep grade around the slope of mountainous area and the sections crossing the valleys, most of these areas have a longitudinal grade of more than 12% where even climbing of jeep is difficult.

Table 2-1 <u>Pavement Conditions of the Existing Roads (km)</u>

Classification \ Section			No.1	No.2	No.3	No.4	No.5	Total
Flat Terrain	Pavement	Good						
		Poor				1.5		1.5
		Bad				0.5		0.5
	Improvement(1)	Good						
		Poor						
		Bad						
	Improvement(2)	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 road	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
	Total		38.2	73.3	14.6	22.6	20.0	168.7
Hilly Terrain	Pavement	Good						
		Poor						
		Bad						
	Improvement(1)	Good						
		Poor						
		Bad						
	Improvement(2)	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 road	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
	Total		5.0	20.0	33.7	16.3	6.9	81.9
Mountainous Terrain	Pavement	Good						
		Poor						
		Bad						
	Improvement(1)	Good						
		Poor						
		Bad						
	Improvement(2)	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 road	Good						
		Poor		1.0	4.0	2.0	2.0	9.0
		Bad		9.0	9.0	18.0	3.0	39.0
	Total		5.5	14.2	41.0	40.1	9.8	110.6
Grand Total			48.7	107.5	89.3	79.0	36.7	361.2

II-2 Results of Soil and Aggregate Investigation

2-1 Soil Conditions along the Proposed Route

The soils distributed along the proposed route are classified into 4 grades; from grade I to IV in view of their physical and mechanical properties. The classification criteria and suitability for the material of road are shown in Table 2-2, and Figure 2-1 shows the results of such classifications of proposed route corresponding to each grade.

The grade I soils are classified into A-1-b, A-3 and A-2-4 in accordance with AASHO classification system and they are good to acceptable as the material of subbase course, while they are also generally acceptable for the material of base course if treated by mechanical stabilization with cement or bituminous materials.

The grade II soils are classified into A-3, A-2-4 and A-2-6. Though laterite soils are classified into A-2-4, A-2-6 and A-6, they are covered by this grade. The Grade II soils are, being rolled sufficiently with carefully controlling moisture content, generally acceptable for the material of subbase course. Also they can be acceptable for the base course material if stabilized with cement.

The soils of A-3 and A-2-4 of low plasticity are, if stabilized with bituminous materials mixing around 40% of aggregate, also acceptable as the materials of base course.

The Grade III soils are conventional clayey soils and classified into A-6 and A-7-6. The soils of this grade are unacceptable for the material of subbase course. Also when CBR value of this soil is small, there may be a case where stable and economical pavement can be gained using Grade I and II soils to form upper part of subgrade.

The Grade IV soils consist of black cotton clay and kaolin clay and classified into A-6 and A-7-6.

The soils of this grade have no trouble when they are dried, but the strength will be extremely lowered when they absorb the water in the wet season. Therefore it is advisable not to use them as the materials of embankment. In case of cuttings it is desirable to form upper part of subgrade by the Grade I or II soils.

2-2 Soil Stabilization with Cement and Bituminous Materials

The Grade I and II soils can retain the unconfined compression strength of around 12-22kg/cm^2 when they are stabilized with 6 to 8% of cement. However, for the materials containing less than 10% of fine particle with 0.074mm or small diameter as like the sand of Rufiji River, the effect of soil stabilization is less noticeable.

Table 2-2 Engineering Classification of Soils Distributed at Shallow Depth

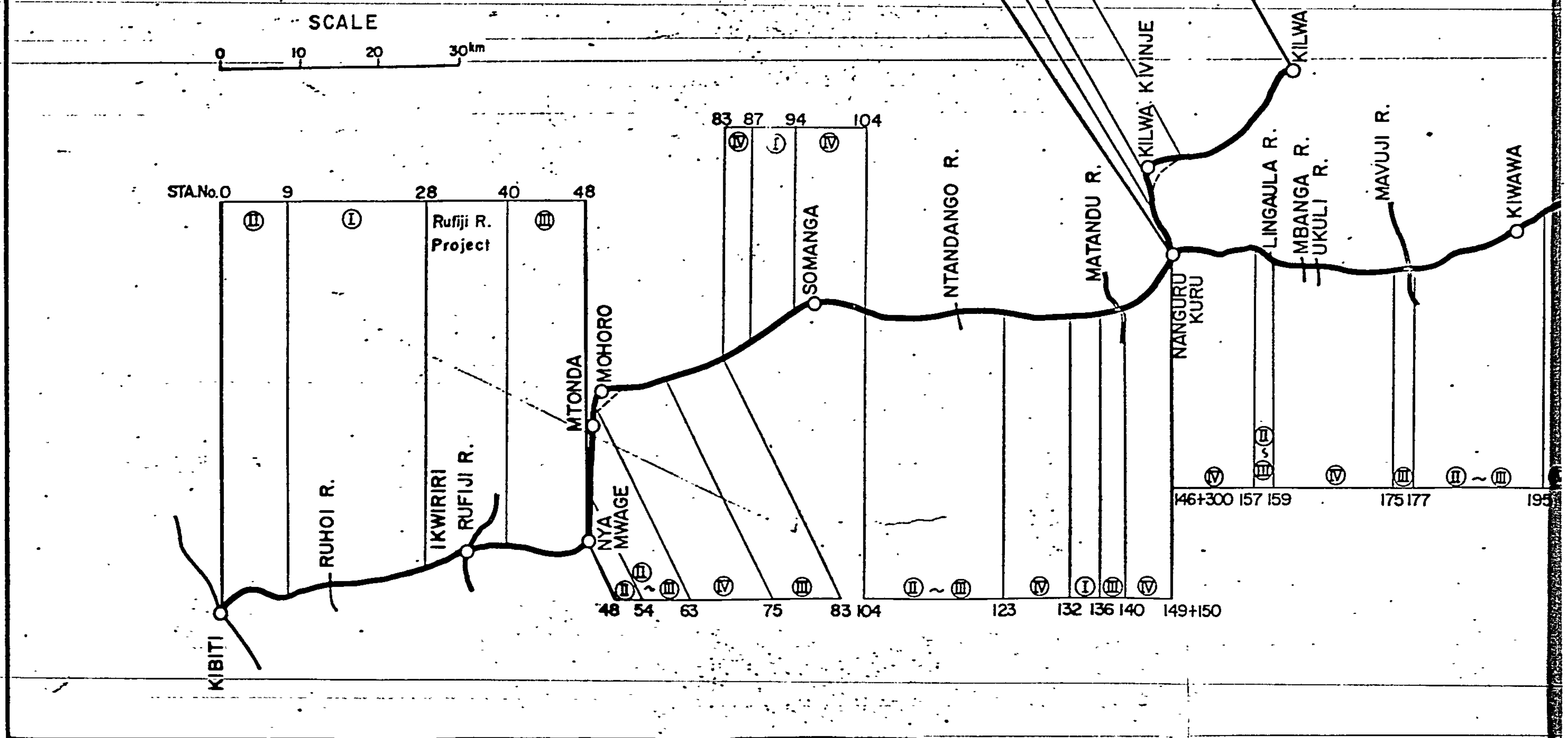
Grade	Classification Criteria	Suitability for Road Material					Remarks
		for Embankment Material	for Replacement Material	for Subgrade Material	for Subbase Course Material	for Base Course Material	
I	AASHO Classification A-1-6, A-3 and A-2-4 CBRs = 17~40 % Estimated CBRm > 25 %	Excellent	Excellent	Excellent	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 distributed 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	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 = 1~2 %	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 area are included in this Grade. Some clayey soils in flat planes are included also.
IV	AASHO 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 distributed in both hilly and flat area is included in this Grade. Yellowish brown kaolin clay in hilly area is included also.

Note: CBRs denotes the CBR value of the soaked specimen compacted under natural moisture content with the compaction effort of 18.4 kg.cm/cm³

CBRm denotes the CBR value at soaked condition corresponding to 95% of the maximum dry density, γdmax. γdmax is obtained by compacting sample under the compaction effort of 25.6 kg.cm/cm³ (the modified Proctor).

No.	Section	Grade				Distance (KM)
		(I)	(II)	(III)	(IV)	
1	Kibiti to Nyamwage	19	9	8	0	36.00
2	Nyamwage to Nangurukuru	11	6	40	44.15	101.15
3	Nangurukuru to Kiranjerange	0	14	22	50.7	86.70
4	Kiranjerange to Lindi	4	45.23	0	27	76.23
5	Nangurukuru to Kilwa Masoko	0	21.38	5	4	30.38
	Total (KM)	34	95.61	75	125.85	330.46

Note: II - III, included as III



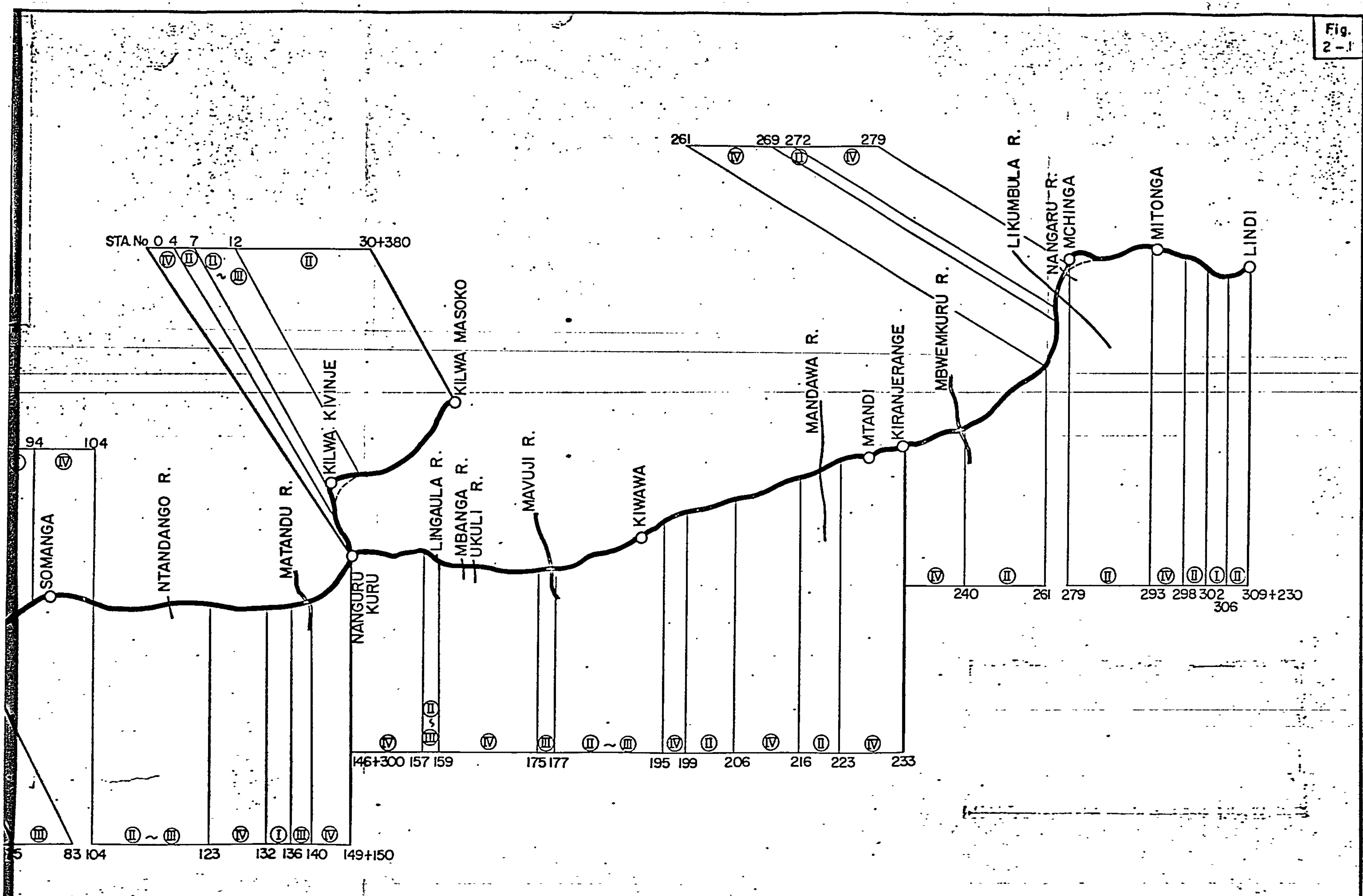


Fig. 2-1 SOUTHERN COASTAL LINK ROAD PROJECT

SOIL SECTION DEPENDING ON GRADE OF SOIL CONDITION

Admixtures of the sand at Matandu River, soft sand-stone near Kibiti, crushed stone like hard limestone near Nangurukuru and Mchinga shows sufficient strength with Marshal stability of more than 500kgs as the base course material when they are stabilized with straight asphalt, provided that the mixing ratio between sand of Matandu River and course aggregates at 3 sites is 62:38 and the amount of straight asphalt to be used is 4 to 6.5% of said admixtures.

The river sand near Ruhoi River does not mix the crushed stone indicating more than 250kgs of Marshal stability when they are stabilized with emulsified asphalt. On the other hand, the sand near Rufiji River and Ntandango were confirmed to gain more than 250 kgs of Marshal stability when they are mixed with crushed stone and fillers smaller than 3mm in diameter provided that in this case, mixing ratio of sand and the additives is approximately 60:40 and the amount of emulsified asphalt used ranges from 9.5 to 12%.

2-3 Aggregates

Between Nangurukuru and Lindi, there exists promising quarry sites at the interval of an appropriate distance, therefore the supply of course aggregate of crushed stones are readily available, while from Nangurukuru to Kibiti, there are few quarry sites that can produce plently of aggregates with high quality.

Regarding fine aggregate, however, river sand and other sand with relatively good quality are easily obtainable at the area from Nangurukuru to Kibiti. But from Nangurukuru to Lindi, the distribution of good quality sand are limited.

II-3 General Description of the Plan

3-1 Basic Policy for Road Planning

(1) Geometric design criteria for roads to be adopted in this study are, beside the design criteria which was agreed with the Tanzania Government in December, 1975, "Geometric Design Criteria For Rural Roads, United Republic of Tanzania" and "Standard Specification for Geometric Design of Rural Highway" adopted by AASHO.

(2) As regards route location, the proposed route was located, in principle, along the existing road. However, for the existing structures such as bridge and culvert and the structures presently under construction, the route was located to be served also as a construction road.

(3) Longitudinal alignment was planned to be left at existing terrain as much as possible within permissible range of design criteria, so that the amount of earth work can be kept at minimum.

Proposed height of embankment at the flood periphery was designed to be same as H.W.L. plus 1.0m of clearance height to make all weather road.

(4) Effective width of the travelled way was designed to be 6.5m with 2 lanes, the width of shoulder are set at 1.8m at standard section and at the area of deep cut, it was reduced to 1.2m. Also at each village, the bus bay of one lane are to be installed at both sides of the road.

(5) The cost of pavement works occupies the largest portion among the total construction cost, therefore study was made on the most economical pavement structure. At the same time several stage construction plans were studied to keep the initial investment minimum beside the study on the original plan as shown in Fig. 2-2.

Table 2-3 Extension of Proposed Routes (km)

Section No.	Flat Area	Hilly Area	Mountainous Area	Total
No.1 Section	40.50	3.00	4.50	48.00 (including Rufiji)
No.2 Section	79.95	8.00	13.20	101.15
No.3 Section	31.70	24.00	31.00	86.70
No.4 Section	33.13	8.90	34.20	76.23
No.5 Section	19.08	3.40	7.90	30.38
Total:	204.36	47.30	90.80	342.46

II-4 Design Criteria

4-1 Design Speed

Flat to rolling terrain	100 km/hr.
Rolling to Hilly "	80 "
Mountainous	60 "

4-2 Carriageway Width and Shoulder Width

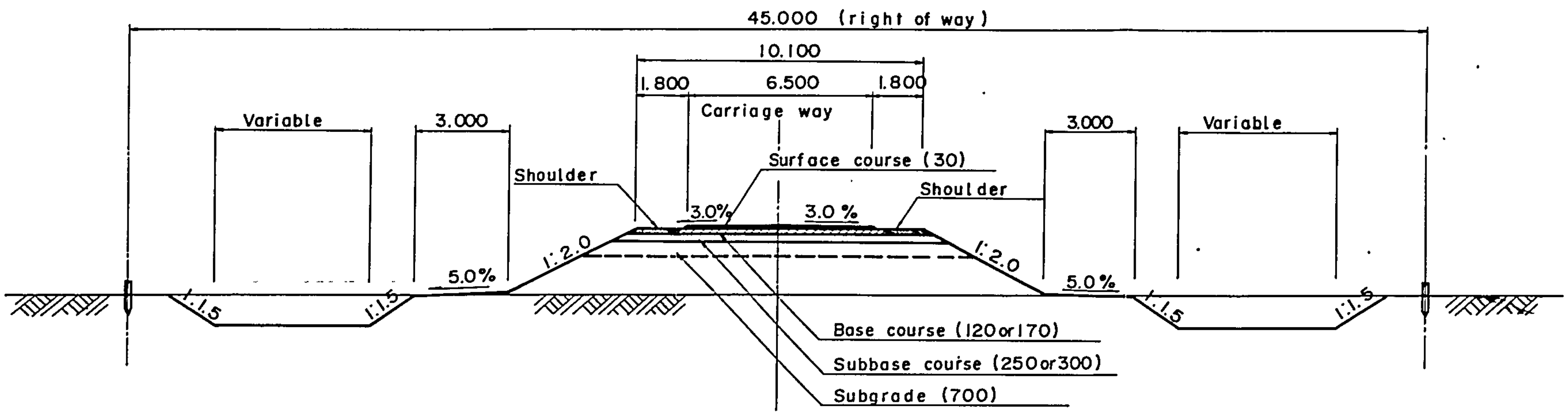
Roadway	6.5m
Shoulders	1.8m

but can be reduced to minimum of 1.2m in deep cuts (greater than 2m)

TYPICAL CROSS SECTION

FIG 2-2

Embankment Section



Cutting Section

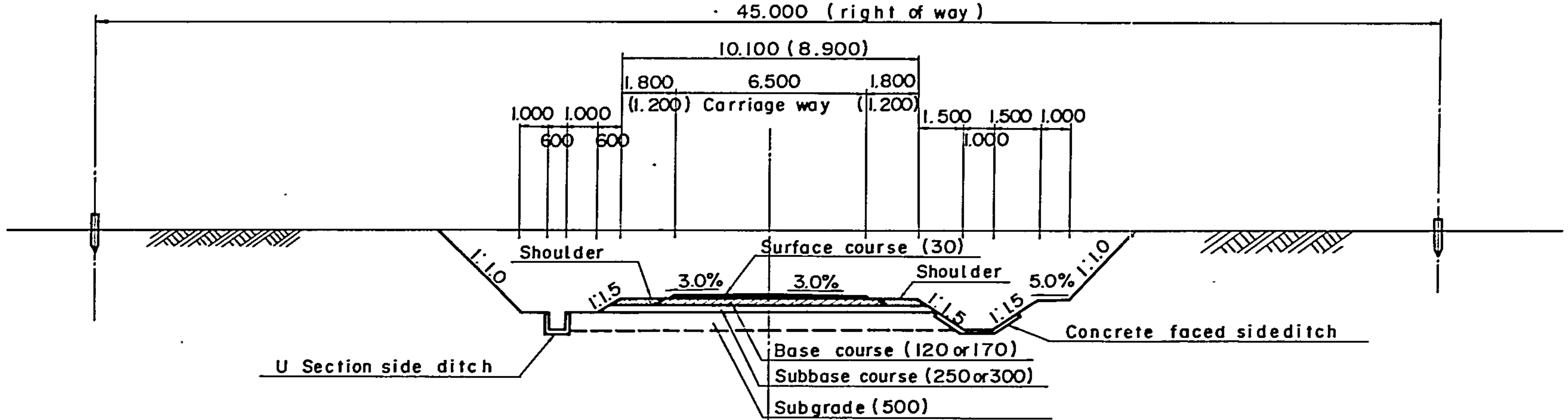


FIG.	SOUTHERN COASTAL LINK ROAD PROJECT
2-2	TYPICAL CROSS SECTION

4-3 Maximum Grades

Flat to Rolling terrain	5 %
Rolling to Hilly "	6 "
Mountainous	8 "

4-4 Super-elevation

Maximum Super-elevation rate	8.0 %
Maximum Cross Fall (normal crown)	3.0 "

4-5 Maximum Radious of Horizontal Curves

Desirable	300 m
Absolute Minimum	230 "

II-5 Planning of Alignment and Cross Section

5-1 Horizontal Alignment

According to the design criteria as shown in CHAPTER II-4, the desirable sharpest permisible horizontal curve radius is specified to be 300m and minimum sharpest permisible horizontal curve radius is specified to be 230m. In this plan, however, the curve radius are designed as large as possible and the number of curves are reduced to make a simple alignment. At the part of circular curve with the radius of less than 1,500m, transition curve was inserted.

Although the proposed route is basically located along the existing road, at the flat area, it is located to pass through high land deviating low land area, and at the mountainous area, the route is located to deviate from valleys and area of unstable slope where the rain fall is concentrated.

5-1-1 No.1 Construction Section (Kibiti - Nyamwage)

At the flat area around Rufiji River, scale of existing road alignment is large except at the area near Kibiti.

At the 10km section from Kibiti at mountainous area, difference of altitude between high and low land is around 120m, therefore the proposed route was located by studing several comparative routes considering their vertical alignment.

In the flat area, large scale alignment is planned along the existing road. However in the 12km section around Rufiji River it was left remained where the detail design of road was already completed.

At the bending section of almost right angle located near Nyamwage, relatively large curvature (R=700m) was inserted for the purpose of short cut.

5-1-2 No.2 Construction Section (Nyamwage - Nangurukuru)

Up to the Matandu River is being flat area near coast, then the proposed route was located along the existing road. However at the area of flood periphery near Mohoro, the route was changed to be located at high land of mountain side for the purpose of short cut. The existing road with bad alignment in the village of Somanga was also by-passed toward mountain side to deviate from the village for the purpose of improving existing alignment and short cut.

At the crossing point of Matandu River, the straight route was located between the existing road and the bridge under construction.

The junction of Nangurukuru is presently located at the area of the highest mountain summit. In order to improve the vertical and horizontal alignment of main route, the route is changed to be located in the low land of relatively flat area at western side.

5-1-3 No.3 Construction Section (Nangurukuru - Kiranjerange)

The most of this section are mountainous, the existing route runs through the ridge of a terrace having good drainage conditions. Therefore the proposed route was located along the existing road by improving existing road alignment.

At the crossing point of Mavuji River, the existing bridge is detoured toward west side, then the route was located at east side of the existing bridge with straight alignment. At the deep valley of mandawa River, the alignment is set at R=1,500m after locating most suitable river crossing point considering the connection with road at both sides.

5-1-4 No.4 Construction Section (Kiranjerange - Lindi)

In this section the proposed route runs from flat area of Mbwemkuru River to coast line of Lindi passing through mountaious areas located at both sides of coast line at Mchinga.

For crossing the Mbwemkuru River, the proposed route was located to pass straight through existing river and flood periphely along the east side of existing bridge.

In the section about 5km in front of Mchinga, since there are several meandering rivers, the proposed route was located to deviate from these rivers as much as possible.

In the section climbing from coast line of Mchinga to the terrace of Likonga and the section descending from the terrace of Likonga to the coast line of Lindi, the longitudinal grade are very steep, then the best alignment was selected by comparing several alternate routes.

In the section approx. 3km this side of Lindi, the proposed route was so located as to make use of the existing road as much as possible because the existing road retains sufficient width and good surface conditions.

5-1-5 No.5 Construction Section (Nangurukuru - Kilwa Masoko)

The existing road in this section is served as an approach road leading from Nangurukuru to Kilwa Masoko via Kilwa Kivinje. Since this route is running to Kilwa Kivinje it detours largely. Therefore the new route was proposed to be located to by-pass Kilwa Kivinje with the purpose of short cut. Consequently approx. 8km was reduced against an extension of the existing road.

Up to about 10km from Nangurukuru is of mountainous area and remaining part is flat near the coastline. The existing road alignment in the flat area is very good, therefore, the proposed route was located along the existing road by partially improving the existing alignment.

5-2 Profile Plan

The maximum longitudinal grade at the mountainous area was set at 8% while minimum value in the flat area was set at 0.2% considering drainage condition of road surface.

The embankment height at the section of Grade I to II was set at the height equal to the thickness of pavement (0.5m) and in the section of Grade IV, it was set at the height equal to the pavement thickness plus thickness of upper part of subbase course (1.2m) as a standard.

In the area of flood periphery, the proposed height was determined on the basis of assumed H.W.L. plus 1.0m of clearance height by confirming flood marks and hearing as well as results of hydrological analysis.

At the part of cuttings, it was planned by considering drainage condition so that the amount of earth works can be kept minimum.

5-2-1 No.1 Construction Section

The present scope of this design was planned to connect with both end points of 12km section covered by Rufiji River Bridge project, of which detail design was already completed. Regarding high water level (H.W.L.) in the flood periphery of Rufiji River, it is designed to be 17.5m as adopted at the time of detail design. Then the proposed height of the road is designed to be 18.5m by adding 1.0m of clearance height to above H.W.L. At the point 5km away from Kibiti, the maximum longitudinal grade was set at 8%.

5-2-2 No.2 Construction Section

According to the hearings in the area, the existing road at Mohoro area had been innundated about 2.0m at maximum resulting from flooding of the Rufiji River. Therefore minimum proposed height was designed to be 11.0m assuming H.W.L. as 10.0m.

H.W.L. at the Matandu River is planned to be 10.5m as a result of flood marks by hearing and hydrological analysis.

At the several points in the mountaious area from Matandu River to the junction of Nangurukuru, the maximum grade were set at 8%.

5-2-3 No.3 Construction Section

The most part in this section are gentle hilly area, so profile plan was made to fit with existing terrain, in this section there exists Ringakur, Mavuji and Mandawa Rivers running through deep valleys, then the profile plans were made as low as possible to reduce construction cost of bridge substructures and earth work at approach portion. The H.W.L. at Mavuji River was planned to be 35.00m and the maximum gradient was set at 7.8%.

5-2-4 No.4 Construction Section

In the mountainous area from Kiranjerange to Mbwemkuru River with gentle topography, vertical alignment was planned to fit the existing terrain. H.W.L. of Mbvemkuru River was set at 24.50m.

In the section entering into mountainous area from Mbvemkuru River, section ascending to the terrace of Likonga from Mchinga and descent slope section from the airport at the terrace of Lindi to the coast line, the maximum grades were set at 8%.

In the section up to approx. 3km from Lindi, the conditions of pavement and alignment are good, thus the vertical alignment was planned along the existing road.

5-2-5 No.5 Construction Section

As the route from intersection at Nangurukuru located in the summit of mountain to the point to by-pass Kilwa Kivinje lays on the mountainous area, the gentle alignment was planned along with the mountain side.

Up to the point approx. 20km from Kilwa Masoko the proposed alignment runs along the existing road passing through central part of flat peninsula. Therefore the minimum embankment height was planned to be 0.5 - 1.0m considering drainage conditions in a cross direction.

The vertical alignment at the intersection of the existing route leading to Kilwa Kivinje was planned to fit the height of the existing road.

5-3 Crossing Plan

5-3-1 Component of Road Width

The component of road width was, as a result of discussion with Tanzania Government, determined as shown in the Fig. 2-2.

The width of the carriage way is designed to be 6.5m, provided with 2 lanes and width of road shoulder to be 1.8m, provided, however, at the section where the depth of cut exceeds 2.0m, it is reduced to 1.2m to reduce the amount of earth work. The component of bridge width are designed to be 7.5m i.e., 6.5m for carriage way, 0.5m for shoulder.

At the villages situated along the existing road, the widening areas to be served as a bus bay are planned to be installed at both sides of the road. The widening area has a width of 3.0m with extension of 50.0m and tapered section of 25m length at both sides.

The cross fall in the standard area was set at 3% at both carriage way and shoulder. The slope gradient of embankment was set at 1:2 and that of cut section to be 1:1 as a standard. As a means of slope protection, grass planting method is planned. Particularly as the slopes at both ends of the bridge structures tend to be damaged by the flood flow, the masonry work is planned at the area south of Nangurukuru where the plenty of aggregates are available, and in the area north of Nangurukuru where the supply of aggregates are scarce, special slope is planned by means of precast concrete block.

5-3-2 Pavement Structure

Based on the results of soil and aggregate investigations as described in CHAPTER II-2, the pavement structures were planned on the basis of the following basic idea:

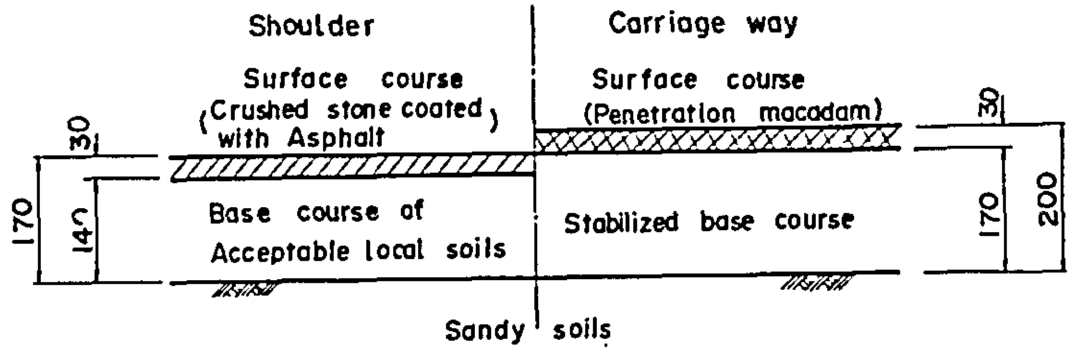
1. The surface course of the entire road shall be paved with penetration method in the thickness of 3cm.

2. As regards the base course, in order to improve the adhesiveness and stickness against surface course, local sandy soils of good quality (Grade I and II soils having low or no plasticity) or admixture of this material and crushed stone being stabilized with bituminous materials shall be used.

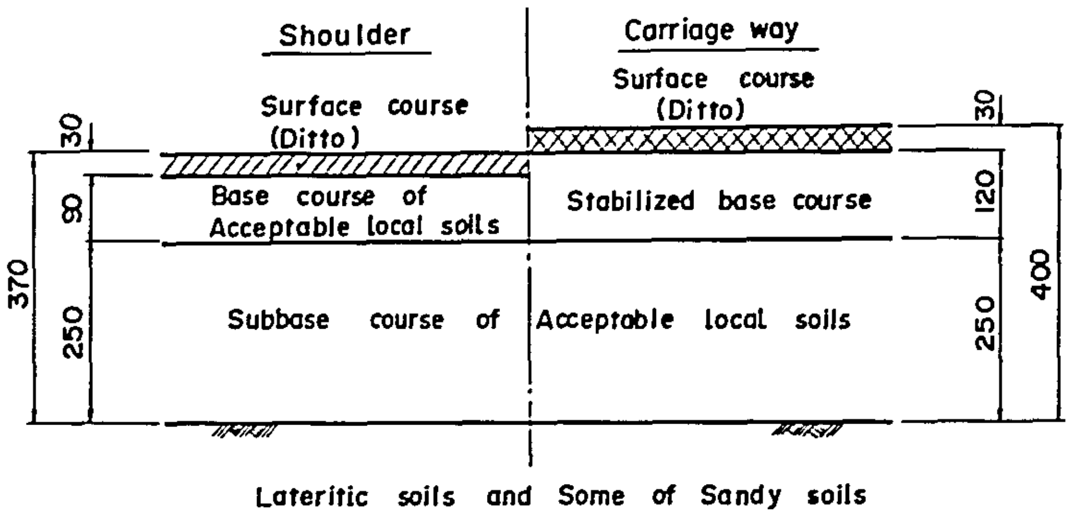
FIG 2-3

Pavement thickness corresponding to soil classification

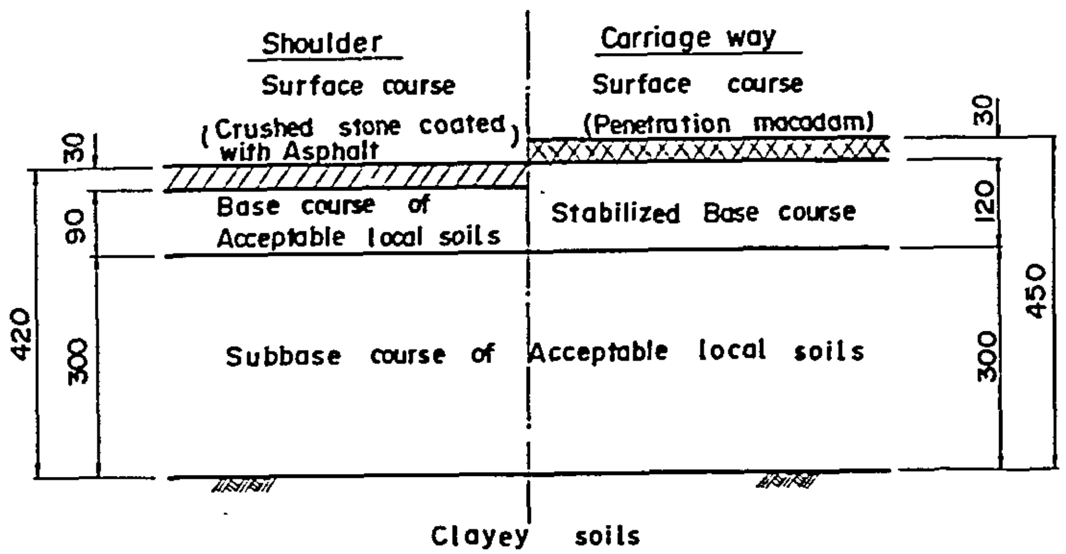
Grade - I



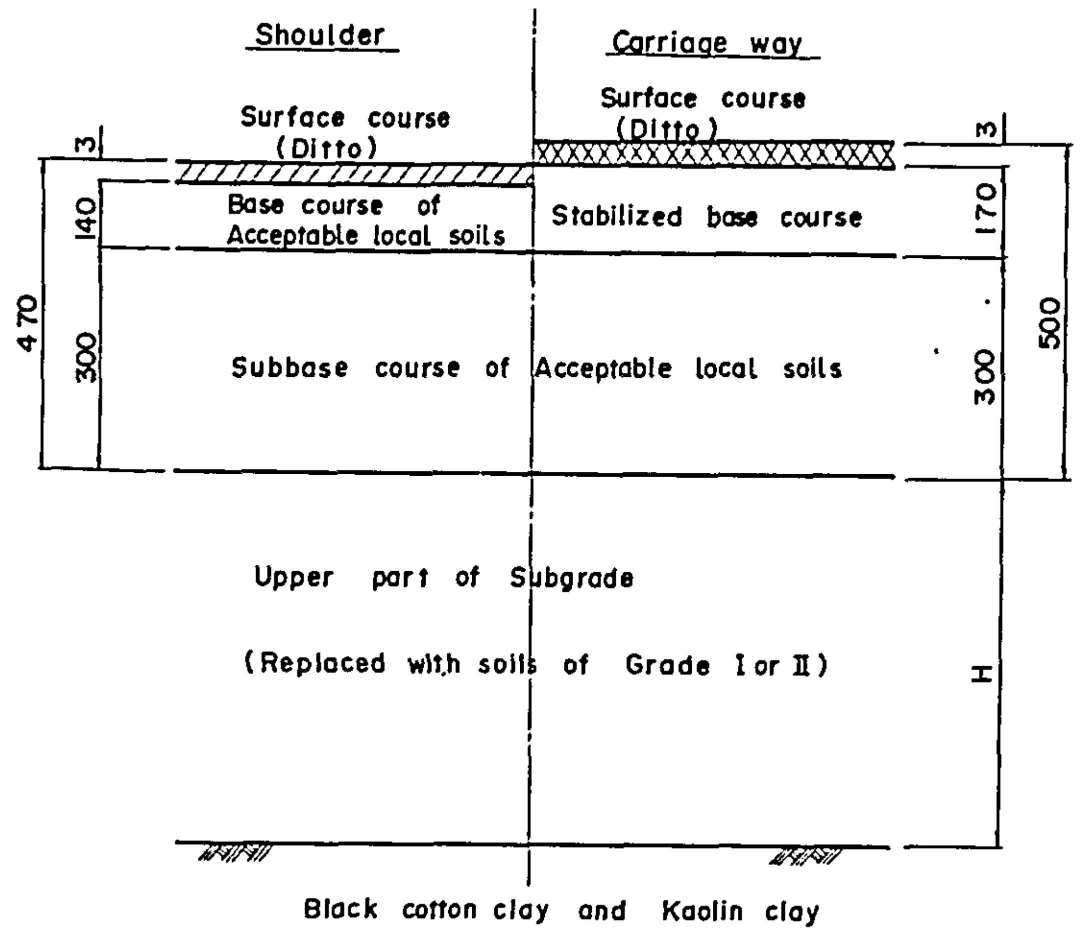
Grade - II



Grade - III



Grade - IV



Replacement thickness H : 700 mm for Embankment portion
500 mm for Cutting portion

FIG.	SOUTHERN COASTAL LINK ROAD PROJECT
2-3	PAVEMENT THICKNESS CORRESPONDING TO SOIL CLASSIFICATION

In the northern part of the existing road, economical supply of crushed stone is difficult, therefore at the section north of Somanga, instead of using crushed stone, sand of Ruhoi River shall be used as much as possible, of which stability effect can be expected.

In the southern part of Somanga, admixtures of local sandy soils of good quality and crushed stones to be stabilized with bituminous materials shall be used.

3. As the materials of subbase course, local Grade I or II soils shall be used.

4. For the area of Grade IV soils, Grade I or II soils shall be used to form upper part of subgrade.

The results of above study is shown in Fig. 2-3. However, for the following respects, further study is planned to be carried out:

i: Where the adopt of soil stabilization with bituminous materials becomes extremely uneconomical for the base course, other alternate method shall be studied.

ii: Study on the economic merit and demerit to use good quality soils to be brought from other area to form upper part of subgrade at the area of Grade III soils is to be made in case by case.

II-6 Earthwork and Drainage Planning

6-1 Earthwork Plan

As a result of the soil investigation as described in CHAPTER II-2, soils of the area along the proposed route were classified into Grade I to IV, as shown in Fig. 2-1.

In the embankment section of Grade I - III, naked ditch for drainage was planned at both sides of the road, and the soils excavated at this time are planned to be used as the embankment materials.

In the embankment section of Grade IV, due to bad ground conditions, higher embankment was planned to alleviate traffic load for the foundation ground. However in case Grade I or II soils are not available near the site, Grade I or II soils shall be used only for subgrade and for subbase, locally available soils shall inevitably be used.

At the cutting section of Grade IV soils, since cut off soils can not be used as the materials of subgrade and base course, appropriate spot shall be selected to discharge waste soil.

6-2 Drainage Plan

The amount of precipitation to be considered for drainage plan was, based on the hydrological data, estimated to be 66mm/hr.

For the drainage ditch at the cutting section, as shown in Fig. 2-2 concrete faced side ditch and U section side ditch were considered to be adopted by estimating the cross sectional area of flow of the ditch based on the amount of discharge and flow velocity.

For the drainage of the embankment, naked ditch was planned to be installed at the point 3m away from toe of slope to protect subbase course.

Also for the parts of existing road connecting the proposed route and the connecting road to the inhabited area, pipes of 600mm in diam. was planned to be installed so as not to divide the side ditch of main route.

As regards hydraulic design of culvert, pipes of 800mm 1,200mm and 1,800mm in diam. are planned to be layed based on the results of hydrological analysis.

Minimum cross fall and longitudinal grade was set at 3% and 0.2% respectively to improve the drainage conditions.

For the final drainage treatment, the drainage ditch was so planned as to let the flow into natural valleys as much as possible to reduce the flow of drainage ditch as well as avoiding the influence to the main route and surrounding area.

II-7 Stage Construction

In order to improve economic effect of the road, the stage construction plans were considered as shown in Fig. II-2 beside the original plan.

As the methods of stage construction, considering the convenience for future construction, the following 4 plans (original plan and plans No. 2-4) are ultimately proposed.

Plan No.1 (Original Plan)

Complete construction without stage for whole project area including carriage way and shoulder, between Kibiti - Lindi and Nangurukuru - Kilwa Masoko.

Plan No.2

No.1 construction section between Kibiti to Nyamwage, shall be completed from first stage because of large traffic volume. From Nyamwage to Lindi and Nangurukuru to Kilwa Masoko of No.2 to 5 construction sections, since the traffic volume is small the carriage way shall be stage constructed to complete one lane at first step while shoulder shall be completed.

Plan No.3

Similar to plan No.2 except that the shoulder shall also be stage constructed.

Plan No.4

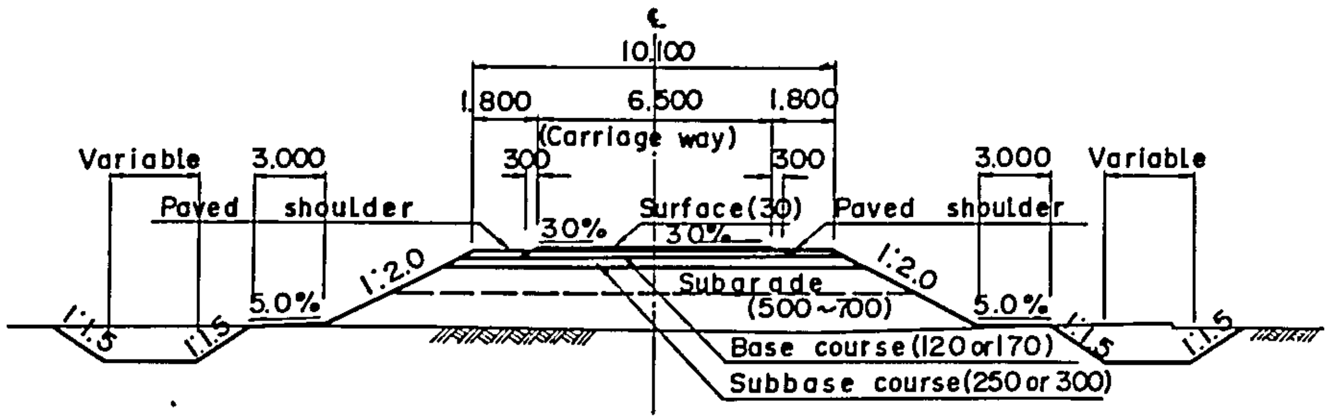
From Kibiti to Lindi and Nangurukuru to KilwaMasoko of the entire sections shall be stage constructed including both carriage way and shoulder. At the first stage the route shall be served as gravel road.

The typical cross sections of these plans are shown in Fig. 2-4.

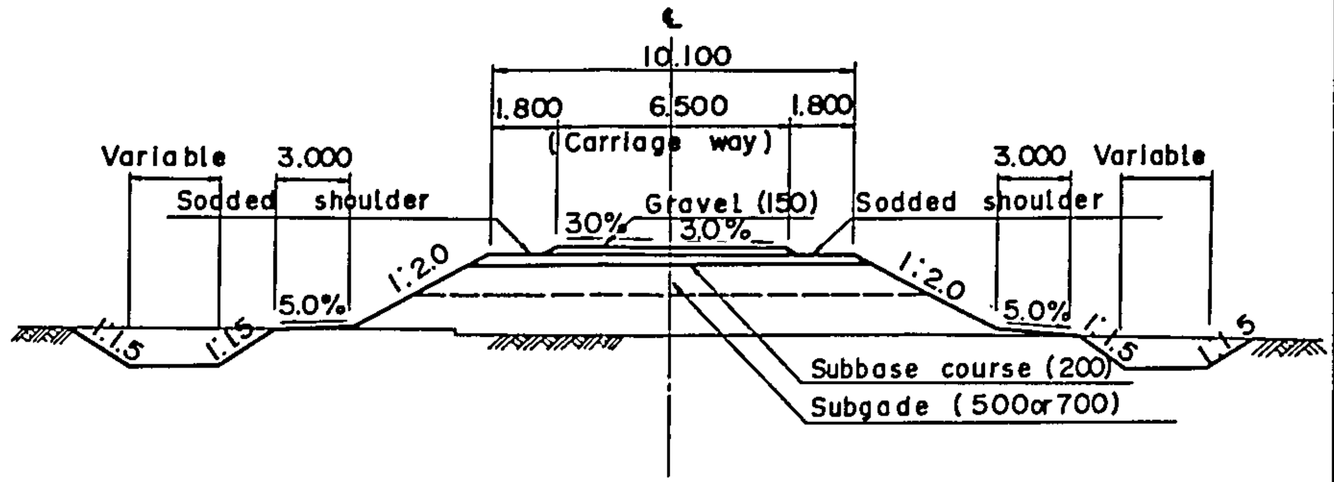
FIG 2-4

TYPICAL CROSS SECTION & CONSTRUCTION PLAN BY SECTION

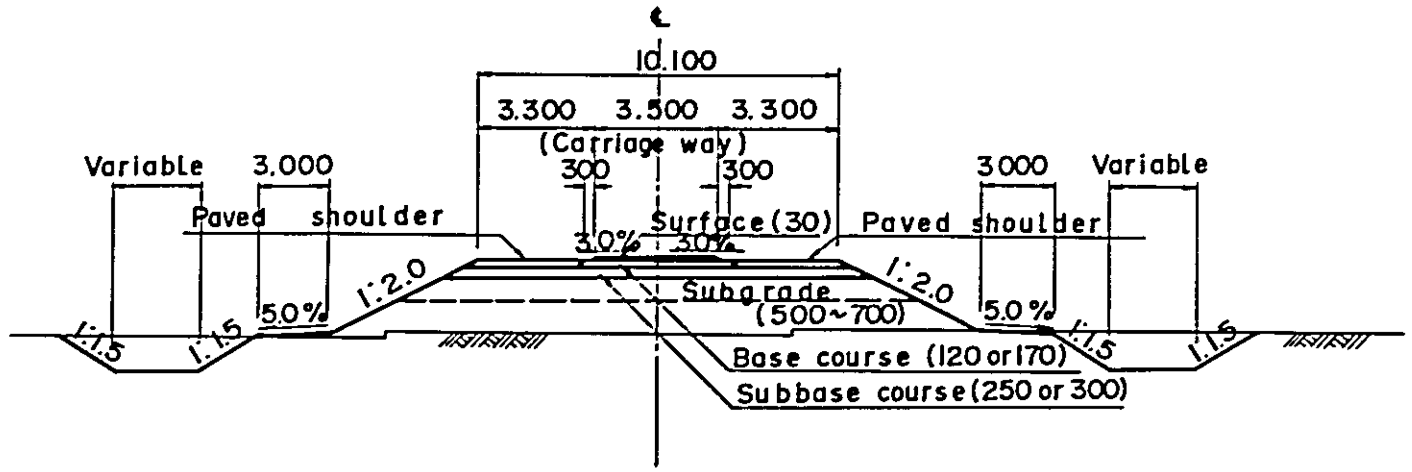
TYPE-A (Initial overall construction)



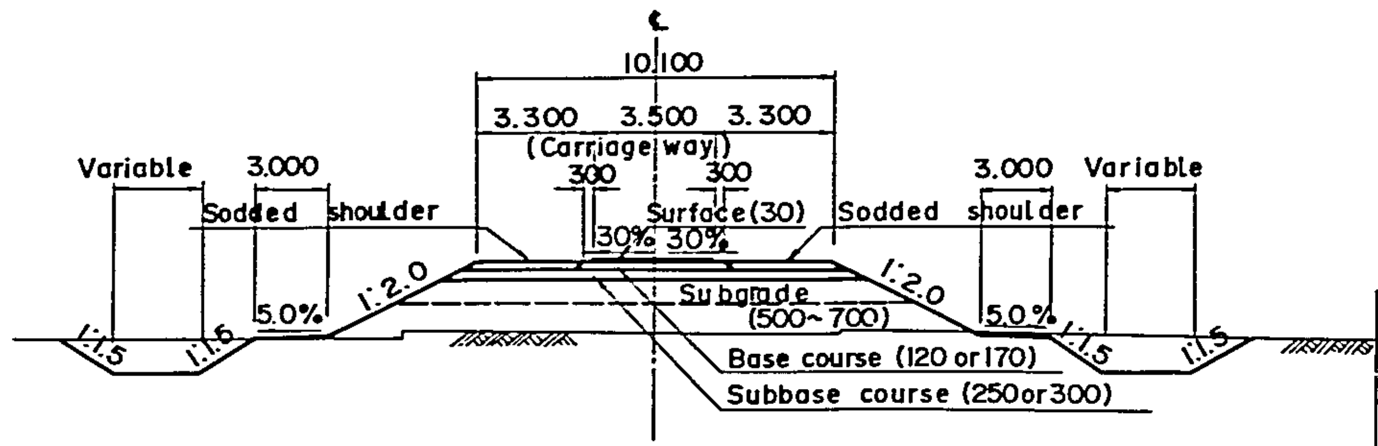
TYPE-D (Stage construction)



TYPE-B (Stage construction)



TYPE-C (Stage construction)



Section / timing / Construction Plan	Section 1		Section 2		Section 3		Section 4		Section 5	
	①	②	①	②	①	②	①	②	①	②
Plan 1	A	—	A	—	A	—	A	—	A	—
Plan 2	A	—	B	A	B	A	B	A	B	A
Plan 3	A	—	C	A	C	A	C	A	C	A
Plan 4	D	A	D	A	D	A	D	A	D	A

NOTE: ① First stage
② Second stage
A : TYPE-A
B : 〃 -B
C : 〃 -C
D : 〃 -D

FIG.	SOUTHERN COASTAL LINK ROAD PROJECT
2-4	TYPICAL CROSS SECTION & CONSTRUCTION PLAN BY SECTION

CHAPTER III BRIDGE CONSTRUCTION PLANNING

III-1 Survey of Existing Bridge Conditions

The existing bridge conditions was surveyed for Matandu, Mavuji and Mbwenkuru River Bridges as well as other medium to small bridges and pipe culverts at 33 places. Most of bridges are located south of Nangurukuru.

Between Nyamwage and Nangurukuru, Many small rivers are existing apart from Matandu River. But almost no structures are constructed across these rivers.

Between Nangurukuru and Kilwa Masoko, there are few bridges, they are mostly pipe culverts and many of these culverts were temporarily constructed after old bridges were damaged.

The existing bridges are provided with 1 lane and the roadway width is approx. 3.5m. Namely, existing road becomes extremely narrow at the part of the bridges.

The width of pipe culverts are same as that of existing road. But some of those temporarily constructed culverts have the width smaller than that of existing road.

1-1 Matandu River Bridge

Bailey bridge with two spans is under construction and the substructure is almost completed. The abutment at the left side was constructed at 6m backword from bank slope considering collapse of slope of river bank, whereas at the right side the abutment was constructed at forward of slope surface thus narrowing river channel.

According to the hydrological survey, water level at the time of large flood in the past is confirmed to reach near the crown of right side abutment. Near the existing bridge the river is curved, therefore the structure is assumed to become unstable when the slope of river bank will be eroded in future. In case that substructure of bailey bridge will be used after removing superstructure, large scale repair is considered necessary by means of raising of crown of substructure etc.

1-2 Mavuji River Bridge

Bailey bridge with one span was constructed, but as their super and substructure are temporarily constructed, substructure is seriously damaged.

1-3 Mbwemkuru River Bridge

Bailey bridge with 6 spans and 120m length was constructed, and the superstructure is supported by stone masonried abutment at the right side. The left side abutment was constructed at forward of slope of river bed. The foundation is partly scoured.

2 piers at main stream are relatively stable conditions, but 3 piers at right side are large in scale paralyzing cross sectional area of flood flow. The piers at main stream can be used if repaired, however since foundation conditions are not clear, future durable year can not be defined. Other abutment and piers are proposed to be entirely re-constructed.

1-4 Medium to Small bridges and pipe culverts

The characteristic of medium to small bridges is the short length against width of the rivers. Therefore embeded part of abutment are extremely scoured. Floor slab of most superstructures are damaged. Although some of pipe culvert were recently repaired by the Tanzania Government, their area of flow cross section are not sufficient.

Approximately 20% out of those surveyed medium to small bridges and pipe culverts are relatively in good conditions.

1-5 Evaluation of Existing Bridges

The study was made on the case of using existing 2 lanes bridges by improving existing substructures of Matandu and Mbwemkuru Bridges, and improving medium to small bridges of good conditions. The results are as follows:

(1) As compared with the case of reconstruction of new bridge, both super and substructure, the difference of construction cost is small. Since it becomes separate structures, there may be a case that the construction cost is increased resulted from cost up for the construction of access road.

(2) Durable years of the repaired portion of existing bridge can not be defined.

(3) New bridge with 1 lane to be constructed in parallel with existing bridge is planned to have a length sufficient for the flow cross section. Therefore the length of new bridge differs from that of existing bridge.

(4) For the purpose of providing safe and stable bridges throughout the project life, there are some uneasiness to use the existing bridge in view of structural and hydrological consideration.

Therefore it is advantageous to reconstruct every existing bridges providing 2 lanes instead of utilizing existing bridges.

III-2 Result of Hydrological Survey

The annual rainfall of the project area is around 1,000mm/year and mostly concentrated in the rainy season through December to April. In this survey rainfall analysis was carried out by compiling daily rainfall records at precipitation stations located near the proposed route.

Rainfall intencity curve for use in the flood calculation of medium and small rivers was prepared by using probable and depth-duration curve of rainfall at Kilwa Kivinje located at about halfway of proposed route where plenty of precipitation data are available.

2-1 Study on the Existing Bridges at Major 3 Rivers

The each of Matandu, Mavuji and Mbwenkuru rivers is extremely meandering with unimproved channel, and the river channels are narrow as compared with the scale of drainage basin, forming vast flood plains. These trends are particularly eminent at Matandu and Mavuji Rivers, and the flood is flown down while innundating extensively. Therefore the traffic crossing the Matandu river are impassable during flood period as the bridge is not completed.

Among three rivers the Mbwenkuru river has relatively stable channel and large cross sectional area of flow. As a bridge construction plan the study was made on the sufficient bridge length to safely let the design discharge by sifting up H.W.L. above the observed flood stage. The results are shown in Table III-1.

The design discharge is referred from "Feasibility Report on Dar es Salaam/Lindi Coastal Link Road Project, Overseas Technical Cooperation Agency, 1971".

Table 3-1 Factors of Major Three Rivers

Item / River	Catchment Area (km^2)	Discharge (m^3/s)		H.W.L. (m)	Bridge Length (m)		
		Design	Max.		Main Stream	Flood Opening	Total
Matandu	15,210	2,000	4,530	10.5	80	Right Bank 100 Left Bank 500	680
Mavuji	3,030	1,000	1,980	35.0	80	Right Bank 100	180
Mbwemkuru	16,460	2,000	4,810	24.5	120	Right Bank 120 Right Bank 60	300

The bridge length as determined in this plan are studied, by obtaining cross sectional area and water surface slope from the result of measurement, using following formula (i)

$$\left.\begin{array}{l} V = 1/r \cdot R^{2/3} \cdot I^{1/2} \\ Q = V \cdot A \end{array}\right) \; . \; . \; . \; . \; . \; (i)$$

where; Q: Discharge (m^3/s)
A: Cross Sectional Area (m^2)
V: Average flow velocity (m/s)
n: Coefficient of Roughness

(main stream; $n=0.03$)
(flood portion; $n=0.045$)

R: Hydraulic Radius (m)
I: Water Surface Slope

The swell head at the time of extraordinary flood are, when calculated by formula (i) (correlation between discharge and water surface flow), approx. 30cm at Mbwemkuru River and less than 10cm at other 2 rivers, provided that clearance under girder from H.W.L. at three rivers is 1.2m.

2-2 Study on Other Small Rivers

For the small rivers, bridges are constructed mainly near Lindi district. In the other area, the traffic are secured only by corrugated pipes along the existing road or stones piled in the river bed, then it may become obstacle for traffic when overflowing. Therefore the study was made on the scale of bridge and number of corrugated pipes required by calculating amount of discharge for small rivers at 77 places.

2-2-1 Basic Policy for the Planning

The structures across small rivers are, basically, by means of bridge. However if the amount of discharge is small and the flood can be scattered due to plain topography, corrugated pipes shall be installed. The scale of the plans is as follows;

Bridges: w=1/10(10 years return period)

Corrugated Pipes: w=1/3(3 years return period)

Design discharge was calculated based on the following formula (ii)

$$Q = \frac{1}{3.6} \cdot f \cdot A \cdot \gamma \qquad \cdots\cdots (ii)$$

where: Q; Discharge (m^3/s)
f; Coefficient of run-off (f=0.3)
A; Catchment Area (km^2)
γ; Intensity of the time of concentration (mm/hr)

Rainfall intensity formula

$$\begin{cases} \gamma_{1/10} = \dfrac{9681}{t + 38.3}(mm/hr) & : \text{bridge} \\ \gamma_{1/3} = \dfrac{6476}{t + 38.3}(mm/hr) & : \text{corrugated pipes} \end{cases}$$

t ; Time of Concentration (min.)

$$t = \frac{\text{length of flow (m)}}{\text{flow velocity(m/min.)}} = \frac{L}{20 \cdot i^{0.6} \times 60 \text{ (min.)}}$$

2-2-2 Claculation of Design Discharge and Study on the factors

Bridges
Design discharges were calculated for the 49 small rivers. On the basis of these design discharge, the length of bridges were determined by obtaining required cross sectional area assuming design flow velocity as v = 3.0 - 4.0 m/s.

The bridge length, design discharge and other factors in the catchment area are shown in Table 3-2. The clearance between H.W.L. and girder was set at 1.0m.

Corrugated Pipes
For the small rivers (valleys) at 28 places, design discharges were calculated and number of corrugated pipes required was studied, assuming design flow velocity as v =3.0 - 3.5 m/s. Diameter of pipes to be used was set at 1.8m, effective for 80% cross section.

Factors of catchment area, design discharge and number of corrugated pipes required are shown in Table 3-3.

Table 3-2 (1) Discharge (Bridge - 1)

(w=1/10)

Section	Station		Area, Length and Rainfall Intensity				Q	q	Bridge Length
			A (km²)	L (km)	T (min.)	R (mm/hr.)	(m³/s)	(Q/A) (m³/s/km²)	(m)
1	No.14 + 700		21.10	10.0	136	55.5	98	4.6	14.00
	No.17 + 300		1186.00	70.0	2076	4.6	453	0.4	4-span 60.00
	No.24 + 780		13.27	2.4	51	108.6	120	9.0	16.50
2	No.68 + 700		147.77	32.5	416	21.3	263	1.8	16.50
	No.74 + 450		115.20	35.0	541	16.7	160	1.4	19.50
	No.80 + 400		19.80	5.6	69	89.9	149	7.5	14.00
	No.86 + 800		64.52	20.6	340	25.6	138	2.1	16.50
	No.87 + 725		37.70	13.8	177	45.0	142	3.8	16.50
	No.98	No.98 +350							11.50
		No.99 +500							11.50
		No.100 +300	365.40	62.5	921	10.1	308	0.8	11.50
	No.100	No.100 +675							11.50
	No.103 + 330		86.83	20.0	272	31.2	226	2.6	19.50
	No.106 + 875		219.08	42.4	742	12.4	227	1.0	19.50
	No.116 + 875		81.15	25.8	408	21.7	147	1.8	19.50
	No.117 + 800		8.42	6.0	79	82.4	58	6.9	14.00
	No.120 + 225		19.82	10.3	144	53.1	88	4.4	14.00
	No.126 + 600		7.10	3.8	41	122.8	73	10.2	14.00
	No.128 + 500		3.25	3.6	42	121.2	33	10.1	11.50
	No.130 + 400		67.05	18.3	270	31.4	176	2.6	2-span 28.00
	No.136 + 670		8.53	6.8	93	72.6	52	6.1	11.50
	No.144 + 910		15.95	5.9	63	95.7	128	8.0	16.50
3	No.158 + 450		338.00	39.0	617	14.8	417	1.2	2-span 33.00
	No.163 + 215		80.20	23.0	276	30.9	207	2.6	19.50
	No.164 + 650		96.40	22.0	235	33.5	285	3.0	19.50
	No.167 + 300		8.60	6.0	61	97.3	70	8.1	14.00

Table 3-2 (2) Discharge (Bridge - 2)

(w=1/10)

Section	Station	Area, Length and Rainfall Intensity				Q	q (Q/A)	Bridge Length
		A (km²)	L (km)	T (min.)	R (mm/hr.)	(m³/s)	(m³/s/km²)	(m)
3	No.180 + 200	6.67	4.7	54	104.6	59	8.8	14.00
	No.184 + 75	20.60	12.0	98	70.9	120	5.9	14.00
	No.192 + 275	76.20	16.0	185	43.4	276	3.6	2-span 33.00
	No.196 + 625	5.45	3.3	25	152.6	70	12.8	14.00
	No.215 + 640	157.77	23.5	240	34.8	458	2.9	2-span 28.00
	No.221 + 950	48.00	10.0	76	84.5	339	7.1	16.50
	No.222 ~ No.223: No.222 + 900	33.10	8.8	67	91.9	254	7.7	14.00
	No.222 ~ No.223: No.223 + 65							14.00
	No.229 + 60	8.25	6.0	52	106.9	74	9.0	11.50
	No.232 + 650	18.40	7.6	70	89.3	137	7.4	14.00
4	No.236 + 400	9.40	5.8	54	105.4	83	8.8	11.50
	No.251 + 350	5.92	4.4	31	139.8	69	11.7	11.50
	No.253 + 75	8.25	5.3	27	149.8	103	12.5	11.50
	No.268 + 200	90.77	14.5	111	65.1	492	5.4	2-span 33.00
	No.268 + 390	6.10	4.3	30	141.2	72	11.8	11.50
	No.272 + 100	7.92	4.8	42	120.8	80	10.1	11.50
	No.274 + 910	561.50	48.6	769	12.0	562	1.0	4-span 66.00
	No.282 + 800	10.48	5.3	46	114.6	100	9.5	11.50
	No.287 + 630	46.35	12.4	121	61.0	236	5.1	2-span 33.00
	No.293 + 740	15.10	10.3	79	82.9	105	7.0	2-span 28.00
	No.296 + 425	112.65	22.0	340	25.6	241	2.1	2-span 28.00
	No.300 + 220	1.85	2.2	19	168.5	26	14.1	11.50
	No.302 + 470	4.63	5.0	35	131.8	51	11.0	2-span 28.00
	No.304 + 250	13.00	4.1	21	164.3	178	13.7	2-span 28.00
	No.306 + 415	7.65	3.6	21	164.1	105	13.7	11.50
5	No.13 + 200	17.00	5.0	58	100.8	143	8.4	14.00
	No.18 + 820	1.12	1.0	15	181.6	17	15.1	14.00

Table 3-3 Discharge (Corrugate Pipe):

(W=1/3)

Section	Station	Area, Length and Rainfall intensity				Q	q Q/A	Number of Corrugated Pipe
		A (km^2)	L (km)	T (min.)	R (mm/hr)	(m^3/s)	($m^3/s/km^2$)	(ϕ=1.8m)
2	No.50 + 500~ No.51 + 500	55.60	13.0	196	27.6	128	2.3	18
	No.57 + 400~ No.59 + 00	150.00	40.0	467	12.8	160	1.1	23
	No.65 + 700~ No.67 + 700	18.92	8.7	163	32.1	51	2.7	8
	No.101 + 440	2.72	3.0	69	60.6	14	5.1	3
	No.102 + 280~ No.102 + 890	12.93	9.0	161	32.6	35	2.7	5
	No.111 + 500	6.40	4.8	81	54.4	29	4.5	5
	No.113 + 200	10.67	8.8	148	34.7	31	2.9	5
	No.132 + 200	3.25	3.6	41.6	81.1	22	6.8	4
	No.140 + 130	1.13	1.0	15	152.3	12	10.6	2
	No.141 + 700	3.40	3.0	26	100.3	29	8.5	5
	No.143 + 300~ No.143 + 700	5.93	5.2	51	72.9	36	6.1	6
3	No.183 + 600	2.20	2.5	31	93.3	18	7.9	3
	No.185 + 40	1.38	1.9	25	102.2	12	8.7	2
	No.185 + 900	2.70	2.3	30	94.3	22	8.1	4
	No.187 + 450	4.12	4.0	54	69.9	24	5.8	4
	No.197 + 750	2.77	3.7	28	94.7	23	8.3	4
	No.199 + 630~ No.199 + 700	4.51	4.0	33	91.2	35	7.8	5
	No.231 + 160	3.00	2.4	24	103.2	26	8.7	4
	No.237 + 150	6.62	4.2	41	81.8	46	6.9	7
4	No.254 + 100	3.27	4.4	22	107.2	30	9.2	5
	No.269 + 910	2.22	1.9	15	122.7	23	10.4	4
	No.276 + 300	2.12	2.4	15	120.6	22	10.4	4
	No.289 + 840	6.85	4.9	52	71.5	41	6.0	6
	No.303 + 400	2.20	2.6	17	117.8	22	10.0	4
	No.305 + 500	2.53	2.4	15	133.7	26	10.3	4
	No.307 + 800	3.30	3.9	20	111.8	31	9.4	5
5	No. 4 + 600	1.78	1.6	15	139.7	18	10.1	3
	No.15 + 220	3.33	2.0	36	86.8	24	7.2	4

III-3 Results of Soil Investigation at the Proposed Bridge Sites

3-1 Matandu, Mavuji and Mbwemkuru Bridge Sites

The soil profile at the sites of Matandu, Mavuji and Mbwemkuru Bridges are shown in Fig. 3-1 and 3-3. As indicated in these Figures, the bridges to be constructed across major three rivers shall generally be supported by piles of relatively large length of 10 to 20m. Particularly at the Mbwemkuru rivers, piles of more than 20m in length shall be required at some part.

3-2 Other medium to small bridges sites

As a result of soil investigation of the sites by test borings, there are some places where the bridges can be supported by relatively short piles. However at Ruhoi, Ntandango, Nanguru and Mbanja rivers, comparatively long piles i.e., 10 to 18m in length, shall be required.

III-4 General Description of the Plan

4-1 General Description

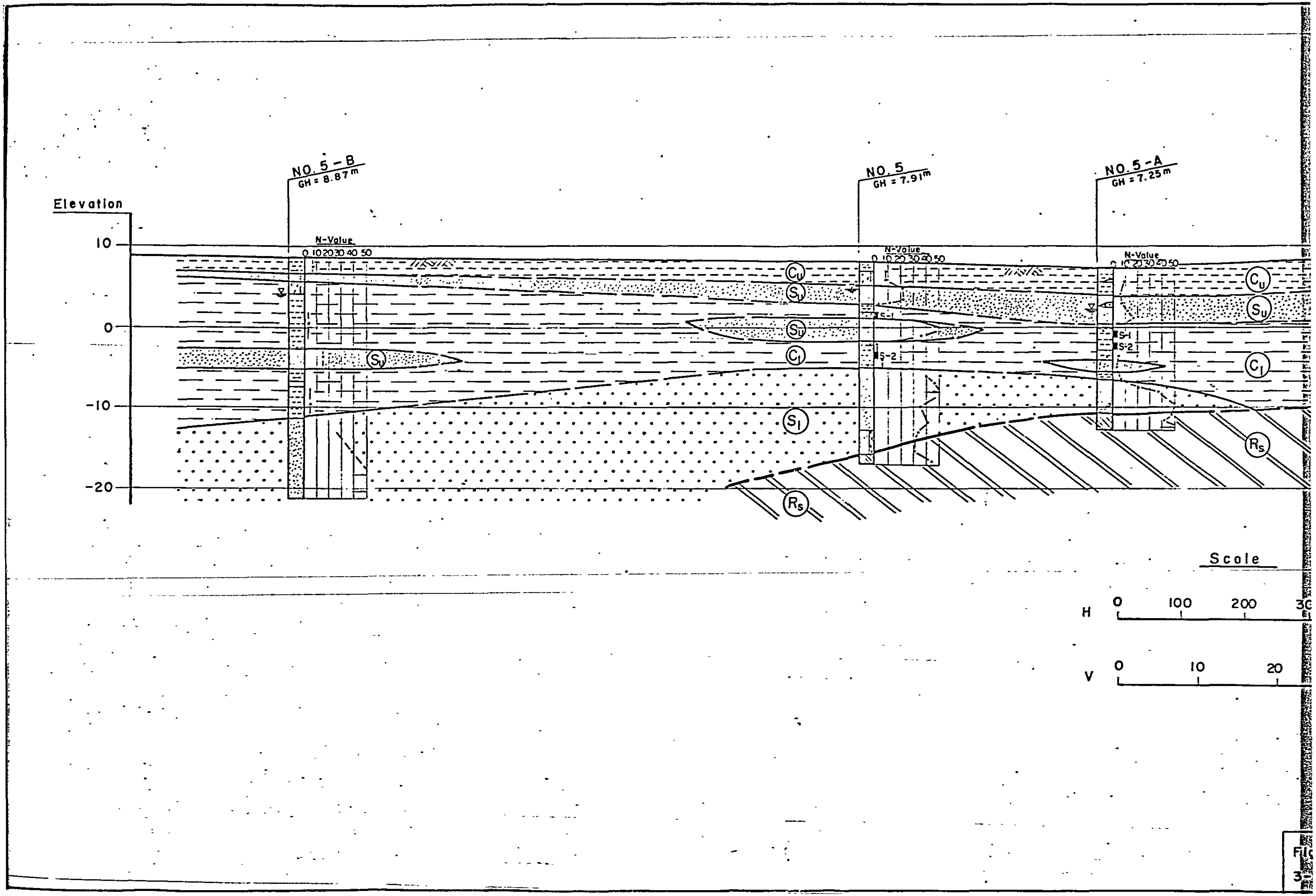
The bridge construction sites were determined by studying data of hydrological survey for the waterways across the existing road.

The number of bridge construction sites are planned to be 61 including main bridge and flood opening bridges at major three rivers, and total extension of bridges length are 2,180m.

The number of bridge construction sites and extension in each construction section are shown in Table 3-4.

Table 3-4 Bridge Plan

Construction Section	Description	Number of Bridge Site	Extension (Km)	Remarks
No.1	Medium to Small Bridge	2	31	
No.2	Main Bridge Flood Opening Bridge Medium to Small Bridge	1 2 19	82 630 297	Matandu River "
No.3	Main Bridge Flood Opening Bridge Medium to Small Bridge	1 1 14	82 112 259	Mavuji River "
No.4	Main Bridge Flood Opening Bridge Medium to Small Bridge	1 3 15	122 198 336	Mbwemkuru River "
No.5	Medium to Small Bridge	2	28	
Total		61	2177	



NO. 5 - B
GH = 8.87m
NO. 5
GH = 7.91m
NO. 5 - A
GH = 7.25m
Elevation
10
0
-10
-20
N-Value
0 10 20 30 40 50
Cu
Su
Cl
Sl
Rs
S-1
S-2
Scale
H
0
100
200
V
0
10
20

Fig
3-

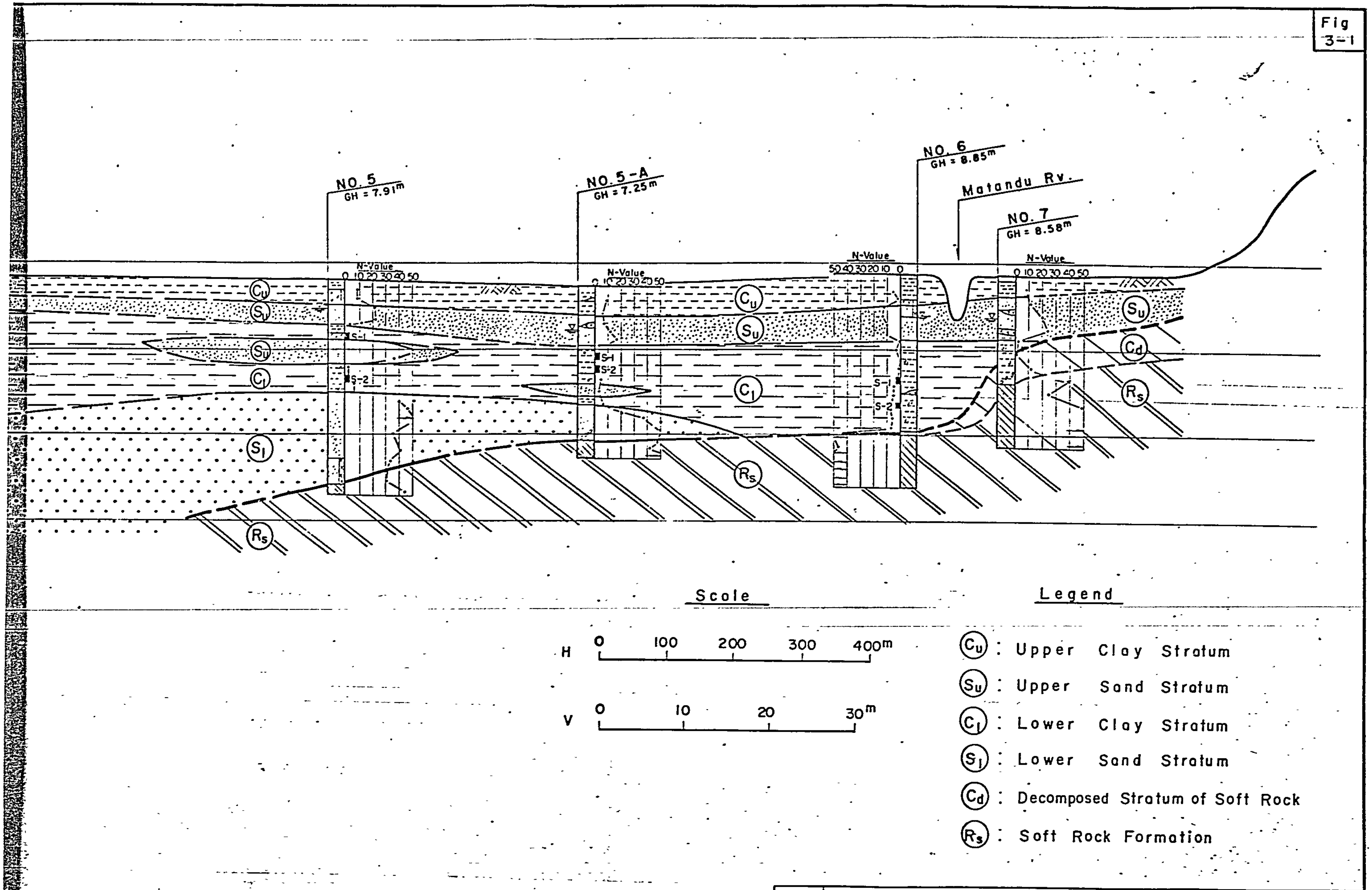


Fig 3-1	SOUTHERN COASTAL LINK ROAD PROJECT
	SOIL PROFILE AT MATANDU RIVER

Fig 3-2

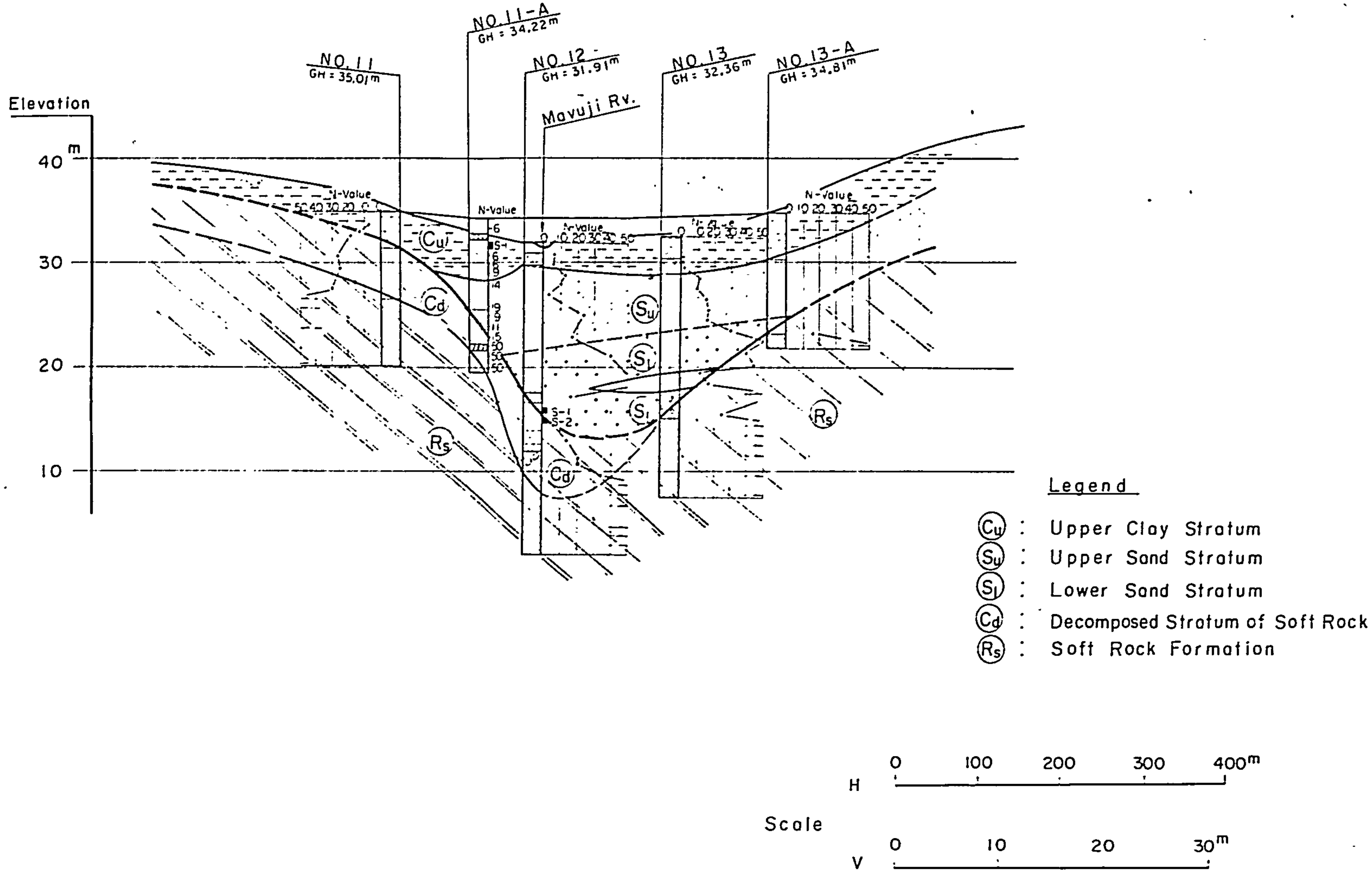


Fig 3-2	SOUTHERIN COASTAL LINK ROAD PROJECT SOIL PROFILE AT MAVUJI RIVER

Fig. 3-3

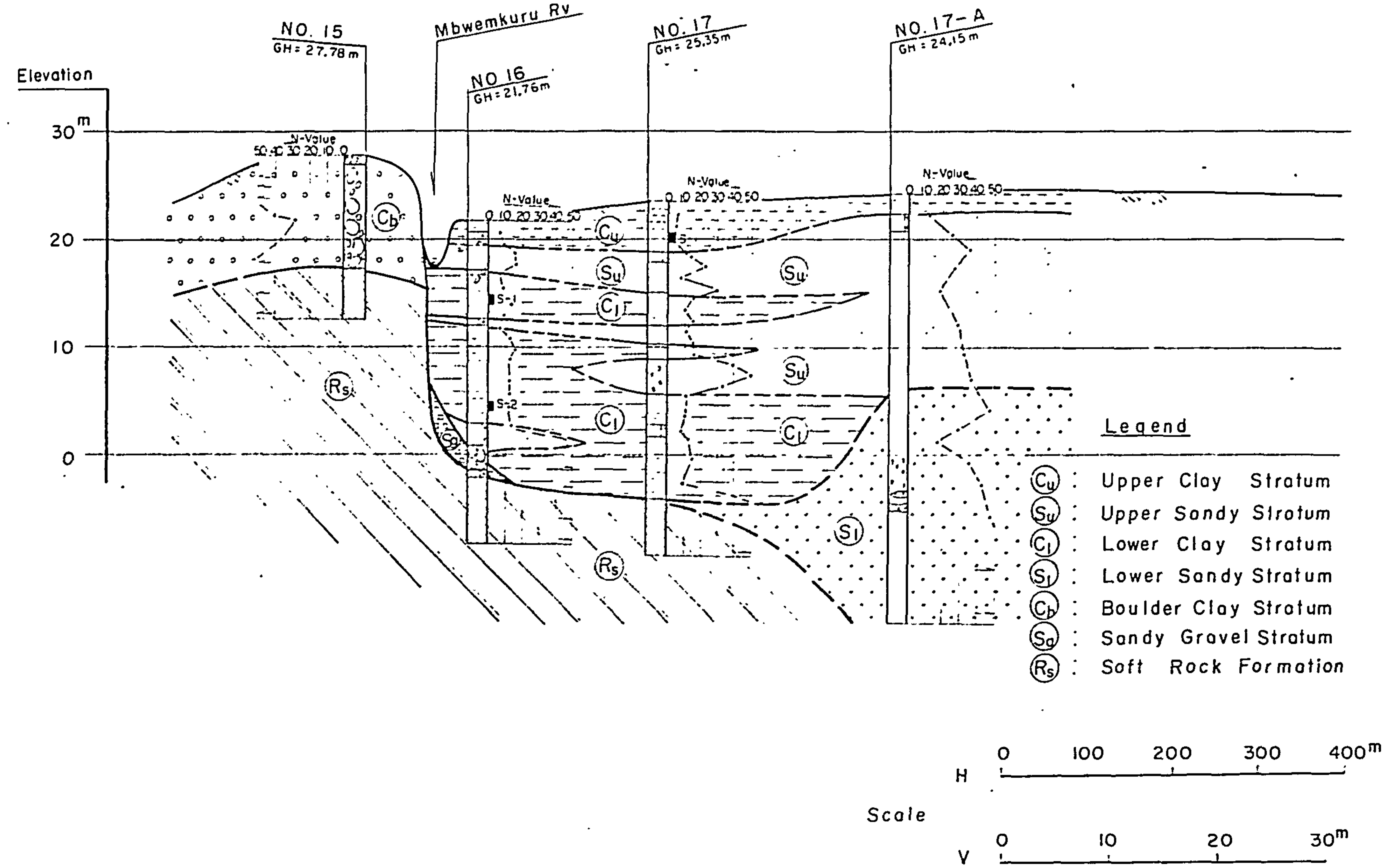


Fig 3-3	SOUTHERN COASTAL LINK ROAD PROJECT
	SOIL PROFILE AT MBWEMKURU RIVER

4-2 Basic Policy for Bridge Plan

In the bridge construction plan, the following factors were taken into consideration:

(1) For the main bridge at major three rivers, long span bridge type shall be adopted within economic feasibility to prepare against collapse of slope of river bank.

(2) For flood opening bridges and bridges for small rivers, standardized bridge type of around 10-20m span lengths shall be adopted.

(3) The structures of piers for flood opening bridges shall be economical enough and requiring less construction period.

(4) Steel piles shall be used for foundation works.

(5) Every bridges shall be constructed with 2 lanes at the same time and stage construction will not be adopted. (Refer to III-6-7)

III-5 Design Criteria

Design criteria as described in CHAPTER I shall be adopted for bridge plan and the use of these criteria can be considered as follows:

5-1 Live Load

Based on the studies made for BS153, H.A.Loading and AASHO H-20, S-16-44 Loading, H.A.Loading was selected for the safety.

5-2 Bridge Width

As per design criteria

5-3 Materials

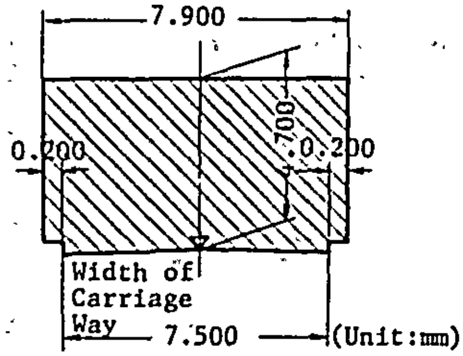
(1) Steel Plate, Shaped Steel and Reinforcement

The materials of Japanese Industrial Standard (JIS) corresponding to BS4360 Grade 43 (Steel Plate) BS785 (Reinforced Steel) are selected to be used.

(2) Concrete

Compressive strength of test pieces obtained in the sites is σ_{28}=330 - 350 kg/cm^2 and allowable compressive stress is σ_{ca}=60 kg/cm^2.

5-4 Clearance Diagram for Bridges (AASHO)



III-6 Structure of the Bridge

6-1 Type of Superstructure

The main bridges at three major rivers are, from economic and constructive view point, designed as truss type to be composed of small members with span length of 40m.

Flood opening bridges and the bridges for small rivers are designed as H-beam bridges of 19.0m, 16.0m and 13.5m span length; and reinforced concrete bridge with span length of 11.0m as a standard type. Standard cross section of these bridges are shown in Fig. 3-4 Fig. 3-7.

As regards H-beam bridge, three types of span length shall be used depending on the bridge lengths. Reinforced concrete bridges are to be constructed across small rivers of less than 10m width.

As a floor slab for steel bridge longer than 50m, in order to shorten construction period, corrugated steel plate is to be used with base concrete placed on it. For the bridges shorter than 50m, steel reinforced concrete floor slab shall be used.

6-2 Type of Substructure

6-2-1 Abutment

14 standard types of abutment are planned rainging from 3.5m to 10m in height. For the abutment with the height of more than 8m, in order to relieve the earth pressure, the structure as shown in Fig. 3-8 was adopted. The depth from bottom of the abutment to the present foundation ground is planned to be approx. 1.5m. Then the most suitable standard type was selected according to the height of abutment.

As a pile foundation, H-beam steel of 400 x 400mm in size was adopted to be driven up to the strutum having sufficient bearing capacity. The pile length shall be around 5 to 20m.

6-2-2 Bridge Piers

The piers of main bridge at major three rivers are designed as wall type as shown in Fig. 3-9 in order to counter against scouring and flow velocity at the time of flood. The structure are of steel reinforced concrete, depth of the piers under river bed was planned to be approx. 3m. At the river bed near footings, counter measures to prevent scouring are planned by means of cobble stones etc.

As a foundation pipe, steel pipe piles of 500mm in diam. are adopted. 500mm in diam. steel pipe of pile bent is planned to be used for the piers of flood opening bridge and medium to small bridge as shown in Fig. 3-10. The top of piles to support superstructures shall be reinforced concrete.

The surface of steel pipe exposed on the ground shall be painted for rust prevention.

FIG. 3-4

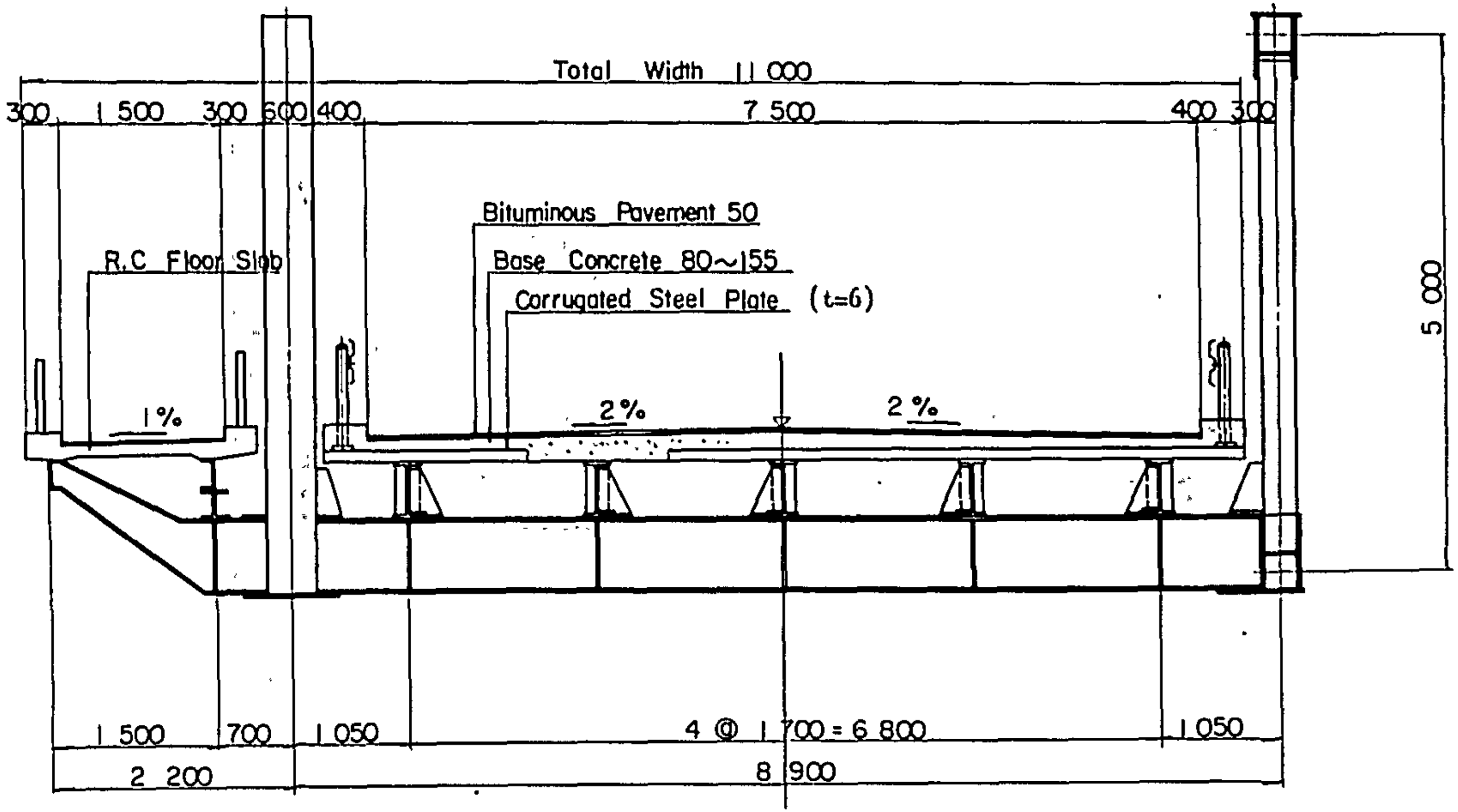


FIG.	SOUTHERN COASTAL LINK ROAD PROJECT
3-4	STANDARD CROSS SECTION OF MAIN BRIDGES

FIG. 3-5

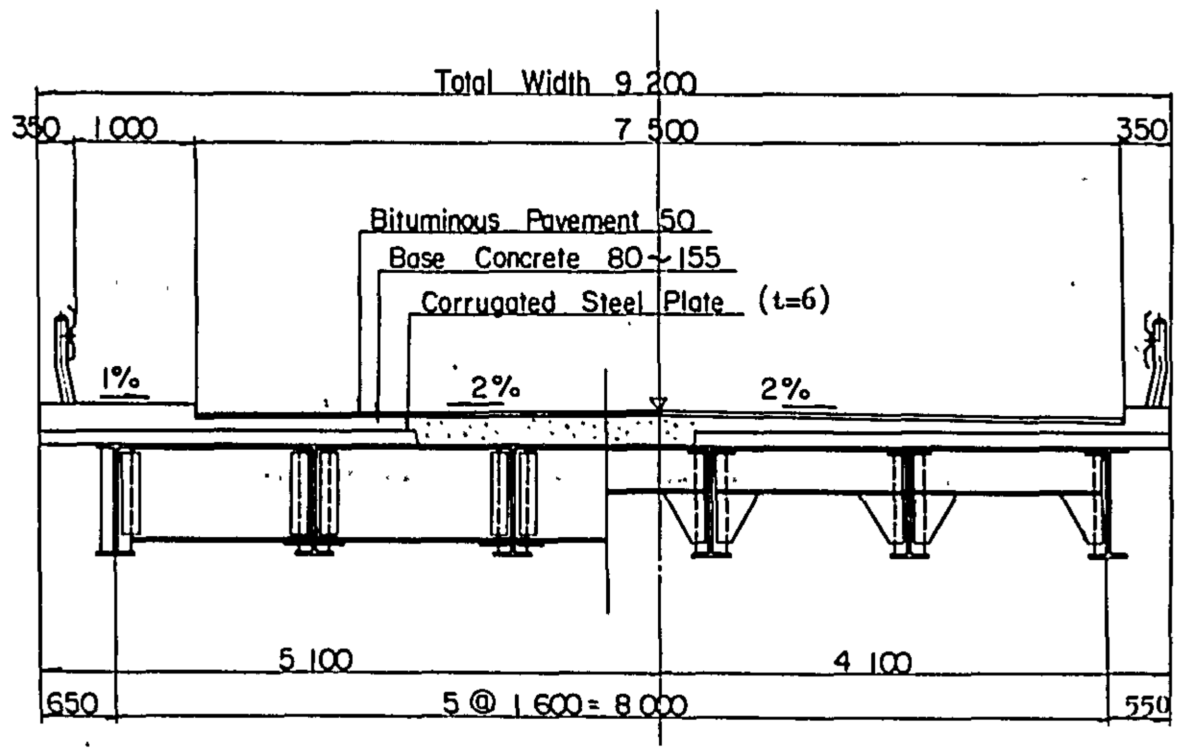


FIG. 3-5

SOUTHERN COASTAL LINK ROAD PROJECT

STANDARD CROSS SECTION OF FIOOD OPENNING BRIDGES

FIG. 3-6

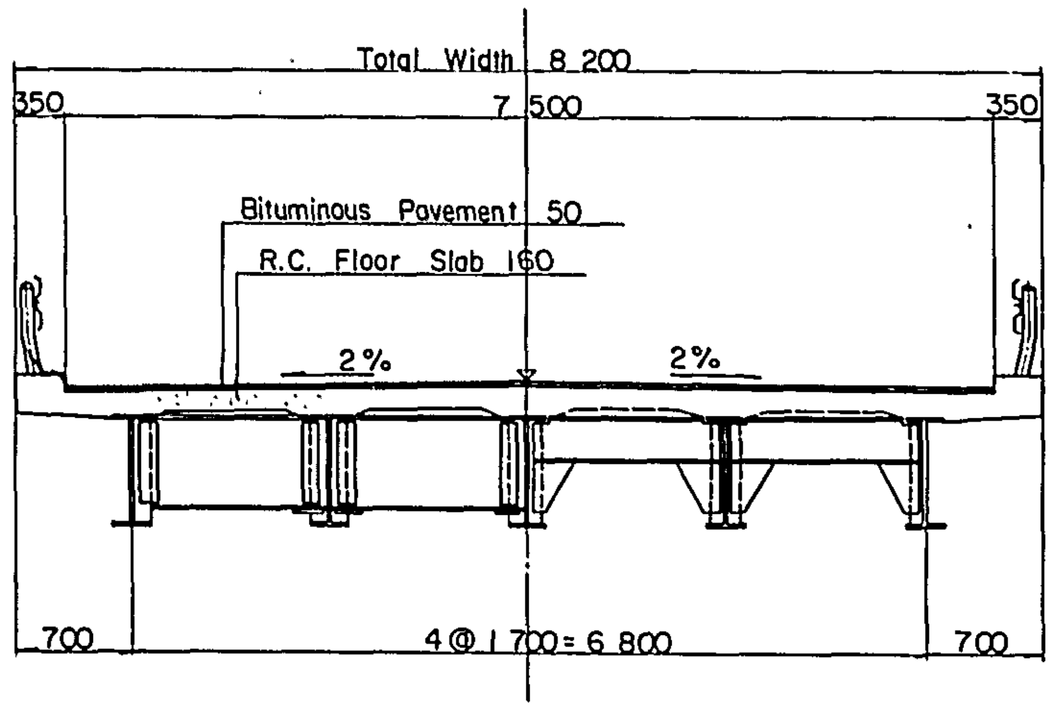


FIG.	SOUTHERN COASTAL LINK ROAD PROJECT
3-6	STANDARD CROSS SECTION OF MEDIUM TO SMALL BRIDGES

FIG. 3-7

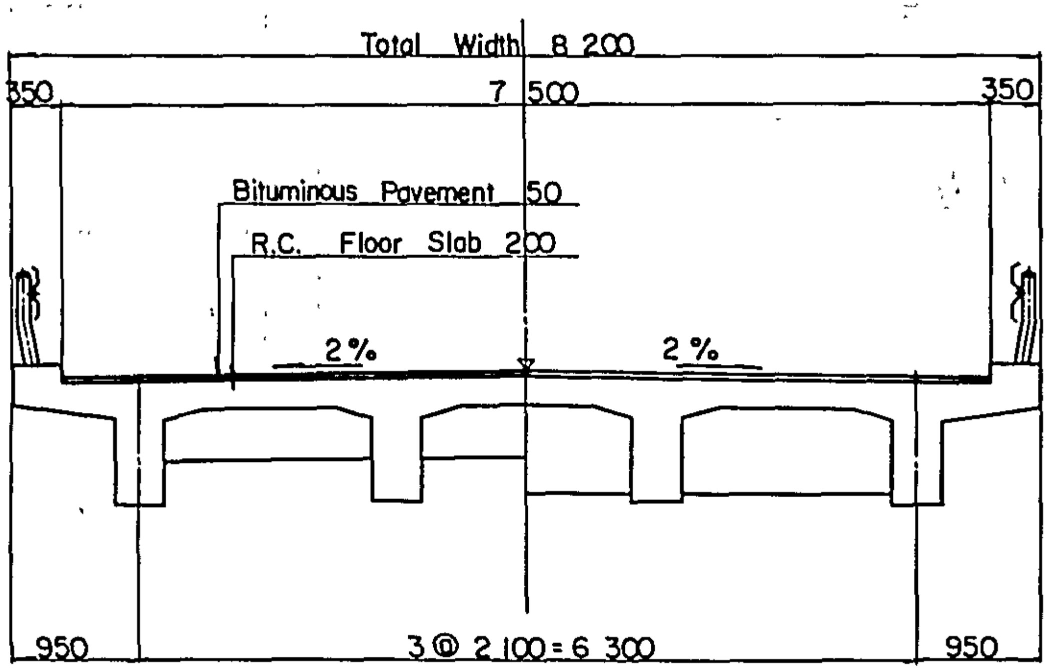
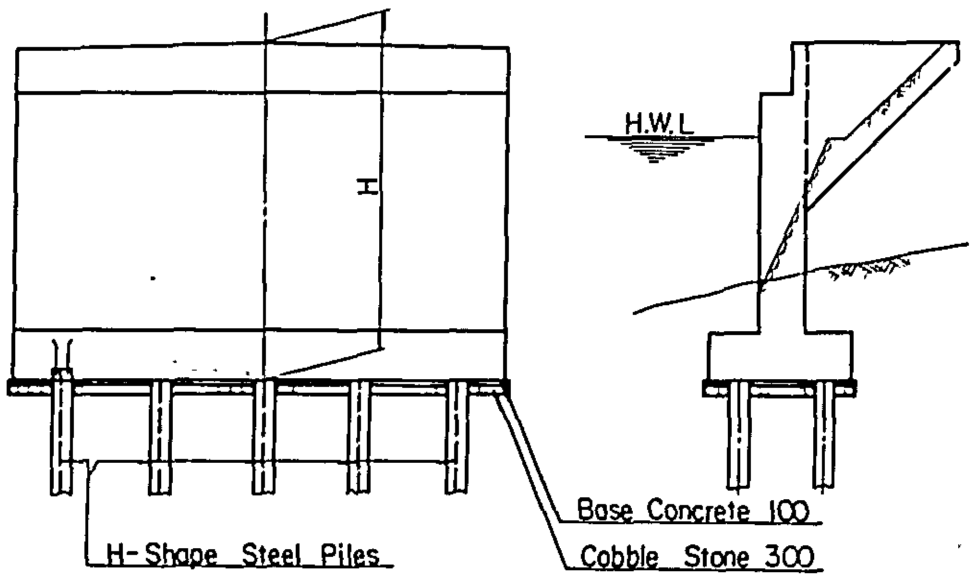


FIG.	SOUTHERN COASTAL LINK ROAD PROJECT
3-7	STANDARD CROSS SECTION OF SMALL BRIDGES (R.C TYPE)

3.5 ≦ H ≦ 7.5



8.0 ≦ H ≦ 10.0

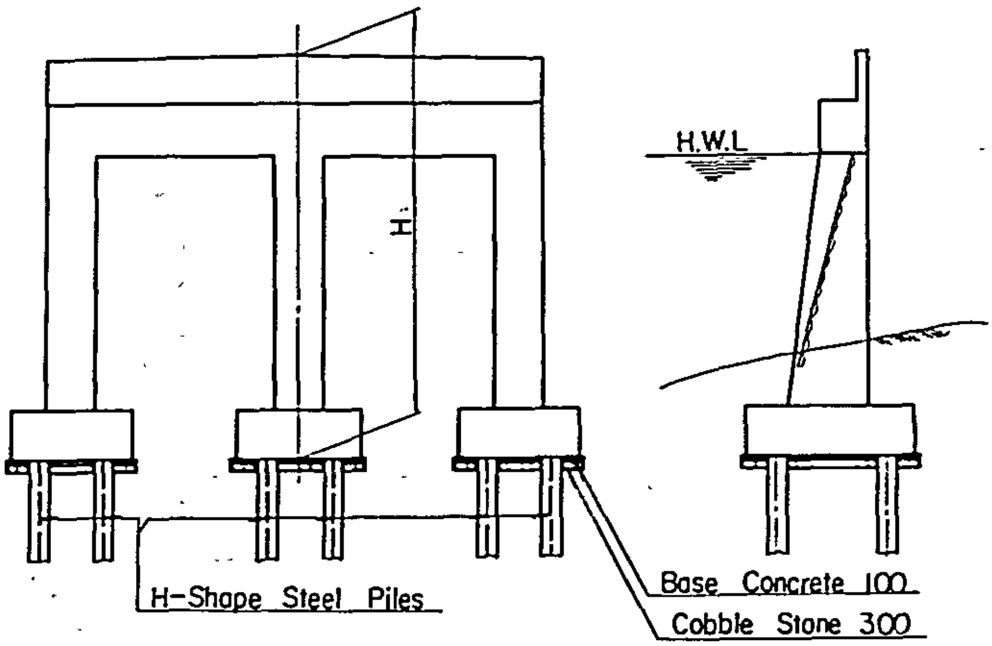


FIG.	SOUTHERN COASTAL LINK ROAD PROJECT
3-8	STANDARD TYPE OF ABUTMENTS

FIG. 3-9

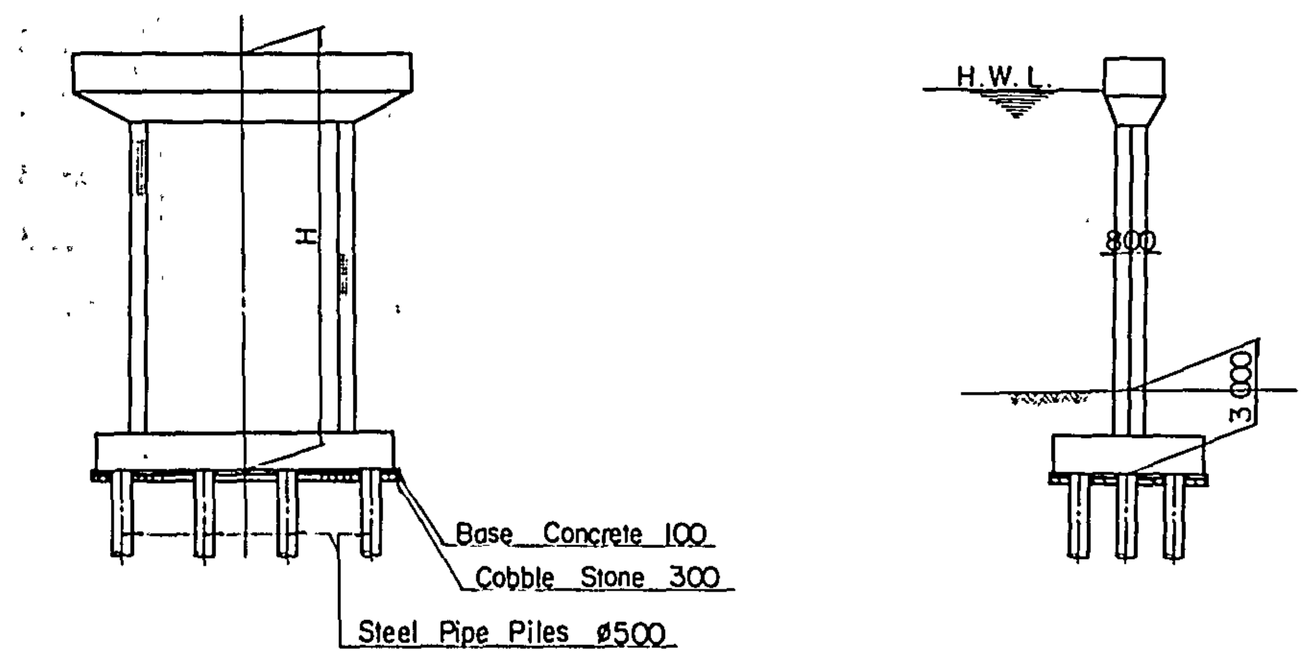
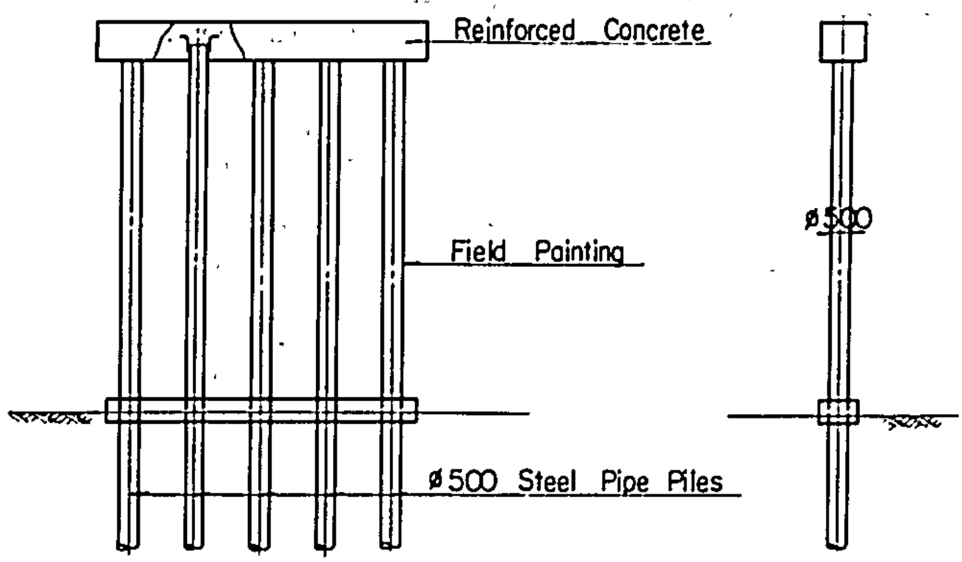


FIG.	SOUTHERN COASTAL LINK ROAD PROJECT
3-9	PIER FOR 3-MAIN BRIDGES

FIG. 3-10

FLOOD OPENNING BRIDGE



MEDIUM BRIDGE

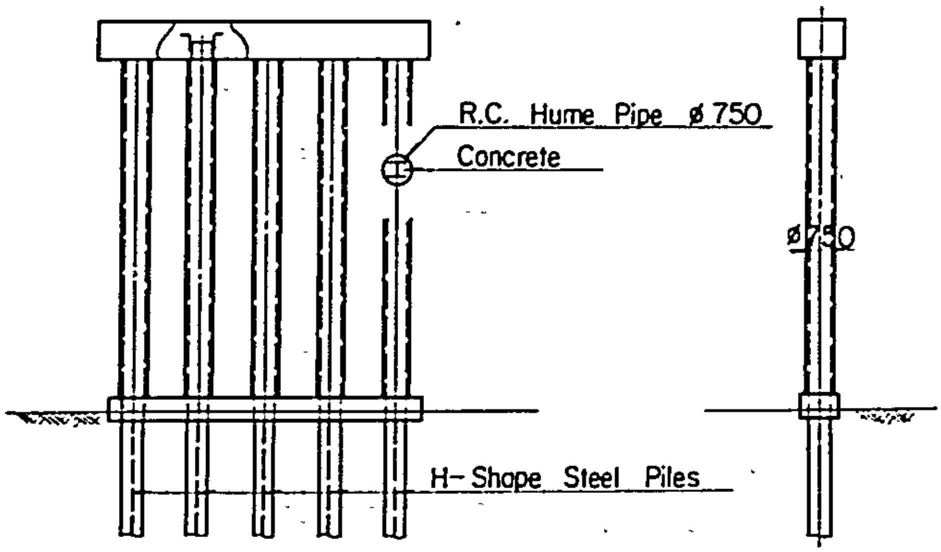


FIG.	SOUTHERN COASTAL LINK ROAD PROJECT
3-10	PIER FOR FLOOD OPENNING BRIDGES AND MEDIUM BRIDGES

6-3 Matandu River Bridge

Total length of this bridge is designed to be 712m composed of 82m of main bridge 520m and 110m of flood opening bridges at right and left side respectively.

The main bridge is composed of 2 spans of pony truss with 40m each span length and the flood opening bridge is composed of 37 spans at the right side and 8 spans at the left side, of H-beam standard girder with 13.5m each length. The footway of main bridge is located out of truss and that of flood opening bridge with 1.0m width shall be mounted up by 10cm along the carriage way.

The body of abutment at main bridge is 6m in height and embeded depth of piles are 18m. Piers of main bridge is 12m in height and embeded depth of piles are 10m. The abutment of flood opening bridge are almost similar to that of main bridge except for the difference in the embeded depth of piles.

6-4 Mavuji River Bridge

This bridge has a total length of 192m composed of 82m of main bridge and 110m of flood opening bridge at the right side bank. At the main bridge, 2 spans of pony truss with 40m each length shall be erected as in the case of Matandu river bridge. The flood opening bridge is composed of 8 spans of H-beam standard bridge with 13.5m each length. The height of abutment for main bridge are 7.0m and embeded depth of piles are approx. 11m.

The height of piers is 10m and embeded depth of piles is approx. 8m as shallow foundation is possible.

6-5 Mbwemkuru River Bridge

Total extension of this bridge is 320m composed of 122m of main bridge and total 198m of flood opening bridge to be erected separately at three places at right side bank in each length of 66m.

The main bridge is composed of 3 spans of pony truss with 40m each length. The flood opening bridges are composed of 4 spans H-beam standard bridge with 16.0m each length at one place, totaling 12 spans.

The height of left side abutment at main bridge is 3.5m since shallow foundation is possible due to good soil conditions. The height of piers and right side abutment are 9.5m and 7.5m respectively. The pile foundation is adopted. Embeded depth of piles is as deep as approx. 25m due to variation of soil conditions as compared with that of left side abutment.

6-6 Medium to Small Bridges

Total 52 bridges were planned to be constructed with the bridge length ranging from 11.5m to 66.0m. 37 bridges are designed as H-beam standard bridge in the total extension of approx. 780m. 15 bridges are designed as steel reinforced bridge in the total extension of approx. 170.

The location of bridge construction sites and the types of bridge structures are shown in Table 3-5.

6-7 Stage Construction of Bridge

The study was made on the construction cost and workability of construction method for the conditions that the construction of the bridges at major three rivers which involve some problem in construction, and all substructures shall be completed within the first stage whereas as to the superstructure of medium to small bridges and flood opening bridges only one lane shall be constructed at first stage.

As a result of this study, revealed is the fact that so much effect of stage construction can not be expected because the construction cost for the first stage becomes approx. 80% of that for original plan i.e., simultaneous construction for 2 lanes. In addition the bridge structures may become extremely complexed reducing the merit of using standard girder.

Therefore for the reasons mentioned above, all bridges are not to be stage constructed and 2 lanes shall be simultaneously constructed.

Table 3-5 (1) Planning of the New Bridges

Section	Distance	Bridge Type	Item			Remarks
			Length	Carriageway Width	Footpath Width	
1	No.14 + 700	H-Steel Girder	14.0	7.5	-	
	24 + 780	"	16.5	"	-	
2	68 + 700	"	"	"	-	
	74 + 450	"	19.5	"	-	
	80 + 400	"	14.0	"	-	
	86 + 800	"	16.5	"	-	
	87 + 725	"	"	"	-	
	98 + 350	R.C. Girder	11.5	"	-	
	99 + 500	"	"	"	-	
	100 + 300	"	"	"	-	
	100 + 675	"	"	"	-	
	103 + 330	H-Steel Girder	19.5	"	-	
	106 + 870	"	"	"	-	
	116 + 875	"	"	"	-	Ntandango River

Table 3-5 (2) Planning of the New Bridges

Section	Distance	Bridge Type	Item			Remarks
			Length	Carriageway Width	Footpath Width	
2	No.117 + 800	H-Steel Girder	14.0	7.5	-	
	120 + 225	"	"	"	-	
	126 + 600	"	"	"	-	
	128 + 500	R.C. Girder	11.5	"	-	
	130 + 400	H-Steel Girder	28.0	"	-	2-span
	136 + 670	R.C. Girder	11.5	"	-	
	138 + 00	H-Steel Girder	518.0	7.5	1.0	Matandu River Flood Openning
	138 + 930	Pony Truss	81.7	"	1.5	- do - Main Bridge
	139 + 150	H-Steel Girder	112.0	"	1.0	- do - Flood Openning
	144 + 910	"	16.5	"	-	
3	158 + 450	"	33.0	"	1.0	Lingaula River 2-span
	163 + 215	"	19.5	"	"	Mbanga River
	164 + 650	"	"	"	"	Ukuri River
	167 + 300	"	14.0	"	"	Namitanba River

Table 3-5 (3) Planning of the New Bridges

Section	Distance	Bridge Type	Item			Remarks
			Length	Carriageway Width	Footpath Width	
3	No.176 + 560	Pony Truss	81.7	7.5	1.5	Mavuji River Main Bridge
	176 + 700	H-Steel Girder	112.0	"	1.0	Flood Openning
	180 + 200	"	14.0	"	-	
	184 + 75	"	"	"	-	
	192 + 275	"	33.0	"	1.0	Kiwawa River 2-span
	196 + 625	"	14.0	"	-	
	215 + 640	"	28.0	"	-	Mandawa River 2-span
	221 + 950	"	16.5	"	-	
	222 + 900	"	14.0	"	-	
	223 + 65	"	"	"	-	Near Matandu
	229 + 60	R.C. Girder	11.5	"	-	Nead Kiranjerange
	232 + 650	H-Steel Girder	14.0	"	-	
4	236 + 400	R.C. Girder	11.5	"	-	
	240 + 300	Pony Truss	122.5	"	1.5	Mbwenkuru River Main Bridge

Table 3-5 (4) Planning of the New Bridges

Section	Distance	Bridge Type	Item Length	Item Carriageway Width	Item Footpath Width	Remarks
4	No.240 + 600	H-Steel Girder	66.0	7.5	1.0	Mbwenkuru River Flood Openning
	240 + 850	"	"	"	"	"
	241 + 350	"	"	"	"	"
	251 + 350	R.C. Girder	11.5	"	-	
	253 + 75	"	"	"	-	
	268 + 200	H-Steel Girder	33.0	"	1.0	2-span
	268 + 390	R.C. Girder	11.5	"	-	
	272 + 100	"	"	"	-	
	274 + 910	H-Steel Girder	66.0	"	1.0	Nanguru River 4-span
	282 + 800	R.C. Girder	11.5	"	-	
	287 + 630	H-Steel Girder	33.0	"	1.0	Near Likonga 2-span
	293 + 740	"	28.0	"	-	Near Mitonga 2-span
	296 + 425	"	"	"	-	Mbanja River 2-span
	300 + 220	R.C. Girder	11.5	"	-	

Table 3-5 (5) Planning of the New Bridges

Section	Distance	Bridge Type	Item			Remarks
			Length	Carriageway Width	Footpath Width	
4	No.302 + 470	H-Steel Girder	28.0	7.5	-	2-span
	No.304 + 250	"	"	"	-	2-span
	No.306 + 415	R.C. Girder	11.5	"	-	
5	No.13 + 200	H-Steel Girder	14.0	"	-	
	No.18 + 820	"	"	"	-	

CHAPTER IV CONSTRUCTION COST AND WORK SCHEDULE

IV-1 Construction Cost

Table 4-1 shows the total construction cost for the extension of approximately 300km from Kibiti to Lindi and approximately 30km from Nangrukuru to Kilwa Masoko. Table 4-2 shows the items for Table 4-1.

The above construction cost is estimated according to the following prerequisites:

(1) The respective unit price shall be based on the one at October 1975.

(2) The inflation after 1975 is not considered.

(3) The rate of exchange between Tanzanian Shillings and U.S. Dollar is made as follows:
One U.S. Dollar = 8.1 Tanzanian Shillings

(4) Machineries and plant facilities for use in the construction work shall be provided from Japan and the residual value of these machineries and plant facilities after completion of the construction work shall be zoro.

(5) The construction cost is estimated for not only the original plan but also other three plans of stage construction to reduce initial investment in the first stage construction.

(6) The above construction cost is a economic cost excluding taxes.

Table 4-1 Construction Cost (Unit: 1,000 Shs.)

Plan	First Stage Investigation	Second Stage Investigation	Total
1	750,621	0	750,621
2	692,459	92,892	785,351
3	670,135	98,675	768,810
4	622,243	206,190	828,433

Notes: Plan 1 - Original plan in which all sections are constructed to complete at first stage.

Plan 2 - Only section 1, where the traffic volume is relatively high, is constructed to complete at first stage. Sections 2-5 are constructed by stage.

Plan 3 - Section 1 is same as Plan 2. Sections 2-5 are constructed by stage not being paved the shoulder.

Plan 4 - All sections are constructed by stage.

But concerning the bridge construction, a complete two-lane bridge is adopted for all four plans.

Table 4-2 Items for Construction Cost

(unit: 1000 Tanzanian Shillings)

Plan	Section	Direct Construction Cost (A)						(B) Contingency (A) x 20%	(C) Supervision (A)+(B) x4%	Total (A)+(B)+(C)	Local Currancy	Foreign Currency
		Preparation	Earthwork	Small Construction	Pavement	Bridge	Total					
1	1	1,730	8,757	5,541	27,486	1,649	45,162	9,027	2,162	56,351		
	2	7,649	34,270	21,459	87,432	48,054	198,865	39,784	9,541	248,189		
	3	6,270	35,730	19,730	77,811	23,730	163,270	32,649	7,838	203,757		
	4	5,946	29,270	18,162	64,676	36,811	154,865	30,973	7,432	193,270		
	5	1,514	6,595	5,892	24,189	1,108	39,297	7,865	1,892	49,054		
	TOTAL	23,109	114,622	70,784	281,594	111,352	601,459	120,298	28,865	750,621	332,514	418,107
2	1	1,730	8,757	5,541	27,486	1,649	45,162	9,027	2,162	56,351		
	2	8,027	34,270	21,459	96,757	48,054	208,568	41,703	10,000	260,270		
	3	6,594	35,730	19,730	85,703	23,730	171,486	34,297	8,243	214,027		
	4	6,243	29,270	18,162	71,892	36,811	162,378	32,486	7,784	202,649		
	5	1,595	6,595	5,892	26,514	1,108	41,703	8,351	2,000	52,054		
	TOTAL	24,189	114,622	70,784	(233,756) 308,352	111,352	(554,703) 629,297	125,864	30,189	(692,459) 785,351	333,784	451,567
3	1	1,730	8,757	5,541	27,486	1,649	45,162	9,027	2,162	56,351		
	2	7,865	34,270	21,459	92,649	48,054	204,297	40,865	9,811	254,973		
	3	6,459	35,730	19,730	82,189	23,730	167,838	33,568	8,054	209,459		
	4	6,108	29,270	18,162	68,784	36,811	159,135	31,838	7,649	198,622		
	5	1,514	6,595	5,892	24,486	1,108	39,595	7,919	1,892	49,405		
	TOTAL	23,676	114,622	70,784	(208,297) 295,594	111,352	(528,730) 616,027	123,217	29,568	(670,135) 768,810	329,810	439,000
4	1	2,000	8,757	5,541	34,189	1,649	52,135	10,432	2,514	65,081		
	2	8,379	34,270	21,459	105,432	48,054	217,595	43,514	10,432	271,541		
	3	6,919	35,730	19,730	93,838	23,730	179,946	36,000	8,649	224,595		
	4	6,514	29,270	18,162	78,270	36,811	169,027	33,811	8,108	210,946		
	5	1,730	6,595	5,892	29,757	1,108	45,081	9,027	2,162	56,270		
	TOTAL	25,542	114,622	70,784	(176,162) 341,486	111,352	(498,459) 663,784	132,784	31,865	(622,243) 828,433	326,405	502,026

Note: The figures in bracket are the first stage pavement work.

IV-2 Maintenance and Repair Cost

Maintenance and repair cost after completion of the work were estimated for the following items.

2-1 Road

Table 4-3 Maintenance Cost for Road

(Unit: 1,000 Shs.)

Plan	Item	Cost	Remarks	Total
1	Overlay for Penetration Macadam	68,920	every 5 years	68,920
2,3	"	44,326	"	44,326
4	Overlay for Crushed Stone	27,570	"	27,570
Common	Pavement Maintenance	3,703	every year	4,594
	Shoulder Maintenance	162	"	
	Cutting Grass	621	"	
	Detch and Culvert Maintenance	108	"	

2-2 Bridge

Table 4-4 Maintenance Cost for Bridge

(Unit: 1,000 Shs.)

Plan	Item		Cost	Remarks	Total
Common	Repainting	Metal Bridge	2,621	every 10 years	3,567
		Plank Sheet	838	"	
		Pile above the Earth	108	"	
	Clearance at the end of Wet Season		30	every year	30

IV-3 Work Schedule

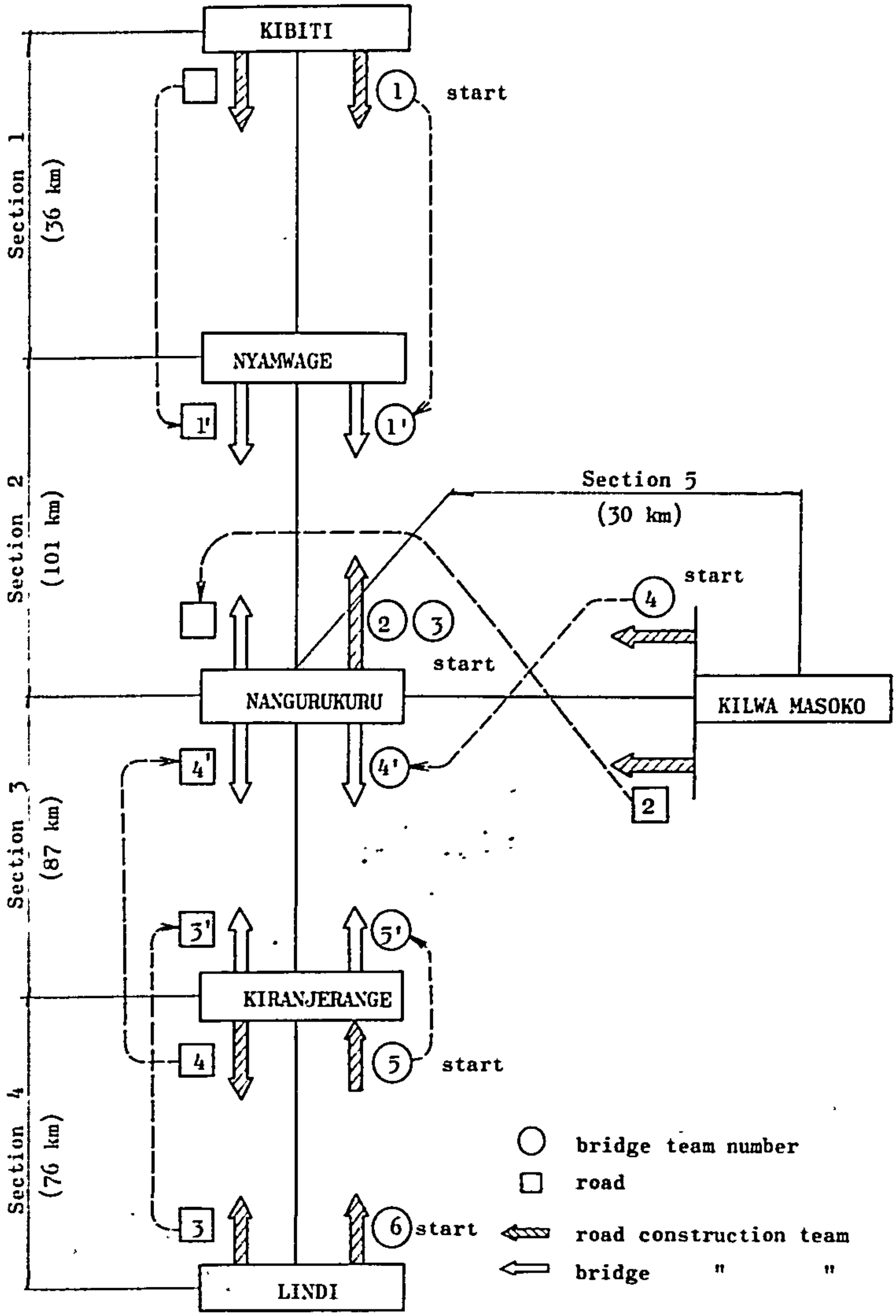
According to Table 4-5, the field work shall require five years. As for the stage construction, one lane paved road or gravel road shall be constructed at the first stage, and after 15 years two lanes paved road shall be constructed.

The construction shall proceed with establishment of base camps at Kibiti, Lindi and Kilwa Masoko. Subcamps are established at Mohoro, Nangurukuru and Kiranjerange.

6 teams for bridge shall start construction at the first year, and 4 teams for road shall start construction at the next year folowing the work schedule (Table 4-5) and the construction sequence (Fig. 4-1).

As shown in the work schedule, the four months (from January to the end of April) are the wet season of the year, and no other works than preparation works are possible during the season.

FIG. 4-1 CONSTRUCTION SEQUENCE



Note: A year later road construction team will start.

Table 4-5 Work Schedule

Section		Type	Item	1		2		3		4		5		6		
Season				wet	dry	wet	dry	wet	dry	wet	dry	wet	dry	wet	dry	
Work Site Survey																
Preparation																
SECTION 1	Kibiti ~ Nyamwage	Road	Corrugated Pipe													
			Earth Work													
			Slope Protection, Drain													
			Base and Pavement													
		Bridge	Small Bridge													
SECTION 2	Nyamwage ~ Nangurukuru	Road	Corrugated Pipe													
			Earth Work													
			Slope Protection, Drain													
			Base and Pavement													
		Bridge	Main Bridge													
			Flood Openning Bridge													
			Small Bridge													
SECTION 3	Nangurukuru ~ Kiranjerange	Road	Corrugated Pipe													
			Earth Work													
			Slope Protection, Drain													
			Base and Pavement													
		Bridge	Main Bridge													
			Slope Protection, Drain													
			Base and Pavement													
SECTION 4	Kiranjerange ~ Lindi	Road	Corrugated Pipe													
			Earth Work													
			Slope Protection, Drain													
			Base and Pavement													
		Bridge	Main Bridge													
			Flood Openning Bridge													
			Small Bridge													
SECTION 5	Nangurukuru ~ Kilwa Mosoko	Road	Corrugated Pipe													
			Earth Work													
			Slope Protection, Drain													
			Base and Pavement													
		Bridge	Small Bridge													

CHAPTER V ECONOMIC EVALUATION

V-1 General

In this chapter, the present regional traffic on and in the vicinity of the proposed southern coastal road is studied and the future traffic volume is etimated by macroscopic methods for normal traffic, generated traffic and diverted traffic on the basis of such studies.

Section 5.4 of this chapter deals with the calculation of the vehicle operating cost which was worked out on the basis of a survey of the costs of fuel, lubricant oil, tyres and vehicles as at October 1975.

The future traffic volume and operating cost by vehicle type thus obtained are used as the basis for calculating the operating benefit derived from the improvement and additional construction of roads. Further, the benefit derived from the elimination of detour traffic via Songea and Iringa between Dar es Salaam and southern regions that can be expected from the construction of an all-weather coastal road, as well as the benefit derived from the diversion of some traffic to the southern coastal road from the Coastal Shipping Lines, are calculated.

The sum total of all these benefits and the costs are studied for comparison of a number of alternative plans to obtain the cost-benefit ratio, internal rate of return and net present value which are employed for evaluation of the project from the economic point of view.

V-2 Existing Conditions of Regional Traffic

2-1 Existing Condition of the Coastal Road

Table 5-1 shows the existing condition of the coastal road running from Dar es Salaam to Mtwara.

Table 5-1 Existing Condition of Coastal Road

Road Surface \ Section	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 5-1 indicates that the two-lane road between Dar es Salaam and Mtwara having a total length of 565.5km comprises 178.5km (32%) of bitumen paved sections, 66km (12%) of engineered gravel road sections, 118.7km (21%) of improved earth road sections, and 202.3km (35%) of earth road sections. Thus, the table shows that the coastal road is needful of improvement in many of its sections.

As it runs along the coastline, the road passes through relatively flat terrains. Hilly to mountainous terrain covers only about 20% of the total length, whereas rolling to hilly terrain and flat to rolling terrain account for 13% and 67% respectively of the total road length.

2-2 Traffic Volume

The past traffic volume in the whole of Tanzania lacks any specific pattern of secular change and its growth rate also varies by year and region. The pattern of past secular change in the traffic volume on the southern coastal road is not clear just as the nation-wide traffic pattern. As seen in Table 5-2, the daily traffic volume on the coastal road ranges from 10 to 100 vehicles, though this is subject to variation by census point.

Fig. 5-1 showing the 1974 annual average daily traffic volume in the whole of Tanzania indicates that the traffic volume on the paved section between Dar es Salaam and Kibiti was the largest with 280 - 80, followed by traffic volume across the Rufiji river which counted 90 vehicles/day. The traffic volume between Mohoro and Lindi was the smallest with 50-60 vehicles/day.

The results of the OD distribution survey conducted by COMWORKS near the census point-055 at Nangurukuru in September 1968 are diagramatically shown in Fig. 5-2.

Fig. 5-2 indicates that Dar es Salaam is closely interlinked with Lindi, Mtwara and other major local cities and towns by the coastal road, but the intrazonal trips within sections between Dar es Salaam and Mtwara are rather small in number.

The survey of the OD distribution of commodities by commodity type conducted in November 1969 disclosed that the commodity movement is large between Dar es Salaam and Kisarawa District and between Dar es Salaam and Rufiji District. Conspicuousness amoung the commodities are construction materials and agricultural products transported from Kisarawa and Rufiji to Dar es Salaam and general cargoes supplied from Dar es Salaam to Rufiji, Lindi and Mtwara.

Vehicles bound for Kisarawa and Rufiji from Dar es Salaam are not loaded in many cases, indicating that they carry construction materials and agricultural products to Dar es Salaam and return with small quantities of general cargoes to be supplied to local areas.

Table 5-2 Vehicle Type Classification on Southern Coastal Road

Census Point	Year	Vehicle Type Classification (%)				Daily Traffic Volume
		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)	"	0.8	16.8	67.2	15.2	42
Utete - Nyamwage (South of Utete)	"	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)	"	1.7	24.3	49.7	24.3	38
Lindi - Mtwara (South of Lindi)	"	8.6	26.1	54.3	11.0	97
Average (%)		5.1	20.6	56.8	17.5	

Source: Planning Unit, Ministry of Communication and Transport

Table 5-3 Vehicle Type Classification on Roads Linked to Southern Coastal Road

Census Point	Year	Vehicle Type Classification (%)				Daily Traffic Volume
		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)	July '73	1.0	32.0	49.8	17.2	68
Newara - Mtwara (East of Newara)	July '73	1.4	38.7	32.0	27.9	49
Masasi - Nanganga (East of Masasi)	Apr. '72	3.1	32.8	38.1	26.0	44
Mingoyo - Mtwara (South of Mingoyo)	Apr. '72	5.2	20.8	58.4	15.6	58
Mingoyo - Mtwara (West of Mingoyo)	Apr. '72	0.5	25.5	49.0	25.0	69
Average (%)		3.5	29.7	43.3	23.5	

Source: Planning Unit, Ministry of Communication and Transport

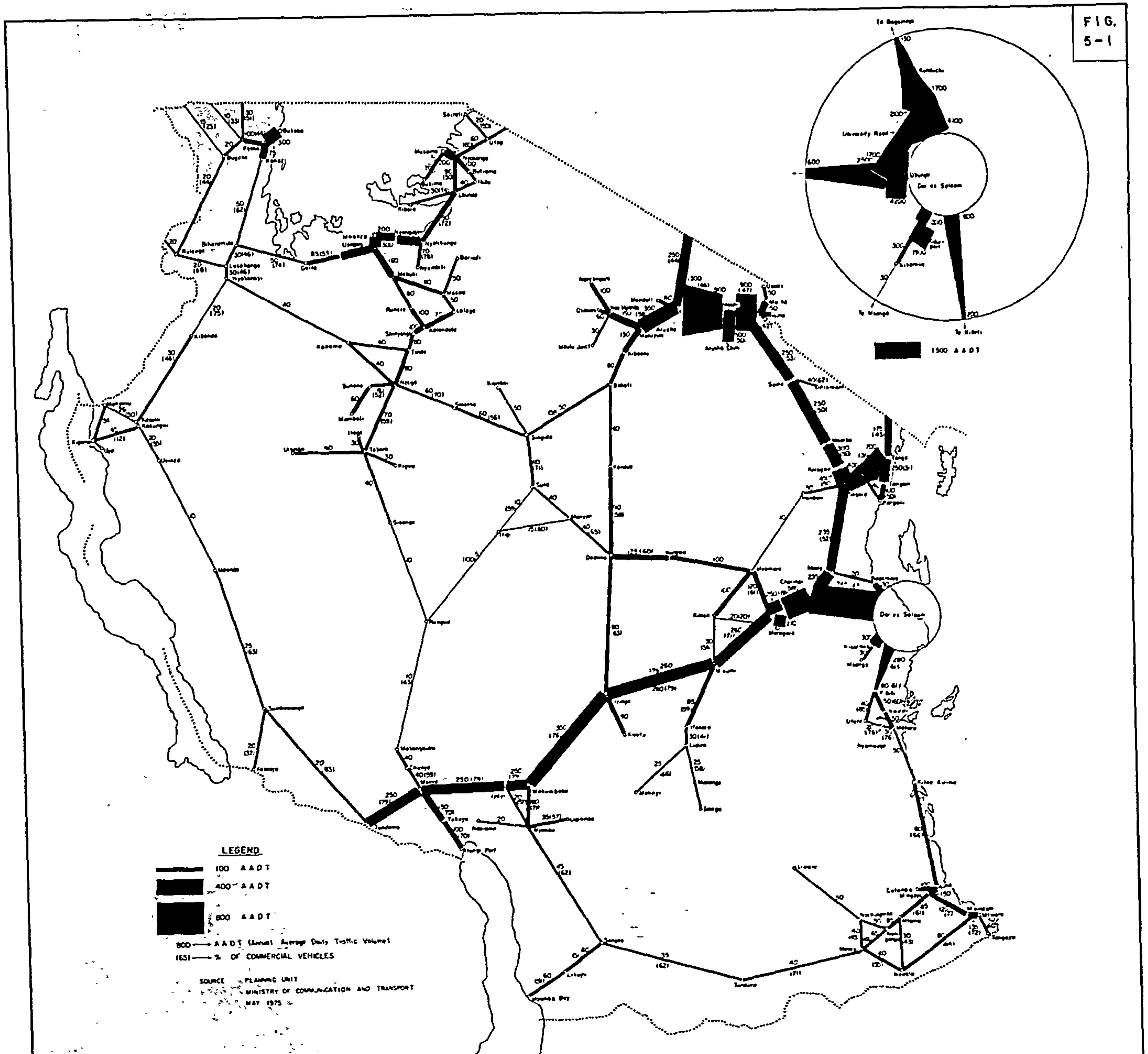


FIG. 5-1

SOUTHERN COASTAL LINK ROAD PROJECT

ROAD TRAFFIC VOLUMES IN 1974

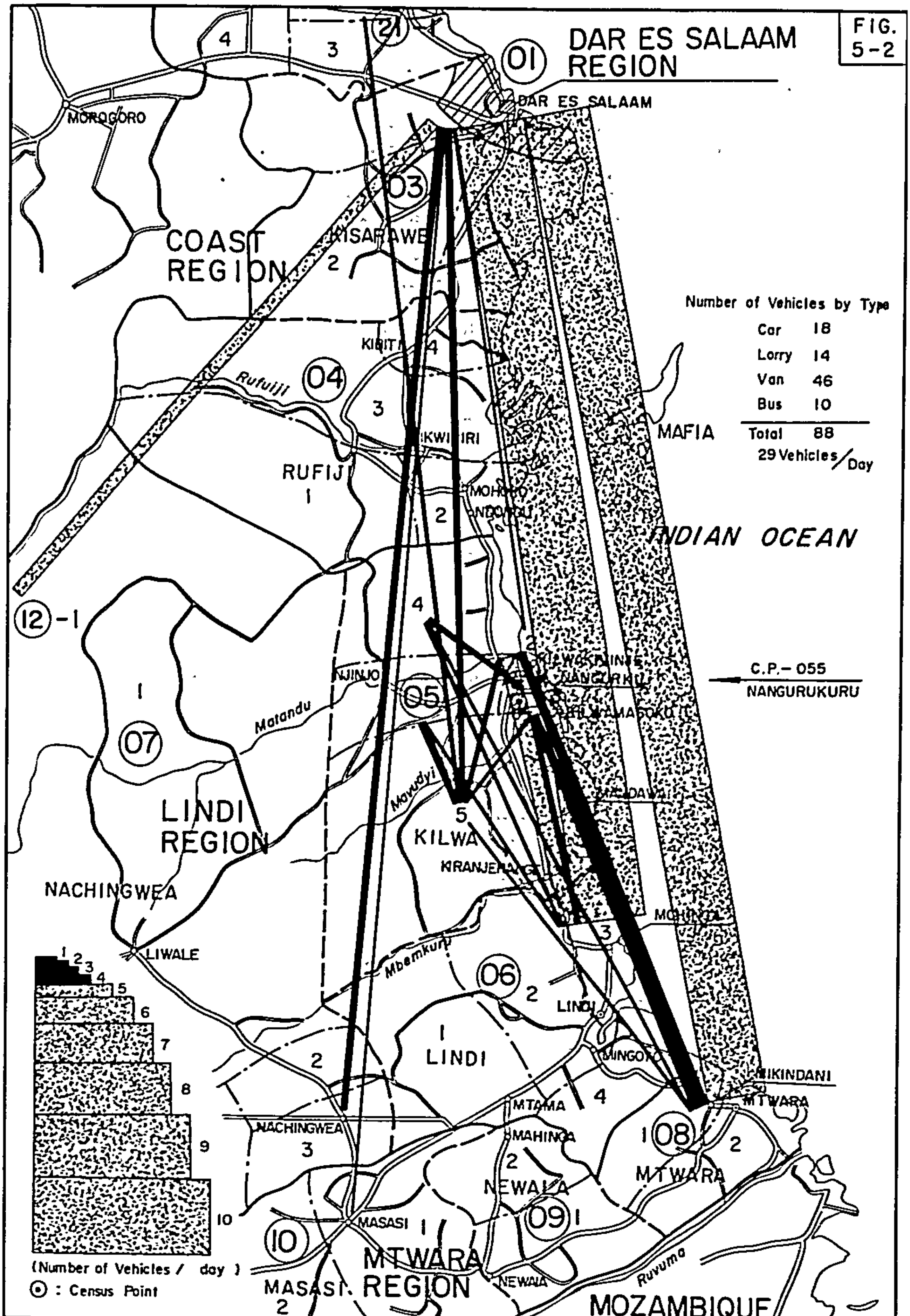


FIG. 5-2	SOUTHERN COASTAL LINK ROAD PROJECT
	TRAFFIC DISTRIBUSION AT THE CENSUS POINT-055 (NANJURUKURU) Sept. 1968

As regards the relationship between the traffic volume and the vehicle type classification, it is known that the vehicle type classification on the existing coastal road varies according to the income level, degree of urbanization, road conditions, and industrial and economic development in respective regions. In the vicinity of cities, for instance, the number of cars utilized for business, commuting to work and going to school is large. In local areas, on the other hand, the car utilization rate declines and vans, pickups and lorries for commodity transportation are used more extensively partly because of the poor road condition.

The vehicle type classification is considered a function of the traffic volume, and the ratio of cars generally rises with the increase of the traffic volume.

Lyon Associates, Inc. discovered that there exists a close correlation between the vehicle type and the traffic volume from the films obtained by photographic survey which covered the whole country. They checked their analytical data against those of the traffic survey conducted by COMWORKS and other organizations, and confirmed that the existence of the said correlation is justifiable.

Table 5-4 shows the correlations between the traffic volume and the vehicle type classification thus obtained. Lyon Associates, Inc. estimated the vehicle type classification on main trunk roads and local main roads in the whole of Tanzania on the basis of the classification shown in this table.

Table 5-4 Vehicle Type Classification by Traffic Volume

Daily Traffic Volume	Vehicle Type Classification(%)			
	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.

However, judging from the data of past traffic surveys, the values shown in Table 5-4 cannot be directly applied for classification of the vehicle type classification on the southern coastal road. The vehicle type classification on the coastal roads is therefore studied below.

Tables 5-2 and 5-3 show the vehicle type classification on the coastal road as obtained from the data of past observations.

As is clear from Tables 5-2, 5-3 and 5-4, the ratio of cars running on the southern coastal road and its vicinities is far lower than the national average, and this is assignable to the following two reasons.

1) The condition of the coastal road is not good enough to promise confortable road ability and smooth passage of cars because earth road sections constitute the greater part of it. Further, it is uneconomical to take the road by car because its poor condition causes considerable fatigue and damage of the car and it is difficult to find a repair station in case the car goes out of order.

2) The income level in the regions along the road is not high enough for the people to use cars, and buses are more economical.

Table 5-5 shows the vehicle type classification on the southern coastal road as estimated from the regional characteristics of the southern coastal road and the vehicle type classification in the whole of Tanzania which are both indicated in the aforementioned three tables (5-2, 5-3 and 5-4). By effecting some corrections to Table 5-5, Fig. 5-3 can be obtained.

Table 5-5 Vehicle Type Classification on Southern Coastal Road

Daily Traffic Volume (vehicle/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
1,000 - 1,500	34	18	40	8	100
1,501 - 2,000	37	17	40	6	100

The future traffic volume by vehicle type was obtained by estimating the traffic volumes of all types of vehicles and by classifying the vehicles using the composition ratios shown in Table 5-5 and Fig. 5-3.

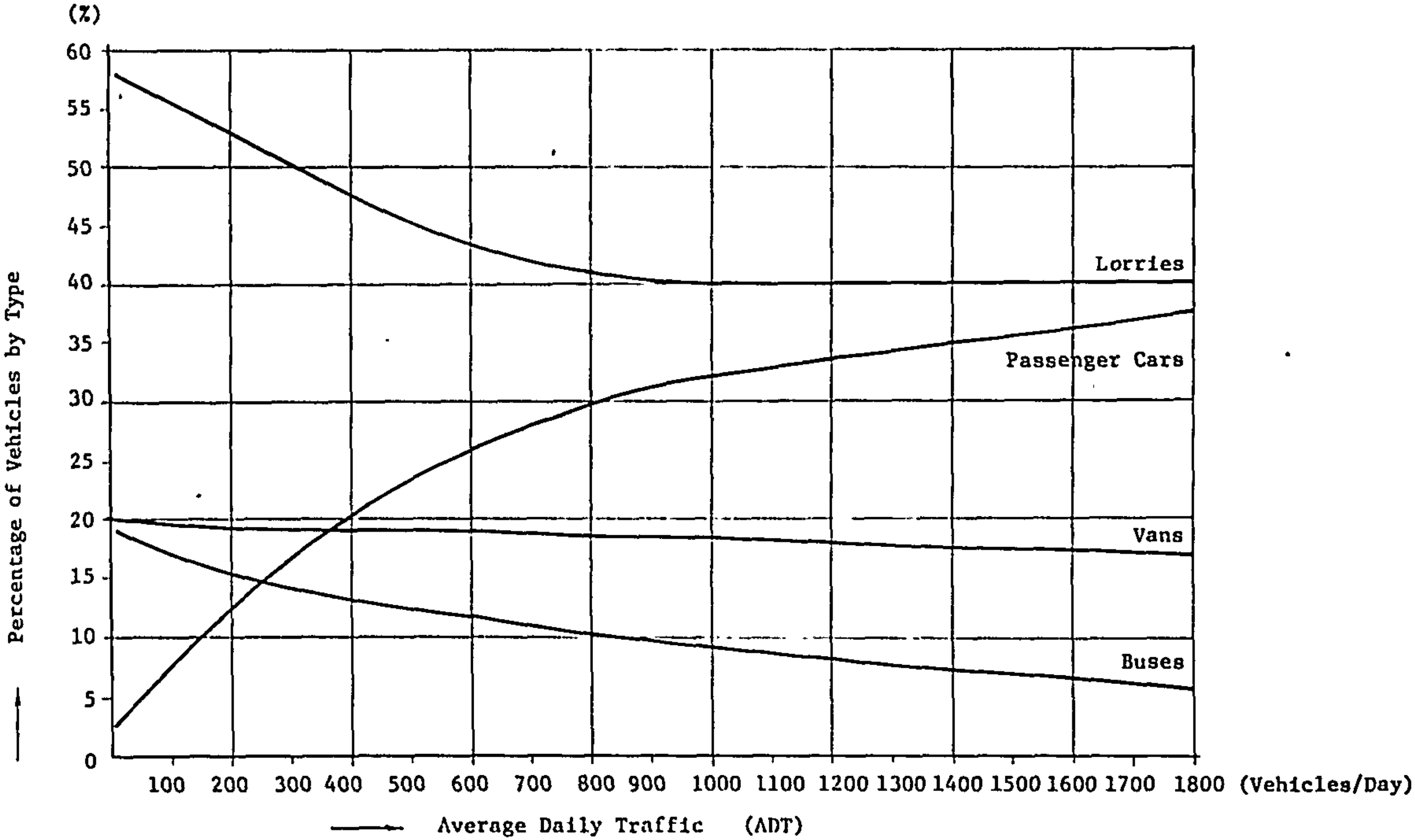


FIG. 5-3 RELATIONSHIP BETWEEN TRAFFIC VOLUME AND VEHICLE CLASSIFICATION

V-3 Estimation of Future Traffic Volume

3-1 Normal Traffic

As listed below, there are a number of methods devised and applicable to the estimation of traffic volume.

1) Method of estimating the future trend of traffic volume from the data of past trend

2) Correlation analysis method

3) Gravity model method

4) United analysis method

5) Model building method

6) Entropy method

7) Purpose correlation method

8) Multivariate analysis method

In Tanzania, detailed data of which accuracy is high enough to serve the purpose of estimating traffic volume by rigid model equations are not available. A more detailed explanation is given below about the absence of such data.

1) Before starting the field survey, the team visited the competent authorities (Ministry of Works, Ministry of Communications and Transport, Regional Development Office, etc.) to collect traffic and transportation data, but discovered to no such materials as would enable the team to grasp the OD pattern of traffic and the past trend of traffic volume.

2) Traffic surveys have been conducted at different census points in Tanzania by various organizations since about 1968. However, since none of them were conducted in a systematic and coordinated manner, it is difficult to clarify the past trend of traffic volume from the data of such surveys.

3) As is clear in Fig. 5-4, the changes in traffic volume by season (wet and dry) or by the time of shipment of agricultural products are far more conspicuous than the secular changes, and this makes it inevitable to give up the plan to cast light on the past trend of traffic volume at any specific point.

4) From the said viewpoint, analysis of the past trend of traffic volume was attempted by none of the foreign consultant firm which have conducted economic or technical surveys of

Tanzanian roads in the past. These firms are: a) Lyon Associates, Inc. which prepared "Report on Economic and Engineering Study of TANZANIAN HIGHWAY", and b) United Research Company which prepared "Report on the Economic Feasibility of Two International Road Links in Tanzania".

For reason described above, conclusion was reached that it would be impractical to conduct a microscopic analysis which calls for the availability of accumulated accurate data, and that a macroscopic method would be suited to the analysis of the long-term trend which involves many indeterminate factors.

The macroscopic analysis was conducted by the method detailed below, and the results thereof were examined from all angles before determining the final values.

A total of 18,240 coefficients of simple correlation were calculated for 192 major industrial and economic indices in Tanzania, and they were indicated in a simple correlation matrix.

The following are the major indices employed:

Population, Number of Workers by Industrial Sectors, Earnings and Sector-wise Expenditures, G.D.P. at Sector , G.D.P. per Capita, Export Values by Item, Export Volumes by Item, Import Values by Item, Number of Operating Vehicles by Type, Holding Rate (vehicle/person), Number of Registered Vehicles by Type, Railway Goods Traffic and Railway Passengers, Sea-borne Goods Handled, Passenger Transport Volume and Export and Import Volume Airway Passengers and Cargoes Carried, Agricultural Production by Crop, Livestock Production in Number, Forestry Production by Tree Species, Fish Catch in Volume and Value, Number of Factories, Number of Factory Workers, Industrial Production by Item, Cement Consumption, Mining Production in Volume and Value, Petroleum Production in Volume, Casoline and Diesel Oil Consumption, Electric Power Production and Consumption, etc.

The simple correlation matrix of the indices enumerated above, those considered to be closely associated with the number of operating vehicles by type are shown in Table 5-6.

Table 5-6 indicates that there exists a close correlation between G.D.P. and the number of operating vehicles by type and between G.D.P. and the railway, sea-borne and air-borne cargoes and passengers, which makes it justifiable to estimate the future traffic volume on the basis of the correlation between G.D.P. and the number of operating vehicles by type.

Table 5-6 Simple Correlation Matrix

Items	Year	G.D.P. at Factor Cost	Consumption Gasoline	Diesel
Population	0.9971	0.9905		
Total Recurrent and Development Expenditure	0.9337	0.9165		
G.D.P. at Factor Cost	0.9929	1.000		
G.D.P. 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 of Gasoline	0.9962	0.9933		
Diesel	0.9867	0.9919		
Electricity Production	0.9984	0.9930		
Local Sales	0.9991	0.9922		

The past growth rates of population, G.D.P., number of operating vehicles by type, and gasoline and diesel oil consumption turn out as shown below in Table 5-7.

Table 5-7 Annual Average Growth Rates of Population, G.D.P. and Number of Operating Vehicles by Type

	1960 - 65	1965 - 69	1970 - 74	1965 - 74	Fore-cast
Population	2.5	2.6	2.7	2.6	—
G.D.P.	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
All Vehicle Types	-	4.2	4.8	4.5	-
Gasoline	-	3.8	2.6	3.2	-
Diesel Oil	-	10.3	8.3	9.0	-
Gasoline + Diesel Oil	-	6.9	5.7	6.2	-

The traffic volume can be considered the function of the number of operating vehicles and the fuel consumption, and its growth rate is vehicled to stand midway between the growth rate of fuel consumption and that of the number of operating vehicles.

Since the growth rate of G.D.P. is somewhere between the growth rate of fuel consumption and that of the number of operating vehicles and the close relationship is conspicious between G.D.P. and other transport indices, it is possible to substitute it for the growth rate of future traffic volume.

Hence, the growth rate of future traffic volume is taken at 5%, and this value can be justified because the annual growth rate of G.D.P. estimated by FAO for areas south of Sahara is 5.2% as shown in Table 5-8.

Table 5-8 Future Growth Rate of G.D.P. (percent/year)

	1962-85	1970-75	1975-85
Latin America	5.6	-	6.1
South America	5.0	4.9	5.7
Asia and Far East	5.9	-	6.6
Africa South of Sahara	4.9	-	5.2
Southwest Africa and Middle East	5.7	-	5.7

Source: Provisional Indicative Words Plan for Agricultural Development, FAO

The validity of the said 5% growth rate can also be substantiated by the results of East Africa Transport Survey in which the future growth rate of traffic volume in Tanzania is estimated at an average of 7%, with light vehicles (passenger cars and vans) assumed to grow at a rate of 8% and heavy vehicles (trucks and buses) at 6%.

There is little difference between the estimated traffic volume of vehicles of all types and the sum total of traffic volume of respective types of vehicles obtained by applying the growth rate of each type of vehicle. Hence, the total traffic volume was obtained using the future growth rate of G.D.P., and the future traffic volume of each type of vehicle was estimated using the correlation between the traffic volume and the vehicle classification.

When a bridge is constructed across the Ruvuma River which runs along the border line between Tanzania and Mozambique, the Southern Coastal Road will become an international trunk road. So the completion of the Ruvuma Bridge crossing the Ruvuma River is expected to cause rapid increase of traffic volume.

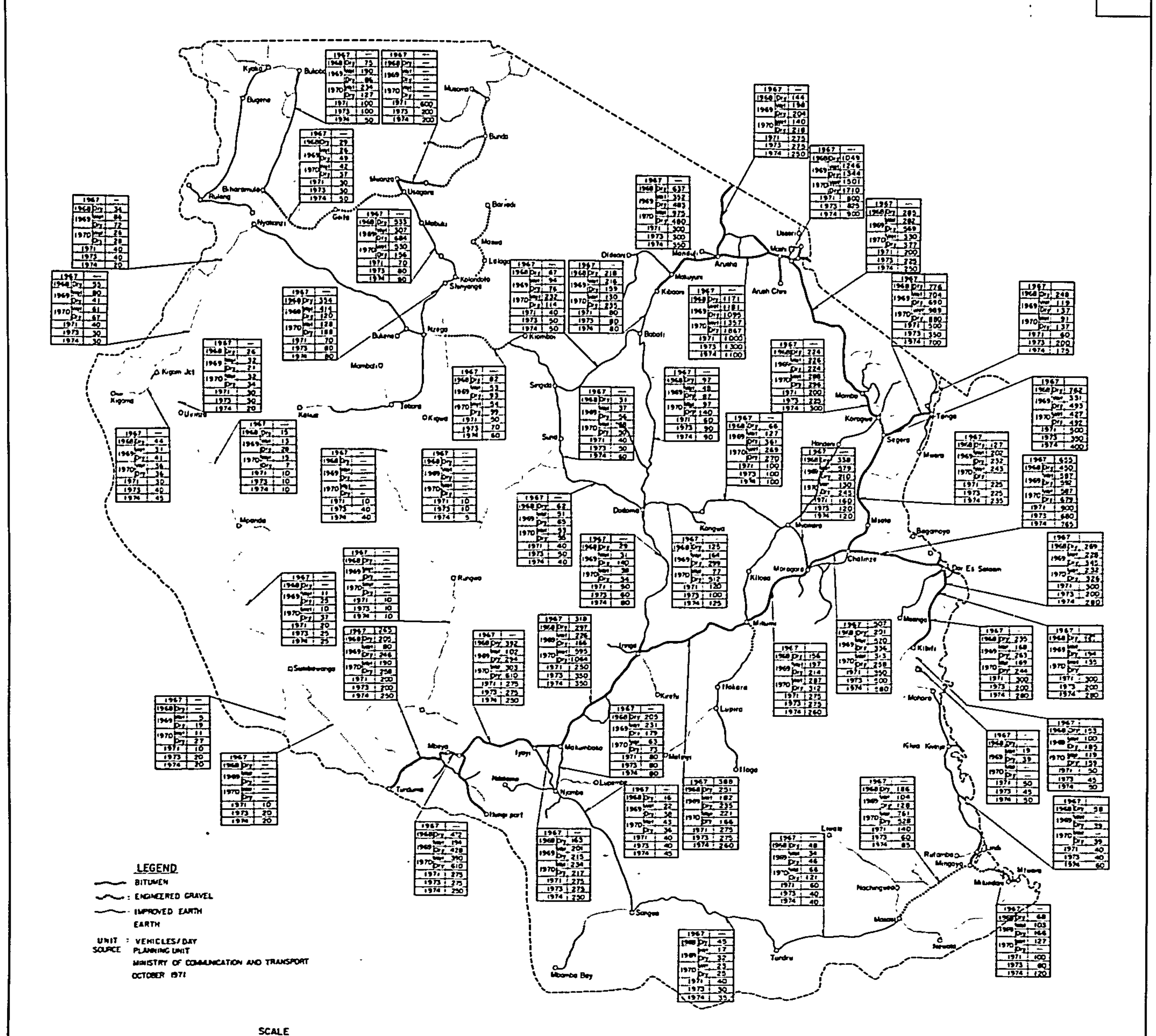
At present, there are no data concerning Mozambique and it is difficult to delineate the influence area of the proposed Ruvuma Bridge. However, since the Tanzam Highway can be considered an international trunk road and the estimated growth rate of its traffic volume is as shown in Table 5-9, the growth rate of traffic volume after completion of the bridge was taken at 7% to estimate the future traffic volume. The results of this estimation are shown as Case 2.

Table 5-9 Estimated Average Annual Growth Rate of Traffic Along the Tanzam Highway

Road Section	Improved Roadx	
	1967-1969	1970-1980
Dar es Salaam ~ Morogoro	7%	7%
Morogoro ~ Mbeya	6%	7%
Mtwara ~ Mbeya	6%	7%
Kapiri Mposhi ~ Mpika	8%	10%

Source: Development Potential of Tanzam Highway

FIG. 5-4



SOUTHERN COASTAL LINK ROAD PROJECT

FIG. 5-4 DRILY TRAFFIC VOLUME (1967-1974)

3-2 Generated Traffic

Considering the industrial, economic and traffic conditions in the regions along the southern coastal road and the accuracy and contents of the relevant data, it appears that there are no other methods than described below which can be applied for estimation of the generated traffic

Specifically, the difference in the traffic volume on the coastal road between the dry and wet seasons is to be taken into account, and the ratio of the dry season traffic volume to the wet season traffic volume is to be employed as the ratio of generated traffic to normal traffic. A detailed explanation of this method is given below.

In the wet season, the roadability declines extremely especially in the earth road sections which become muddy, soft and slippery. In some cases, passage of vehicles becomes absolutely impossible. In the dry season, however, the road surface becomes hard and provides good roadability which can never be expected in the wet season.

This roadability difference by season closely resembles that caused by whether the road is improved or not. Neither the wet season nor the dry season lasts longer than one year which is too short for any notable change to take place in the industrial and economic condition in the regions along the coastal road, so that the increase of traffic volume in the dry season is assignable to the improvement of roadability and the consequent reduction of transport cost, although the regional climatic condition is another contributory factor. Hence, it can be justified to regard the increment of traffic volume in the dry season as induced traffic.

It follows, therefore, that the seasonal variation of traffic volume due to the difference in roadability can be interpreted as the traffic volume difference caused by whether the road is improved or not.

Accordingly, the traffic volume increment in the dry season over the wet season traffic volume was obtained by the stochastic method described below, and the most probable value obtained was used for the estimation of generated traffic.

Fig. 5-5, prepared on the basis of about 370 data covering the whole of Tanzania, shows the frequency distribution of the ratio of the dry season traffic volume to the wet season traffic volume.

The figure indicates that the most probably value of the ratio is +10%. However, the lowest value on the southern coastal road is 20%, so that it was employed as the ratio of generated traffic to the normal traffic which can be expected by improving the earth road sections into paved roads.

Further, the traffic volume generated by improvement from earth road to gravel road and from gravel road to paved road was obtained by applying an increment rate of 20% according to the ratio of benefit per vehicle which can be derived in each stage of improvement.

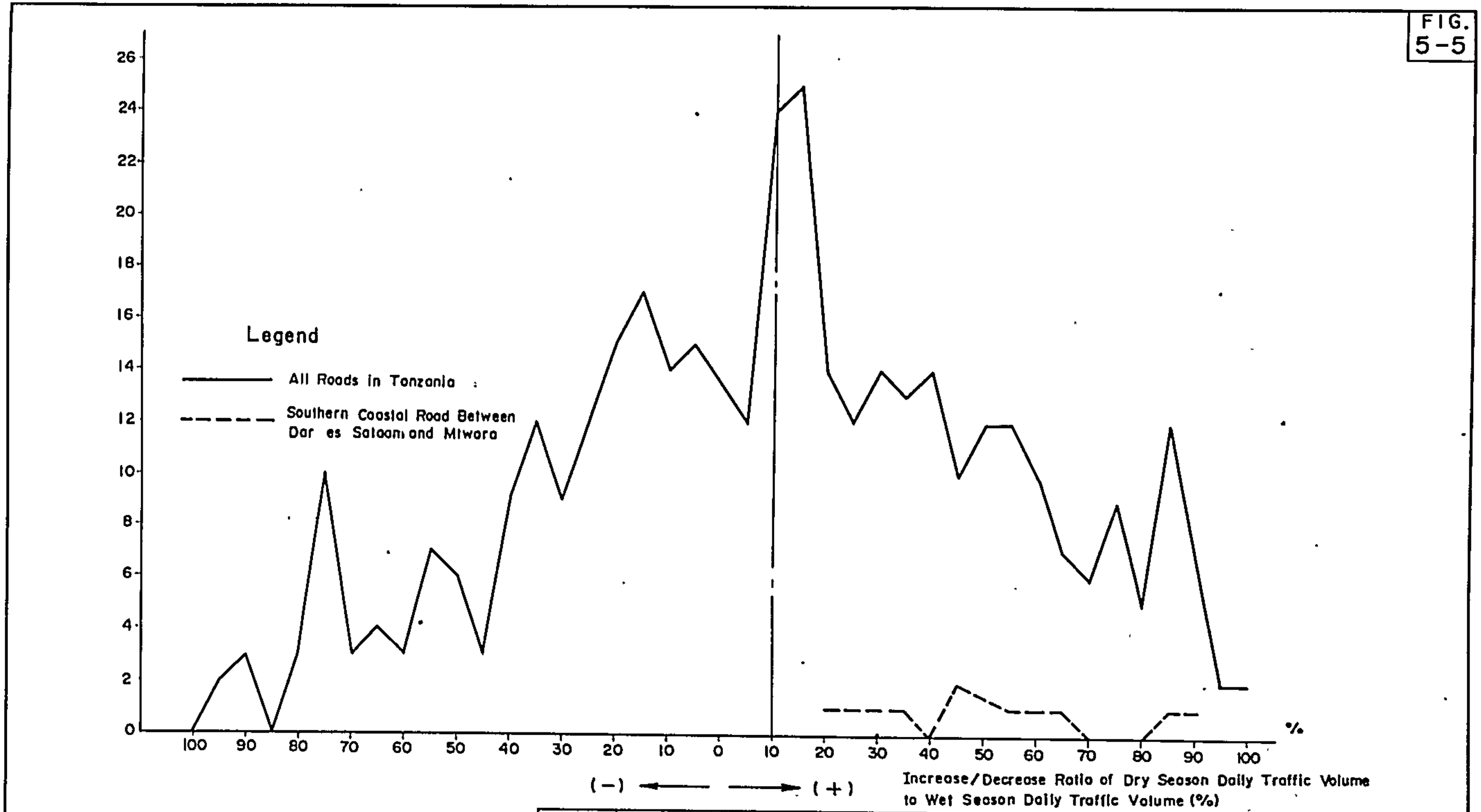


FIG.	SOUTHERN COASTAL LINK ROAD PROJECT
5 − 5	FREQUENCY DISTRIBUTION OF RATIO OF DRY SEASON TRAFFIC VOLUME TO WET SEASON TRAFFIC VOLUME AT SAME CENSUS POINT

3-3 Diverted Traffic

Implementation of the project will create diverted traffic from roads and shipping lines. Traffic from roads will come from the traffic demand between Dar es Salaam and southern regions, which will be diverted to the coastal road upon its completion. Diverted traffic volume from shipping lines will come from the coastal shipping lines.

3-3-1 Diverted Traffic from Coastal Shipping Lines

The diverted traffic volume from coastal shipping lines, which is expected to be produced by the construction ot the southern coastal link road, was estimated on the basis of the flow chart shown in Fig. 5-6.

At present, there are two competitive transport means between Dar es Salaam and southern regions, i.e., the coastal road and the coastal shipping lines serving on three routes (D.S.M. ~ Kilwa Masoko, D.S.M. ~ Lindi, and D.S.M. ~ Mtwara).

Fig. 5-7 shows the contribution rate curve of the coastal road prepared from the shares of the two transport routes in the total cargo volume and the differences in transport cost and time between them. The curve depicts the vehicle utilization rate without the improvement of the coastal road, which will grow when the road becomes available with improvement. The difference in the vehicle utilization rate without and with the road improvement, is taken as the rate of traffic volume diversion from the shipping lines.

Assuming that all this deverted cargo volume will be carried by lorries, the diverted traffic volume can be obtained by dividing it by the average loading capacity of 4 t/lorry.

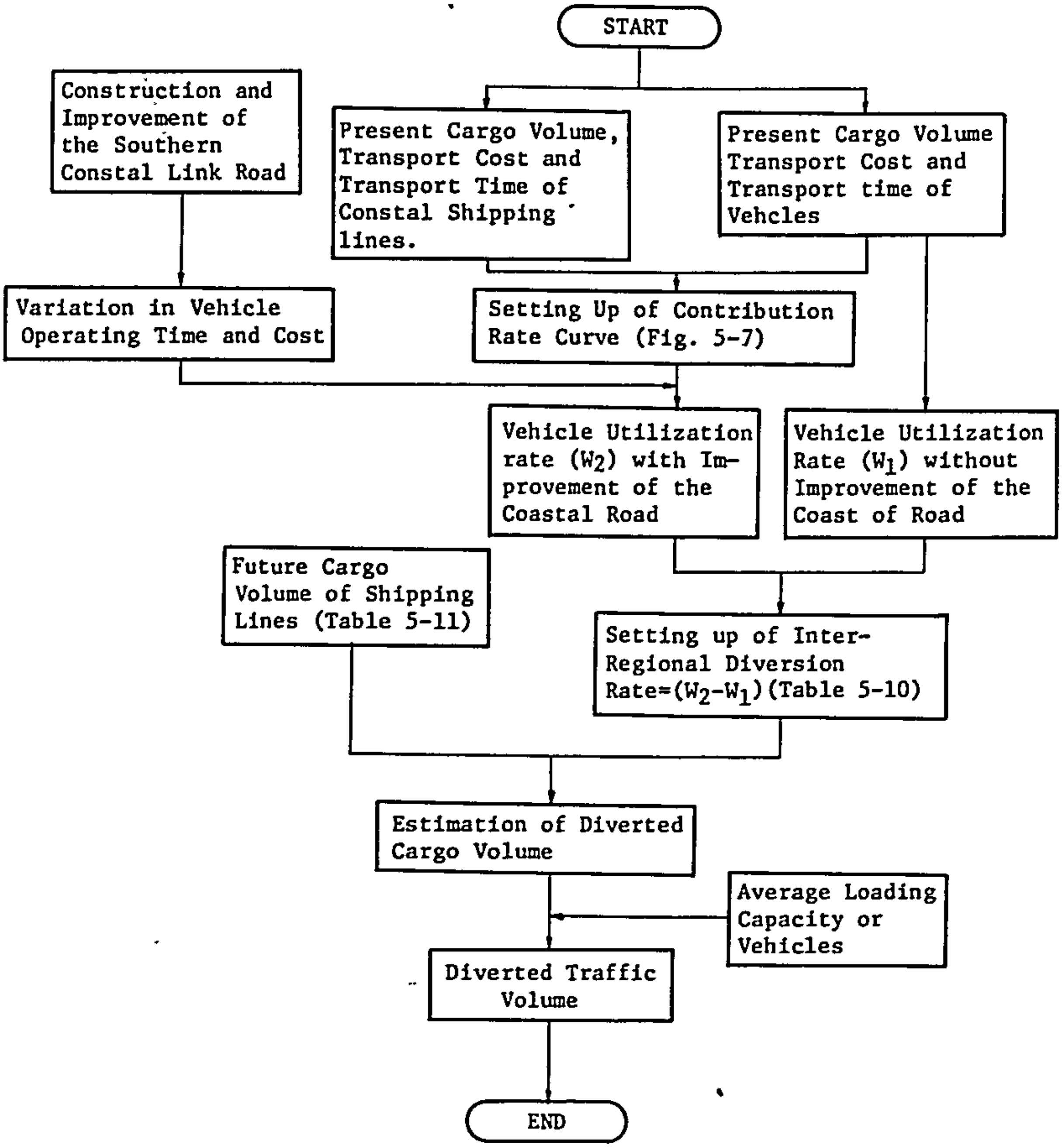


Fig. 5-6 Estimated Flow of Traffic Diversion from Shipping Lines to Southern Coastal Road

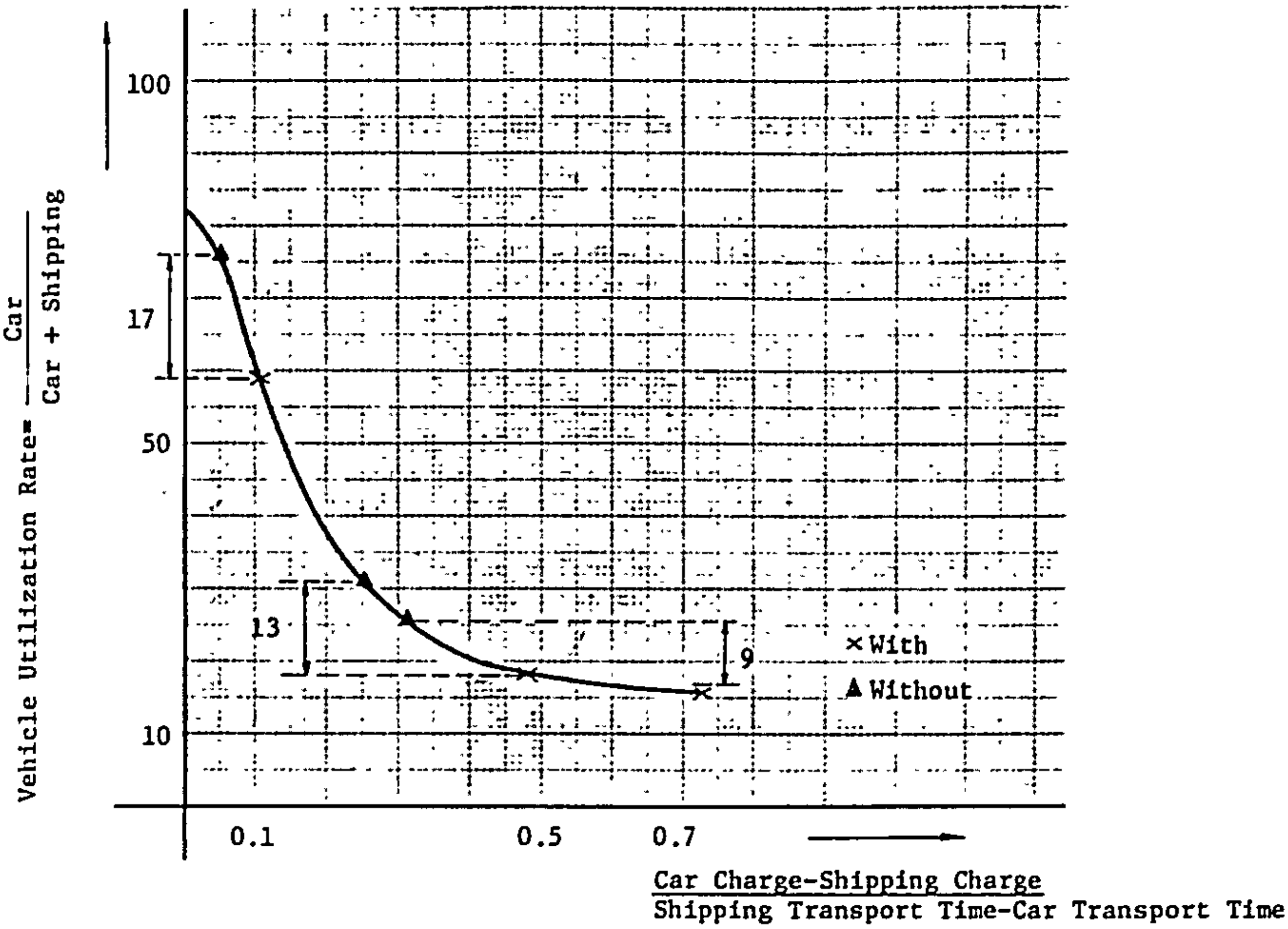


Fig. 5-7 Contribution Rate Curve for Determination of of Traffic Volume Diversion Rate

Table 5-10 Diversion Rate

	D.S.M. ∿Kilwa Masako	D.S.M. ∿ Lindi	D.S.M ∿Mtwara
Diversion Rate	17	13	9

Table 5-11 Commodity Movement within Traffic Division Areas (t/year)

	1974	1982	1992	2002	2011
D.S.M.∿ Kilwa	2728	3183	3996	4832	5575
D.S.M.∿ Lindi	8758	10240	12856	15547	17939
D.S.M.∿ Mtwara	89580	124955	156878	189713	218900
Total	101066	138378	173730	210092	242414
Target year value /1974 value	1.00	1.37	1.72	2.08	2.40

3-3-2 Diverted Traffic Volume from Detour Route to the Castal Route

Between Dar es Salaam and southern regions, it is likely that traffic diversion to the coastal road will come from Tunduru Dar es Salaam section because of the long travel time and additional operating cost required to cover this section as well as its OD distribution.

Since the future traffic demand already estimated by the G.D.P. growth rate method must be excluded from the traffic demand in this section, the prospective diverted traffic volume was obtained using the ratio of the traffic cost on the existing coastal road to that on the detour route.

The diverted traffic volume was obtained by applying the ratio of detour route cost to the improved coastal road cost to this prospective diverted traffic volume.

Thus, the diverted traffic was obtained according to the following flow chart using the operating cost ratio.

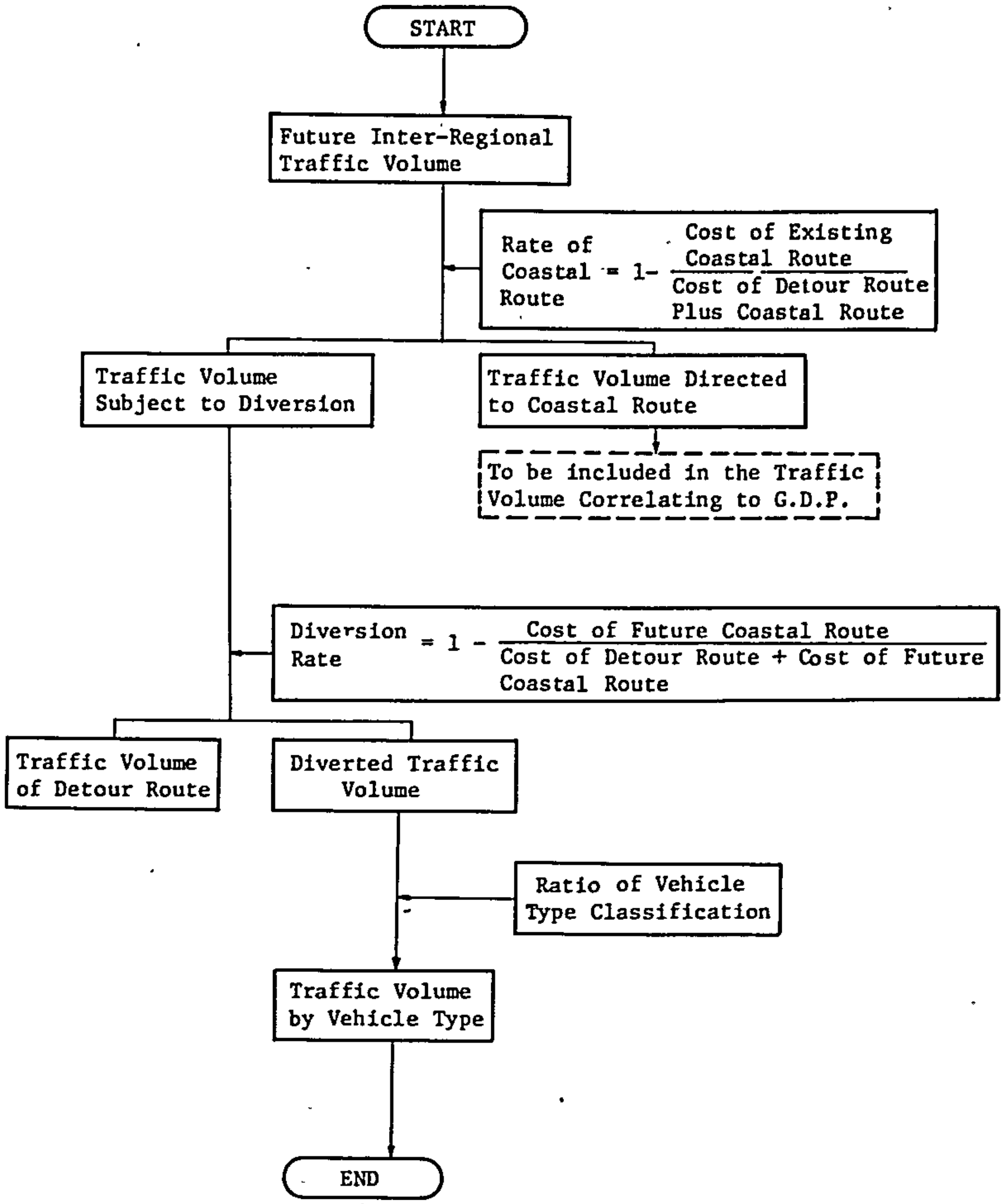


Fig. 5-8 Flow Chart for Estimating Diverted Traffic Volume from Detour Route to Coastal Route

3-4 Results of Estimation of Future Traffic Volume

On the basis of an engineering study covering the design speed, route, structure of road cross-section, pavement structure, number of lanes and other factors, four alternative plans were formulated to be adopted in this project, i.e., original plan and other three staged plans to be completed as original one.

Then the estimate of traffic volume and economic evaluation were made for whole and each of four plans mentioned below and for each construction section shown in Table 5-12.

Plan 1 : Construction of a two-lane paved road for the entire route.

Plan 2 : Construction of a two-lane road in Kibiti-Nyamwage section which has greater traffic volume than other sections, and a one-lane road in Section 2-5 where the traffic volume is relatively small. Thereafter, with the growth of traffic volume two-lane paved roads are to be constructed in these sections to be completed in 15 years as in the form of original plan.

Plan 3 : Same as Plan 2, except that no shoulder pavement is planned for the first stage construction in Sections 2-5.

Plan 4 : Construction of a two-lane gravel road for the entire route, then improved to a paved road in 15 years as in the form of original plan.

The proposed road are divided into following 5 construction sections.

Table 5-12 Division of Construction Sections

Section	Road Section	Road Extension (km)	
		Existing	Proposed
No.1 Section	Kibiti-Nyamwage	36.70	36.00
No.2 "	Nyamwage-Nangurukuru	107.50	101.15
No.3 "	Nangurukuru-Kiranjerange	89.30	86.70
No.4 "	Kiranjerange-Lindi	79.00	76.23
No.5 "	Nangurukuru-Kilwa Masoko	36.70	30.38
Total	Kibiti-Lindi Nangurukuru-Kilwa Masoko	349.20	330.46

Notes 1. The 12km length of Rufiji river section is excluded from the road length.

2. All plans presuppose the completion of the Rufiji Bridge.

The future traffic volume were estimated for above 4 alternate plans to be divided into case-1 in which traffic volume grows at an annual rate of 5% and case-2 in which traffic volume grows at an annual rate of 7% as the Southern Coastal Road becomes an international trunk road consequent upon the construction of a bridge across the Ruvuma River, the boundary with Mozambique.

Table 5-13～5-16 show the estimated future traffic volumes for each alternative plan and case.

Table 5-13 Future Traffic Volume in Each Section

Plan 1.2.3. Case 1

(Unit: Vehicle/day)

			1973	1982	1992	2002	2011
1	Kibiti ~ Nyamwage	Normal Traffic	95	151	247	402	623
		Generated Traffic	-	30	33	33	33
		Diverted Traffic	-	11	15	19	21
		Sub Total	95	192	295	454	677
2	Nyamwage ~ Nangurukuru	Normal Traffic	50	80	130	211	328
		Generated Traffic	-	0	19	19	19
		Diverted Traffic	-	11	15	19	21
		Sub Total	50	91	164	249	368
3	Nangurukuru ~ Kirangerange	Normal Traffic	40	64	104	169	262
		Generated Traffic	-	0	15	15	15
		Diverted Traffic	-	10	14	18	20
		Sub Total	40	74	133	202	297
4	Kiranferange ~ Lindi	Normal Traffic	40	64	104	169	262
		Generated Traffic	-	13	14	14	14
		Diverted Traffic	-	10	14	18	20
		Sub Total	40	87	132	201	296
5	Nangurukuru ~ Kilwa Masoko	Normal Traffic	30	43	71	115	178
		Generated Traffic	-	9	10	10	10
		Diverted Traffic	-	1	1	1	1
		Sub Total	30	53	82	126	189

Table 5-14 Future Traffic Volume in Each Section

Plan 1.2.3 Case 2

(Unit: Vehicle/day)

			1973	1982	1992	2002	2011
1	Kibiti ~ Nyamwage	Normal Traffic	95	165	324	638	1173
		Generated Traffic	-	33	38	38	38
		Diverted Traffic	-	11	15	19	21
		Sub Total	95	209	377	695	1232
2	Nyamwage ~ Nangurukuru	Normal Traffic	50	87	171	336	617
		Generated Traffic	-	0	21	21	21
		Diverted Traffic	-	11	15	19	21
		Sub Total	50	98	207	376	659
3	Nangurukuru ~ Kiranjerange	Normal Traffic	40	69	137	269	494
		Generated Traffic	-	0	17	17	17
		Diverted Traffic	-	10	14	18	20
		Sub Total	40	79	168	304	531
4	Kiranjerange ~ Lindi	Normal Traffic	40	69	137	269	494
		Generated Traffic	-	14	16	16	16
		Diverted Traffic	-	10	14	18	20
		Sub Total	40	93	167	303	530
5	Nangurukuru ~ Kilwa Masoko	Normal Traffic	30	47	93	183	336
		Generated Traffic	-	9	11	11	11
		Diverted Traffic	-	1	1	1	1
		Sub Total	30	57	105	195	348

Table 5-15 Future Traffic Volume in Each Section

Plan 4 Case 1

(Unit: Vehicle/day)

			1973	1982	1999	2002	2011
1	Kibiti ～ Nyamwage	Normal Traffic	95	151	337	402	623
		Generated Traffic	-	25	36	36	36
		Diverted Traffic	-	6	16	19	21
		Sub Total	95	182	389	457	680
2	Nyamwage ～ Nangurukuru	Normal Traffic	50	80	178	211	328
		Generated Traffic	-	0	33	33	33
		Diverted Traffic	-	6	16	19	21
		Sub Total	50	86	227	263	382
3	Nangurukuru ～ Kiranjerange	Normal Traffic	40	64	142	169	262
		Generated Traffic	-	0	27	27	27
		Diverted Traffic	-	5	15	18	20
		Sub Total	40	69	184	214	309
4	Kiranjerange ～ Lindi	Normal Traffic	40	64	142	169	262
		Generated Traffic	-	2	3	3	3
		Diverted Traffic	-	5	15	18	20
		Sub Total	40	71	160	190	285
5	Nangurukuru ～ Kilwa Masoko	Normal Traffic	30	43	97	115	178
		Generated Traffic	-	0	2	2	2
		Diverted Traffic	-	1	1	1	1
		Sub Total	30	44	100	118	181

Table 5-16 Future Traffic Volume in Each Section

Plan 4 Case 2

(Unit: Vehicle/day)

			1973	1982	1999	2002	2011
1	Kibiti ~ Nyamwage	Normal Traffic	95	165	498	638	1173
		Generated Traffic	-	28	43	43	43
		Diverted Traffic	-	6	16	19	21
		Sub Traffic	95	199	557	700	1237
2	Nyamwage ~ Nangurukuru	Normal Traffic	50	87	263	336	617
		Generated Traffic	-	0	48	48	48
		Diverted Traffic	-	6	16	19	21
		Sub Traffic	50	93	327	403	686
3	Nangurukuru ~ Kiranjerange	Normal Traffic	40	69	210	269	494
		Generated Traffic	-	0	7	7	7
		Diverted Traffic	-	5	15	18	20
		Sub Traffic	40	74	232	294	521
4	Kiranjerange ~ Lindi	Normal Traffic	40	69	210	269	494
		Generated Traffic	-	10	20	20	20
		Diverted Traffic	-	5	15	18	20
		Sub Traffic	40	84	245	307	534
5	Nangurukuru ~ Kilwa Masoko	Normal Traffic	30	47	144	183	336
		Generated Traffic	-	3	22	22	22
		Diverted Traffic	-	1	1	1	1
		Sub Traffic	30	51	167	206	359

V-4 Vehicle Operating Cost

The vehicle operating cost was calculated by the following procedure and by referring to the bibliography listed under the notes.

(1) The prices of fuel, lubricant oil, tyres and new cars, effective as of October 1975, were studied in Tanzania and broken down into the retail price, sales tax, customs duty and profit in order to obtain the net price of fuel, lubricant oil, tyres and vehicle of each type.

(2) The net price thus obtained was used to calculate the fuel cost, lubricant cost and tyre cost by the vehicle type (passenger car, pickup, 9-ton truck, and 50-passenger bus), terrain (flat to rolling, rolling to hilly, and hilly to mountainous), and surface condition (bitumen paved, gravel, and earth).

The cost calculation that followed was worked out by vehicle type, terrain and surface condition.

(3) The maintenance labour cost and the cost of maintenance parts were calculated using the labour cost and the average vehicle price, respectively.

(4) The wage cost was calculated on the basis of the operator's wages and his average working hours.

(5) Depreciation cost, interest, and insurance cost were calculated.

(6) All the cost calculated in Steps (1) - (5) were summed up.

The operating cost thus obtained for each vehicle type, terrain and surface condition is shown in Tables 5-17~5-19.

Notes: 1. Jan de Weille, "Quantification of Road User Savings," (International Bank for Reconstruction and Development).

2. Lyon Associates, Inc., "Economic and Engineering Study, Tanzania Highway"

Table 5-17 Summary of Vehicle Operating Costs on Varying Quality of Surface - Flat to Rolling Terrain

(Tanzanian Cents/ Vehicle Kilometer)

Type and Quality of Surface	Cars	Pickups	Trunks	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	289.31	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 5-18 Summary of Vehicle Operating Costs on Varying of Surface - Rolling To Hilly

(Tanzanian Cents/ Vehicle Kilometer)

Type and Quality of Surfacing	Cars	Pickups	Truncks	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 5-19 Summary of Vehicle Operating Costs on Varying Quality of Surface - Hilly to Mountainous Terrain

(Tanzanian Cents/ Vehicle Kilometer)

Type of 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

V- 5 Economic Evaluation

5-1 Cost

The cost subjected to economic evaluation is the cost before tax which is expected to be incurred for road and bridge construction in each section under the four plans and which is divided into construction cost (preparatory cost, direct construction cost, overhead cost, and supervision cost for construction) and maintenance and management cost.

The capital requirement to cover these costs under each plan and in each job section varies by year. Hence, the annual amount of investment required for each plan and each section was obtained on the basis of the investment plans which were so formulated as would be consistent with the construction schedule within the duration of the project life.

A more detailed explanation is given on these investment plans. If the construction work is started on July 1, 1977 and completed in five years, then the improved coastal road can be opened to traffic on July 1, 1982. According to the construction schedule, however, sections 1, 4 and 5 are planned to be completed on June 30, 1981. Hence, benefit calculation was worked out on the assumption that these sections would be opened to traffic on July 1, 1981.

Plan 4 envisages the construction of a gravel road for the entire route, to be improved to a paved road in 15 years. The benefits of this plan were therefore calculated assuming that they would be derived from a gravel road from 1982 to 1998 and from a paved road from 1999 to 2011.

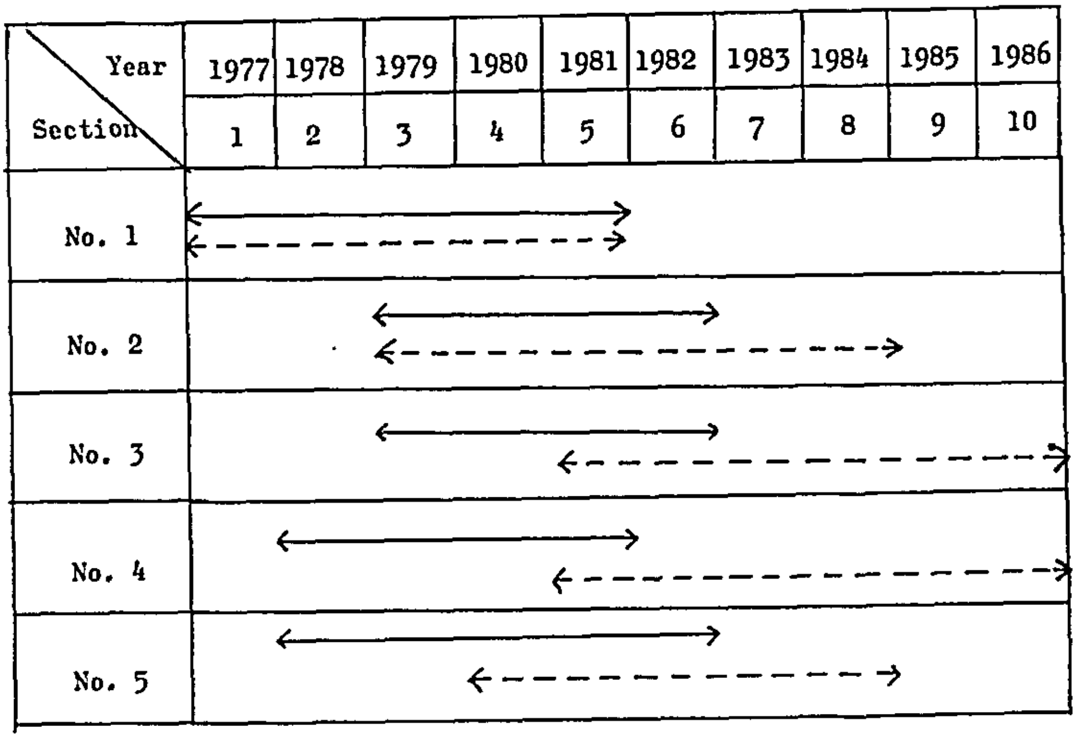
In order to check the validity of these investment plans, economic evaluation was also made on an alternative investment plan shown in Fig. 5-9 in which the time and period of investment are protracted.

The present value calculation was worked out on July 1, 1977, the year of commencement of construction work, taken as base year, and with the conversion rate from Japanese yen to Tanzanian shillings taken at Sh.1 = 37 yen. The construction cost was calculated on the basis of the unit prices effective as at October 1975, and excludes taxes.

In the calculation of the maintenance cost, it was assumed that the overlay of pavement and the bridge painting work would be performed at intervals of 5 years and 10 years, respectively. Thus, the costs of intermittent maintenance works and the annual average maintenance cost were summed up for each year and each plan to obtain the aggregate total cost.

Since "With and Without Comparison Method" was employed, the annual difference in the maintenance cost between newly constructed road sections and the existing road was put to economic evaluation, assuming that the maintenance cost of the existing road would not be required after improvement of its earth road sections.

Fig. 5-9 Investment Program for Each Section



Notes: ———— Original Plan

- - - - - Plan A (Alternate plan to put off construction period of plan No.2 in later years)

5-2 Benefit

The following direct benefits were studied in the economic evaluation.

1) Reduced operating expenses derived from improvement or new construction of road.

2) Benefit derived from the diversion of detour traffic between Dar es Salaam and southern regions via Iringa and Morogoro districts to the improved southern costal road.

3) Benefit derived from the diversion of some cargo volume from coastal shipping lines to the improved southern coastal road.

The reduced operating expenses was obtained using the data of road inventory of the existing and improved roads, estimated future traffic volume by vehicle type. Table 5-20 shows the operating cost per vehicle for each section and each vehicle type.

As seen in Table 5-20, the operating cost of cars and vans is expected to be reduced by 50 - 60% by the road improvement work, and that of lorries and buses by 60 - 70%.

Table 5-21 shows the sum totals of the above three benefits. The distribution ratio of these benefits varies by year and plan, but it is evident that the benefit of reduced operating expenses derived from normal traffic will occupy the greater part of all benefits as seen in the case of 2011 in which the benefit derived from normal traffic is expected to account for 95% of all benefits but those derived from generated traffic and diverted traffic are estimated at only 3% and 2%, respectively.

As regards the benefits derived from 4 plans which has already been explained in Section V-3-4 calculations were worked out for the following two cases.

Case 1: Traffic volume grows at an annual rate of 5%.

Case 2: Traffic volume grows at an annual rate of 7% as the southern coastal road becomes an international trunk road consequent upon the construction of a bridge across the Ruvuma river which divides Tanzania and Mozambique.

Table 5-20 Operating Cost per Vehicle by Section and Vehicle Type

(Shs/vehicle)

Year / Vehicle / Section	Present (A)				Future (B)								
	Car	Van	Lorry	Bus	Car	Van	Lorry	Bus		Car	Van	Lorry	Bus
1	4,221	5,058	16,769	17,331	2,165	2,477	6,299	6,787	①	2,056	2,581	10,470	10,544
									②	48.7	51.0	62.4	60.8
2	16,303	19,888	69,771	70,597	6,077	6,954	17,685	19,053	①	10,226	12,934	52,086	51,544
									②	62.7	65.0	74.7	73.0
3	10,946	13,234	45,195	44,411	5,332	6,163	15,640	16,766	①	5,614	7,071	29,555	27,645
									②	51.3	53.4	65.4	62.2
4	10,146	12,347	42,494	41,441	4,693	5,456	13,877	14,849	①	5,453	6,891	28,617	26,592
									②	53.7	55.8	67.3	64.2
5	4,656	5,608	18,896	19,086	1,845	2,124	5,402	5,803	①	2,811	3,484	13,494	13,283
									②	60.4	62.1	71.4	69.6

Notes: ① : (A) - (B)

② : $\frac{(A) - (B)}{(A)} \times 100$ (%)

Table 5-21 Benefit by Plan and Case

(1,000 Shs/year)

	Type of Benefit	1981	1982	1992	1999	2002	2011
Plan 1.2.3. Case 1	Normal	6,504	22,807	50,367	-	78,619	116,759
	Generated	0	1,357	3,618	-	3,618	3,618
	Diverted	0	647	1,135	-	1,813	2,274
	Total	6,504	24,811	55,120	-	84,050	122,651
Plan 1.2.3. Case 2	Normal	6,821	24,651	64,984	-	119,273	201,265
	Generated	0	1,620	4,204	-	4,204	4,204
	Diverted	0	647	1,135	-	1,813	2,274
	Total	6,821	26,918	70,323	-	125,290	207,743
Plan 4 Case 1	Normal	5,474	19,431	43,162	67,982	78,619	116,759
	Generated	0	908	1,069	5,631	7,631	5,631
	Diverted	0	412	789	1,610	1,813	2,274
	Total	5,474	20,751	45,020	75,223	86,063	124,664
Plan 4 Case 2	Normal	5,741	21,005	55,696	100,200	119,273	201,265
	Generated	0	986	1,232	7,745	7,745	7,745
	Diverted	0	412	789	1,610	1,813	2,274
	Total	5,741	22,403	57,717	109,555	128,831	211,284

5-3 Project Evaluation

(1) In the economic evaluation of the four alternative plans, the cost benefit ratio and the internal rate of return were obtained for each combination of project life (20 years and 30 years), increase/decrease range of cost and benefit (± 15% and ± 30%), and growth rate of traffic volume (5% for Case 1 and 7% for Case 2). Further, sensitivity analysis was conducted to study how the internal rate of return changes with the increase or decrease of cost and benefit. Calculations for this analysis were performed with either cost or benefit taken at a fixed value.

(2) Fig. 5-10 ~ 5-13 show the results of the above calculations. Fig. 5-10, prepared with the project life taken at 30 years, indicates that the values of internal rate of return are clearly divided into Case 1 group and Case 2 group and are within the range of 4% — 7.3%. In Fig. 5-12 prepared with the project life taken at 20 years, the upper limit of the internal rate of return is 3.5%, which indicates that the reduction of the project life by 10 years results in a very large decline of benefit.

The reason can be mentioned that as the future traffic volume takes the pattern of increasing in a geometrical ratio, benefit will gradually be increased and even if the benefit is discounted at present value, absolute amount of the benefit to be produced in 10 years from 20 to 30 years later is large, thus considerable amount of benefit equal to the one that can be obtained if the project life is extended by 10 years is deprived of in this case in which project life was taken at 20 years.

(3) When the construction of an improved coastal road over its entire route is taken as the measure of judgement, Plan 3 is most economically advantageous, followed by Plan 2, Plan 4 and Plan 1 in that order.

(4) The average internal rate of return of the project as a whole is shown in Fig. 5-10 Fig. 5-13. Reviewed by section, however, the value of internal rate of return is subject to a large fluctuation. Table 5-22 shows the values of internal rate of return calculated by section for Plan 2 and Plan 3.

Table 5-22 Internal Rate of Return by Section

(Case 1 : Project life – 30 years)

Section	Plan 2	Plan 3
1	15.4	15.5
2	6.0	6.2
3	1.8	2.0
4	2.2	2.6
5	2.5	2.8

The above table indicates that Section 1 exhibits by far the highest economic effect of all sections. If economic effect alone is taken into consideration, therefore, top priority is to be given to Section 1, followed by Sections 2, 5, 4 and 3 in that order.

(5) Plan A shown in Fig. 5-9, which was formulated as an alternative to Plan 2 to put off the investment period, produces an internal rate of return of 6.6% when 30 years for case 1.

The original Plan 2, on the other hand, produced 4.4% of internal rate of return under the same conditions. This means that a greater economic benefit can be obtained by putting off the investment period.

(6) While the discussion advanced above centres on the evaluation of measurable benefits, the project is expected to produce various direct and indirect effects as well as various derivative as shown in Fig. 6-1. Therefore, the validity of the project should be judged not by its economic evaluation alone, but from a broader synthetic and long-term point of view.

FIG. 5-10

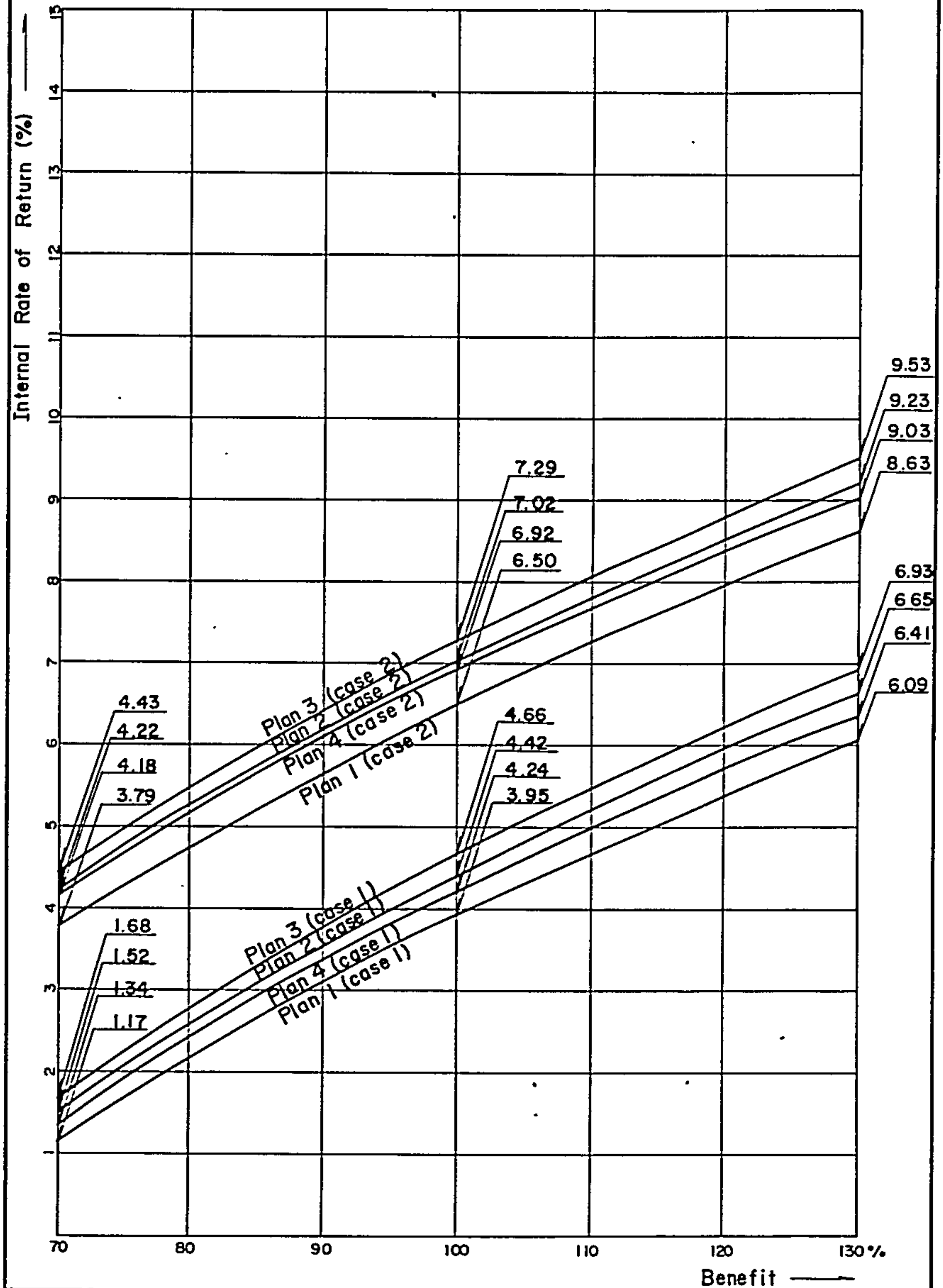


FIG. 5-10	SOUTHERN COASTAL LINK ROAD PROJECT
	SENSITIVITY ANALYSIS (Benefit : ±30 %, Cost : 100 % , Project Life : 30 years)

FIG. 5-11

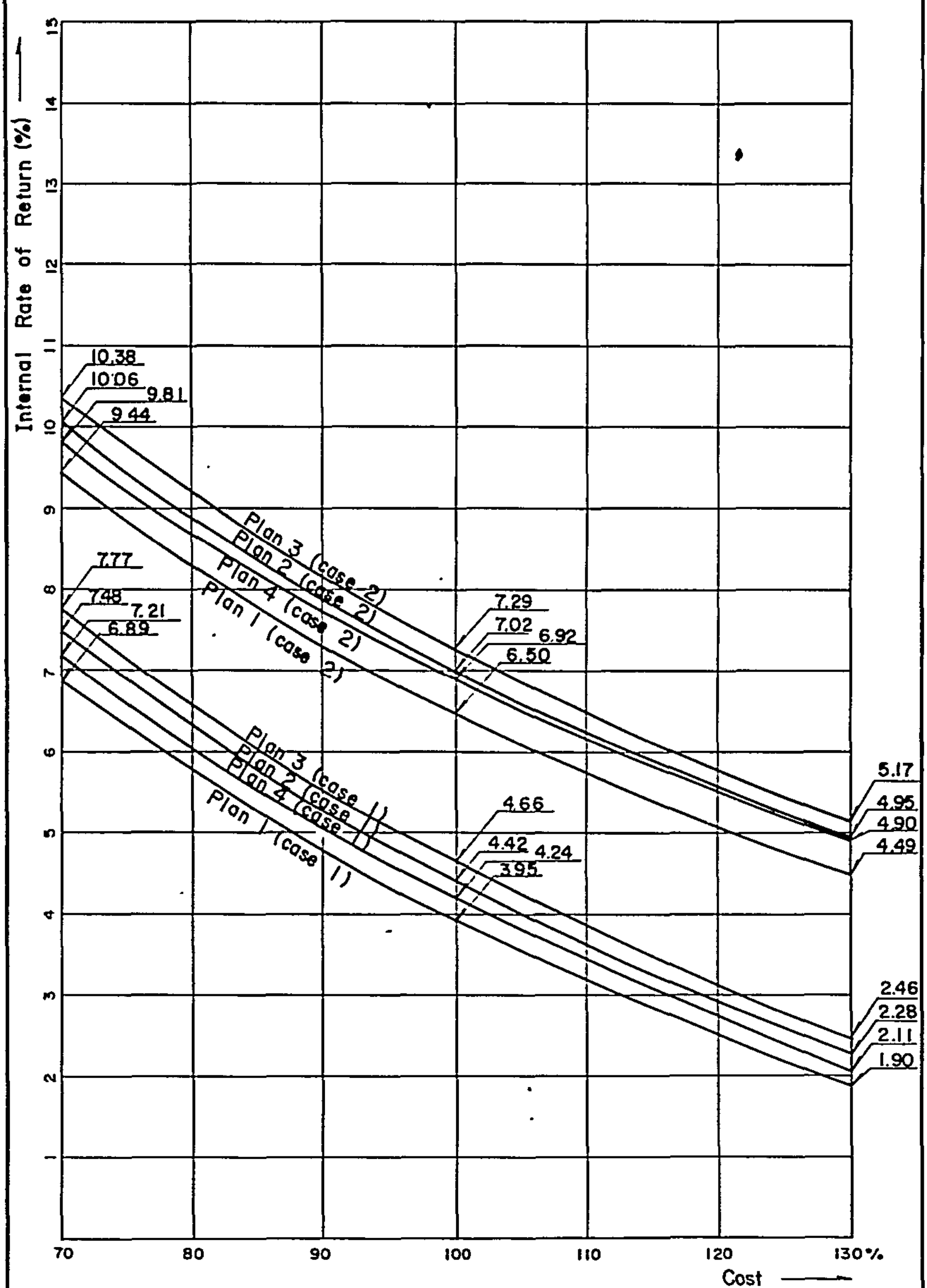


FIG. 5-11	SOUTHERN COASTAL LINK ROAD PROJECT
	SENSITIVITY ANALYSIS (Benefit : 100 %, Cost : ±30 %, Project Life : 30 years)

FIG. 5-12

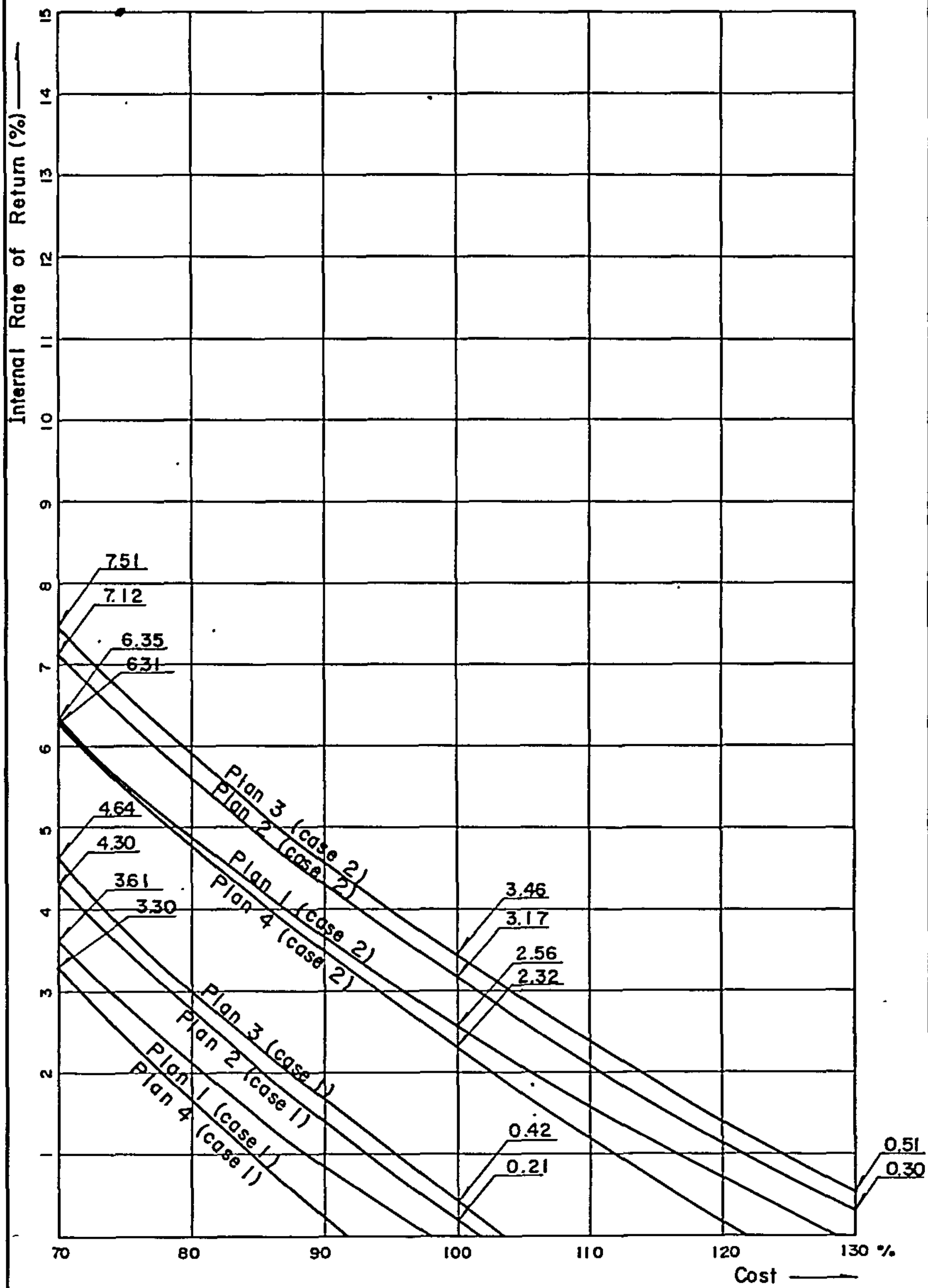


FIG.	SOUTHERN COASTAL LINK ROAD PROJECT
5-12	SENSITIVITY ANALYSIS (Benefit : 100 %, Cost : ±30 %, Project Life : 20 years)

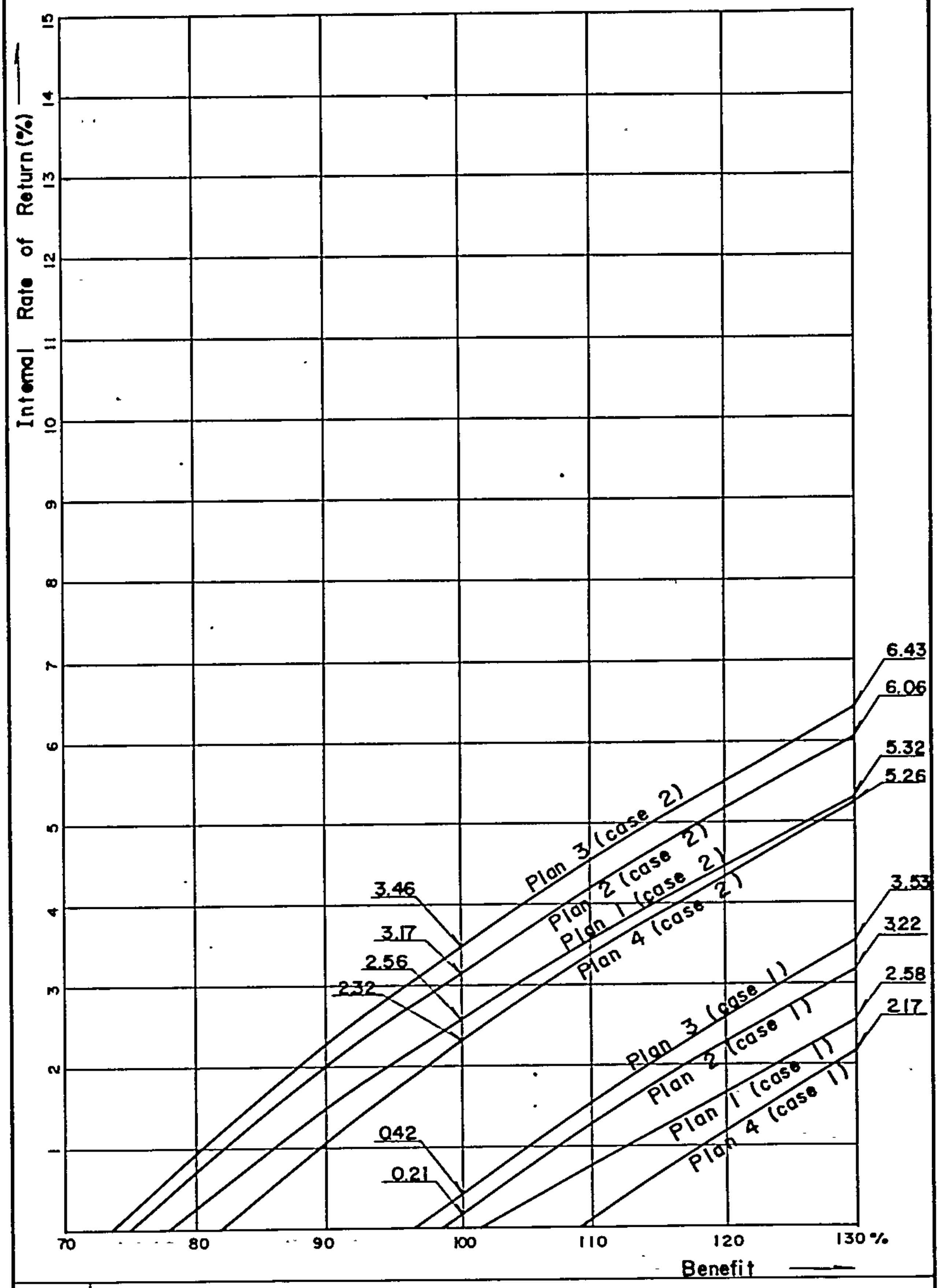


FIG.	SOUTHERN COASTAL LINK ROAD PROJECT
5-13	SENSITIVITY ANALYSIS (Benefit : ±30 %, Cost : 100 %, Project Life : 20 years)

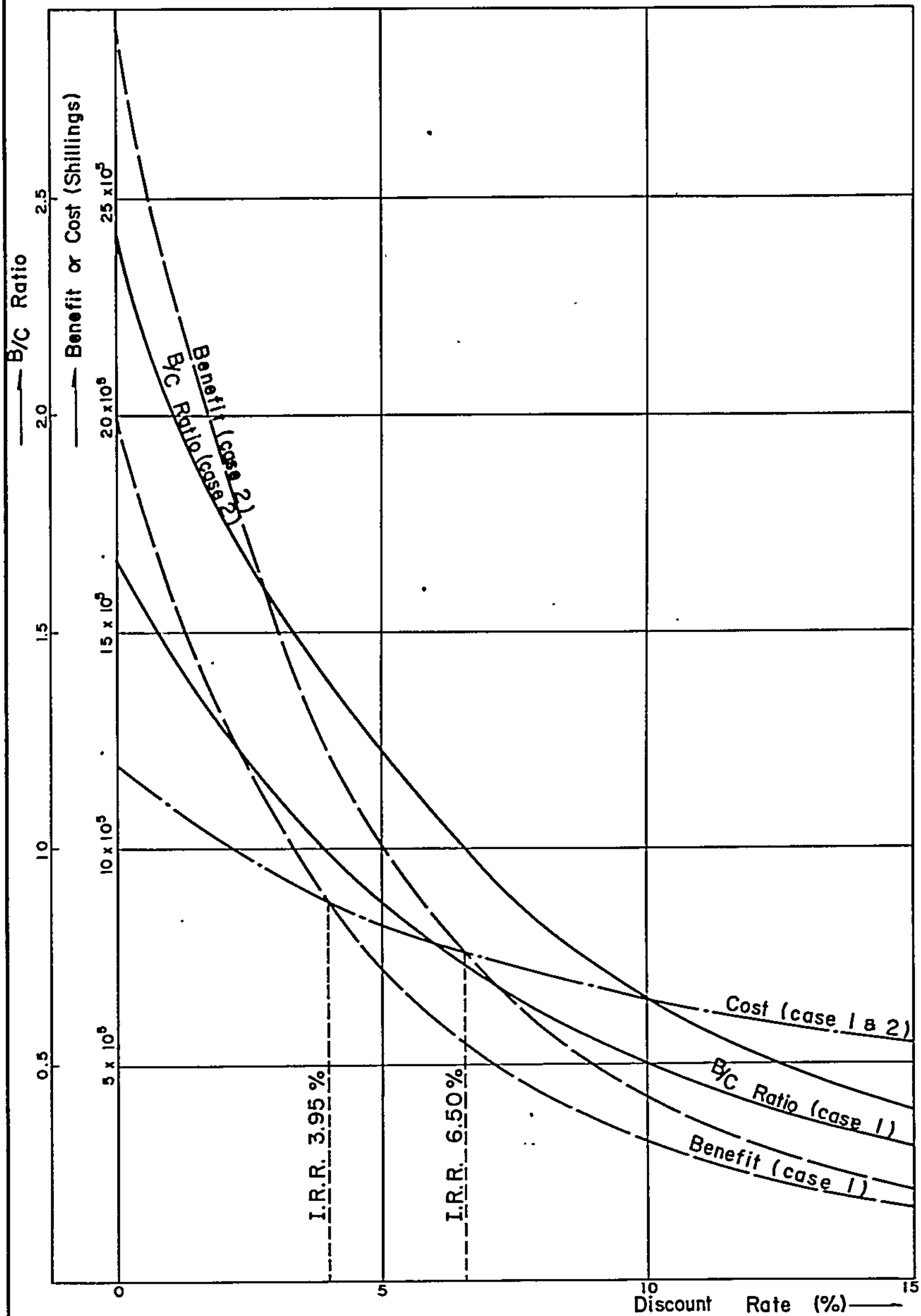


FIG. 5-14	SOUTHERN COASTAL LINK ROAD PROJECT
	RELATION BETWEEN B/C RATIO, COST, BENEFIT AND DISCOUNT RATE FOR PLAN. I. (Project Life : 30 years)

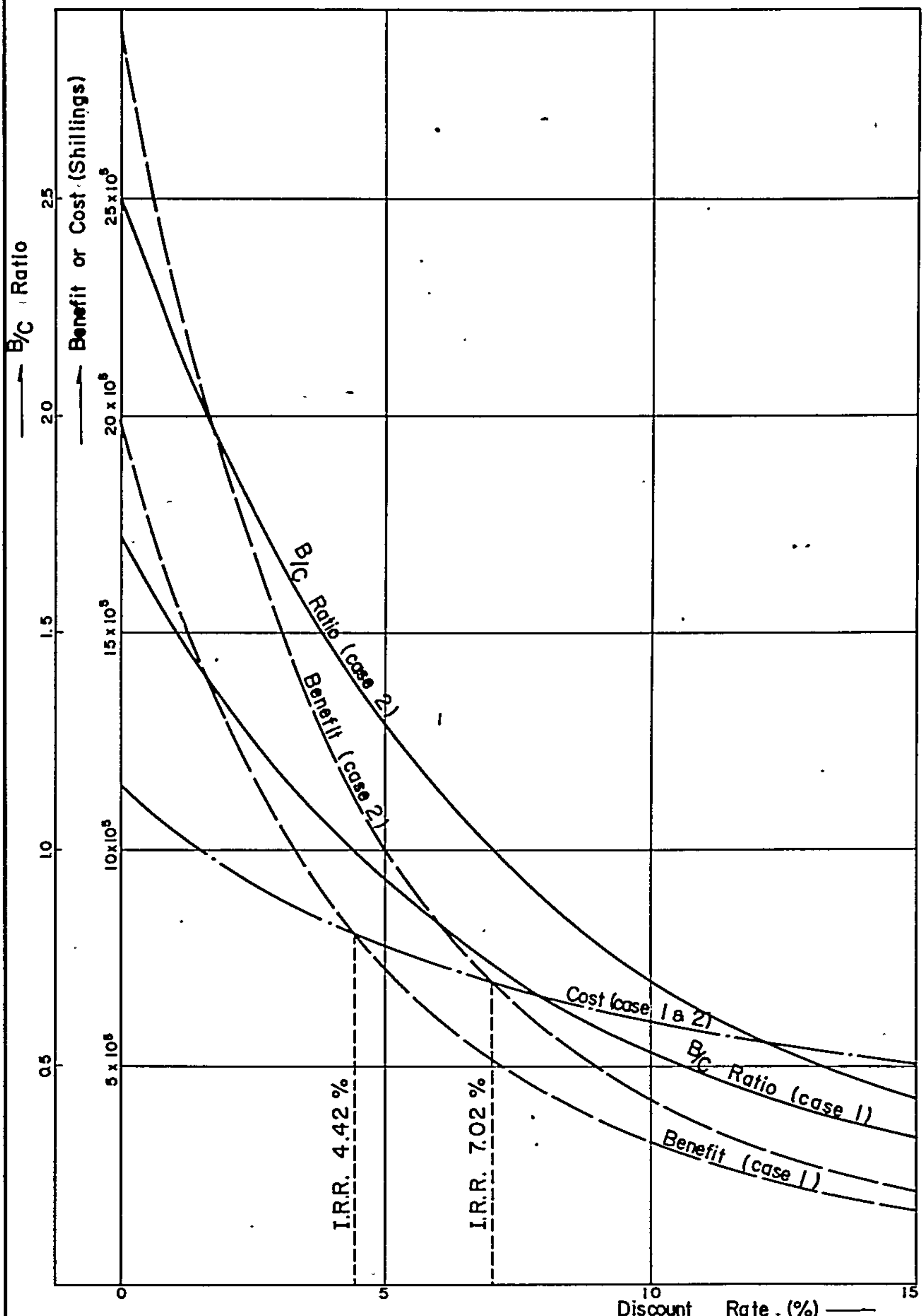


FIG. 5-15	SOUTHERN COASTAL LINK ROAD PROJECT
	RELATION BETWEEN B/C RATIO, COST, BENEFIT AND DISCOUNT RATE FOR PLAN 2 (Project Life : 30 years)

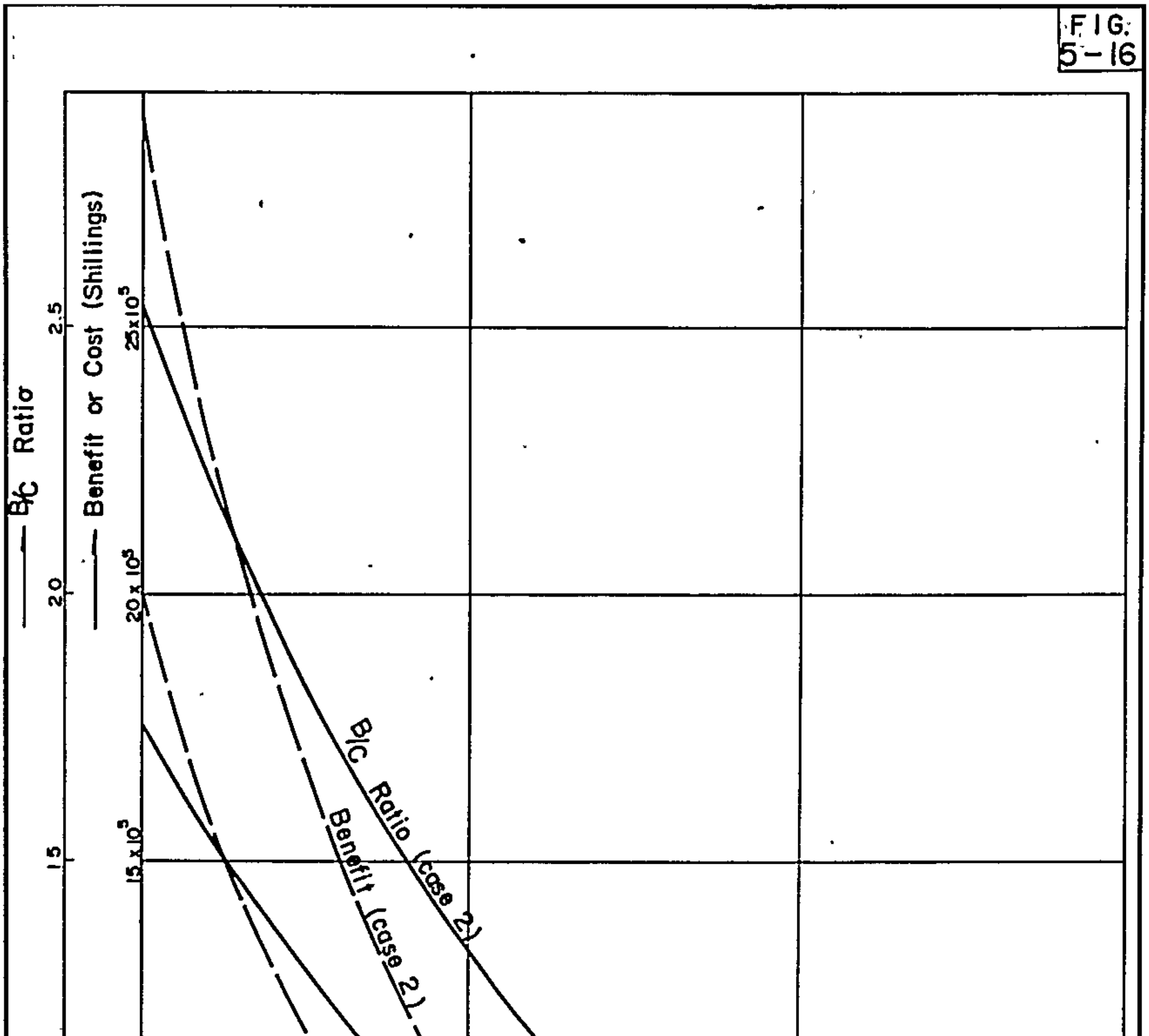


FIG. 5-16	SOUTHERN COASTAL LINK ROAD PROJECT
	RELATION BETWEEN B/C RATIO, COST, BENEFIT AND DISCOUNT RATE FOR PLAN 3 (Project Life : 30 years)

FIG. 5-17

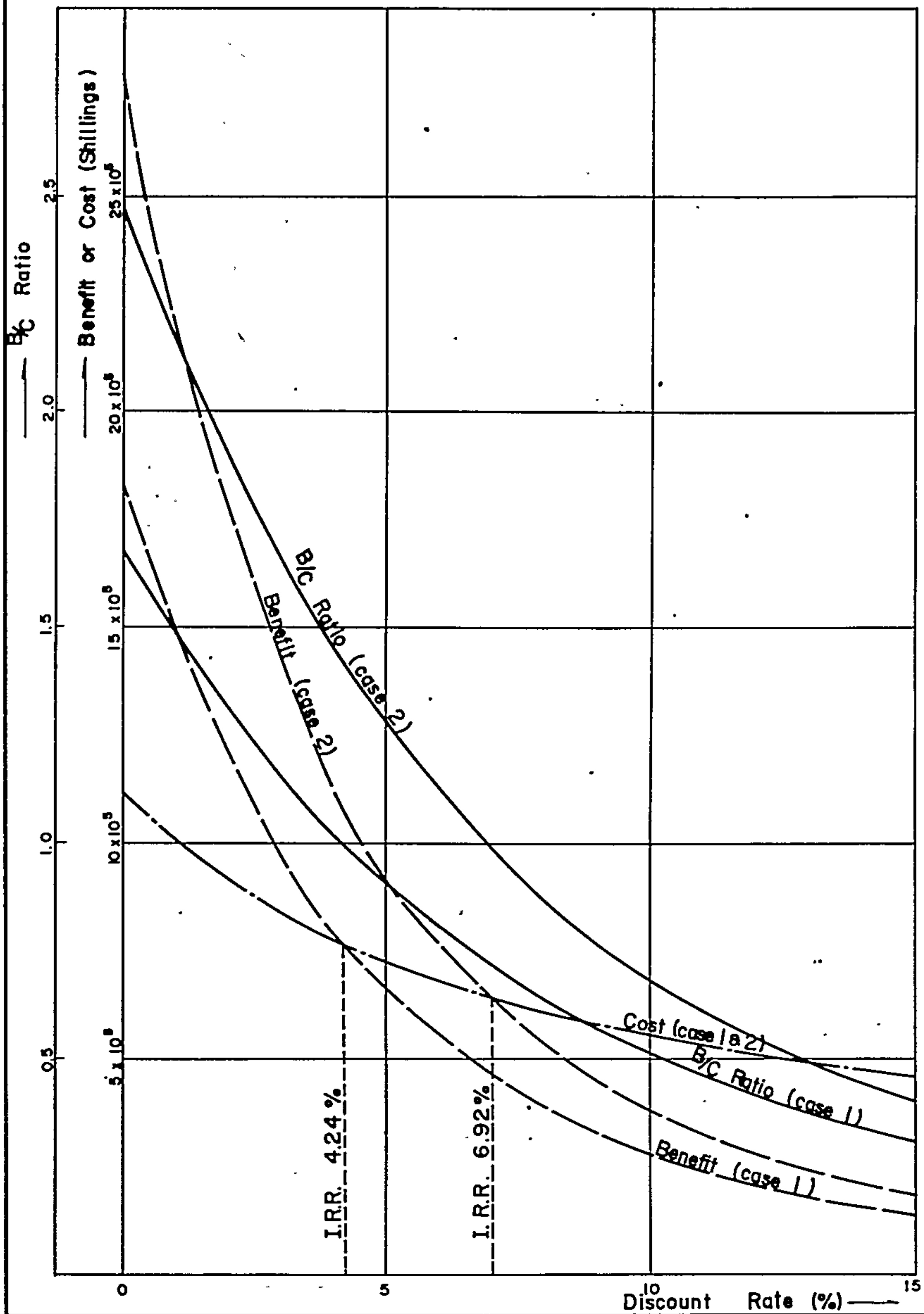


FIG.	SOUTHERN COASTAL LINK ROAD PROJECT
5-17	RELATION BETWEEN B/C RATIO, COST, BENEFIT AND DISCOUNT RATE FOR PLAN 4 (Project Life : 30 years)

CHAPTER VI CONCLUSIONS AND RECOMMENDATIONS

VI-1 Engineering Planning

1. In selecting Mohoro district bypass, a comparative study was made on another route which stretches straight from Nyamwage into the mountainous area and takes a shortcut through Mohoro to make a detour around the flood area. However, this alternative route was disregarded because of its high construction cost, and the originally selected route of which alignment was designed to make a minimum required detour around the flood area was adopted.

2. Kilwa Kivinje bypass runs through Kilwa Kivinje making a long detour of the existing road. In the alignment design, therefore, a route which takes a direct shortcut from the site of the former airport and descends along the hillside in the direction of Kilwa Masoko was selected.

3. On the basis of the data of soil investigation, soils distributed along the proposed route classified into Grades I to IV. Pavement structure and application of local soils to embankment were studied according to their classification.

4. No soils that can be used for base materials are available in the project area, and there is no choice but to use crushed stones or locally available good soils of Grade I or II after stabilization. For the subbase course construction, it was determined to use the said locally available good soils or the admixture of such soils and crushed stones after stabilizing them with asphalt. This determination was made to reduce the material cost and minimize the stripping between the subbase course and the surface course. For the southern half section proposed route, admixture of locally available good soil and crushed stones to be stabilized with asphalt is planned be used for base course.

5. For the road construction work, beside the original plan staged construction were considered such as to serve as one lane road at the first stage. However in studying the bridge construction work, its execution in stages was concluded to be undesirable for the following reasons and it was determined to design the cross-section for construction of a two-lane bridge.

   1) The stage construction of the bridge incurs a higher total cost than the construction of a complete two-lane bridge.

   2) The economic advantage of the stage construction is only slighly higher than the construction of a complete two-lane bridge.

   3) The stage construction not only invites structural complexity but also makes the execution of the second-stage work extremely difficult.

6. Bridges across the Matandu, the Mavuji and the Mbwemkuru were designed to be supported by steel piles having a length of 10 to 20m. It was concluded that piles longer than 20m would be required in some parts of the Mbwemkuru bridge site. Other smaller bridges were planned to be supported by steel piles ranging from several to 20m according to the soil condition.

VI-2 Evaluation of the Project

1. In the evaluation of this project, the following three alternate plans were made against an original plan in which all sections are constructed to complete with 2 lanes pavement from first stage.

   Notes : Plan 1 - Original plan, all sections are constructed as 2 lanes paved road to complete at first stage.

   Plan 2 - Only section 1, where the traffic volume is relatively high, is constructed to complete at first stage. Sections 2-5 are constructed by stage. (Only 1 lane for surface course and shoulder is by gravel pavment)

   Plan 3 - Section 1 is same as Plan 2. Sections 2-5 are constructed by stage and the shoulder is not being paved.

   Plan 4 - All sections are constructed by stage. (2 lanes road is of engineering gravel. Shoulder is by grass planting)

   However every bridges are constructed to complete with 2 lanes.

   The proposed road are divided into following five (5) construction sections.

Table 6-1 Division of Construction Sections

Section	Road Section
No.1 Section	Kibiti - Nyamwage
No.2 "	Nyamwage - Nangurukuru
No.3 "	Nangurukuru - Kiranjerange
No.4 "	Kiranjerange - Lindi
No.5 "	Nangurukuru - Kilwa Masoko

2. The internal rate of return of this project are, therefore, obtained as in the following table for each of above 4 alternate plans.

Table 6-2 <u>Internal Rate of Return by Plan, Case and Project Life</u>

I.R.R. / Plan	I.R.R. (30 Years)		I.R.R. (20 Years)	
	Annual Growth Rate of Traffic		Annual Growth Rate of Traffic	
	5% (Case 1)	7% (Case 2)	5% (Case 1)	7% (Case 2)
1	4.0	6.5	-	2.6
2	4.4	7.0	0.2	3.2
3	4.7	7.3	0.4	3.5
4	4.2	6.9	-	2.3

It is indicated that if the project life is taken for 30 years, the internal rate of return (I.R.R.) are within a range of 4.0 7.3%, whereas its upper limit goes down to 3.5% if the project life is taken for 20 years.

3. From above results, it is revealed that the most influencial factor that affect I.R.R. is wheather the project life is 20 or 30 years, followed by the fact that annual growth rate of traffic volume is wheather 7 or 5%. It is also obvious that difference between each plan is negligible.

4. If judged from the economic point of view alone, Plan 3 is most advantageous, followed by Plans 2,4 and 1, while an engineering study of Plan 3 discloses the facts that the wear of shoulders is liable to be accelerated as the vehicles are forced to run on shoulders when passing by each other and rainwater is prone to percolate through unpaved shoulders into the subbase course and subgrade.

   Since the difference in the internal rate of return between Plan 3 and Plan 2 is negligible, it is recommended that Plan 2 shall be adopted as the most optimal plan.

5. The internal rate of return of this project by respective section are obtained as in the following table indicating that the section 1 is considerably advantageous as compared with other section from the economic point of view as its I.R.R. exceeds 15%.

Table 6-3 Internal Rate of Return by Section

Section \ I.R.R.	I.R.R. (%)	
	Plan No.2	Plan No.3
1	15.4	15.5
2	6.0	6.2
3	1.8	2.0
4	2.2	2.6
5	2.5	2.8
Average	4.4	4.7

Notes: Above figures correspond to the case of annual growth rate of traffic volue : 5%

Project life : 30 years

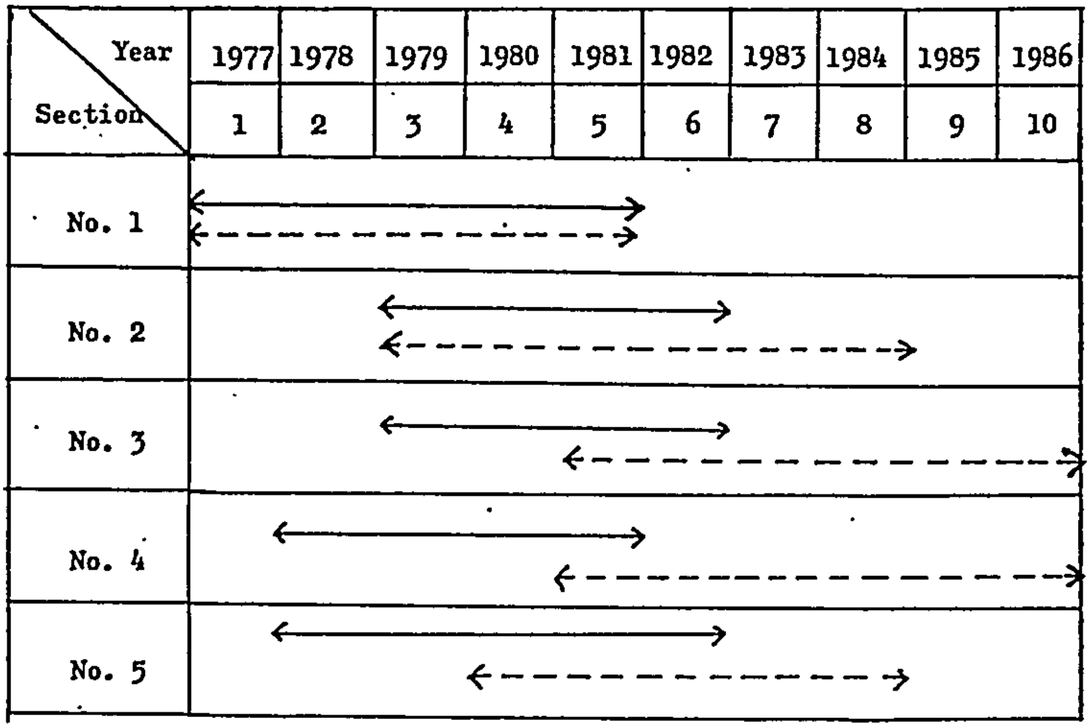
6. It is therefore desirable that the construction work shall be started in section 1. If consideration is given to the economic aspects alone, it is advisable to proceed from section 1 to section 2, 5, 4 and 3 in that order. From the engineering point of view, however, top priority should be given to section 1, followed by sections, 4, 5, 2 and 3.

   However, considering the convenience for lading sea-borne construction machinery to minimize the difficulty involved in the construction work, it is advisable to start working in port areas such as Lindi and Kilwa Masoko and proceed to inland areas.

   It is therefore recommended that the priority order of sections shall be determined from the engineering point of view.

7. For the plan No.2 which is considered most advantageous from the technical and economic view points, the study was made on the I.R.R. of alternative to this plan to put off the construction period, the result is that its I.R.R. can be raised up to 6.6%, i.e., approx. 50% up against the original plan of which I.R.R. is 4.4% by putting off the investment period for respective sections as shown below.

Fig. 6-1 Investment Program for Each Section



Notes: ←——→ Original Plan

←- - -→ Alternate Plan to put off construction period of plan No.2 in later year

Therefore this work schedule is worth valuable to be sufficiently studied as it can contribute to the overall increase of internal rate of return by proceeding the construction from the section of high I.R.R. while putting off the start of construction and extending the construction period without sticking to certain fixed schedule.

If the duration of the construction schedule is extended, a number of benefits can be expected such as the smoother procurement of equipment and materials, effective utilization of labour force, distribution and reduction of the initial capital input for construction machinery.

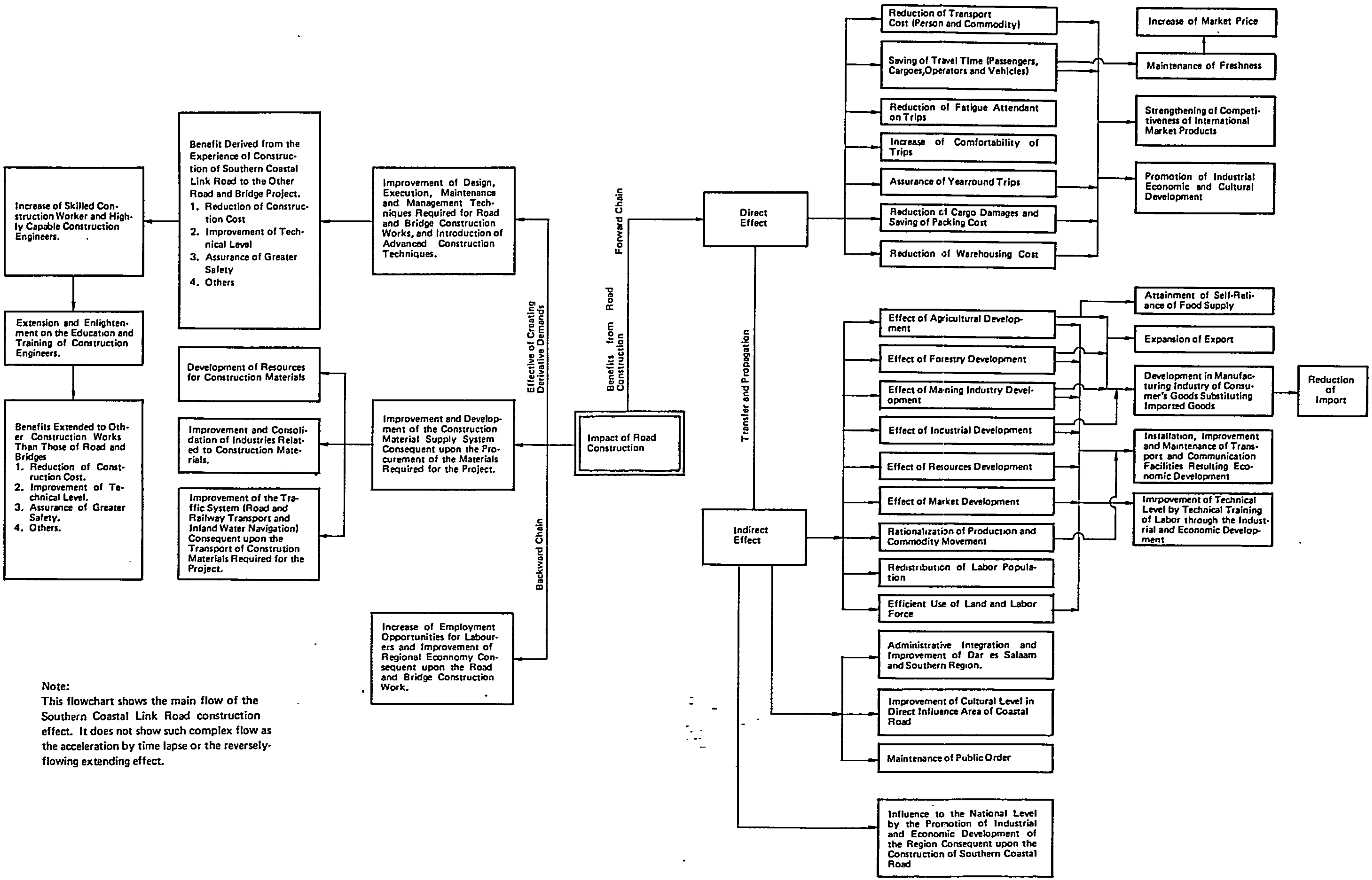
The construction cost attainable by extending the construction schedule was therefore calculated assuming that the construction cost would be reduced to about 95% of the initially estimated value.

8. The proposals made above are based chiefly on the economic evaluation in which direct benefits were subjected to an economic analysis as well as on the studies made from the engineering point of view.

As shown in Fig. 6-2, the project is expected to produce a diversity of other important and intangible effects, such as administrative integration and improvement of Dar es Salaam and southern regions, and promotion of regional, industrial and economic development.

It cannot therefore be justified to judge the validity of the project only on the basis of its economic evaluation. The significance of the project should be studied and grasped from a broad, comprehensive and long-range point of view.

Fig. 6-2 Impact Effect of Southern Coastal Link Road Project



Note:
This flowchart shows the main flow of the Southern Coastal Link Road construction effect. It does not show such complex flow as the acceleration by time lapse or the reversely-flowing extending effect.