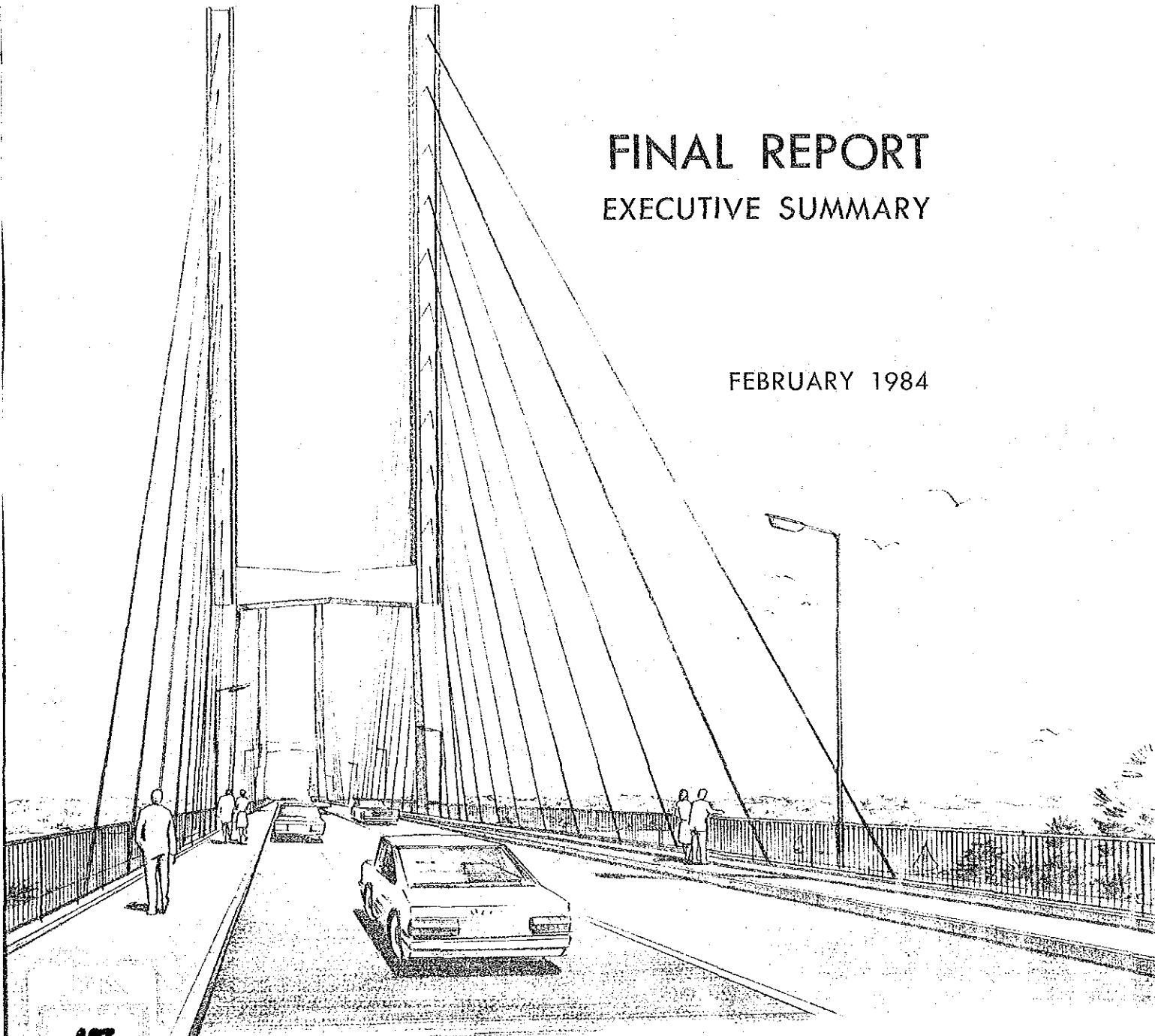


REPUBLIC OF KENYA
FEASIBILITY STUDY
ON
KILIFI BRIDGE CONSTRUCTION PROJECT

FINAL REPORT
EXECUTIVE SUMMARY

FEBRUARY 1984

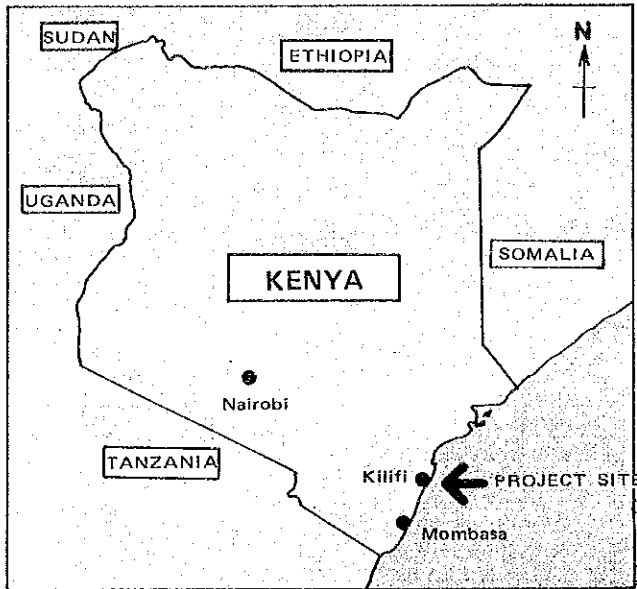


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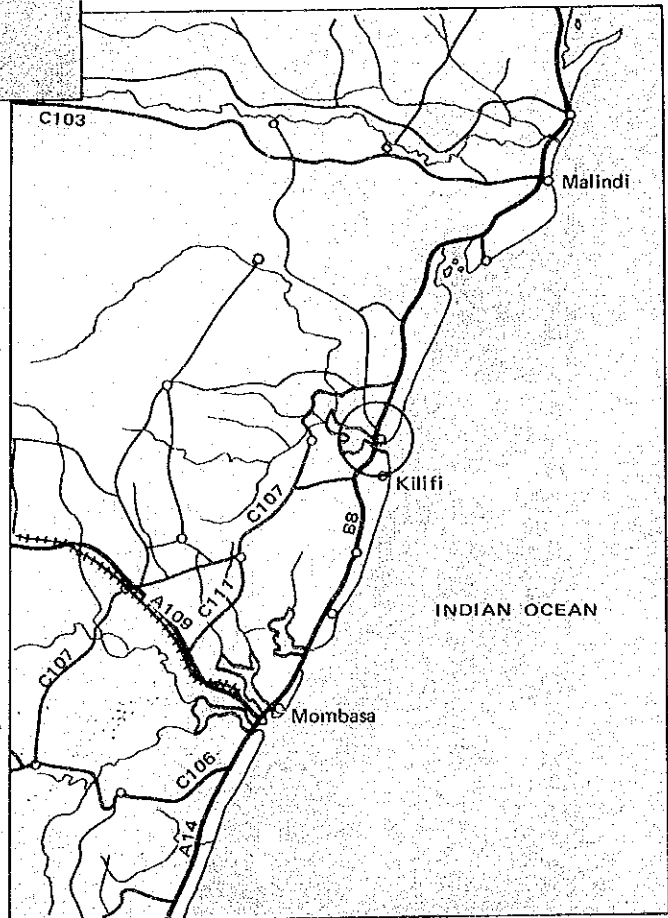
JAPAN INTERNATIONAL COOPERATION AGENCY

SDF
84-020 (1/3)

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PROJECT LOCATION MAP



CONTENTS

CONCLUSION

RECOMMENDATION

SUMMARY OF THE FEASIBILITY STUDY

1. Existing Condition of the Study Area	3
2. Future Traffic Volume	3
3. Alternative Route Study	5
4. Alternative Bridge Study	6
5. Preliminary Design of Road	6
6. Preliminary Design of Bridge	10
7. Project Cost Estimate	12
8. Economic Analysis	12
9. Financial Analysis and Implementation Schedule	13

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In response to the request of the Government of the Republic of Kenya, the Government of Japan decided to conduct a feasibility study on the Kilifi Bridge Construction Project in accordance with laws and regulations in force in Japan and Kenya. The Japan International Cooperation Agency responsible for the implementation of the technical cooperation programs of the Government of Japan, carried out the Study in close cooperation with the Ministry of Transport and Communications of the Republic of Kenya.

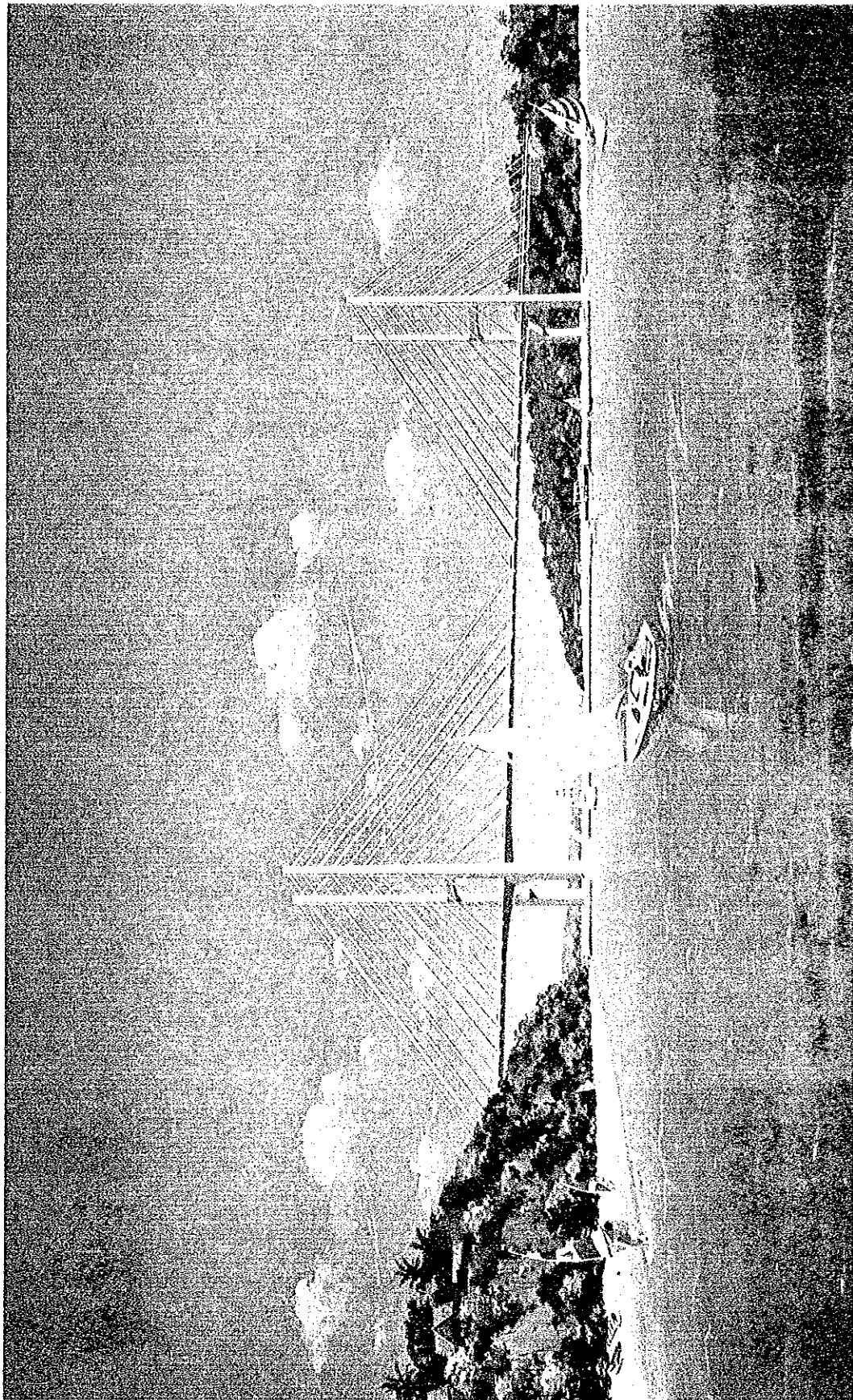
CONCLUSION

1. The result of the economic study shows that the Benefit Cost Ratio (B/C) is 1,088 and Economic Internal Rate of Return (EIRR) is 12.89%, hence this project can be considered as firmly profitable.
2. The project cost is estimated at 359,608,000 K.Shs. at 1983 prices. A major portion of which is for the construction of the bridge.
3. The selected crossing point of the bridge over the creek is at about 400 meters down stream from the existing ferry crossing (B-Route).
4. The selected bridge design is the cable stayed concrete girder type that has a total length of 420 meters and a central span of 250 meters.

RECOMMENDATION

1. This project is judged to be a very beneficial project from the Kenya national economy and social perspectives, its implementation at the earliest possible time is recommended.
2. Before the preparation of any detailed engineering design of the project, further investigation such as the topographic survey, the subsurface investigation, the material survey and the bathymetric survey should be carried out.
3. The technology for the construction of the cable stayed concrete bridge has made a remarkable progress in recent years. The proposed bridge in this study, having a central span of 250 meters would be one of the longest bridge of this kind in the world.

Therefore, it is desirable that the new construction technology and the valuable knowledge of the experts will be employed and reflected in the design and the construction of this bridge.



BIRD'S-EYE VIEW OF KILIFI BRIDGE

SUMMARY OF THE FEASIBILITY STUDY

1. Existing Condition of the Study Area

The east coast of Kenya especially the coastal line has a high potential for development. The historical, meteorological, socio-economic and environmental conditions of this area are very promising. The B-8 road on which the Kilifi Bridge will be constructed and which passes through this high potential area is therefore a very important link in the transportation network of the area.

The crossing on the Kilifi creek is operated by selfpropelled pontoon ferries whose load capacity restrictions prohibit heavy trucks which are over 15 ton load. The crossing has for a long time been a major bottleneck on this important road and subsequently a constraint to development along the B-8 road. Taking into account the high development potential area and the problems of the crossing of the Kilifi creek, the Kilifi Bridge is required to be constructed as soon as possible. The construction of this bridge will mean that the traffic flow and the activities along the B-8 road will be supported.

The study area consists of the Kilifi side and Mnarani side with the Kilifi creek inbetween. The population of Kilifi township and Mnarani is about 42,600 and 626 respectively (1979 population census). The commercial area is located along the D551 road and some parts of the E921 road. Along the seashore of the Kilifi creek, housing area and government utility are located on the Kilifi townside. Residential areas are located on both sides of the creek with their adjacent areas and the hinderland as open spaces left for crop and livestock farming. The existing situations of the study area are shown in the photo 1 to photo 8.

2. Future Traffic Volume

The results of forecast of the future traffic volume are shown in Table 1. The number of the total vehicles in above mentioned Table is including normal and induced traffic volume. Annual growth rates are 5.1 percent, 5.3 percent and 5.2 percent during the periods of 1983 to 1990, 1990 to 2000 and 2000 to 2010 respectively.

Table 1 ESTIMATED FUTURE TRAFFIC VOLUME BY YEAR AND BY PURPOSE

Year	PURPOSE						Total Vehicles
	Going to work	Business	Going Home	Tourism	Personal	Others	
1983	156 (15.9)	665 (67.7)	46 (4.7)	94 (9.6)	11 (1.1)	11 (1.1)	983 (100.0)
1990	279 (15.4)	1,194 (65.8)	82 (4.5)	216 (11.9)	22 (1.2)	21 (1.1)	1,814 (100.0)
2000	448 (14.8)	1,901 (62.6)	122 (4.0)	489 (16.1)	39 (1.3)	38 (1.2)	3,037 (100.0)
2010	700 (13.9)	2,930 (58.2)	178 (3.5)	1,105 (21.9)	64 (1.3)	62 (1.2)	5,038 (100.0)



Photo 1

The existing B-B road near the ferry terminal at Kilifi side. The width of the pavement is about 6.0 meters and a 1.5 meters soft shoulder is provided on both sides of the road.



Photo 5

Main street of the Kilifi township. Both the commercial and residential areas are located along this road.



Photo 2

The existing B-B road at the Manarani side. The horizontal alignment is almost in a straight line and the widths of the pavement and shoulders are 6.0 meters and 1.5 to 2.0 meters respectively.



Photo 6

The existing E921 road. The widths of the pavement and pedestrian way are about 6.0 meters and 1.5 meters respectively.

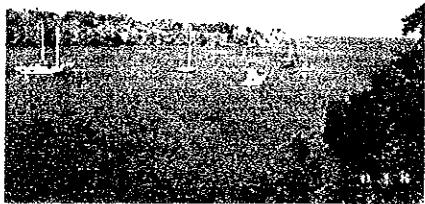


Photo 3

General view of the Kilifi creek crossings. A view towards the Kilifi side.



Photo 7

Residential areas in the Kilifi township. The proposed road is to avoid disrupting such established settlement.



Photo 4

General view of the Kilifi creek crossing. This photograph is taken from the proposed bridge construction site in Kilifi to the Mnarani Club.



Photo 8

The town center at the Mnarani side. There are some residences in this area. The proposed road project is to preserve such areas.

3. Alternative Route Study

Taking into account the accurate reconnaissance survey, the basic considerations of the route location, the site conditions, three alternative routes; route A, route B and route C are proposed as shown in Fig. 1.

Judging from the economic, technical and environmental aspects, the alternative route B is the most superior plan. With this, the alternative route B is selected.

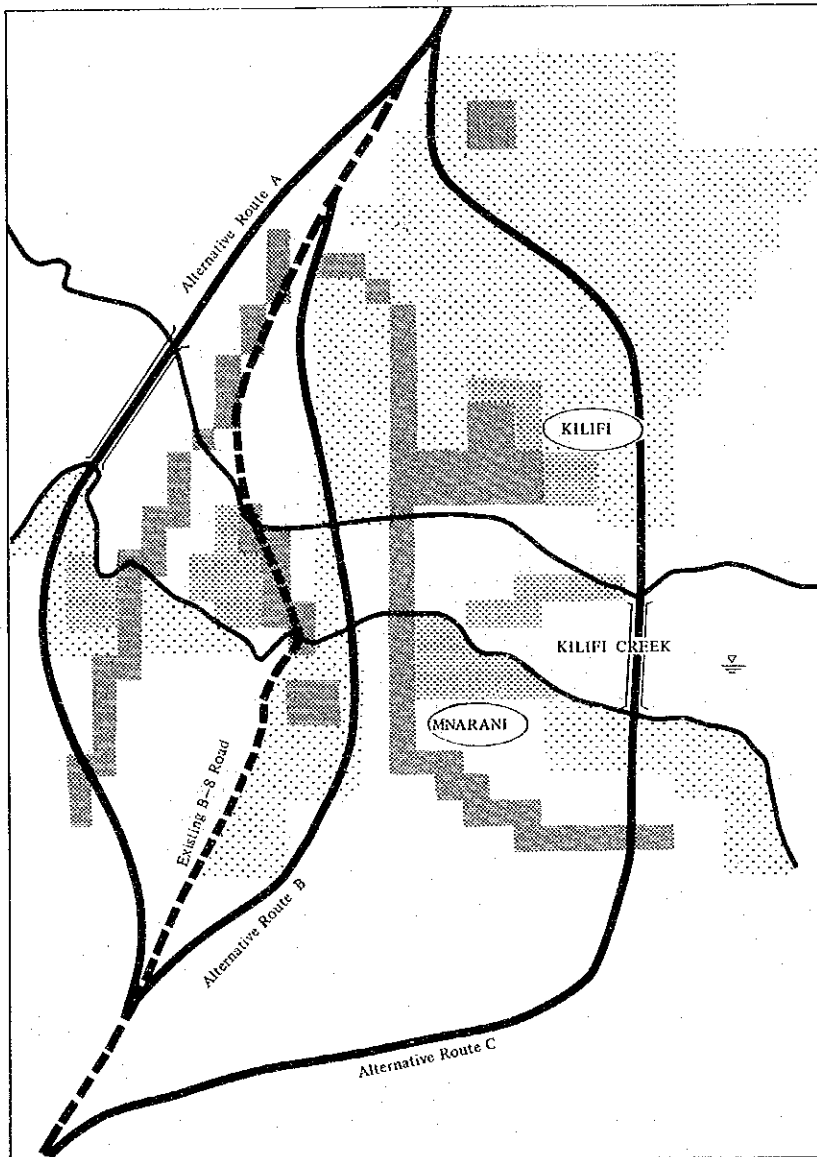


Fig. 1 LOCATION OF PROPOSED ALTERNATIVE ROUTES

4. Alternative Bridge Study

The alternative bridge study is carried out on the base of the topographic survey, subsurface investigation, bathymetric survey and sufficient reconnaissance survey. Five alternative plans are proposed as shown in Table 2.

A total bridge length of 420 meters is selected and design for the positioning of bridge piers is much dependent on the Kilifi creek condition.

The cable-stayed concrete girder bridge with a central span of 250 meters in length Alternative (3) is selected for this feasibility study.

The reasons are as follows:

- (a) The construction costs of Alternative (3) is the minimum as shown in the alternative construction cost analysis.
- (b) The construction workability of foundation for Alternative (3) is superior to the others due to its location at shallower water.
- (c) Alternative (3) has a wide under-clearance, with ample rooms for the passage of ships both recreational and commercial. Moreover, the profile of this alternative is also compatible to the surrounding natural features.

5. Preliminary Design of Road

Based on the design criteria, the result of the various field surveys that include sounding survey, topographic survey and subsurface investigation and sufficient reconnaissance survey, the preliminary road engineering is carried out.

Total road length including the bridge is 4,116 meters and the alignment and typical cross-section of the road are illustrated in Fig. 2 and Fig. 3.

Table 2 ALTERNATIVE BRIDGE PLAN

	Profile of Bridge (Unit: m)	Bridge Cost 1,000 K.shs.
Alternative (1)	<p>(Cable Stayed Steel Girder)</p>	296,889
Alternative (2)	<p>(Steel Truss)</p>	282,292
Alternative (3)	<p>(Cable Stayed Steel Girder)</p>	264,164 (265,653)*
Alternative (4)	<p>(Concrete Girder with one Hinge)</p>	283,877
Alternative (5)	<p>(Concrete Girder with Three Hinges)</p>	274,697

()* Result of the preliminary bridge design.

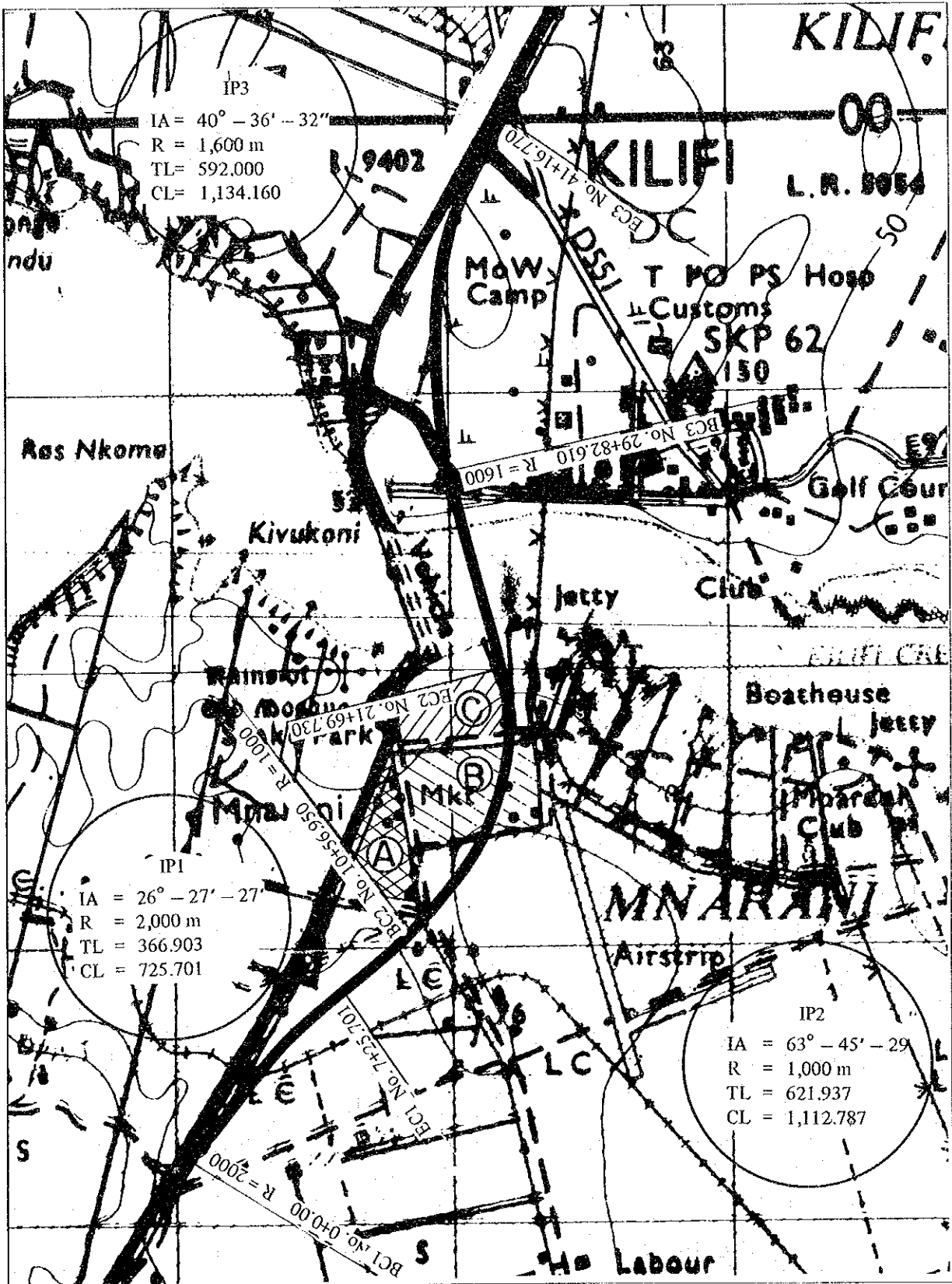


Fig. 2 HORIZONTAL ALIGNMENT PLAN

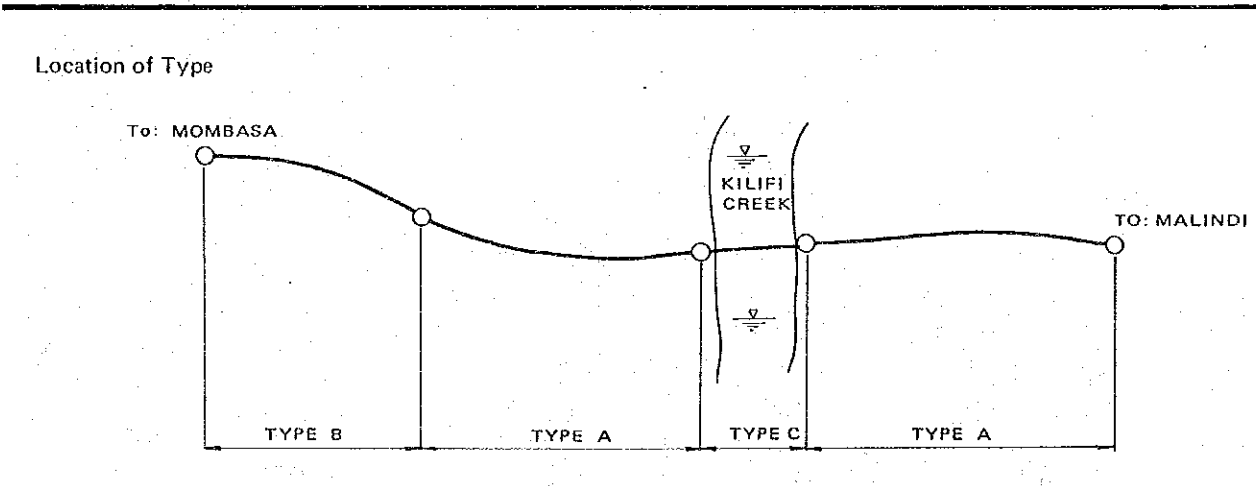
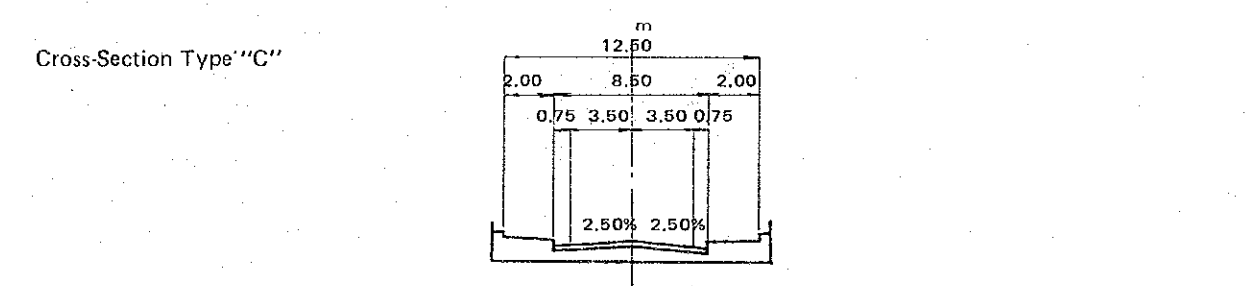
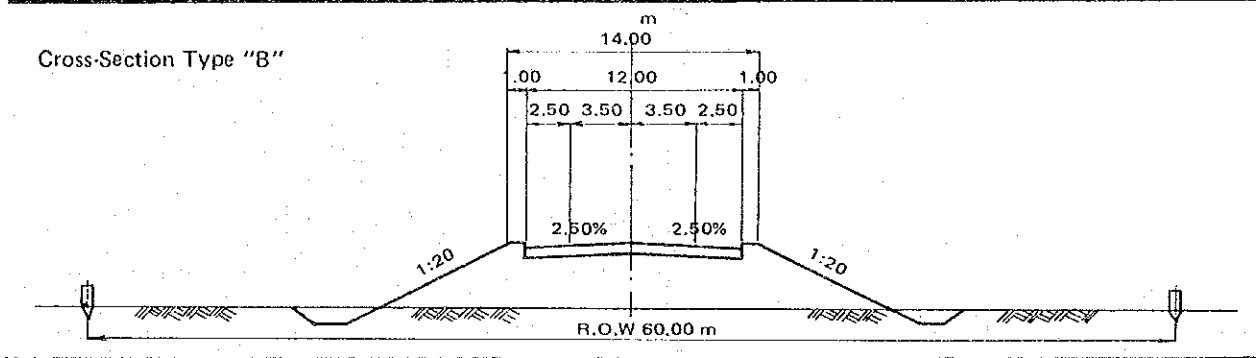
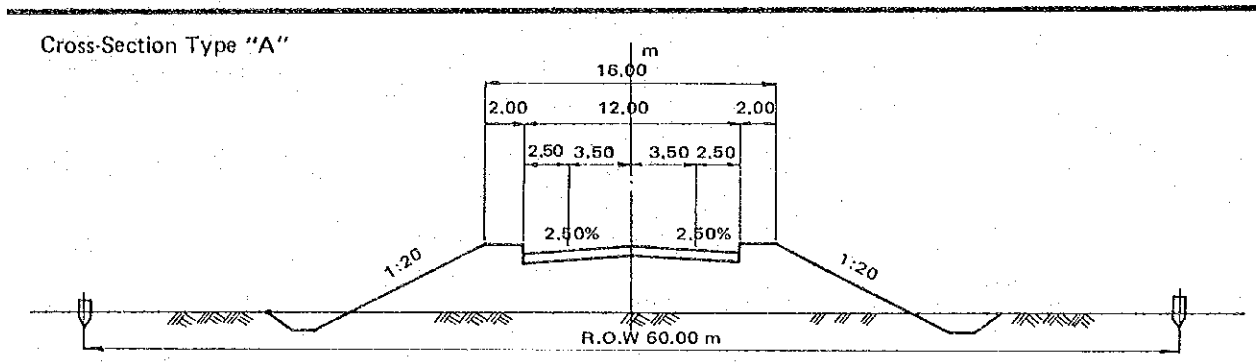


Fig. 3 CROSS-SECTION OF ROAD

6. Preliminary Design of Bridge

The preliminary design of bridge is carried out on the design of the cable stayed prestressed concrete girder bridge with a central span of 250 meters and a total bridge length of 420 meters which is proposed as the result of the alternative bridge study. General view of the bridge is illustrated in Fig. 4.

(a) Cables

The spiral wire strand is adopted for the stayed cable considering that this must be a popular one though it must be protected completely against corrosion.

Each strand has a diameter of 15.2 millimeters and is composed of wires each with a diameter of 5 millimeters. Each cable is in turn composed of 19 to 37 strands in demand to the design tensile strength.

(b) Main Girder

The main girder has a mono-box configuration and the web of the box form an angle of 27° with the vertical (pitch 1 : 2) in due consideration of the aerodynamic stability.

The depth of the main girder is 2.40 meters except a portion near the tower where the main girder has a greater depth of 3.70 meters to sustain the greater bending moment.

(c) Tower

The tower which is made of reinforced concrete has two pillars corresponding to the cables of double planes. The bottom part the pillar is connected directly with the footing on the foundation piles.

Two pillars are connected with thick beam which supports the main girder and strut which against such horizontal thrust as wind force, and make up a rigid frame.

Each foundation of tower consists of cast-in-place concrete piles with a diameter of 2.0 meters. The minimum penetration depth below the seabed is 25 meters.

(d) Abutment

The stiff coral limestone which is expected to be the bedrock is encountered within 3 meters to 5 meters deep below the ground surface.

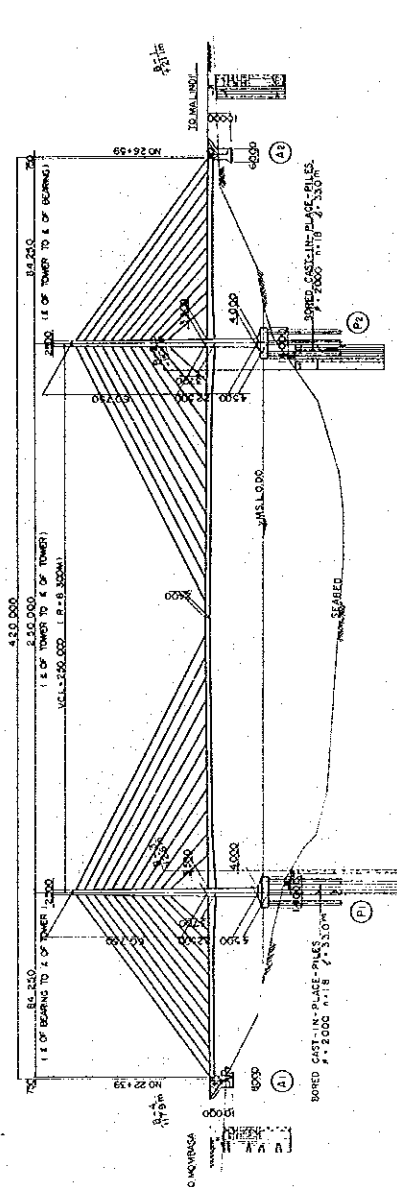
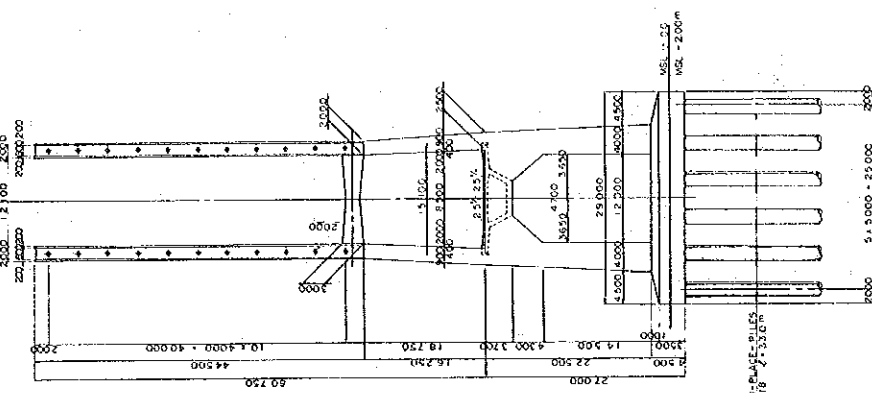
The foundation of the abutment shall be the spread footing type that is to rest on this coral limestone layer.

The negative force of 25 tons to 429 tons works from the superstructure to the abutment. In order to use the abutment as a counter weight, the main girder of superstructure is anchored to the abutment by P.C. strands.

**GENERAL VIEW OF KILIFI BRIDGE
CABLE STAYED CONCRETE GIRDER BRIDGE**

ELEVATION SCALE * 1 : 1000

CROSS SECTION SCALE * 1 : 300



PROPOSED ROAD	EXISTING ROAD	ACCUMULATE DISTANCE	STATION	GRADE	HORIZONTAL CURVE
25.050	25.050	0.00	167	276.0	4.50
25.950	25.950	10.00	168	230.0	0.00
26.085	26.085	20.00	169	230.0	0.00
26.514	26.514	30.00	170	230.0	0.00
26.614	26.614	40.00	171	249.0	0.00
27.283	27.283	50.00	172	249.0	0.00
27.574	27.574	60.00	173	249.0	0.00
28.200	28.200	70.00	174	249.0	0.00
28.250	28.250	80.00	175	249.0	0.00
28.250	28.250	90.00	176	249.0	0.00
28.250	28.250	100.00	177	249.0	0.00
28.523	28.523	110.00	178	230.0	0.00
28.614	28.614	120.00	179	230.0	0.00
28.614	28.614	130.00	180	230.0	0.00
28.614	28.614	140.00	181	230.0	0.00
28.614	28.614	150.00	182	230.0	0.00
28.614	28.614	160.00	183	230.0	0.00
28.614	28.614	170.00	184	230.0	0.00
28.614	28.614	180.00	185	230.0	0.00
28.614	28.614	190.00	186	230.0	0.00
28.614	28.614	200.00	187	230.0	0.00
28.614	28.614	210.00	188	230.0	0.00
28.614	28.614	220.00	189	230.0	0.00
28.614	28.614	230.00	190	230.0	0.00
28.614	28.614	240.00	191	230.0	0.00
28.614	28.614	250.00	192	230.0	0.00
28.614	28.614	260.00	193	230.0	0.00
28.614	28.614	270.00	194	230.0	0.00
28.614	28.614	280.00	195	230.0	0.00
28.614	28.614	290.00	196	230.0	0.00
28.614	28.614	300.00	197	230.0	0.00
28.614	28.614	310.00	198	230.0	0.00
28.614	28.614	320.00	199	230.0	0.00
28.614	28.614	330.00	200	230.0	0.00
28.614	28.614	340.00	201	230.0	0.00
28.614	28.614	350.00	202	230.0	0.00
28.614	28.614	360.00	203	230.0	0.00
28.614	28.614	370.00	204	230.0	0.00
28.614	28.614	380.00	205	230.0	0.00
28.614	28.614	390.00	206	230.0	0.00
28.614	28.614	400.00	207	230.0	0.00
28.614	28.614	410.00	208	230.0	0.00
28.614	28.614	420.00	209	230.0	0.00
28.614	28.614	430.00	210	230.0	0.00
28.614	28.614	440.00	211	230.0	0.00
28.614	28.614	450.00	212	230.0	0.00
28.614	28.614	460.00	213	230.0	0.00
28.614	28.614	470.00	214	230.0	0.00
28.614	28.614	480.00	215	230.0	0.00
28.614	28.614	490.00	216	230.0	0.00
28.614	28.614	500.00	217	230.0	0.00
28.614	28.614	510.00	218	230.0	0.00
28.614	28.614	520.00	219	230.0	0.00
28.614	28.614	530.00	220	230.0	0.00
28.614	28.614	540.00	221	230.0	0.00
28.614	28.614	550.00	222	230.0	0.00

PLAN SCALE * 1 : 1000

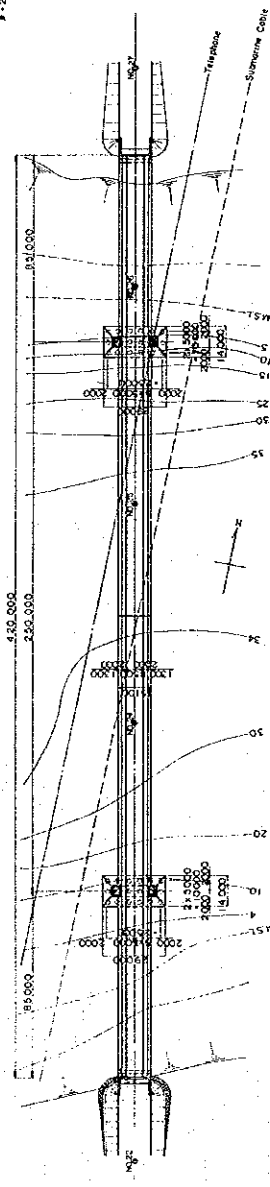


Fig. 4 GENERAL VIEW OF KILIFI BRIDGE
(CABLE STAYED PRESTRESSED CONCRETE GIRDER BRIDGE)

7. Project Cost Estimate

- (a) The project costs consists of the construction cost, engineering fee, land acquisition, compensation and contingency.
- (b) Based on the preliminary engineering study, the quantities for main work items are calculated. Subsequently, the unit cost by main work items are analysed from the aspects of material cost, labour cost, construction equipment, etc. taking also into consideration the local condition in Kenya.
- (c) The project costs are split into two components, that is foreign currency and local currency.
- (d) The Project costs are calculated in 1983 prices.

The project costs are shown in Table 3.

Table 3 PROJECT COST

(Unit: 1,000 K.Shs.)

Item	Currency		
	F.C.	L.C.	T.C.
Bridge	219,582	46,071	265,653
Approach Road	13,618	10,849	24,467
Construction Cost	233,200	56,920	290,120
Engineering Fee	27,851	6,963	34,814
Land Aquisition	—	1,612	1,612
Compensation	—	370	370
Sub-Total	261,051	65,865	326,916
Contingency	26,105	6,587	32,692
Total	287,156	72,452	359,608

- Note: 1) The project cost is expressed in July 1983 prices.
 2) The price contingency is not considered.

8. Economic Analysis

On the basis of the future traffic volume, traffic cost and economic cost, the following results of the economic analysis are arrived.

(a) Net Present Values*

Economic cost	200,331,000 K.shs
Economic benefit	217,882,000 K.shs

Note *: in 1983
 Annual discount rate 12%

(b) Benefit Cost Ratio (B/C) 1,088

(c) Economic Internal Rate of Return (EIRR) 12.89%

9. Financial Analysis and Implementation Schedule

(a) Implementation Schedule

Judging from the scale of the project and the construction method, the implementation schedule is arrived as shown in Table 4.

Table 4 IMPLEMENTATION SCHEDULE

Working Item		1984	1985	1986	1987	1988	1989
Engineering and Evaluation			■				
Land Acquisition and Compensation				■			
Temporary & Other Works				■		■	■
Bridge	Foundations	P ₁			■		
		P ₂			■		
	Abutments	A ₁			■		
		A ₂				■	
	Towers	P ₁				■	
		P ₂					■
	Superstructure					■	■
	Surface and Facilities						
Roads	Approach Roads				■		■
	Access Roads						■

(b) Investment Requirement

Based on the implementation schedule and financial analysis, the investment requirement on each year is estimated as shown in Table 5.

Table 5 INVESTMENT REQUIREMENT

(Unit: 1,000 K.shs, Current Price)

Year	Foreign Currency	Local Currency	Total
1984	5,642	1,424	7,066
1985	12,470	3,405	15,875
1986	54,209	16,240	70,449
1987	102,273	37,644	139,917
1988	162,784	44,305	207,089
1989	116,889	45,991	162,880
Total	454,267	149,009	603,276

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