BASIC DESIGN STUDY REPORT

ON

THE MOROGORO ROAD IMPROVEMENT PROJECT

IN

THE UNITED REPUBLIC OF TANZANIA

APRIL, 1984

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to the request of the Government of the United Republic of Tanzania,the Government of Japan decided to conduct Basic Design Study on The Morogoro Road Improvement Project and entrusted the study to the Japan International Cooperation Agency. The JICA sent to Tanzania a study team headed by Mr. Yukitake Shioi, Tohoku Regional Construction Bureau, Ministry of Construction from January 30 to February 20, 1984.

The team had discussions with the officials concerned of the Government of Tanzania and conducted a field survey. After the team returned to Japan, further studies were made and the present report has been prepared.

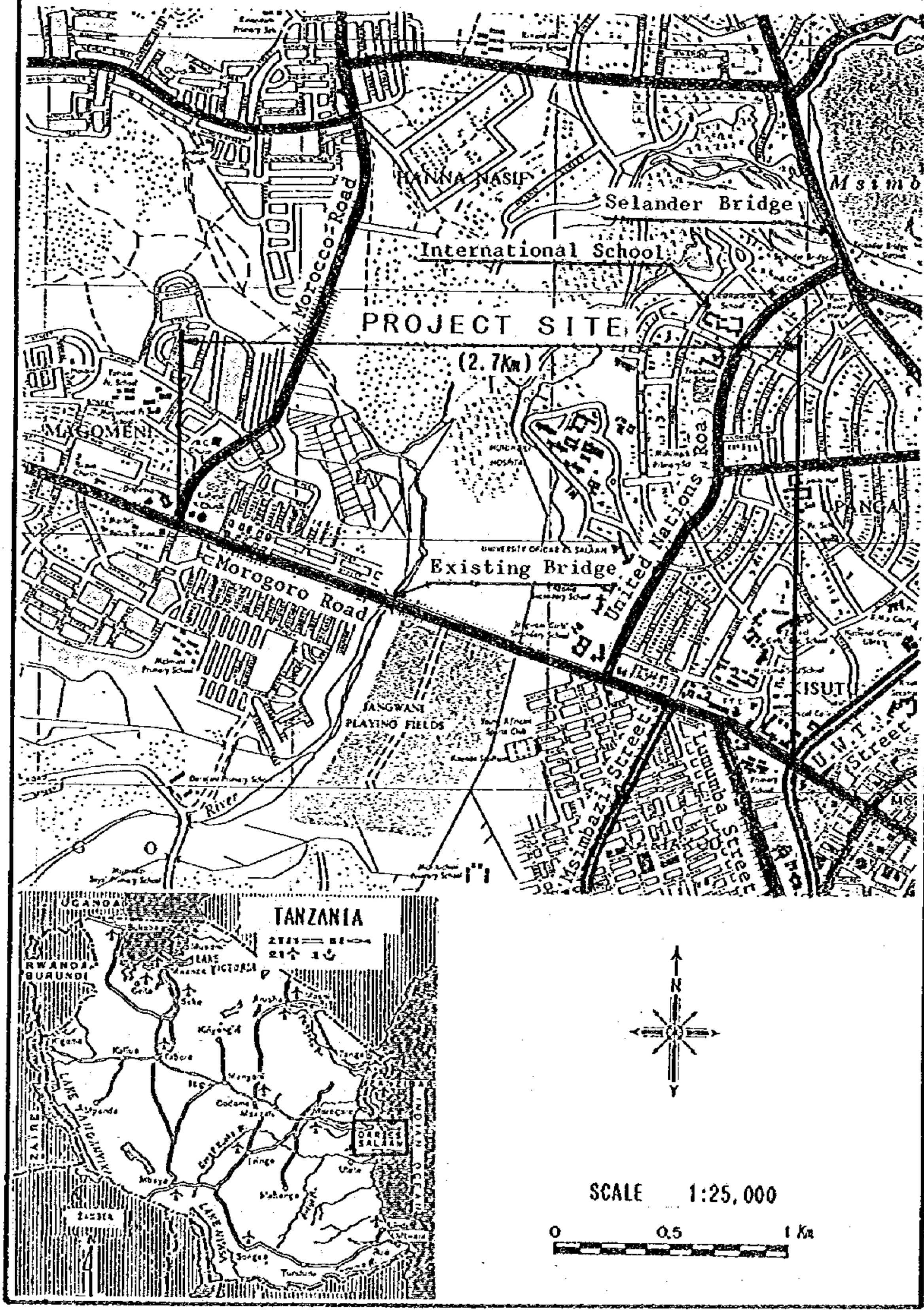
I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Government of the United Republic of Tanzania for their close cooperation extended to the team.

April, 1984

Keisuke Arita
President
Japan International Cooperation Agency

LOCATION MAP



SUMMARY

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In response to the request by the Government of the United Republic of Tanzania for assistance in improving the Morogoro Road at Dar es Salaam, the Government of Japan has sent through the Japan International Cooperation Agency (JICA) a study team headed by Mr. Yukitake SHIOI, Inspector for Environment, Tohoku Regional Construction Bureau, Ministry of Construction, to conduct the Basic Design Study on the Morogoro Road Improvement Project from 30th of January to 20th of February, 1984. This report summarizes the results of the investigation, including later study and analyses of the data that were obtained therefrom.

In the United Republic, though the national road network system is yet to be completed or the sufficient maintenance on the existing roads have not been done due to various difficulties, such as the rapid population concentration in the metropolis recently, with an increase ratio of 8% per annum, while the nationwide increase of population being 3% approximately. And especially along the Morogoro Road in question, there have been many houses, offices and factories built there, so that there was a remarkable increase in traffic volume, 14,000 vehicles/12 hrs. as of March, 1982, while usual capacity limit for a two lane dual carriageway road is said to be 10,000 vehicles/day. Therefore, traffic congestion is a matter of usual occurrence, causing a lot of trouble to the commuters everyday. In addition, there are shut-downs in the traffic in the Road due to flooding of the Msimbazi Creek in the rainy season, across which the Morogoro Road can only go into the metropolis. Therefore, the function of the metropolis itself is being much affected under such unfavourable conditions of the Road.

In order to solve such unfavourable conditions in the existing road, following three items of works are the main contents of the Projects.

(i) In the 2.7 km stretch of the Morogoro Road, wherein the present Improvement Works are proposed, the existing 2 lane dual carriageway road shall be widened to 4 lane dual carriageway road, with the 5 junctions with other roads contained therein are also to be improved, including channelization and traffic

signals, if required. By these arrangements, the capacity of the Morogoro Road will be much increased, thereby dissolving the traffic congestion, that has been suffered by the citizens so far.

(2) At the same time, in the portion of the Road that crosses the Msimbazi Creek, 3.0 m of raise in the roadway surface is to be conducted, thereby enabling it to have a flood of 300 m^3/sec approximately, once in every 10 years magnitude, can flow down the Creek with about 1 m of free board left, without any danger to the public traffic at all.

(3) In order to have the flood discharge as quickly and smoothly as possible, bridges (2 places, 4 nos., one separate bridge for each direction of traffic) and a box culvert (1 number, 6 spans of 3.7 m internal width, each) is to be constructed by reinforced concrete.

Outline of the construction works is as follows:

Total Length of the Widening (including 5 junctions)			2,730 m
Total Width (after widening)			24.0 m
Median Strip		3.0 m	
Carriageway	4 @ 3.25 m	= 13.0 m	
Shoulders	2 @ 0.50 m	= 1.0 m	
Bicycle Lanes	2 @ 1.25 m	= 2.5 m	
Walkway	2 @ 2.25 m	= 4.5 m	

In the embankment section, however, additional protective shoulder of 0.50 m, each, are to be provided outside of the walkways, so that total width is 25.0 m

Embankment Height	EL. +6.70 m (about 3.0 m above the existing Road.)

Bridges & Box Culvert

No.1 Bridge (right bank side)	Bridge Length, 17.9m, two nos., span 17.2 m, Total Width 11.75m, R.C. T-shaped girder, Foundation, steel pipe pile, ∅500mm, 50@12m.
Box Culvert (central portion, Jangwani playing field)	Total Length, 25.42m, Internal Dimension, B=3.70m, H=3.0m, 2x3 spans, Length along the water flow, 25.0m, Reinforced concrete structure.
No.2 Bridge, (left bank side, removing the existing one.)	Bridge Length, 47.0m, two nos., span 3@15.4m, Total Width 11.75m, R.C. Hollow Slab Bridge, Foundation ∅500mm, 40@18.0m & 32@15.0m.

Appurtenant Works

Raising the Electric Supply Lines;

3.5m of raising, 11 kV & 33 kV lines, 1 set each, length 100m, with new towers (2 nos.) erected.

International Telephone Cables;
(Replacement and new cables erected)

4 nos., 1,300m of length each, approximately.

Main Water Supply Pipe;
(Replacement and new pipe laying)

450mm∅, length 850m, 1 no.

The construction schedule is programmed so as to minimize the effect of the construction work on public traffic passing through the site, by switching the passage of public traffic, stage by stage.

23 months of construction period is deemed to be suitable and appropriate, after studying contents of the works, respectively.

The local portion of the construction cost is estimated to be TSh 12.5 million approximately, mostly of which is consumed for purchasing local materials (stones, aggregates & wooden materisls) in addition to local labour cost.

However, in view of very tight economic situation prevailing in Tanzania, it would be the matter of the supreme importance that the Tanzanian Government will allocate necessary quantity of fuel (diesel oil and petrol) to the contractor, under any conditions.

After completion, for purpose of maintenance, control and management, more than ¥1,000,000 might be required annually, but this expenditure is to be borne by the Ministry of Works of Tanzanian Government.

Due to implementation of the Project, smoother traffic flow in the Morogoro Road than ever could be anticipated, thereby even other traffic in the metropolis improved, so that, by the Project Implementation, an overall favourable effects upon the social and economic situation in Tanzania can be expected.

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CHAPTER 1

THE STUDY

CHAPTER 1 THE STUDY

The Morogoro Road in the United Republic of Tanzania, being not only the almost single trunk road that links most of the principal cities in the country with Dar Es Salaam, her Metropolis, but it also maintains its vital importance as one of the important urban trunk roads in and around the Metropolis. There has been a drastic increase in the traffic along the Road recently, with many houses and enterprises being situated along it. In spite of this traffic volume increase, any improvement or widening works could not have been conducted on the Road so far, so that extraordinary congestion of the Road has been in repetition everyday in peak hours.

Also the Road suffers often shutdowns in traffic in the rainy season, since it has only less than 1 m of embankment height above the bed of the Msimbazi Creek, which the Road has to cross directly before going into the Metropolis, so that the Road suffers inundation above it unavoidably, affecting the function of the Metropolis itself, seriously.

Under such situation, the Government of the United Republic of Tanzania has requested the Government of Japan to improve the Morogoro Road. In response to this request, the Government of Japan has organized the Basic Design Study Team, through the Japan International Cooperation Agency (JICA), headed by Mr. Yukitake SHIOI, Inspector for Environment, Tohoku Regional Construction Bureau, Ministry of Construction, and sent the Team to Tanzania in the period between 30th January to 20th February, 1984.
(Please refer to Appendix I, as for the request from the Government of Tanzania, members of the Team, schedule and Minutes of the Meetings exchanged.)

CHAPTER 2

BACKGROUND OF THE PROJECT

CHAPTER 2 BACKGROUND OF THE PROJECT

2-1 GENERAL SITUATION IN THE UNITED REPUBLIC

The United Republic of Tanzania is located in the eastern coast of the East Africa, between latitude 1° - 11° south, with a total area of 945,087 km^2 and with a population of 17,480,000 approximately according to a census conducted in 1978, with annual increase rate of about 3%, so that by 1984 the population should have exceeded 20 million, presumably.

About 40 - 50% of her national production has been shared by agriculture (hunting and fishery inclusive), and though recently industrial developments have been in progress but their share in the national economy is still limited. And her economy has been in agony by the acute inflation that ensued the oil crisis in 1973, so that comparing the 1981 prices with those of 1970, 3 to 5 times prices increases has been recorded in the nation-wide scale, and in the Dar Es Salaam district specifically this ratio has been as high as 3 to 6.75 times.

And a large deficit was suffered in the foreign trade also in that, although the annual trade deficit used to be something TS 600 - 700 million until 1973, the deficit became as large as TS 5,000 million in average after 1978. Therefore, the Government of Tanzania had to denominat the conversion rate of TS, which had been US$1.00 = TS 8.00, to TS 12.50 in 1983.

Due to these economic difficulties, and also aggravated by 3% population increase as has been stated, the per Capita Gross Domestic Production in 1982, TS 2,188, does not in any way indicate substantial increase in terms of 1966 price, in spite of its nominal increase compared with the 1970 figure, that was TS 637, as indicated by the official statistics issued by the Ministry of Planning & Economic Affairs, as shown below:

Per Capita Gross Domestic Production

(at Factor's Cost)

Year	1970	1972	1974	1976	1978	1980	1982
Per Capita G.D.P. at Factor's Cost	637	737	976	1,352	1,734	2,002	2,188
In 1966 Price	595	626	628	667	660	665	593

2-2 GENERAL ROAD CONDITIONS IN THE UNITED REPUBLIC

The road in Tanzania consists of National Trunk Roads of 17,000 km and local roads of 17,000 km, in total 34,000 km. 20 years' plan for road improvement and construction had already been prepared for the period, 1981 - 2000, with its first 5 year plan started in 1981.

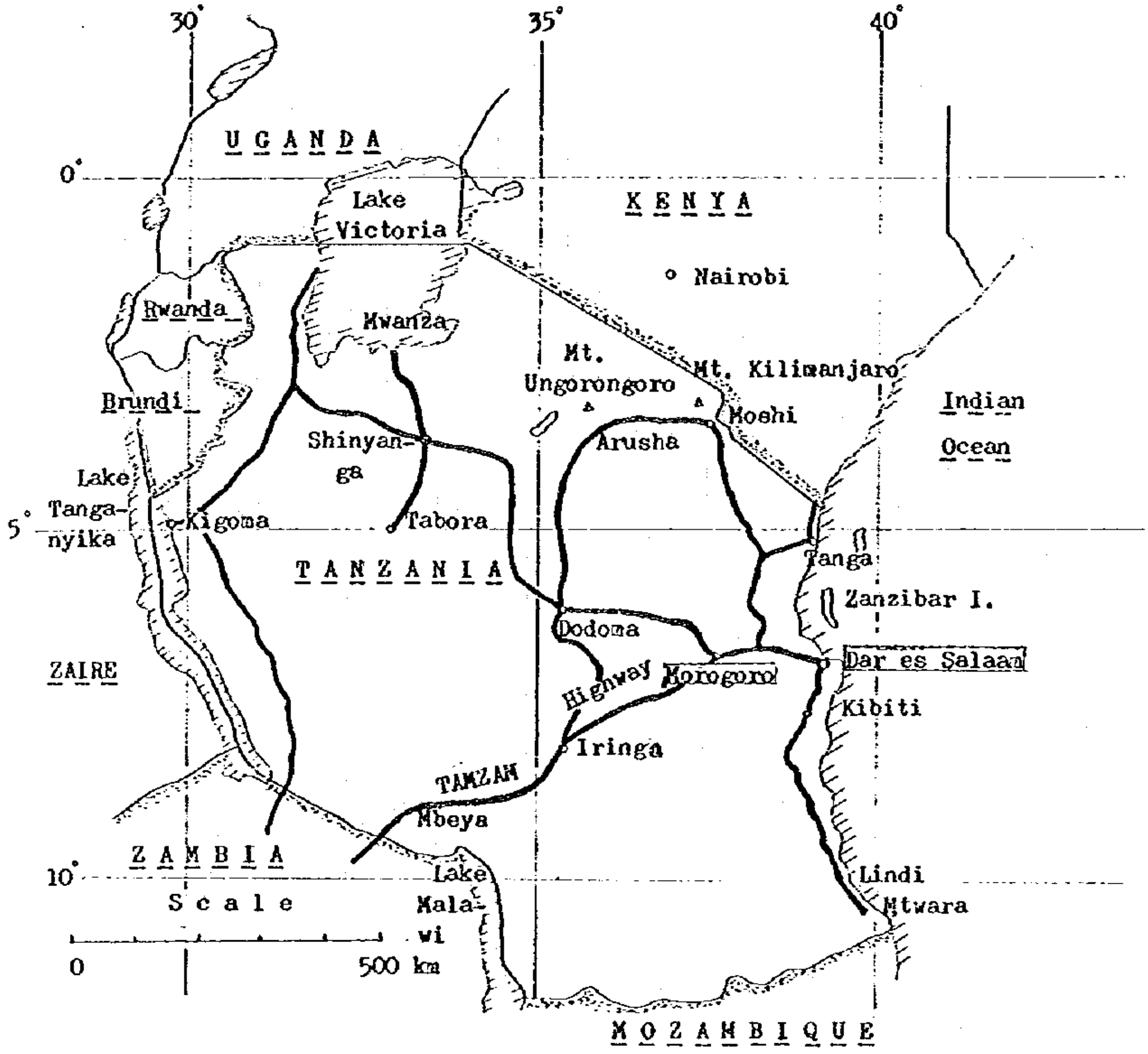
In total, Tsh. 5 billion budget was scheduled, with annual average of Tsh. 1 billion, with the maintenance & repair cost of Tsh. 150 million also provided for.

However, it is only very recently that the importance of highways and roads has been understood, so that the existing roads having been kept unrepaired or not maintained for some considerable time. Therefore, they are mostly under the poorest conditions, sometimes impassable, or even if passable only by jeeps and trucks, but not by passenger cars.

Under such situation, the Ministry of Works has decided to launch a project, in which 15 number of roads with a total length of 3,000 km is to be improved, as indicated in Table 2-1, though some large portion of it is to be assisted by foreign aid.

Among them, much stress is now being laid on the following two roads, that are;

Fig. 2-1 GENERAL MAP OF TANZANIA



Number of Enterprises In Tanzania By District

Dar Es Salaam	468	Along the sea.	Morogoro	44	Along Tanzam Hiway.
Tanga	107		Iringa	19	
Zanzibar Island	29		Mbeya	16	
Mwanza	84	Lake Victoria.	Tabora	20	
Arusha	86	Northern district.	Shinyanga	15	
Moshi	73		Other 13 districts incl.	76	

Table 2-1 UNITED REPUBLIC OF TANZANIA
MINISTRY OF WORKS
PROJECTS FINANCING

FIGURES IN 1,000,000 T.SHS.

PROJECT TITLE	LENGTH	DONOR	1976/77 Loc	/ For	1977/78 Loc	/ For	1978/79 Loc	/ For	1979/80 Loc	/ For	1980/81 Loc	/ For	1981/82 Loc	/ For	1982/83 Loc	/ For	1983/84 Loc	/ For	TOTAL Local	TOTAL Foreign
ROAD DIVISION																				
Major Bridges	-	AD Bank	0.4	2.7	-	0.6	-		-		-		-		-		-		0.4	3.3
D'Salaam Port Access Road	16	FRG Germany	0.4	16.0	3.3	-	0.3	38.0	2.0	52.5	1.0	20.0	-		-		-		7.0	126.5
Rugu Road		FRG	0.1	44.5	-		-		-		-		-		-		-		0.1	44.5
Cotton Feeder Road		W/Bank	5.7	0.5	-		-		-		3.5	35.0	-		-		-		9.2	35.5
Mtwara-Mingoyo-Masasi Road		W/Bank	5.0	32.5	10.0	25.7	1.0	2.4	-		-		-		-		-		16.0	60.6
Trunk Road Maintenance-I		W/Bank	2.0	36.3	5.0	16.4	2.8	13.7	5.0	16.7	0.5	3.2	3.6	13.0	3.3	0.9	6.8		29.0	100.2
Trunk Road Maintenance-II		W/Bank	-		-		-		7.0	34.0	5.0	5.7	15.1	20.0	9.7	1.8	13.5	19.0	50.3	80.5
Kiirumi Bridge	1.82	ADB	1.0	11.7	2.8	3.9	0.7	2.5	6.0	24.0	1.0	22.6	20.0		10.0		12.0		53.5	64.7
Ruvuvu Bridge		ADB					-		-		-		-		-		-			
Mwanza - Musoma Road	184	EEC	-		0.1		7.5	7.4	1.2	45.0	2.2	48.6	2.5	80.0	10.0	45.0	39.6	30.0	63.1	256.0
Songea-Makambako Road	322	UK England	-		-		-		3.0	120.0	65.0	81.2	24.0	100.0	15.6	27.0	15.0	20.0	122.6	348.2
Morogoro-Dodoma Road	256	Brazil	-		-		-		40.4	45.0	12.0	99.6	32.8	50.0	32.5	48.0	4.3		122.0	242.6
Kobero-Rusumo-Isaka Road	332	ADB/ADF/ EEC	0.2		-		1.6	21.5	12.0	82.0	5.9	31.7	22.0	48.6	17.6	18.0	36.4	25.0	95.7	226.2
Dar es Salaam-Tunduma Road	905	W/Bank	-		-		-		-		9.7		11.7		5.5		5.7		32.6	-
Kibiti-Lindi Road	330	Japan	-		-		-		2.0		0.1	88.0	18.7		16.1	5.0	8.7		52.6	93.0
Chalinze-Mkumbara-Tanga Road	325	-	-		-		-		28.6		48.8	3.9	20.0		17.0		7.0		121.4	3.9
Salender Bridge	0.76	Japan	-		-		-		0.3		0.5	4.5	25.0		-		-		25.8	4.5
Pyrethrum Feeder Roads		W/Bank	-		-		-		-		-		0.7	3.0	0.9	5.0	1.0	6.0	2.6	14.0
Arusha-Dodoma Study	525	Italy	-		-		-		-		15.1		-		2.0	11.9	1.4	6.0	18.5	17.9
Transport Study	-	Italy	-		-		-		-		-		-		-		0.3		0.3	-
Mufindi Paper Mills Access Road	47	EEC	-		-		-		-		-		-		10.0	25.0	49.0	38.0	89.0	63.0
Mombo-Lushoto Road		FRG	-		-		-		-		-		-			5.0	0.1	30.0	0.1	35.0
Tea Feeder Roads		W/Bank Norway	0.5	13.3	1.4	1.5	0.2	0.4	-		-		-		-		-		2.1	15.2
TOTAL			15.3	157.5	22.6	48.1	13.9	85.9	109.6	419.2	180.2	444.0	187.4	314.0	137.3	192.6	200.8	174.0	883.9	1,835.3

Chalinze-Segera, connecting Kilimanjaro & Arusha (centre of agriculture & industry in the north) to Dar Es Salaam, and

Kibiti - Lindi, connecting the south (where future large projects are anticipated in spite of its relatively undeveloped condition) to Dar Es Salaam.

Further, it is reported that, along the TANZAM Highway (all weather type) of which maintenance work has been taken care of jointly by the two Governments concerned resulting in relatively good road conditions, several (8, according to a report) of enterprises recently founded their factories nearby Mbeya along the boarder, indicating that good roads are fundamental pre-requisite condition in development.

Therefore, further betterment and provision of transportation system, especially that of road network, would be indispensable for future development of this country.

2-3 CHARACTERISTIC OF THE MOROGORO ROAD

In order to reach anywhere in Tanzania (except the southern portion of it) from the Metropolis, Morogoro Road is a "must" that we have to go through it, and in this context, it is the most important road in the whole Tanzania. And this Improvement Project of the Road is aiming to improve the Road right at its entrance to the Metropolis.

Further, besides the above situation, the suburbs area along the Road has been rapidly developed either for housing sites or that of enterprises, so that resulting rapid expansion of traffic demand has also been very large. (As explained below, this demand seems to be something around 8,000 vehicles/12 hrs. in both ways.) Therefore, the Road has to bear a very large traffic demand everyday which had reached 14,000 vehicles/12 hrs. (in both ways) as of March, 1982., in the Jangwani area.

12 Hrs. Traffic Volume In The Main Trunk Roads In Dar Es Salaam

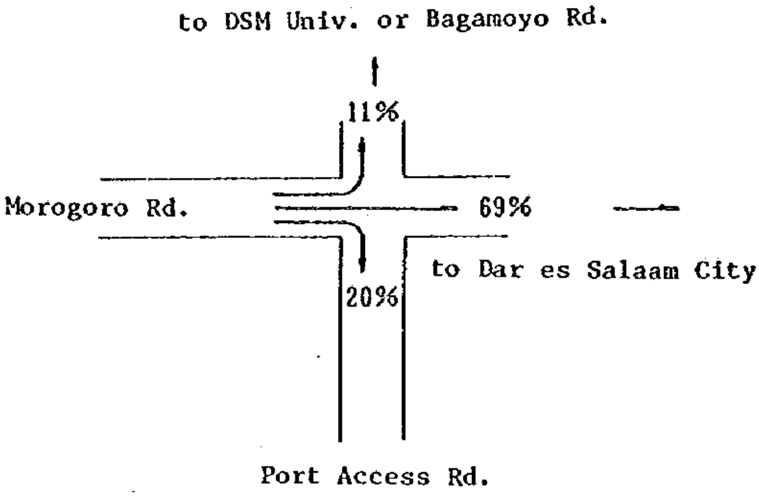
March, 1982

Name of Roads	No. of Lanes	12 Hrs. Traffic Volume
Bagamoyo Rd.	4	20,504
Morogoro Rd.	2	13,919
Uhuru Street	2	11,505
Pugu Rd.	6	30,830
Kilwa Rd.	2	8,922

And further, the above numbers of traffic are composed of following types of vehicles, wherein the very high ratio of buses in the Morogoro Road, are very much evident, in comparison with other roads.

Road	Sedan	Taxi	Common Buses	Articulated Buses	Trucks	Total
BAGAMOYO	14,671	4,244	460 (2.2%)	42 (0.2%)	1,087	20,504
MOROGORO	6,889	4,161	1,285 (9.2%)	305 (2.2%)	1,279	13,919
UHURU	5,466	3,975	737 (6.3%)	75 (0.6%)	1,252	11,505
PURU	19,969	7,045	825 (2.7%)	270 (0.9%)	2,721	30,830
KILWA	4,900	2,358	602 (6.7%)	70 (0.8%)	992	8,922

And also according to an Origin & Destination survey conducted in 1983 at the Ubungo junction of the Road (being located at about 9 km west of the Metropolis, where the Port Access Road branches off toward south) the distribution of traffic toward the metropolis (total number 2,911 vehicles) was as indicated below.



6:00 a.m. - 18:00 p.m. (Friday), 23rd, September, 1983

During this period, 90% of all the busses and 60% of all other types of vehicles were using the Morogoro Road.

Among the 2,911 vehicles as indicated above, 60% originated from the suburbs of Dar Es Salaam, 30% from Morogoro City, the rest, 10%, was from other cities in Tanzania (including some from Zambia).

Based on the above data, as well as the results of traffic count conducted in March, 1982, wherein 6,867 vehicles were counted (between U.N. junction and Jangwani) in one way in 12 hrs., we can conclude that about 8,000 vehicles/12 hrs. of traffic is now being generated everyday from the area along the Morogoro Road (between the Ubungo Junction and Jangwani) as follow:

$$2 \times (6,867 - 2,911) = 2 \times 3,956 \doteqdot 8,000$$ (vehicles/12 hrs. in both ways)

Fig. 2-2 EXISTING CLASSIFIED ROAD SYSTEM

Table 2-2 TRAFFIC VOLUME BY TYPE OF VEHICLE ON MOROGORO ROAD

(Mar. 1982)

Time	Private Cars	Taxi	Common Buses	Articulated Buses	Trucks	Total
7-8	233	110	59	12	43	457
	249	103	63	12	63	490
	(482)	(213)	(122)	(24)	(106)	(947)
8-9	246	182	43	12	46	529
	220	155	38	16	43	472
	(466)	(337)	(81)	(28)	(89)	(1,001)
9-10	269	157	45	12	48	531
	234	148	49	10	44	485
	(503)	(305)	(94)	(22)	(92)	(1,016)
10-11	306	165	45	9	31	556
	271	186	41	10	44	552
	(577)	(351)	(86)	(19)	(75)	(1,108)
11-12	297	176	37	7	44	561
	284	161	40	5	47	537
	(581)	(337)	(77)	(12)	(91)	(1,098)
12-1	234	189	60	9	48	340
	330	181	39	13	65	628
	(564)	(370)	(99)	(22)	(103)	(1,158)
1-2	327	146	41	4	41	559
	326	190	53	7	68	644
	(653)	(336)	(94)	(11)	(109)	(1,203)
2-3	252	129	42	14	36	473
	349	173	54	27	83	686
	(601)	(302)	(96)	(41)	(119)	(1,159)
3-4	357	294	102	30	91	874
	372	197	56	6	69	700
	(729)	(491)	(158)	(36)	(160)	(1,574)
4-5	284	232	89	17	76	698
	389	170	54	13	80	706
	(673)	(402)	(143)	(30)	(156)	(1,404)
5-6	326	198	78	20	39	661
	286	204	73	14	60	637
	(612)	(402)	(151)	(34)	(99)	(1,298)
6-7	205	134	43	11	35	428
	243	181	41	15	45	525
	(448)	(315)	(84)	(26)	(80)	(953)
Total	6,889	4,161	1,285	305	1,279	13,919

UPPER : S ⟶ C
MODEL : C ⟶ S
LOWER : TOTAL

Sub. to City 6,867
City to Sub. 7,052

CHAPTER 3

GENERAL CONDITIONS

IN THE PROJECT AREA

CHAPTER 3 GENERAL CONDITIONS IN THE PROJECT AREA

3-1 GENERAL SITUATION

Dar Es Salaam has long been the metropolis of Tanzania and at the same time, as its name implies, has been a peaceful and prosperous seaport facing the Indian Ocean. Its population was about 850,000 according to 1978 population census, however afterwards about 8% per anum increase was due, so that at present it has about 1,300 thousand population. (This increase rate of 8% is very large a figure compared with the annual increase rate of 3% for the whole Tanzania.)

The monthly average temperature in Dar Es Salaam being 23.3°C in its lowest (July) and 27.6°C in its highest (Feb. & Mar.), with the month of April being the most sultry with humidity of 82%. Two rainy seasons come a year, once in March and April, and the other in October and November, with annual rainfall of 1,000 - 1,100 mm, with the rest of the year being dry.

The 2.7 km stretch of the Morogoro Road which is now being the object of the improvement work, starts from the U.W.T. junction, Kisutu area, and goes west-ward passing through the United Nations junction, going down to the Msimbasi Creek bed, and crosses it with a horizontal length of about 800 m. Again the Road climbs in the Mapipa area up to the opposite bank, and reaches the Morocco Road Junction in the Magomeni area, where the Project terminates.

There is not much difficulty in the geology in its beginning point (and nearby area), as well as its end point at the Morocco Road. In the portion through the Mapipa area where the Road climbs toward Morocco Road, MOW was urgently improving the foundation of the Road, when the Investigation Team visited Dar Es Salaam, so that there will not be any difficulty any more in this area, too.

The portion where the Road crosses the Msimbazi Creek, the upstream side of the Creek bed is called the Jangwani Playing Field, which is very much familiar to the citizens, with many soccer grounds etc. being located. In this area, after removing the top soil of scores of cm of thickness, there appears white sand layer of scores of cm of thickness too. Down below of it, more or less clayey soil appears, but generally the soil is not too much impervious. Therefore, settling of embankment due to consolidation of foundation clayey soil, that may last for a long time after embankment usually, is not likely to be large in its magnitude. (However, in the area, the underground water level is relatively high, about 0.5 m below the surface of the ground even in the dry season.)

Although there is water supply system in Dar Es Salaam, in the 1st or 2nd floor of buildings we may not have any water supply, or even if we have some, only very much coloured water may appear, so that water is a serious problem for people who live there. As for electricity supply, there was not any shut-down of the supply during our stay in the city. However, separate supply source will be provided by Contractor for the purpose for the Project, probably.

As for fuel for the construction plant and equipment (diesel oil and some petrol), definite and resolute attitude of the Tanzanian Government to supply the Contractor with necessary quantity of fuel under any conditions is very important. (Should any plant or equipment comes to frequent stops due to short supply of fuel, the Contractor may raise claim.)

3-2 SOIL INVESTIGATION AND TESTING

The Items of Soil Test

Soil investigation and laboratory tests that were carried out in the investigation period were as follows:

a. Machine Boring (2 holes)

Locations:

No.1 Hole,	at the centre of Morogoro Road across the Msimbazi Creek (Jangwani Playing Field)	10.5 m
No.2 Hole,	near the existing Msimbazi Bridge (right-bank abutment)	16.5 m
Total Depth		27.0 m

b. Ram Sounding Test (4 places)

Locations:

No.1 Hole,	existing Msimbazi Bridge (upstream side, left-hand)	11.0 m
No.2 Hole,	existing Msimbazi Bridge (upstream side, right-hand) (same location with the Maching Boring)	9.0 m
No.3 Hole,	waterway inside the Jangwani Field (upstream, right-hand)	6.0 m
No.4 Hole,	waterway inside the Jangwani Field (downstream, right-hand)	7.0 m
Total Depth		33.0 m

c. Laboratory Testing

The items of tests on the samples obtained from the machine borings.

Sieving test	2
Hydrometer Analysis	2
Specific gravity test	2
Natural Moisture Contest	2

Atterberg Limits	2
Direct Shear test	2
Tri-axial Shear test	2

The items of tests on the embankment materials, sub-base & base course materials.

Shieving test	5
Hydrometer analysis	3
Specific gravity test	3
Natural Moisture Contest	3
Atterbery Limits	3
CBR test, 4 days submergence	3

d. Quarry sites Investigation along the Morogoro Road

Following quarry sites were visited for possible acquisition of aggregates from them, for concrete and asphaltic concrete.

Kunduchi, Msolwa, Mikese, etc.

As for possible sources of sand, several possible sources such as Mbagala (18 km), Tabata (13 km), Bunju (22 km) and Boko (18 km) were found, all of them much nearer to the Dar Es Salaam city.

Results of the Investigation and Tests

a. The foundation of Embankment and Box Culvert

No.1 Machine Boring:

Underground water levels	:	-0.30 m
Thickness of surface soil layer	:	0.60 m
Thickness of coarse sand	:	6.0 m

Standard Penetration Test (N-value) 5 - 10

Artesian water exists in deeper portion than 7 m with N-values of 15 - 17

b. The foundation of Msimbazi bridge (to be re-constructed)

No.2 Machine Boring (near right bank abutment)

Underground water level	:	-0.50 m
Thickness of surface soil	:	0.75 m
Thickness of coarse sand	:	15 m

(at the depth of 4.5 m, there is a layer of fine sand (0.9 m thick) containing clayey material)

Standard Penetrating Test (N-value)

at the depth of 10 m or over	20 or more
at the depth of 16.5 m	37.5

Pile driving depth of 15 m and over is required.

No.1 Ram Sounding (near the left bank abutment of the existing Msimbazi Bridge)

At the depth of 11 m the condition of the ground was almost impenetrable, so that this seemed to correspond with the N = 20 condition at the right bank area, No.2 machine boring.

c. The foundation of waterway bridge, No.2, in Jangwani Field (Water drain from the brewery factory)

No.3 & No.4 Ram Sounding tests

About 12 m of pile driving depth is required.

d. Materials for Embankment:

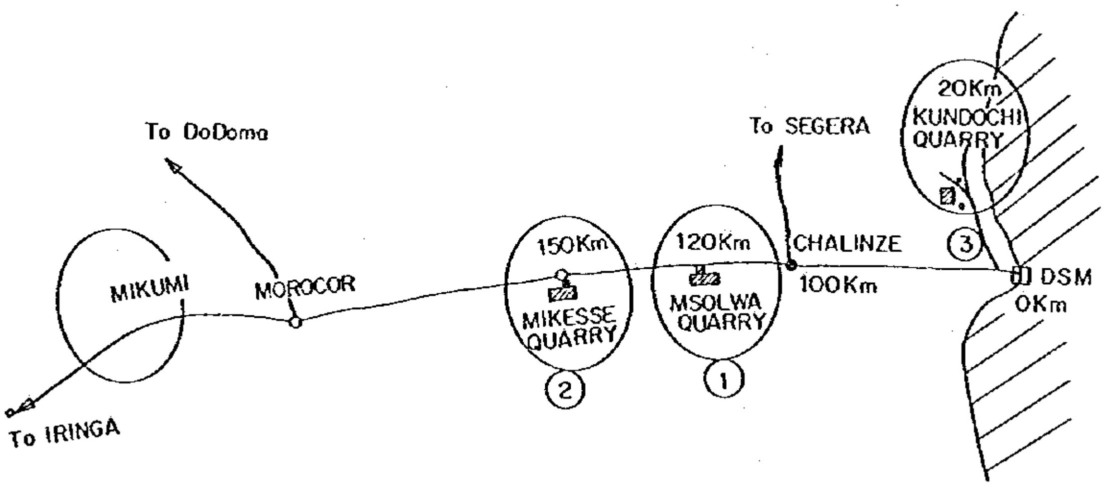
The results of CBR test, 4 days submergence, were as follows:

laterite (two samples) in either case	CBR 3
sand (test pit materials)	CBR 11

It is considered that the sand obtained from Jangwani area is better than the laterite materials obtained from Kunduchi, because inundation of the road may be likely to occur not only after completion but even during the construction, if we are unlucky.

e. Quarry Sites

From quarry sites observations, Msolwa's block stone of gneiss is very good in quality. But it has a problem that the plant was producing crushed stone that contained 9% of soil and sand, because of imperfect installation. The distribution of quarry sites is as indicated in the following map.



3-3 TOPOGRAPHIC SURVEY AND UNDERGROUND FACILITIES

1) Topographic Survey

(1) Length of the Improvement Works

A-Area (widening in the Urban Area) U.W.T. road to United Nations Road	870 m
B-Area (Embankment & Widening Area) United Nations Road to Msimbazi Bridge	900 m
C-Area (Cutting and Widening Area) Msimbazi Bridge to Rotary	500 m
D-Area (Widening in the Suburbs Area) Rotary to Morocco Rd.	460 m
Total	2,730 m

(2) Longitudinal Profile Survey

Longitudinal profile survey was carried out after setting up survey points on the road surface, except the C-Area where the survey was not possible because of the sub-grade improvement work that was conducted by MECO at that time.

Further, levelling survey was conducted between the existing Msimbazi Bridge and the Selander Bridge, located downstream and of which surface is El. +4.01 m, and confirmed that the difference in level between them is about 2.0 m.

(3) Cross Sectional Survey

Several cross sectional surveys were carried out in order to confirm the results of the cross sectional survey that had been carried out before.

(4) Plane Table Survey

Plane table surveys and levelling were conducted for the five junctions of the road, Morocco, United Nations, Msimbazi, Lumumba & U.W.T. Street.

(5) Topographical Survey

Topographical survey was conducted for the area near the existing Msimbazi River Bridge.

(6) Centreline Shifting & Obstructions

In the A-Area, some re-alignment of the centre line of the Road was required in order to minimize numbers of obstructions due to the widening, and afterwards the effect of finally selected (& shifted) centreline upon unavoidable obstructions that need removal was surveyed.

2) The Present Condition of the Underground Facilities

The items of public utilities that are found and need replacement etc. are as follows:

Main Water Supply Pipe (18 in ∅), International Telephone cables, Electric Power lines, sewer & storm water pipes. Water supply pipes and domestic telephone lines for individual houses along the road were not the object of survey, because of too many numbers.

(1) Water Supply Pipe

Control office :	DSM WATER CORRORATION SOLE
Officer in charge:	MR. J.L. SIMA Water Distribution Engineer

As illustrated in Fig. 3-1, 18 inch ∅, main water supply pipe must be shifted, downstream of the present one, across the Msimbazi Creek for a length of 800 m plus.

(2) International Telephone Cables

Control office : TANZANIA POSTS AND TELECOMMUNICATION CORPORATION

Officer in charge: POSTA HOUSE - MR. NDEDYA
External Planning Officer

TELEPHONE HOUSE - MR. YA. SIGARA
Underground Telephone Cable
Maintenance Engineer

The specification for the four telephone cables illustrated in figure 3-1 are as follows:

1	300/0.5	LC PCUT NO. 1	1.40"
2	100/0.5	LC PCUT NO. 2	1.0"
3	Laxative Cable 8 tubes		28.2 mm
4	LC PCQL	250/0.63 mm - 1.88 mm Red cover	

(3) Electric Power Line

Control office : TANESCO ELECTRICAL CABLES

Officer in charge: MR. MTAITA
Regional Manager DSM

As illustrated in Fig. 3-1, 11 kV cable and 33 kV overhead cables, one set each, are crossing the road at the height of 6.5 m. Therefore, raising these cables by 3.5 m or so is definitely required, before starting the earthwork.

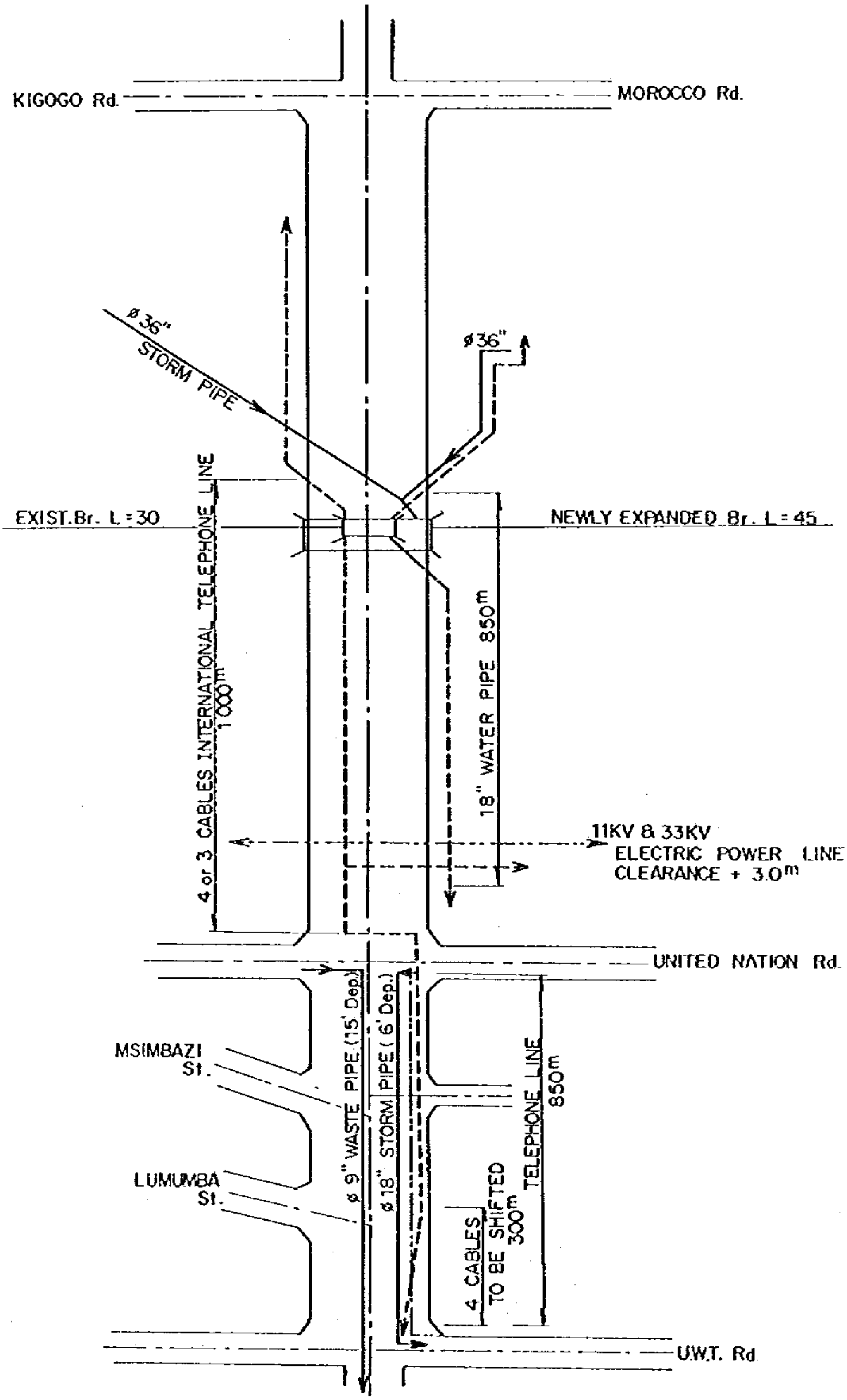
(4) Sewage & Storm Water Pipe

Control office : CITY COUNCIL

Officer in charge: MR. S. TIBANYENDA
City Engineer

As illustrated in Fig. 3-1, there are a 9 inch pipe and a 18 inch pipe from U.N.Rd. to U.W.T. Rd. under the Road, however they don't require replacement.

Fig. 3-1 PRESENT CONDITION OF THE UNDERGROUND FACILITIES



3-4 TRAFFIC COUNT

Because of an overall improvement works conducted by MOW at the Mapipa district of Morogoro Road, the stretch of the Road between United Nations Junction to Magomeni Rotary was totally closed for traffic, with the overall traffic flow in the main urban trunk roads in the Dar Es Salaam city was unavoidably affected, so that usual traffic pattern did not exist at the time of field investigation in Feb. 1984.

Therefore, the traffic count was conducted this time at the points as indicated in Fig. 3-2, obtaining the following results, from which the traffic volume on the Morogoro Road could only be inferred indirectly as follow.

Results of Traffic Count (Vehicles/Hr, Both ways,)

(16th Feb. 1984)

No.	Names of Road	7:00 - 8:00	8:00 - 9:00
1	Bagomoyo Rd.	3,363	2,653
2	Morogoro Rd.	82	79
3	Morocco Rd.	733	489
4	Morogoro Rd.	735	498
5	Port Access Rd.	672	369
6	Morogoro Rd.	584	326
7	Port Access Rd.	494	274
8	Morogoro Rd.	684	383

Among the above vehicle numbers, those for Bagomoyo Rd. (No.1) and Port Access (No.5) should have contained unavoidably diverted traffic due to the closure in the Morogoro Road as above mentioned. (Following calculation is conducted for the time interval between 7:00 A.M. - 8:00 A.M.)

Diverted Traffic in the Bagomoyo Rd.

In 1978, traffic count was 1,950 vehicles/Hr., and with 6% per annum traffic volume increase assumed, this will give 1984 traffic volume of 2,770 vehicles/Hr.

Therefore the diverted traffic is estimated to be;

3,363 - 2,770 = 593 ≑ 590

Diverted Traffic in the Port Access Road

In 1983, traffic count was 401 vehicles/Hr.

Therefore the diverted traffic is estimated to be;

672 - 401 = 271 ≑ 270

Total diverted Traffic in Bagomoyo Road & Port Access Road is,

590 + 270 = 860 (vehicles/Hr.)

Total Traffic in Morogoro Road to be anticipated, if the closure were not effected in Feb. 1984.

860 + 82 = 942

This traffic volume of 942 is very close to the traffic volume that was obtained in 1982 for the Morogoro Road, which was 947 vehicles/Hr. Therefore, we can conclude that as of Feb. 1984, the traffic volume on the Morogoro Road was approximately 14,000/12 hrs, as it was obtained in 1982.

(As for the traffic volume in each junction in order to design respective junction, this can only be obtained in the Detailed Design stage investigation, since this time because of the road closure as mentioned, all the traffic pattern in DSM road network was affected.)

Another remarkable information to be derived from the traffic count conducted this time is that at the Selander Bridge (No.1, Bagomoyo Rd.) there were 6,016 vehicles passing through the point within the 2 hours period (7:00 A.M. - 9:00 A.M.) on 17th Feb. 1984, clearly indicating how much the expansion of the Selander Bridge was effective in increasing the traffic capacity.

Fig. 3-2   TRAFFIC SURVEY POINTS

3-5 WEATHER, TIDAL TABLE AND TRACING OF OLD FLOODS

Rainfall records were collected from Directorate of Meteorology, Dar Es Salaam, as appended in the Appendix V. They consisted of;

Annual Rainfall Data	(5 rain gauge stations),
Annual Maximum Rainfall Data	(6 stations) and
Daily Rainfall Records in 1978	(3 stations).

As for the Tidal Table, all the data for the year of 1984 were collected, as well as for the second half of November 1978, when occurrence of a spell of floods in the Msimbazi Creek was found definite due to the results of tracing of old floods as explained subsequently.

The tracing of old floods was firstly conducted on the right bank area of the Creek (schools and a hospital) where it became apparent that the most recent flood that caused a long term of traffic shut-down in the Morogoro Road was in 1978 (for a week or 10 days). And subsequent investigation in the houses on the left bank area revealed that at that time the water level in the Creek was something 1 ft or so below the cross beam of the existing Msimbazi Bridge (at about El. +4.4 or 4.5 m), so that the depth of inundation above the existing road was 0.7 or 0.8 m.

And it was also confirmed that even in November and December, 1983, there were several times of overflow over the Morogoro Road with the traffic shut-down, for a day or two, with the water remaining on the both side of the Road until January, 1984.

CHAPTER 4

BASIC PLAN AND BASIC DESIGN

CHAPTER 4 BASIC PLAN AND BASIC DESIGN

4-1 OBJECTIVES AND CONTENTS

The Morogoro Road Project aims at to devise a plan in order

- to dissolve traffic congestion in the Road,
- to prevent inundation of the Road at the time of flood and
- to carry out basic design that is necessary and optimum.

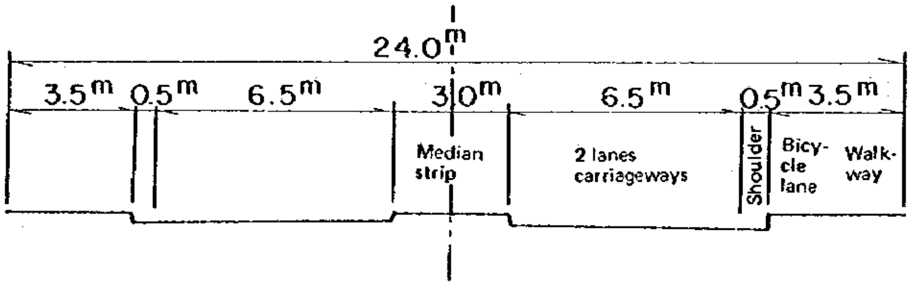
The contents of the Project consists of;

Widening of the Road,
improvement of junctions,
embankment work,
bridge and box culvert work,
replacement of public utilities, either underground
or overhead and other appurtenant works.

4-2 BASIC PLAN

1) Widening of the Existing Road

The traffic volume of the Morogoro Road is now 14,000 vehicles/12 hours as observed in March, 1982, and confirmed by the traffic count conducted this time, in February, 1984, by far exceeding the limit of capacity of 10,000 vehicles/day, for a 2 lanes dual carriageway so that traffic congestion would occur everyday. Therefore, present 2 lanes road need be widened to 4 lanes dual carriageway road, with a median strip, two walkways and two bicycle lanes etc. shall be provided as required. The total width of the road shall be 24 m as indicated in the sketch below, in view of the local conditions in Tanzania as well as urban road standards in Japan taken into account. Design speed of 60 km/hr. shall be employed in general, with the exception of junction, where 40 km/hr. shall be employed.



2) Improvement of Junction

At the 4 junctions, namely Lumumba, Msimbazi, United Nations and Morocco, an overall improvement shall be conducted so far as required. However, at the U.W.T. junctions, since this junction should have already had an improvement conducted, the improvement this time shall be restricted only in order to obtain smooth connection between the existing conditions and that of the widened Morogoro Road.

(1) Auxiliary Lane for Left Turn

Since an auxiliary lane for left turn purpose has already been provided in most of the junctions in Dar Es Salaam according to our investigation, the auxiliary lane shall be provided always, in our design also.

(2) Auxiliary Lane for Right Turn

In order to have smooth traffic flow even for right turning, an auxiliary lane shall be provided in principle at every junction. Because of provision of 3.0 m width for the median strip, the auxiliary lane can be provided easily by utilizing this width.

3) Embankment Construction Plan and Care for Public Traffic During Construction

(1) Embankment Plan

a. The slope of the embankment shall be 1 : 2.0, considering the possibility that the embankment may be submerged in some rainy season.

b. Sands obtained from the Msimbazi Creek shall be used for embankment materials, on condition that the materials are to be dried in the stockpile.
The river bed, from where embankment materials are taken, shall be made flat and smooth not to remain traces of excavation.

c. Embankment slopes adjacent to inlets of box culvert is to be adequately protected by precast concrete blocks of 50 cm x 50 cm x 10 cm, with reinforced concrete frames of 10 m x 5 m in dimension to be provided to accommodate the concrete blocks. Other embankment slopes is protected by latelite or clayey soil with soddings.

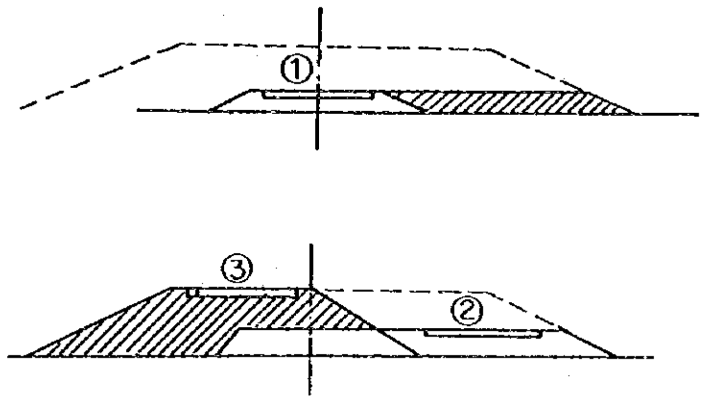
d. In the upstream of the embankment, earth ditch (in a depth of scores of cm) is to be provided, in order to lead rising water to the box culvert, in the initial stage of inundation above the playing field.

(2) Care for Public Traffic During the Construction

With the top width of the embankment being 25 m, and with the slope of 1 : 2.0 and height of more than 3 m above the ground surface, the bottom width of the embankment is almost 40 m wide.

Therefore, partial embankment construction can be adopted through the project, as far as possible, by shifting or restricting the lane for public traffic on one side, while embankment work progresses on the other side.

However, in the cutting section at MAPIPA area, it may be obliged to allow only one way public traffic in an early stage of the construction, due to limited width of the road available in this stage.



① ② & ③ denotes passages of public traffic in stages

4) Layout Plan of Bridges & Box Culvert

(1) The Roads within the Msimbazi Creek Basin

There are two roads crossing the Msimbazi Creek as follow, in upstream of the Morogoro Road, namely

Port Access Road & Kigogo Road.

Port Access Road: Being located at about 4 km upstream from the Morogoro Road, with a total span length of 90 m in 3 bridges as follows:

40 m + 25 m + 25 m = 90 m

Kigogo Road: Being located at about 1.5 km upstream from the Morogoro Road, with a total span length of 46 meter in 4 bridges as follow:

10 m + 10 m + 20 m + 6 m = 46 m

Kigogo Road is now approading completion.

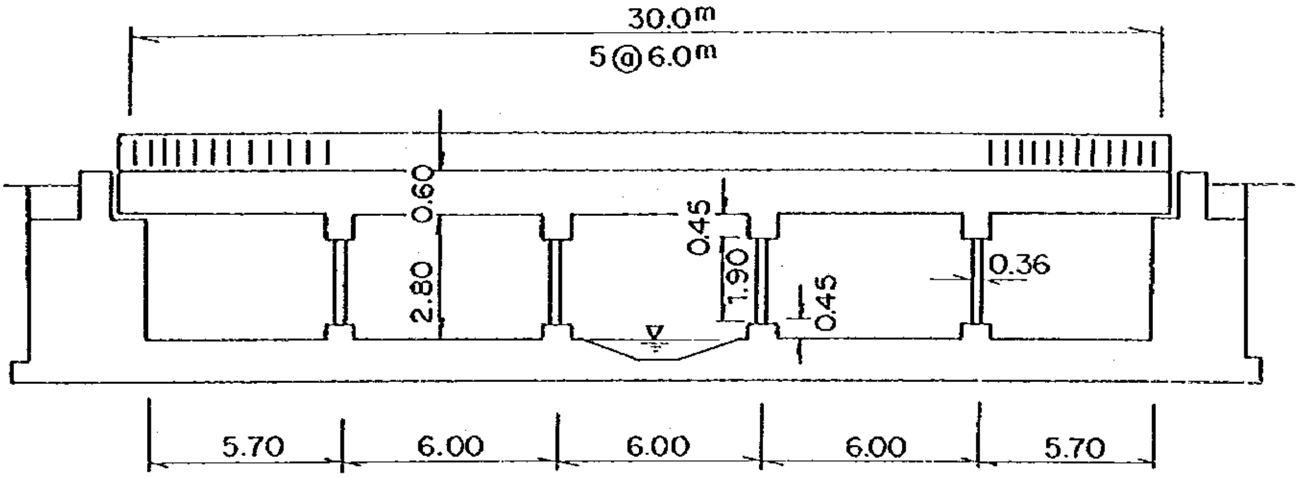
(2) Existing Msimbazi Bridge

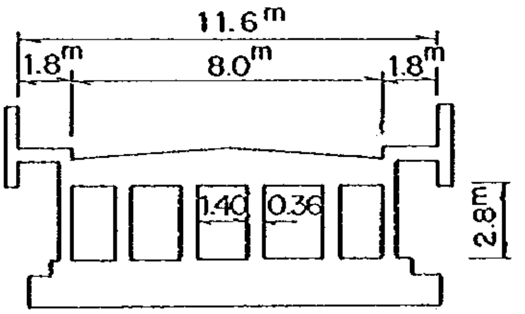
The bridge is said that it was constructed in 1954 - 1957 by Italians.

No information about this existing bridge, such as engineering report, detailed drawing and so on, was obtained during this survey period. Therefore, it is not clear whether or not piles were used in the foundation of the substructure.

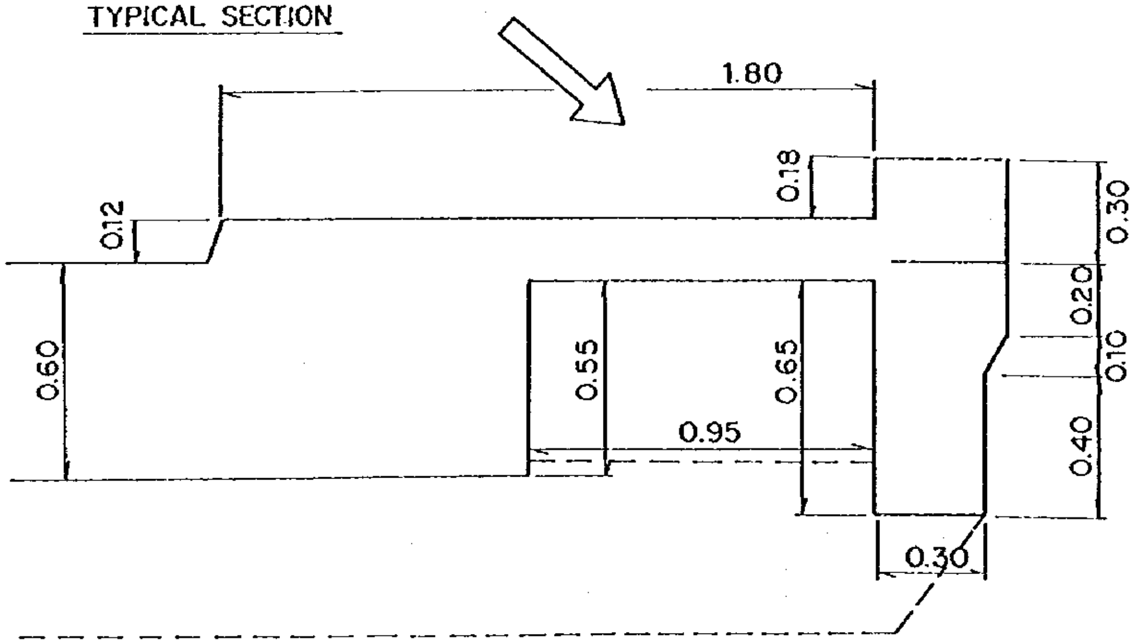
The dimensions of the bridge as measured in the field are as indicated in Fig. 4-1. From observation of concrete surface, there was no indication of concrete to have been deteriorated, but in view of different elevation (existing El. +6.00 m, proposed El. +6.70 m) and different width, the existing bridge has been determined to be demolished.

Fig. 4-1 . EXISTING BRIDGE





TYPICAL SECTION



(3) Layout Plan of Bridges & Box Culvert

The existing Morogoro Road at its Jangwani depression across the Msimbazi Creek consists of the following three structures.

a. Old Jangwani Bridge	:	left side bank, reinforced concrete bridge with a length of 31 m.
b. Drainage for Sewage from brewery factory	:	right side bank, reinforced concrete box culvert, 2.5 m width x 2.0 m height, 1 span only.
c. Submersible Road between above two structures	:	embankment height from the river bed being less than 1 m, but without cross draining structure.

Since one of the two purposes of the project is to reduce the number of times of submergence of the Morogoro Road due to floods, the submersible portion of the road mentioned in above item (3) has to be raised anyway. (The required height of raise is calculated to be 3.0 m on the basis of hydrological analysis. Refer to Section 4.2, 6).

It is proposed, in addition to the 3.0 m raise by embankment, that the Road is improved by constructing the following three cross draining structures, taking into consideration the above mentioned purpose of the Project.

a. New Jangwani Bridge:

A 45 m long new bridge, reinforced concrete, is to be constructed with its pavement surface at El. 6.70 m, while the existing old bridge is 31 m long with its surface at El. 6.0 m.

This elongation of the bridge length aims at widening the existing low water channel, of which width had been reduced by some reason we don't know at this bridge section, with some hindrance being presented against the flood flow, so that by this widening the narrow low water channel could be restored to its original width.

b. Drainage for Sewage from Brewery Factory

Existing drainage system serves mainly for draining sewage from a brewery factory, and consists of concrete lined ditch (3.0 m - 6.5 m width) in upstream, and followed by a box culvert (2.5 m width x 2.0 m height) embedded beneath of the Road. The box culvert is to be replaced with a new bridge of 16 m in clear span, in order to provide required space for steel sheet piling work required for excavation below the ground water elevation, and to provide for smooth flood flow toward downstream.

c. Box Culvert

Six spans of box culvert having inner dimensions of (3.7 m width x 3.0 m height, each) are to be constructed at the near center of the submersible portion of the existing road, so as to drain impounding water above the Jangwani playing field.

The flood water is to be drained by the above three cross draining structures, however, as for hydraulic characteristics, such as average water velocity and total discharge in case of flood etc. are to be referred to Section 4-2, 6) Hydrological & Hydraulic Analyses.

5) Utility Relocations

(1) Principles of Utility Relocations

Urban road projects usually require relocations of many of the public utilities, and this project, too, will require relocation of the following utilities as the indispensable preparatory works. (The evacuation of the inhabitants from all the houses to be removed, of course, has to be carried out under the responsibility of the Tanzanian Government, prior to the commencement of the work, and this necessity was stressed to the Government, already and repeatedly.)

A. Removal of houses (prior evacuation as stated above)

B. Relocation of a main water supply pipe (18 in ø)

C. Readjustment (raising) of electric transmission lines (11 & 33 kV)

D. Relocation of international telephone cable (3 - 4 cables)

E. Closing of old storm water pipe

F. Connection of water supply and domestic telephone lines to houses and offices along the Road, when their mains are to be relocated due to widening of the Road.

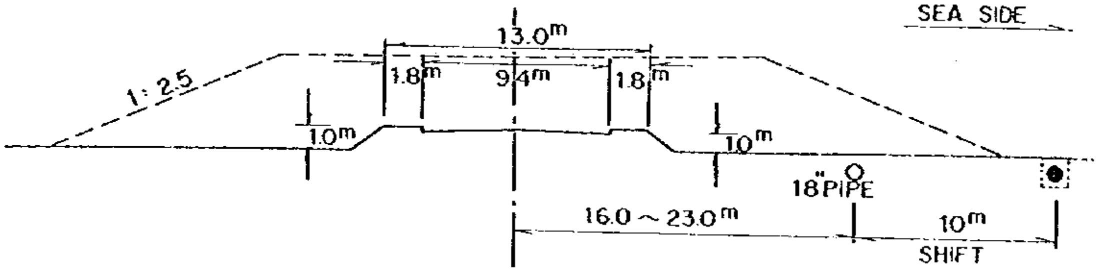
The following principles are proposed so as to realize the smooth operation of these preparatory works.

a. Procurement of materials and spare-parts for these preparatory works in connection with utilities is very difficult in Tanzania, therefore the procurement including transportation to Tanzania are to be included in the Contractor's obligation. And the detailed designs related to such preparatory works are also to be included in the detailed design work by the Consultants.

b. The design and construction of these works are to be made reflecting the local situation and practices in Tanzania, in close and tight contact with the officers in the relevant utility offices and/or organizations.

(2) Methods of Relocating the Utilities

a. Water Supply Pipe



The existing main water supply pipe, 18 in. in diameter, is laid at the downstream side of and in parallel with the Road, and this pipe shall be replaced with a new pipe and shifted towards downstream with a distance of more than 10.0 m.

Timing of relocation work

The relocation of water supply pipe shall be completed before starting earth works.

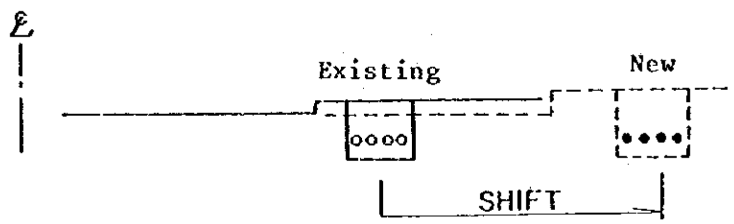
Installation of Water Supply Pipe to Msimbazi Bridge

Water supply pipe can be installed beneath of the walkway of the New Msimbazi bridge, after bridge completion, in a similar manner as the existing old bridge. However, an alternative plan is also worth of studying in which the water supply pipe is to be laid under the low water channel of Msimbazi River right from the very beginning, without the reinstallation beneath of the walkway conducted after completion of the Bridge.

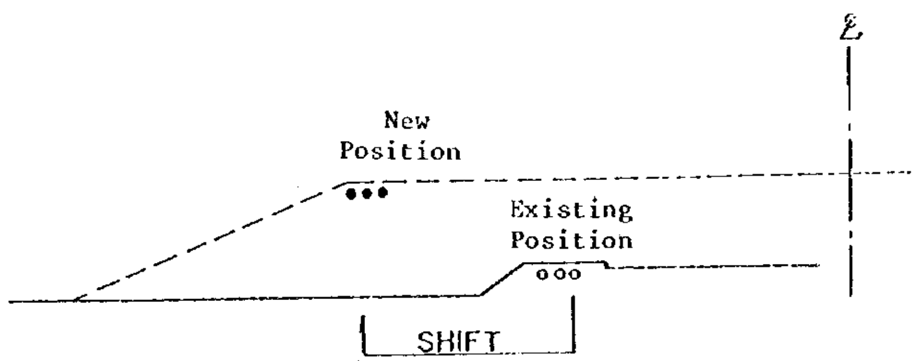
b. International Telephone Cable

There are two cases conceivable for replacement of the international telephone cables.

a) simple shifting: in the urban street, between U.W.T. & United Nations, approximately, where shifting is only due to widening of the Morogoro Road, but not due to raising in elevation.



b) in the embankment section in Jangwani: where after completion of the embankment, new cables are to be laid in the new position, while during the construction the present cables in their present position shall be used as they are now, unless obstructed by some special reason.



Timing of Relocation

Simple shifting work, in the urban street section, need be carried out prior to the commencement of the work there.

However, in the Jangwani area, new cable laying work shall be made after the completion of earthworks in the higher position than the original one.

Installation of Telephone Line to Msimbazi Bridge

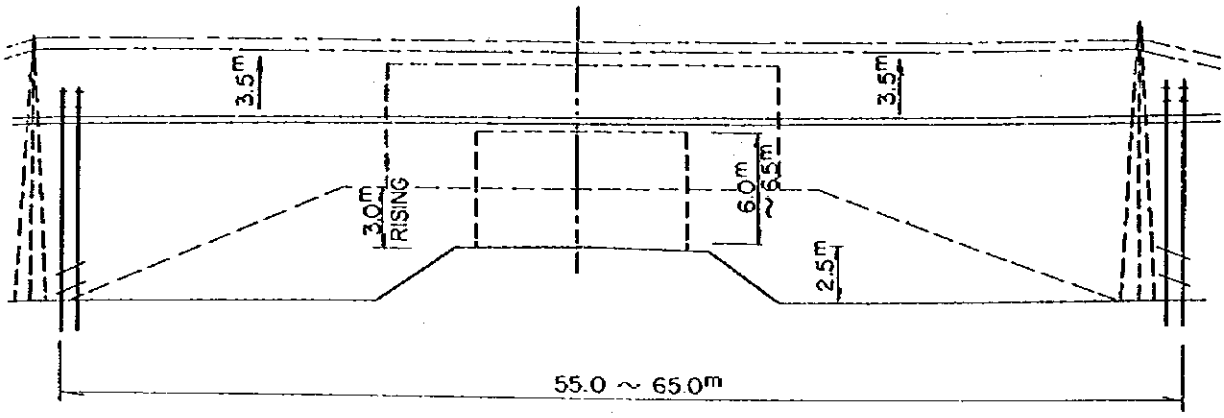
Though the cables are made up watertight in themselves, as well as contained in watertight steel pipes, these cables have to be finally installed below the walkway of Msimbazi bridge, after its completion. (After demolition of the existing bridge until completion of the New Bridge, these cables have to be replaced aside temporarily, keeping the function of the telephone cables alive.)

In addition to the international telephone cables as stated above, those cables for domestic telephone use under the walkway of the urban portion (between U.W.T. and United Nations, approximately) may have to be shifted also, due to the widening of the Road.

c. Electric Transmission Lines and Pylon

Electric transmission lines of 33 kV & 11 kV are crossing over the Morogoro Road at STA. No. 13+7, approximately.

The existing overhead clearance is 6.5 m above the road surface, however since the road at this point requires hightening and widening, the transmission lines and related towers shall be raised by about 3.5 m.

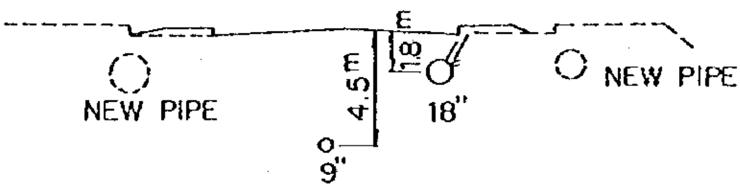


Timing of Relocation

At the early stage.

d. Sewer Pipe and Storm Water Pipe

Sewer pipe, 9 in. in diameter, and storm water pipe, 18 in. in diameter, are existing at the depth of 4.5 m and 1.8 m, respectively, from the road surface.



Two nos. of new storm water pipes (600 mmϕ) are to be provided in relation to the widening of road.
(Closure for the old storm water pipe might be required in connection with the piping work.)

e. Removal of Houses, Buildings Etc.

In relation to the widening of the Road, removal work of houses, buildings and other facilities as follow are required.

A.	Private Houses	14 - nos.
B.	Public Building (A part of the Primary Court)	1 - no.
C.	Electric Poles	40 - nos. (approx.)
D.	Road Lighting Pole	20 - nos. (approx.)

<u>Timing of Removal (including evacuation of inhabitants)</u>

At the early stage.

6) Hydrological & Hydraulic Analyses

The major objectives of hydrological & hydraulic analyses related to the Project are summarised in the three points as follows:

(a) What is the magnitude of floods to be expected in the Msimbazi Creek?
(b) What is the height of water level in the Jangwani area due to the above floods?
(c) What is the average velocity of water inthe flood draining structure?

In this section, quantitative solutions for the above questions are now to be sought of, as much as possible. However at the same time, some questions as follow would also arise.

(d) Comparative study of accuracy between several rainfall observatories in the area.
(e) What was the approximate magnitude of 1978 flood that suspended the traffic for a week or so.

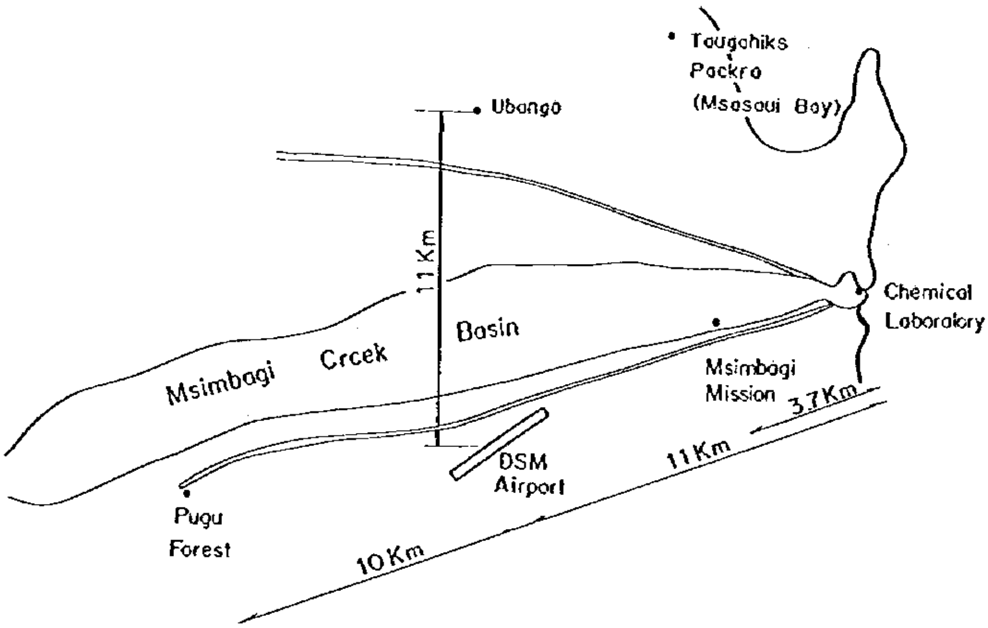
Explanation and or calculation as for the above questions, (d) & (e), are to be given in the relevant Appendix V in order to obtain simplicity and easy in reading, so that only questions (a), (b) and (c) are to be discussed here in detail, with the following sequence.

Rainfall Observatories & Their Distribution
Statistical Analysis of the Rainfall Data at the DSM Airport
Calculation of Flood Discharge Based on the Rainfall Data
Flood Hydrograph & Resulting Water Level in the Jangwani Area
Arrangement of Bridges & Box Culverts in the Jangwani
Depresssion & Resulting Velocity of Flood in These Structures

Rainfall Observatories & Their Distribution

6 numbers of rainfall observatories as follow were found in and nearby the Project area, and their location as well as kinds of rainfall data available are as indicated in the following table and sketch.

Names of the Observatories	Kinds of Data Available		
	(1) Annual Rainfall Data	(2) Annually Maximum Daily Rainfall	(3) Daily Rainfall Mar. - May, Oct.& Nov. '78
DSM Airport	'57 - '82	'54 - '82	Yes
Chemical Laboratory	'54 - '82	'54 - '82	Yes
Msimbazi Mission	'56 - '82	'53 - '82	Yes
Tanganyika Packers	'57 - '82	'52 - '82	No
Ubungo Maji	'59 - '82	'81 - '82	No
Pugu Forest	No	'50 - '82	No



Statistical Analysis on the Rainfall Data at the DSM Airport

The three kinds of rainfall data as tabulated above are attached here in Appendix V, and also as explained in the same Appendix, the annually maximum rainfall data at the Dar Es Salaam Airport were found to be the best one in its accuracy, so that these data at the Airport were selected, for purpose of further analysis of flood discharge from the Msimbazi Creek.

The calculation of annually maximum rainfall for any return period, as indicated in the Table 4-1, revealed that following probable rainfall (mm/day) would be anticipated.

$$\text{Log } (R-37.8) = 0.3039\xi + \log 35.1 \quad \text{.........................} \quad (1)$$

where, R = Annually maximum rainfall (mm/day)

ξ = Coefficient in the Error Function

Calculation of Flood Discharge Based on the Rainfall Data

The probable rainfall data as derived from the above calculation was further used to convert them into the peak discharge of the floods, based on the Rational formulae as follows:

$$T = \frac{L}{72(\frac{H}{L})^{0.6}} = 8.2 \text{ Hrs.} \quad \text{..............................} \quad (2)$$

$$r = \frac{R24}{24}(\frac{24}{T})^{2/3} = 0.0853 \; R_{24} \quad \text{............................} \quad (3)$$

$$Q_p = \frac{1}{3.6} f.r.A = 2.843 \; R_{24} \quad \text{............................} \quad (4)$$

where, T = Arrival time of flood

H = Difference in the elevation, between the highest point in the catchment area and the point in sideration, where the flood discharge is to be calcu- calculated. = 210 m

L = Length of the river, between above two points = 30 km

A = Area of basin = 240 km^2

R_{24} = Daily rainfall, (or R in the eq. (1))

f = Coefficient of discharge = 0.50

The reasons of coefficient of discharge, 0.50, was adopted were that the longitudinal profile of the Msimbazi Creek is very gentle, with the average gradient of only 0.7% ($= \frac{H}{L} = \frac{210\ m}{30\ km}$).

The average annual rainfall in the area being in the magnitude of (more or less)1,000 mm, so that the basin is in most of the time under some dry condition, but not necessarily wet.

For purpose of comparison and study, standard coefficient of discharge adopted in Japan are transcribed from "Formulae In The Hydraulics", Japan Society of Civil Engineers, as follow.

Conditions in the Basin under Question	Value of f, Coefficient of Discharge
Steep Mountain Area	0.75 - 0.90
Mountain Hill of the Tertiary Period	0.7 - 0.8
Hilly Land & Forested Area	0.5 - 0.75
Flat & Cultivated Land	0.45 - 0.60
Paddy Field when being irrigated	0.7 - 0.8
Rivers in Mountain Area	0.75 - 0.85
Small Brooks in Flat Area	0.45 - 0.75
Large River, more than half of which basin is flat	0.50 - 0.75

Fig. 4-2 Exceeding Probability & Return Period of the Annually Maximum Daily Rainfall

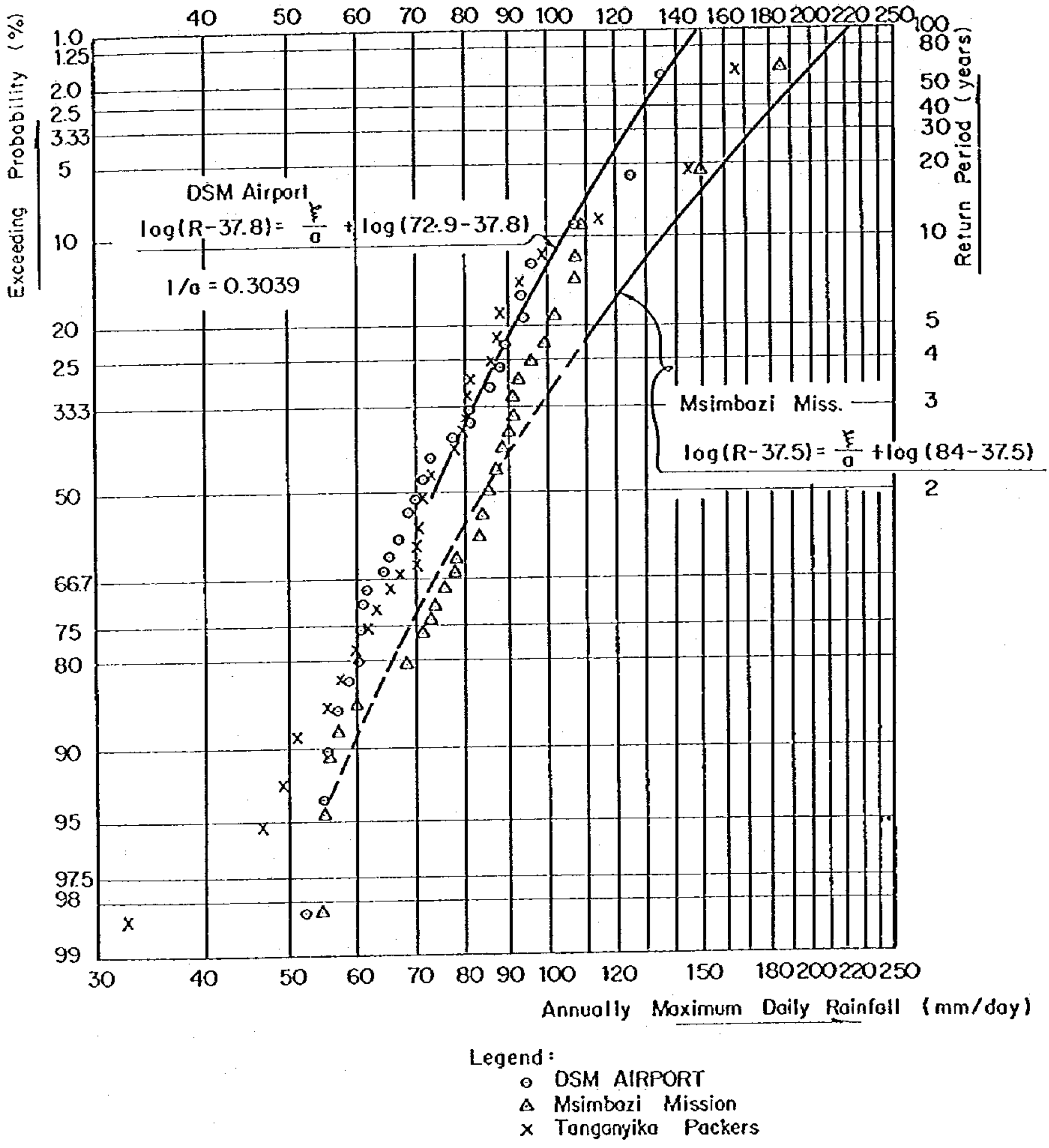


Table 4-1 DSM AIRPORT, RETURN PERIOD OF ANNUALLY MAXIMUM RAINFALL

	Date	R (mm/day)	log R	R-37.8	log (R-37.8)	$\left\{\log \frac{R-37.8}{35.1}\right\}^2$
1	6-4-68	136.9	2.1364	99.1	1.9961	0.2032
2	10-11-63	126.5	2.1021	88.8	1.9484	0.1625
3	13-11-75	108.4	2.0350	70.6	1.8488	0.0921
4	2-5-55	95.5	1.9800	57.7	1.7612	0.0466
5	20-11-80	94.1	1.9736	56.3	1.7505	0.0421
6	3-5-57	94.0	1.9731	56.2	1.7497	0.0418
7	22-5-54	89.7	1.9528	51.9	1.7152	0.0289
8	4-2-61	88.1	1.9450	50.3	1.7016	0.0244
9	10-12-59	86.4	1.9365	48.6	1.6866	0.0200
10	8-5-82	81.0	1.9085	43.2	1.6355	0.0081
11	16-4-72	80.5	1.9058	42.7	1.6304	0.0072
12	12-4-60	77.7	1.8904	39.9	1.6010	0.0031
13	7-4-78	72.4	1.8597	34.6	1.5391	0.0000
14	28-4-73	70.2	1.8463	32.4	1.5105	0.0012
15	4-5-79	70.1	1.8457	32.3	1.5092	0.0013
16	25-4-69	69.1	1.8395	31.3	1.4955	0.0025
17	26-11-77	68.2	1.8338	30.4	1.4829	0.0040
18	28-4-64	66.8	1.8248	29.0	1.4624	0.0069
19	16-4-65	65.4	1.8156	27.6	1.4409	0.0109
20	10-4-62	62.0	1.7924	24.2	1.3838	0.0261
21	20-4-58	61.7	1.7903	23.9	1.3784	0.0279
22	25-1-56	61.2	1.7868	23.4	1.3692	0.0310
23	3-5-81	61.1	1.7860	23.3	1.3674	0.0317
24	14-1-74	59.1	1.7716	21.3	1.3284	0.0470
25	11-4-66	57.4	1.7589	19.6	1.2923	0.0640
26	21-12-67	55.8	1.7466	18.0	1.2553	0.0841
27	15-3-76	55.4	1.7435	17.6	1.2455	0.0899
28	4-5-70	52.7	1.7218	14.9	1.1732	0.1385
	TOTAL		52.5025			1.2470
	Average		1.8751		1.5459	
			Rg = 75.0		Ro = 35.1 - b = 72.9	

$$b_1 = \frac{136.9 \times 52.7 - 75.0^2}{2 \times 75.0 - (136.9 + 52.7)} = -40.1$$

$$b_2 = \frac{126.5 \times 55.4 - 75.0^2}{2 \times 75.0 - (126.5 + 55.4)} = -43.4$$

$$b_3 = \frac{108.4 \times 55.8 - 75.0^2}{2 \times 75.0 - (108.4 + 55.8)} = -29.8$$

Average Value b = -37.8

$$S_x = \sqrt{\frac{1.2470}{28}} = 0.2110$$

$$\frac{1}{a} = \sqrt{\frac{2N}{N-1}} \cdot S_x = \sqrt{\frac{2 \times 28}{27}} \times 0.2110 = 0.3039$$

$$\log (R-37.8) = \frac{\xi}{a} + \log(72.9 - 37.8)$$

Return Period (Years)	Value of ξ	Value of Daily Rainfall (mm)
2	.0000	73
3	.3045	81
5	.5951	91
10	.9062	104
20	1.1631	117
30	1.2971	125
40	1.3859	130
50	1.4522	135
100	1.6450	149

The Msimbazi Creek seems to belong in the 2nd from the lowest in the above classification, "Small brooks in flat area", as underlined. When we consider that the average annual rainfall in Japan being 1,600 mm or so, much rainy than it is in Dar Es Salaam area (1,000 - 1,100 mm), the adoption of f = 0.50 is sufficient one, but not small anyway.

These calculations have lead us to the results as tabulated in the following Table 4-2.

Table 4-2 Return Period of Daily Rainfall & Resulting Peak Flood Discharge

(1) Return Period (Years)	(2) Daily Rainfall Anticipated (mm/day)	(3) Peak Flood Discharge Anticipated (m^3/sec)	(4) Total Flood Discharge (10^6 m^3)
10	104	296	12.5
20	117	333	14.0
30	125	355	15.0
40	130	370	15.6
50	135	384	16.2
100	149	424	17.9

Flood Hydrograph & Resulting Water Level in the Jangwani Area

The inflow hydrographs of 10- and 50-years floods into the Jangwani Area were determined as indicated in Fig. 4-4, with necessary reference were made to the results of previous calculation as follow:

peak discharge was strictly adhered to,
(10 years flood 296 m^3/sec, 50-years flood 384 m^3/sec)

arrival time of flood of 8.2 hrs., as computed, was followed as much as possible, for 10-years flood 8.0 hrs. and for 50-years flood 9.0 hrs.

total flood discharge was also similar to column (4), Table 4-2.

As for the outflow through the Selander Bridge, based on actual survey conducted on site, the discharge was calculated assuming an overflow weir having 30 m length (parallel to the bridge) with its crest elevation located at El. +0.00 m, wherein the discharge can be calculated by the following formula.

$$Q = C \cdot B \cdot H^{\frac{3}{2}}$$

where, Q = discharge (m^3/sec)

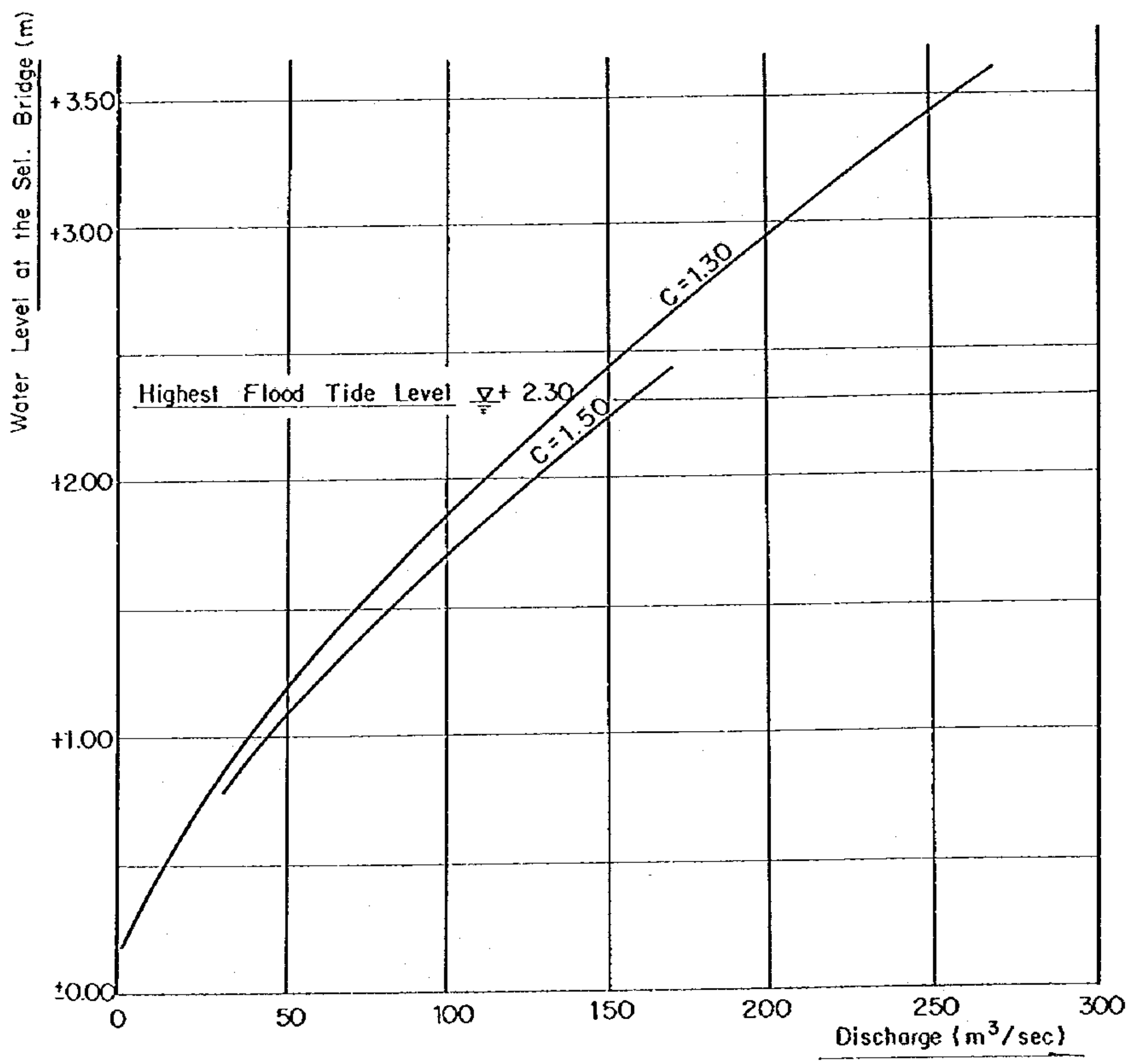
B = crest length (= 30.0 m)

H = water level directly upstream of the Selander Bridge

C = coefficient of overflow.

And as for the value of C, coefficient of overflow, two values, 1.30 & 1.50, were both assumed for 10-years flood in order to analyse what difference are likely to be caused due to the difference. However, for 50-years flood, C = 1.30 only was used to obtain more critical (or higher) value of water level.

Fig. 4-3 DISCHARGE RATING CURVE
(SELANDER BRIDGE)



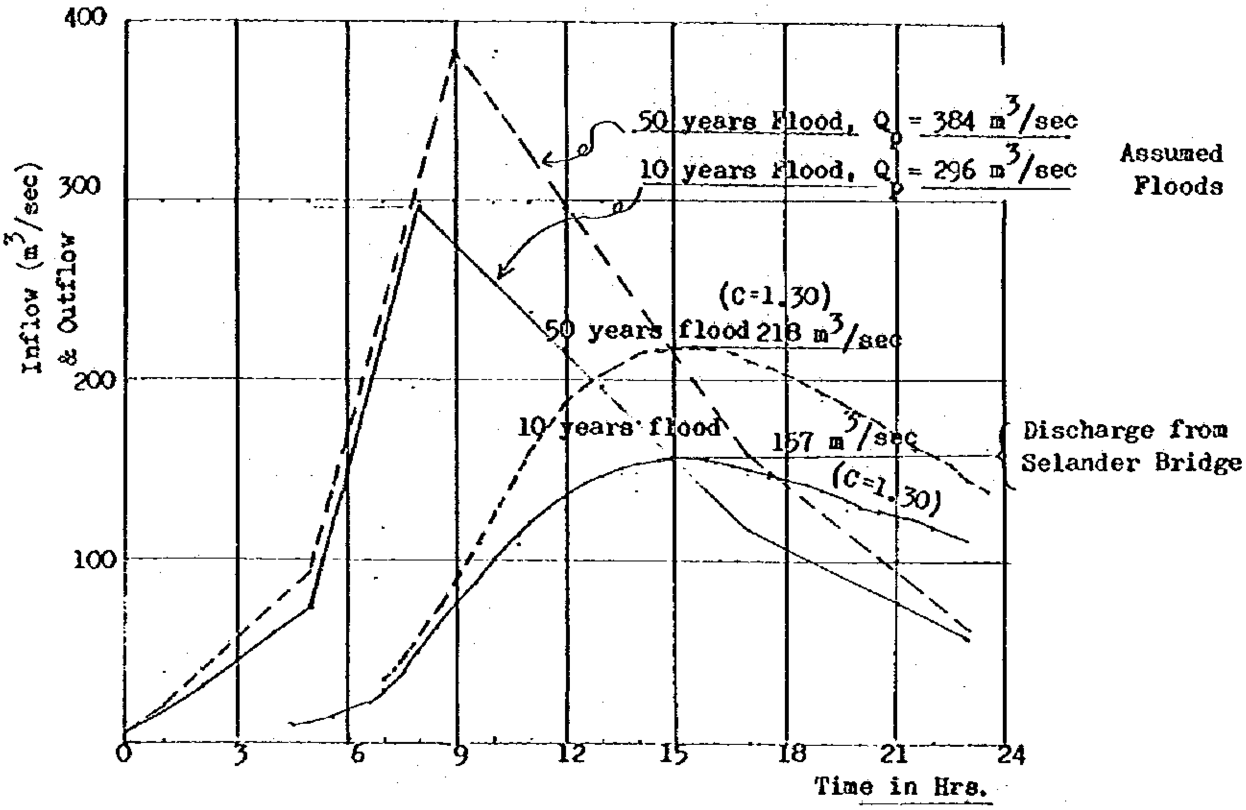
The difference between the inflow hydrograph and discharge from the Selander Bridge is the volume of water to be stored in the river bed between Kigogo Road (approximately) and the Selander Bridge (via the Jangwani area, of course), having an approximate length of 4 km and an area of storage of 2.125 sq.km^2 (= 2.125 x 10^6 m^2). Calculation was conducted at an interval of time of 30 minutes (= 1,800 seconds) each, at every interval the inflow as well as the discharge was calculated, with the difference being divided by the storage area (2.125 x 10^6 m^2) to give change in the water level in the respective time interval. The results of thecalculation is as indicated in Fig. 4-4, with the inflow hydrograph and discharge (upper figure) and water level (lower figure) are indicated. For purpose of clear understanding, the most important results of calculation are as tabulated in the following Table 4-3.

Table 4-3 Water Level in Jangwani Area

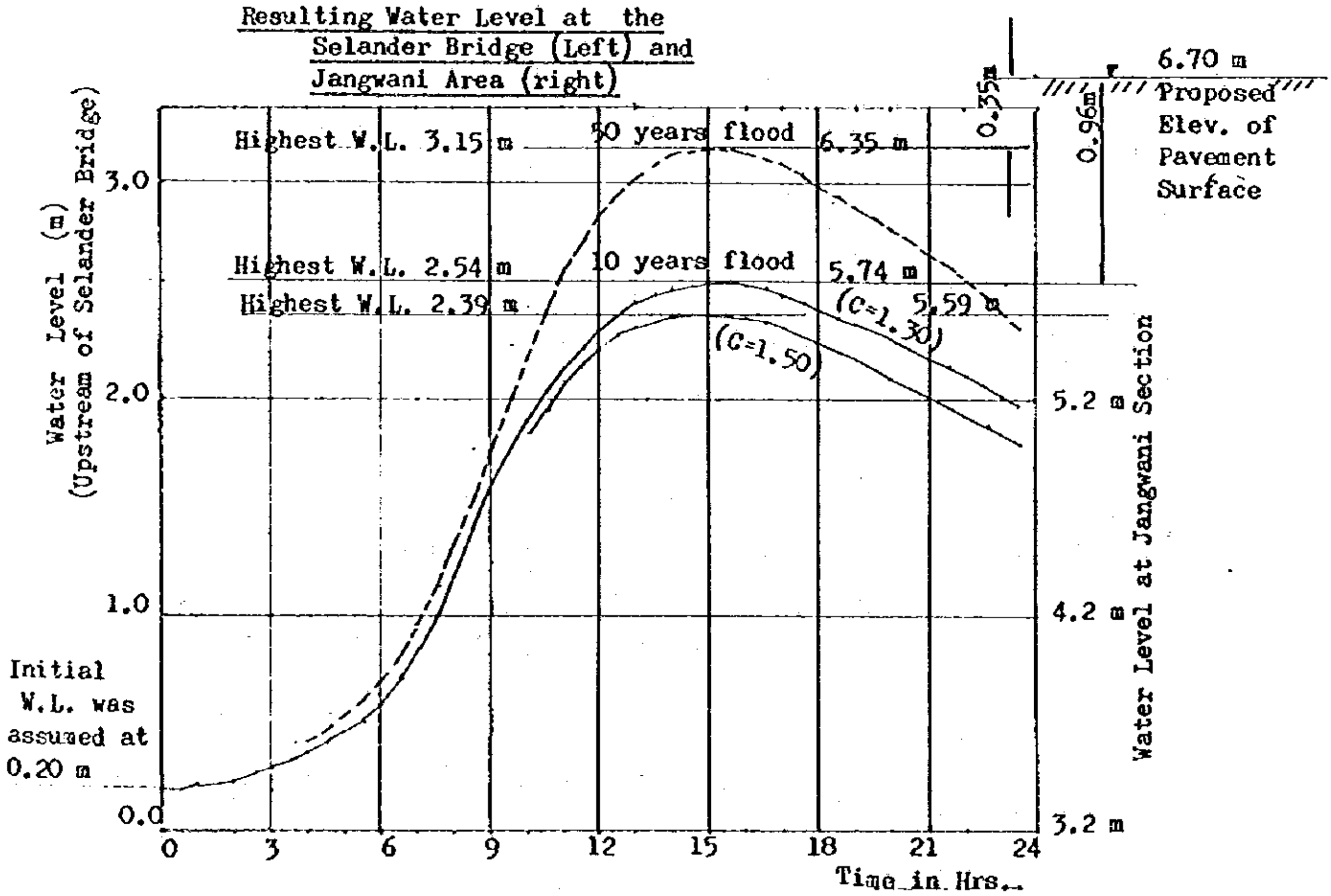
	(1) Peak Inflow (m^3/sec)	(2) Value of C	(3) Peak Discharge from Selander Bridge (m^3/sec)	(4) Highest Water Level	
				Selander B. (El. m)	Jangwani Area (El. m)
10-years flood	296	1.30	157	2.54	5.74
		1.50	166	2.39	5.59
50-years flood	384	1.30	216	3.15	6.35

Note: As an assumption in the calculation, it was assumed that any change in the water level in the Selander Bridge area caused in any time interval (of 30 minutes) will also cause same amount of water level change in the Jangwani area within the same time interval. And further, since the typical ground height beneath of the Selander Bridge being El. +0.00 m, and that of Jangwani area where the Morogoro Road will pass through being El. +3.20 m or so, the water level in the Jangwani area was assumed to be higher than that of the Selander Bridge by 3.20 m always.

Fig. 4-4 Inflow to Msimbazi Creek (Jangwani Area) And Discharge from Selander Bridge



Resulting Water Level at the Selander Bridge (Left) and Jangwani Area (right)



The different value of C, 1.30 & 1.50, give only 15 cm difference in the highest water level attained for the 10-years flood as indicated in the previous Table 4-3. This 15 cm difference, being relatively small one, so that for purpose of further study, water level corresponding to C = 1.30 will be used for purpose of safety, though we haven't any data to tell which value of C would be more suitable than the other, at the moment.

We now introduce some guideline for determining the embankment height, to be constructed on the existing Morogoro Road itself, that about 1.0 m free board is preferably to be left when a flood of which magnitude corresponds to 10-years flood (or peak inflow (at Kigoro area) of 296 ≑ 300 m^3/sec), in order to ensure safety for the public traffic.

Since the highest water level attained in case of 10-years flood being El. 5.74 m, application of the above guideline would give approximate embankment height of El. 6.74 m, and since the El. of existing road in the area being 3.73 m or so, so that if we embank 3.0 m above the existing road surface, the completed road surface of El. 6.70 m would give us a free board of 0.96 m as follows, satisfying the guideline approximately.

free board = (Completed Road Surface, El.) - (Highest Water Level)
= El. 6.70 m - El. 5.74 m
= 0.96 m

Note: (1) If C=1.50 is correct, instead of C=1.30, this would cause additional free board of 15 cm, so that total free board would be 1.11 m as follows.

96 cm + 15 cm = 111 cm

(2) In case the 50-years flood attacking the area, the resulting water level would be El. 6.35 m, with only 0.35 m of free board left, up to the top of the road. This may sound as if the 50-years flood can pass the New Morogoro Road without any difficulty, but this is only a result of calculation. In the actual practice,

however, in the period when water level rising since nobody can tell up to what elevation the water level will rise, so that for the sake of safety of public traffic, well in advance of flood water approaching the top of the New Road, public traffic has to be suspended temporarily, until the flood starts to recede. Such type of unavoidable shut-down of traffic may occur once in every 30 or 40 years, probably. However, this type of shut-down would not last long, in most of the cases, probably not longer than half a day.

The comparison of Morogoro Road inundation, under the present conditions and after 3.0 m of embankment (Improvement Work) is approximately as follows:

Table 4-4 Effect of Proposed Heightening of the Road on Road Shut-down

Magnitude of Flood	Under the Present Conditions	After 3.0 m of Embankment
Middle or large sized flood	One week or 10 days traffic shut-down once, or twice in every 10 years period.	Once in every 30 - 40 years, the traffic may have to be suspended because of high water level approaching the roadway. However, the suspension would be not longer than half a day, probably.
Small sized flood	Traffic shut-down of 1 or 2 days, once or twice a year.	There would be no shut-down of traffic due to small floods, at all.

The effect of 3.0 m embankment upon the traffic shut-down is considered to be something as above, and based on such a consideration, 3.0 m embankment above the existing Morogoro Road can be justified.

Arrangement of Bridges and Box Culverts, and Resulting Flood Velocity

At present, in the Jangwani area there are one bridge and one box culvert as indicated in Column (1) of the following table, Table 4-5, while the present improvement work envisages those works contained in the Column (2), as the flood draining structures.

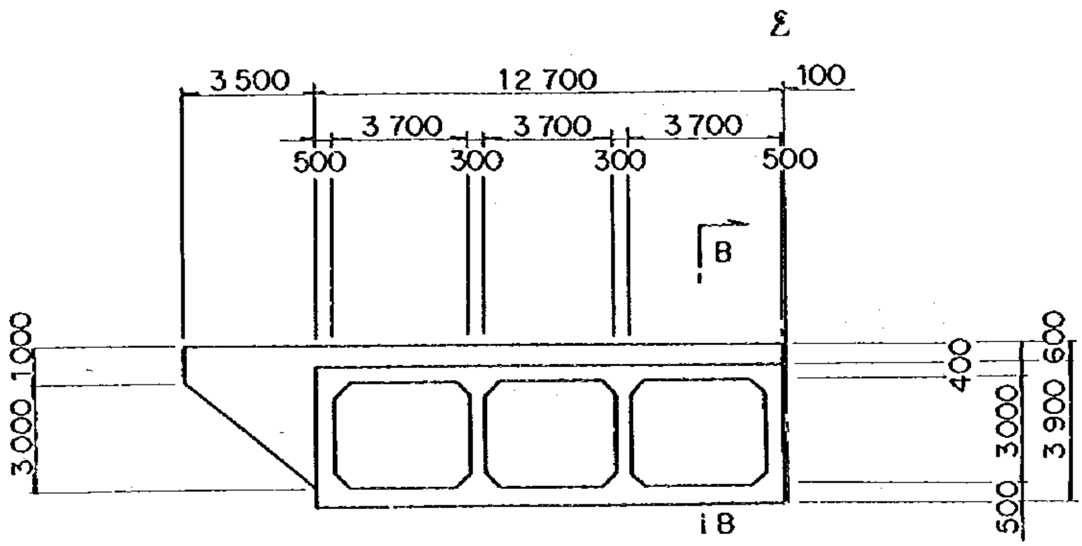
Table 4-5 Comparison of Existing & Improved Draining Structures

(1) Existing		(2) After Improvement	
Reinforced Concrete Bridge	31 mm**	Reinforced Concrete (New) Bridge	45 m*
		Reinf. Concrete Box Culvert	25.5 m
Reinf. Concrete Box Culvert	3.2 m**	Reinforced Concrete (New) Bridge	16 m*

Note: * Clear Span

** To be demolished

After the improvement, as indicated in the above table, a box culvert of total length of 25.5 m, 6 spans of (B = 3.7 m, H = 3.0 m, internal dimension), would be constructed, in order to facilitate drain of inundating water above the playing field (soccer grounds) of which height is at about EL. 3.0 m or so.



As the results of these dimensions and arrangement of draining structures, the mean velocities of flow when 10-years (and 50-years) floods pass through structures are estimated to be 0.9 - 1.2 m/sec approximately, as indicated in Column (6) of the table below.

Table 4-6 Mean Velocity of Floods

	(1) Peak Inflow (m^3/sec)	(2) Value of C	(3) Peak Discharge S. Bridge (m^3/sec)	(4) Estimated Peak at Jangwani (m^3/sec)	(5) Total Area of Flow# (m^2)	(6) Velocity (4)/(5) (m/sec)
10-years flood	296	1.30	157	244*	273.21	0.89
	296	1.50	166	247**	273.21	0.90
50-years flood	384	1.30	218	322***	273.21	1.18

Note: *, **, *** The peak flow of a flood usually decreases approximately in proportion to length of the river in which it flows down, as indicated in the above table also, please compare Columns (1) with (3)). Therefore, Column (4) could be obtained as follows, based on;

total length between Kigogo - S. Bridge 4.0 km,
total length between Jangwani - S. Bridge 2.5 km.

* $157 + (296 - 157)\frac{2.5}{4.0} = 244$

** $166 + (296 - 166)\frac{2.5}{4.0} = 247$

*** $218 + (384 - 218)\frac{2.5}{4.0} = 322$

The above mean velocity is of course an average value for all the area of flow of all the draining structures inclusive, so that in some restricted portion, some larger velocity may occur locally, probably reaching 1.5 - 1.8 m/sec approximately. Therefore, the dimensions of the draining structures are approximately suitable for the flood flow anticipated.

Note: # Calculation of Area of Flow

(1) Completed Surface EL. of Channel	(2) Water Level (EL. m)	(3) Upper Maximum Height of Structure (El. m)	(4) Effective Depth of Water (3)-(1)	(5) Effective Width of Channel (m)	(6) Effective Area of Flow (4)x(5)(m2)
EL.+1.90m	10-y.F. 5.74	5.60m	3.70m	43.3	160.21
EL.+2.70m	50-y.F. 6.35	5.70m	3.00m	22.2	66.60
EL.+2.20m		5.10m	2.90m	16.0	46.4
Total					273.21

$$* \ 157 + (296 - 157)\frac{2.5}{4.0} = 244$$

$$** 166 + (296 - 166)\frac{2.5}{4.0} = 247$$

$$*** \ 218 + (384 - 218)\frac{2.5}{4.0} = 322$$

The above mean velocity is of course an average value for all the area of flow of all the draining structures inclusive, so that in some restricted portion, some larger velocity may occur locally, probably reaching 1.5 - 1.8 m/sec approximately. Therefore, the dimensions of the draining structures are approximately suitable for the flood flow anticipated.

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EL. + 1.90 m	10-y.F. 5.74	5.60m	3.70m	43.3	160.21
EL. + 2.70 m	50-y.F. 6.35	5.70m	3.00m	22.2	66.60
EL. + 2.20 m		5.10m	2.90 m	16.0	46.4
	TOTAL				273.21

4-3 BASIC DESIGN FOR ROADWAY

1) Re-alignment of the Centre line

The centre line of the street from U.W.T. junction to United Nations street has to be shifted about 1.5 m - 2.0 m to the right side facing Jangwani, so as to minimize effect on the existing facilities, buildings and so on, as stated below. Especially in the vicinity of the Msimbazi junction, careful attention was paid to the underground tank of the petrol station in order not to affect it by the widening, and this was the dominant control point for the horizontal re-alignment of 1.5 - 2.0 m, as stated above.

As for the centre line after the United Nations junction toward Morocco Road, existing centre line was maintained.

2) Longitudinal Alignment

(a) The completed surface elevation of the New Road, where the old road remains but widened, was determined to be "5.0 cm higher than the existing level", in view of overlay method of asphaltic concrete to be applied on it.

(b) However, the elevation of the United Nations junction shall be lowered by about 50 cm at its centre so as to decrease very steep existing gradient of 4.5%, down to 3.0%. By this arrangement, it is expected that the driving will become much easier than before, with some increase of road capacity also anticipated.

(c) The proposed height of the Msimbazi Creek Crossing shall be El. +6.70 m, which is 0.70 m higher than the elevation of the existing Msimbazi Bridge. And this elevation, +6.70 m, was determined based on the hydrological study as has been explained under Section 4-2, 6).

3) Pavement Design

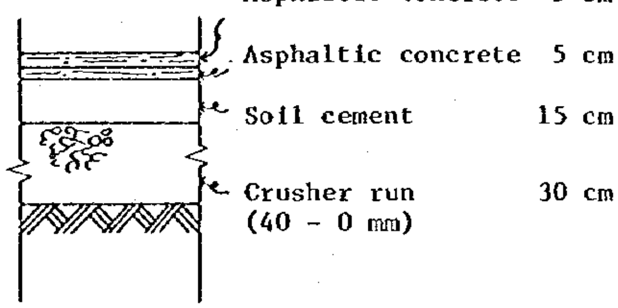
Pavement design shall be made on the basis of the "Design Mannual for Asphaltic Concrete Pavement", issued by Japan Road Association. From the traffic survey data and observation in Dar Es Salaam city, the number of heavy vehicles (more than 10 tons) is estimated to fall within the category, 251 to 1,000 vehicles/day for one direction, as quoted from the "Design Manual for Asphaltic Concrete Pavement".

Traffic Category	Heavy Vehicle Volume (vehicles/day, for one direction)
L	less than 100
A	100 to 250
B	251 to 1,000
C	1,001 to 3,000
D	over 3,000

From the above table, it is concluded that adoption of category B traffic is suitable for futher design of pavement for the Project.

The California Bearing Ratio (CBR) of subgrade is assumed to be 4 from the standpoint of safety side design, since large portion of the pavement rests on the existing ground in the urban (or suburbs) areas, where we have no freedom of selecting subgrade. The required TA and total thickness of pavement are, therefore, required to be 24 cm and 49 cm respectively.

The case of traffic category B		
CBR	TA	Total thickness
3	26 cm	58 cm
4	24 cm	49 cm
6	21 cm	38 cm
8	19 cm	32 cm



Under these conditions, the pavement structure as indicated in the above figure was adopted, namely,

5 cm of asphaltic concrete, surface layer,

5 cm of asphaltic concrete, base layer,

15 cm of stabilized soil cement layer, mixture of locally obtained sand and cement,

30 cm of crusher run layer, 40 mm - 0 mm.

The resulting total thickness and TA value of the above pavement design is,

Total Thickness = 5cm + 5cm + 15cm + 30cm = 55cm

Equivalent Thickness = (5cm + 5cm) x 1.0 + 15cm x 0.55 + 30cm x 0.25
= 10cm + 8.25cm + 7.50cm
= 25.75cm

4) Pedestrian's Walkway and Bicycle Lane

A walkway and a bike lane are to be provided on both sides of the street, but between them no physical obstruction.

Bicycle lane: 1.25 m width, carriageway side, cement concrete pavement

Walkway : 2.25 m width, concrete block pavement of 50 cm x 50 cm x 8 cm

5) Kerb

Height of Curb,

between carriageway and bicycle lane : 20 cm

between carriageway and median strip : 25 cm

6) Roadway Lighting

Lighting poles with a mercury lamp each are to be installed on the both walkways, in the same manner as they were in the Selander Bridge Expansion Project.

The lighting poles are to be located at an internval of 80 m in each walkway to form zigzag shape in plan, if both sides are taken into account.

7) Traffic Signals

In the 4 junctions (except for the U.W.T.), for purpose of safety of vehicles and pedestrians, as well as for increasing traffic capacity, traffic signals are to be provided. Appendix VII indicates the basic design for traffic signals. Also necessary numbers of signals for pedestrians are to be provided.

CHAPTER 5

CONSTRUCTION SCHEDULE AND COST

CHAPTER 5 CONSTRUCTION SCHEDULE AND COST

5-1 MAIN FACTORS AFFECTING THE CONSTRUCTION SCHEDULE

Following two factors have the dominant effects over the construction schedule of the Project.

a. Brrow area of the embankment materials (about 40,000 m^3) was supposed to be within the Msimbazi Creek bed. However, since the downstream area from the existing Morogoro Road being more soft and wet with less trafficability for trucks, so that upstream area might be more suitable as the borrow area, than the downstream one.

   But anyway, the excavated materials have to be stockpiled for some time in order to reduce their water content, before utilizing them for the embankment. Therefore, a few numbers of stockpiles would be placed within the Jangwani area, probably somewhere in the playing field.

b. The production capacity of MECO's crushing plant is not sufficient, at all, in comparison with the requirements in the Project, so that either blockstones, or only primarily crushed stones, obtained from MECO will have to be transported to Msimbazi area, where they will be crushed by crushing plant brought into Tanzania by contractor.

   The best blockstones are available only at Msolwa or nearby area, which is 120 km or so away from Dar Es Salaam.

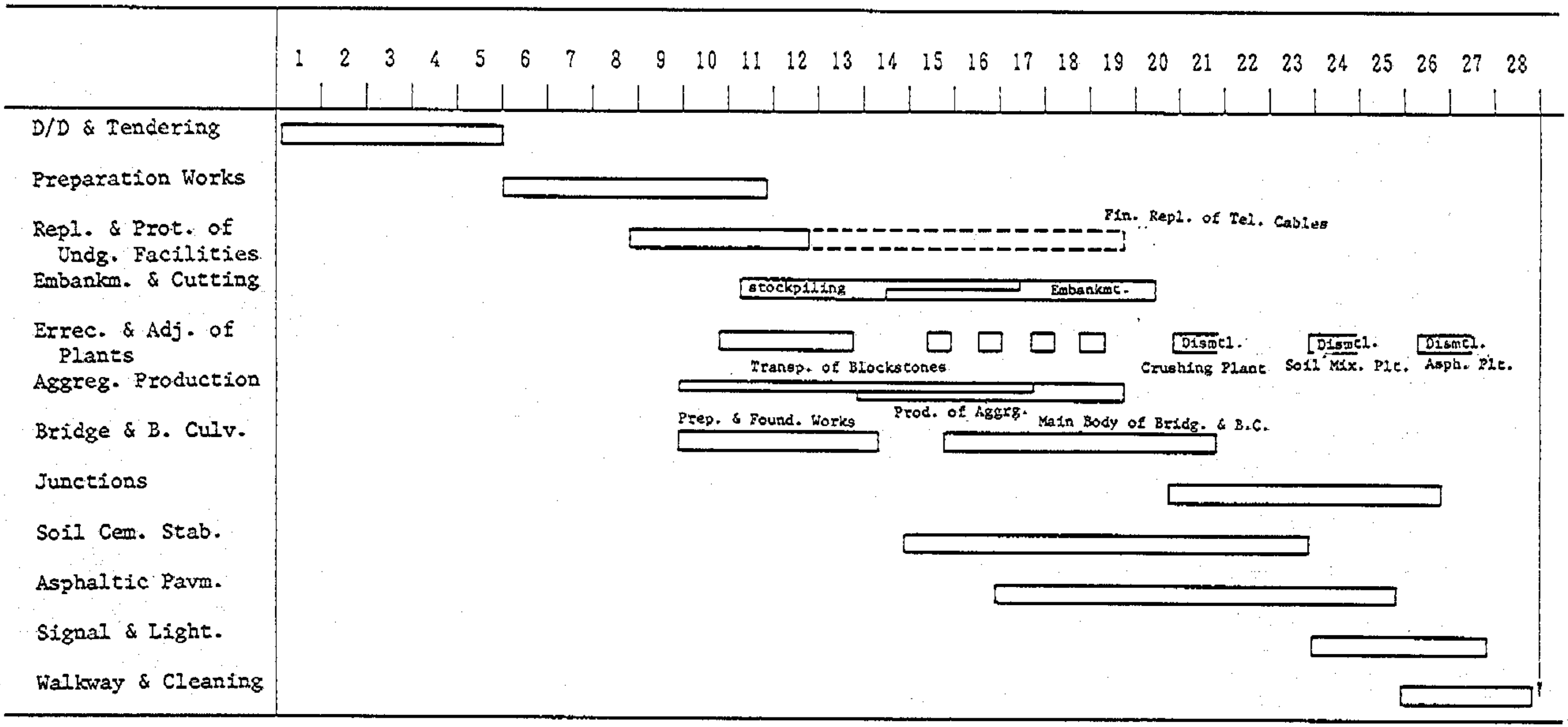
5-2 CONSTRUCTION SCHEDULE

Respective construction period required for each type of works is as follows:

a.	Preparatory Works	
	- until arrival of the first lot of shipment	3 months
	- until completion of field office & quarters	6 months
b.	Shifting of 18 inø water supply main (800 m plus) (including protection work)	3 months
c.	Stockpiling work of embankment materials (50,000 m^3)	4 months
d.	Transportation of Aggregate Materials from Msolwa, crushing and stockpiling	8 months
e.	Crushing Plant, Soil Mixing Plant, Asphalt Plant, erection and adjustment	3 months
f.	Embankment work	6 months
g.	Soil cement base (13,500 ton)	9 months
h.	Improvement of Junctions &	6 months
	Pavement work (9,000 ton)	9 months
i.	Signals & lighting, installation & adjustment	4 months
j.	Walkway & site cleaning	3 months

By the above estimate, the overall construction schedule can be devised as indicated in Fig. 5-1, wherein the first 5 months period was allocated for detailed design, tendering and tender evaluation, etc.

Fig. 5-1 Construction Schedule



5-3 CONSTRUCTION COST

The construction cost estimated so far revealed that TSh 12.5 million approximately would be required, as the local portion of the cost, mostly of which is consumed for purpose of purchasing local products, block stones for aggregates and/or crusher run and materials from Kunduchi etc., in addition to labour cost for operators and labourers of local origin.

CHAPTER 6

ORGANIZATION FOR EXECUTION OF THE IMPROVEMENT WORKS

CHAPTER 6 ORGANIZATION FOR EXECUTION OF THE IMPROVEMENT WORKS

6-1 DURING THE CONSTRUCTION

During the construction of the improvement works, the Ministry of Works of the Government of Tanzania will assume the top position for the overall fieldwork execution, with the details being taken care of by its Road Division. The Consultants, in addition to assisting the MOW, shall carry out management and supervision of contractor's works, based on Specifications and other Contract Documents.

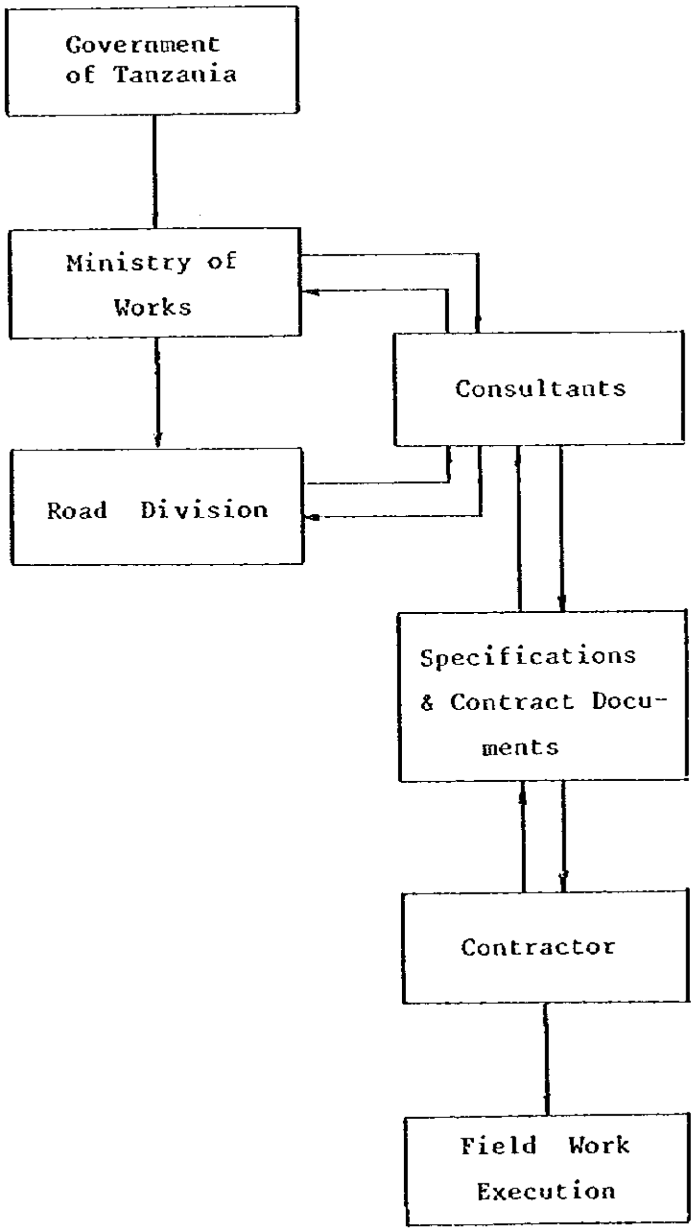
And further, when required, the Consultants shall keep contact with the City Council (as for evaculation from houses to be removed, sewerage and storm water pipes etc.) and Polis (in connection with Traffic control etc.) in order to have smooth progress of the works. (For other public utilities, such as cables and pipes etc., they were mentioned in previous relevant sections, 3-3, 2), already.

6-2 MAINTENANCE, REPAIR AND MANAGEMENT OF THE ROAD

After completion of the Project, the Improved section of the Morogoro Road, 2.7 km approximately, will be maintained and repaired by the Road Division of MOW as a part of the Morogoro Road in general (with a total length of 180 km), with some numbers of equipment as well as personnel have been already assigned for maintenance work purpose of roads in and around the Metropolis, but especially after the completion, further strengthening of this team is expected.

Approximately, Yen 1 million per year may be required for maintenance & repair in the 2.7 km stretch of the Improved section, but this expense is of course to be borne by MOW. And further, a part of the Project, such as signals (for vehicles and pedestrians) need be handed over to the Polis, with necessary instructions of operation are given to the relevant staff.

Fig. 6-1 Organization Chart



CHAPTER 7

EVALUATION OF THE PROJECT

CHAPTER 7 EVALUATION OF THE PROJECT

Following types of direct and indirect effects of the Project are conceivable.

1) Direct Effects

- Decrease in vehicle operating cost due to vanishing of congestion (Appendix VI treats this benefit, specially.)

- Decrease in running time of vehicles due to vanishing of congestion (About 30 minutes of commuting time could possibly be saved, everyday morning.)

- Increase in traffic capacity of the Road due to vanishing of congestion (The widening and improvement of junctions combined will increase the capacity of the Road more than 2 times the existing one.)

- All Weather Road (Maintaining traffic even during the rainy season.)

- Safety for the pedestrians (In the present road, there is not foot path provided for the pedestrian, specifically. However, in the new Road concrete block paved walkways are to be provided, in addition to two bicycle lanes.)

- After completion of the new Road, some large portion of the traffic may be attracted to the new Road because of very much comfortable driving there, so that for the rest of the other trunk roads, possibility of maintenance could be realized.

- Environmental improvement along the new Road, faster and easier transportation.

- Less deterioration of transported goods, maintaining better quality of goods or products

2) Indirect Effects

- Streamnising the urban traffic inside the City (The largest agony of Bus Company in Dar Es Salaam at the moment is that due to the congestion, average operation speed by buses being very low, so that they can transport only very restricted numbers of passengers everyday. This situation could possibly be improved by the Project.)

- Renewal of functions of public facilities to be renewed, such as water pipe main, international telephone cables etc.

- Better efficiency in social activities of any kind,

- Expansion of social productivity

- Prices reduction, due to faster, easier transporation and less damages on goods and products transported.

- Development along the Road

- Higher utilization of land

- Psychological stability for the inhabitants

Because of removal of difficulties in traffic at the entrance to the Metropolis, the communication with the rest of the country will become much more familiar and easy, with more reliance on the road traffic than ever could be brought about, and also with necessary engineering technics transferred.

And further, among the various direct benefit expected due to the implementation of the Project, the savings in the fuel cost (which is a part of the vehicle operation costs) were calculated as indicated in Appendix VI, which indicated that about 6.8 % of Internal Rate of Return could be anticipated, assuring some large saving in the operating costs further into the future.

CHAPTER 8

CONCLUSION AND RECOMMENDATION

CHAPTER 8 CONCLUSION AND RECOMMENDATION

The Morogoro Road, not only due to its very much dominant position in the whole road system in Tanzania, but also due to its importance as one of the indispensable daily commuting roads around the Metropolis, the effects and benefit to be derived from the Project Implementation are large, as has been explained in the previous Chapter 7, such as the appreciable saving in the future fuel cost around the Metropolis, in addition to about 30 minutes of saving in commuting time everyday morning.

In spite of these benefit upon the stabilization of everyday lives of local people, the Tanzanian Government could not afford to carry out the Project so far.

Therefore, if the Japanese Government determines to carry out the Project Implementation based on the Grant Aid basis, this will be definitely beneficial to the future good relationship between the two countries.

However, it would be worth-while to repeat here again that the sufficient supply of fuel has to be ensured and has to be actually conducted to contractor, under any conditions, all through the construction period, since if there are repeated stops in contractor's operation of equipment due to short supply of fuel, this may cause the contractor raising claims.

APPENDIX I

PROJECT PROPOSAL FROM

THE TANZANIA GOVERNMENT

APPENDIX I PROJECT PROPOSAL FROM THE TANZANIA GOVERNMENT

PROJECT PROPOSAL

IMPROVEMENT OF MOROGORO ROAD: MAGOMENI-KISUTU SECTION

1. BACKGROUND

The Morogoro road is one of arterial lines to Dar es Salaam connecting Magomeni, Kisutu and the suburbs of Dar es Salaam, which plays an important role for daily transportation of commodities, vegetables, grain, etc.

Due to the recent increase of traffic volume, the Morogoro road is congested at the entrance of Dar es Salaam, namely the section between Magomeni and Kisutu in daily peak hours.

The present capacity of this road portion is about 1400 vehicles per hour but owing to the excessive congestion in the morning peak hour (7.00 a.m. to 8.00 a.m.) only 900 vehicles per hour can pass through the road portion.

Further, in the rainy season, all traffic is interrupted sometimes in the above section because of inundation caused by flooded Msimbazi creek.

Therefore, improvement of the Morogoro road in that section and resolution of such congestion are urgently required in Dar es Salaam.

Incidentally, high technology and good organization will be required at the implementation stage in order to facilitate traffic movements within the project area.

2. THE PROJECT

The project is located at the section between Morocco Road junction at Mogomeni and UWT road junction at Kisutu and comprises construction of a viaduct and widening of theroad in the above section for a total length of about 2.7 km.

Main Project Feature is as follows:

(I) Viaduct Bridge

About 90m length consisting of continuous box culverts of RC structure without Pile Foundation.

(II) Embankment

Embankment works in both approach roads to the Viaduct Bridge improving the existing road profile of sag shape and pavement works. 710 M long in total.

(III) Widening and improvement of the existing bridge.

(IV) Traffic signals and road widening

Setting of road signals at 4 junctions and road widening from 2 lanes to 4 lanes.

3. ESTIMATED PROJECT COST

The above preliminary plan is prepared from the view point of cost minization, which will be reviewed and decided in the basic design stage. The total estimated project costs is as follows:

(i)	Detailed investigation, basic design and supervision of construction : Yen 200 m		Yen 200 m.
(ii)	Construction proper : Yen		Yen 1,750 m.
	Total estimated project cost		Yen 1,950 m.

4. IMPLEMENTATION SCHEDULE

Implementation schedule of the Project is about 30 months starting from detailed investigation and basic design as follows:

I)	Detailed investigation and basic design	1st - 5th Month
II)	Tendering and contracting	6th - 8th Month
III)	Contract verification	9th Month
IV)	Mobilization of plant and equipment	10th - 14th Month
V)	Earth work and pavement	15th - 30th Month
VI)	Viaduct Bridge construction	19th - 30th Month
VII)	Installation of road signal	25th - 30th Month
VIII)	Completion	30th Month

APPENDIX II

ACTIVITIES OF THE INVESTIGATION TEAM

APPENDIX II ACTIVITIES OF THE INVESTIGATION TEAM

1) Members of the Team

Team Leader		
	Mr. Y. Shioi	Environment Assessor, North-Eastern Construction Bureau Ministry of Construction
Management & Control		
	Mr. T. Komori	Basic Design Section, Grant Aid Division Japan International Cooperation Agency
Hydrology		
	Mr. T. Tamura	Overseas Operation Division, Nippon Koei Co., Ltd.
Bridge Design Engineer		
	Mr. T. Shimura	2nd Civil Engineering Division, Nippon Koei Co., Ltd.
Road Design Engineer		
	Mr. T. Kawakami	Transportation Engineering Dept. Nippon Koei Co., Ltd.
Construction Schedule Engineer		
	Mr. A. Morikawa	Transportation Engineering Dept. Nippon Koei Co., Ltd.

2) Investigations Conducted

30th	Jan.	1984	Arriving DSM	Jap. Emb., JICA, field reconnaissance
31st	"	"		Min. of Finance, MOW, City Council
1st	Feb.	"	Wednesday	City Council, Harbour A., Meteorology
2nd	"	"		Min. of Land, Flood Tracing, MOW Mat. Labo.
3rd	"	"	Friday	City Coun., Min. of Land, Flood, DSM Univ. Survey
4th	"	"		Rainfall Data, Flood Tracing, Underg. Facilities, Surveying
5th	"	"	Sunday	Data Analyses, Kunduchi Quarry, Test Pits, Survey
6th	"	"		Explanation of Minutes, draft, Survey
7th	"	"		Minutes, DSM. Univ., Survey
8th	"	"	Wednesday	Minutes signed
9th	"	"		Jap. Gov. officers returned to Jap. Min. of Land, City Council, Facilities
10th	"	"	Friday	Harbour office, Tax Office, Meteorology, Facilities, DSM Univ., Survey
11th	"	"		Min. of Pln. & E. Affairs, Boring, Msolwa (Aggregates)
12th	"	"	Sunday	Data Analyses, Boring
13th	"	"		Min. of Land, DSM Univ., Boring, Survey, Vehicle's costs
14th	"	"		Min. of Pln. & E.A., Tax Office, Boring, Facilities, Removal of H'ses
15th	"	"	Wednesday	Min. of Pln. & E.A., Min. of Transp. & Commun., Boring & Survey

16th Feb. 1984			Traffic Count, City Council, Tidal Level
17th " "		Friday	Conference with MOW as to details of design, Tidal Level, City Council
18th " "			Farewell to related offices
19th " "		Sunday	Return Preparation
20th "			Return to Japan
22nd " "			Arriving Tokyo

APPENDIX III

MINUTES OF DISCUSSIONS

APPENDIX III MINUTES OF DISCUSSIONS

MINUTES OF DISCUSSIONS

ON

THE MOROGORO ROAD IMPROVEMENT PROJECT, DAR ES SALAMM,

THE UNITED REPUBLIC OF TANZANIA

In response to the request by the Government of the United Republic of Tanzania for assistance in improving the Morogoro Road at Dar es Salaam (hereinafter referred to as "the Project"), the Government of Japan has sent through the Japan International Cooperation Agency (JICA) a study team headed by Mr. Yukitake SHIOI, Inspector for Environment, Tohoku Regional Construction Bureau, Ministry of Construction, to conduct the Basic Design Study on the Project from 30th of January to 20th of February, 1984.

The Team held a series of discussions and exchanged views with the relevant Authorities of the Government of the United Republic of Tanzania.

As a result of the study and discussions, both parties have agreed to recommend to their respective Governments to examine the result of the survey attached herewith towards the realisation of the Project.

February 8th, 1984.

Y. Shioi

Yukitake SHIOI
Leader
Japanese Study Team

for P. J. MKANGA
Principal Secretary
Ministry of Works

Attachments

1. The objective of the Project is to improve the Morogoro Road at Dar es Salaam.

2. The proposed site of the Project is at the section of Morogoro Road between Morocco Road junction at Magomeni and UWT Street junction at Kisutu, with length of about 2.7km.

3. The main role of the Project is as follows :-

   Due to the recent increase of traffic volume, the Morogoro Road is congested at the entrance of Dar es Salaam, mainly the section between Magomeni and Kisutu in daily peak hours.

   Furthermore, during the rainy season, traffic is sometimes interrupted in the above section becuase of inundation caused by flooded Msimbazi Creek.

   Therefore, the main role of the project is to resolve the above mentioned problems.

4. The Japanese Study Team will convey the desires of the Government of the United Republic of Tanzania to the Government of Japan that the latter will improve the Morogoro Road as listed in Annex I within the scope of Japanese economic cooperation in grant form.

5. The Japanese Study Team stressed the necessity to remove properties within right-of-way before the start of construction.

6. The Government of the United Republic of Tanzania will take the necessary measures listed in Annex II on condition that the grant assistance by the Government of Japan is extended to the Project.

7. Both sides confirmed that the Japanese Study Team explained Japan's Grant Aid Programme and that the Tanzanian side understood it.

Annex I

Main Project Feature is as follows :-

(1) Widening and improvement of the existing road from 2 lanes to 4 lanes dual carriageway, with section as shown in the appendix attached.

(2) Embankment for appropriate longitudinal profile higher than the highest flood level anticipated.

(3) Construction of bridges and culverts enough to pass the flood water.

(4) Channelisation at major junctions with provision of traffic signals and lighting, as required.

Annex II

Required Arrangements to be undertaken by the Government of the United Republic of Tanzania

1. To give necessary approval and assistance for the items of investigation that the Consultant may require during detailed design stage, such as mechanical borings, surveying, testing, etc.

2. To secure land necessary for the construction and to clear the site as needed before the start of the construction.

3. To ensure prompt unloading, tax exemption and customs clearance at ports of disembarkation in Tanzania and prompt internal transportation therein of the products purchased under the grant.

4. To exempt Japanese nationals engaged on the Project from customs duties, internal taxes and other fiscal levies which may be imposed in Tanzania with respect to the supply of the products and services under the verified contracts.

5. To accord without delay to Japanese nationals whose services may be required in connection with the supply of the products and services under the verified contract such facilities as may be necessary for their entry into Tanzania and their stay therein for the performance of their work.

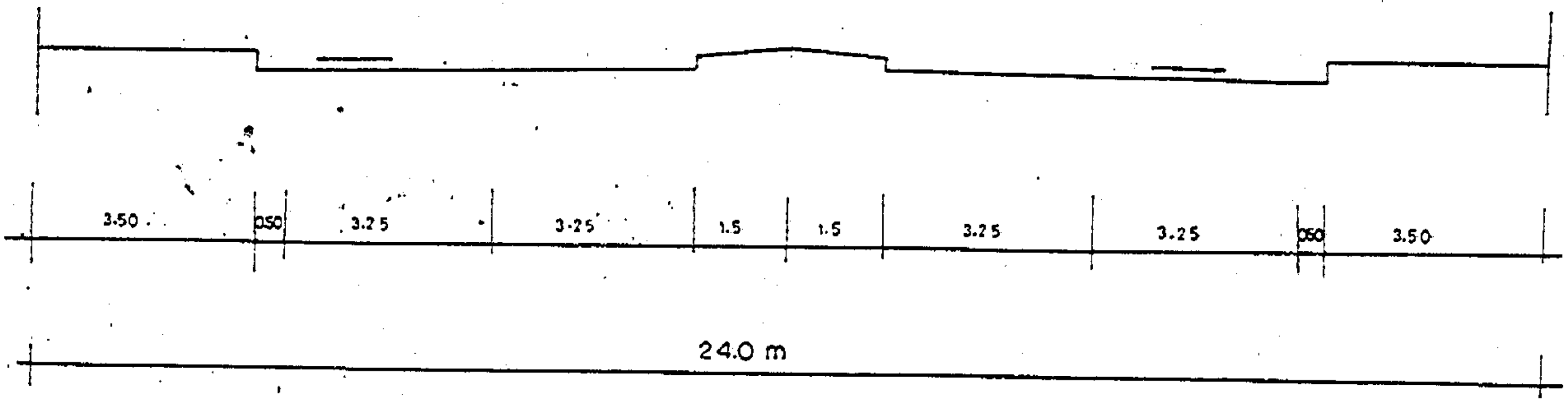
6. To maintain and use properly and effectively the road constructed under the grant.

7. To bear all the expenses, other than those to be borne by the grant, necessary for the construction of the facilities as well as for the internal transportation of the products and services under the grant.

8. To provide the space necessary for such construction as temporary offices, working areas, stock yards and others.

APPENDIX

PROPOSED STANDARD



Scale 1:100

APPENDIX IV

GROSS DOMESTIC PRODUCT

APPENDIX IV GROSS DOMESTIC PRODUCT

Shillings million

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
AT CURRENT PRICES:													
1. Gross domestic Product at F.C	8215	2057	10032	11490	14010	16906	20645	26569	29557	32575	36176	39022	42190
2. Gross domestic Product at M.P	9173	9014	11172	13103	15994	19011	23412	29740	33144	36545	40707	45460	47053
3. Gross National Product at F.C	8192	8010	9990	11439	13973	16935	20545	26401	29512	32500	36064	39645	41952
4. Gross National Product at M.P	9149	9767	11130	13052	15957	18950	23012	29662	33059	36474	40563	45325	47615
5. Net National Product at F.C	7679	8255	9370	10567	13139	16023	19545	25321	20214	31040	34402	37023	39002
6. Net National Product at M.P.	8637	9212	10518	12100	15123	18051	12312	20491	31001	35014	38933	43469	45465
7. Gross Capital formation	2067	2591	2439	2760	3516	4004	4761	5641	6902	8447	8406	9924	9561
8. Private final Consumption Expenditure	6396	6050	8110	9259	11818	14171	15206	21104	25279	26055	32433	33078	35552
9. S a v i n g	1215	1201	2172	1070	799	1310	3501	4011	2210	3650	2029	4760	3943
AT 1966 PRICES:													
10 Gross Domestic Product at F.C	7600	8001	8539	8600	9020	9533	10163	11657	11253	11607	12014	11012	11427
11 Gross Capital Formation	1021	2175	1740	1029	2061	1894	2112	2144	2341	2016	2427	2692	2570
PER CAPITA GDP at F.C													
12 At Current Prices (Shs.)	637	660	737	727	906	1159	1352	1503	1734	1061	2002	2136	2188
13 All 1966 Prices (Shs.)	595	604	625	620	620	652	667	663	660	· 663	665	633	593

APPENDIX V

HYDROLOGICAL & HYDRAULIC ANALYSIS

APPENDIX V HYDROLOGICAL & HYDRAULIC ANALYSIS

1) The Accuracy of Raingauge Stations

There are 6 raingauge stations available in and nearby the basin of the Msimbazi Creek. Among them, the annually maximum rainfall record in the three stations as follow were plotted on the figure on the next page.

	Location
Dar Es Salaam Airport	11 km west of DSM
Msimbazi Mission	between the Creek & Pugu Road
Tanganyika Packers	11 km north of DSM

What is apparent on the figure is that, while the data for the DSM Airport are distributed along the regression line as indicated in the figure, from the lowest rainfall up to the largest one. However in case of Msimbazi Mission, the largest two records indicate very large a deviation from the rest of the data. And same tendency is also observed in case of Tanganyika Packers.

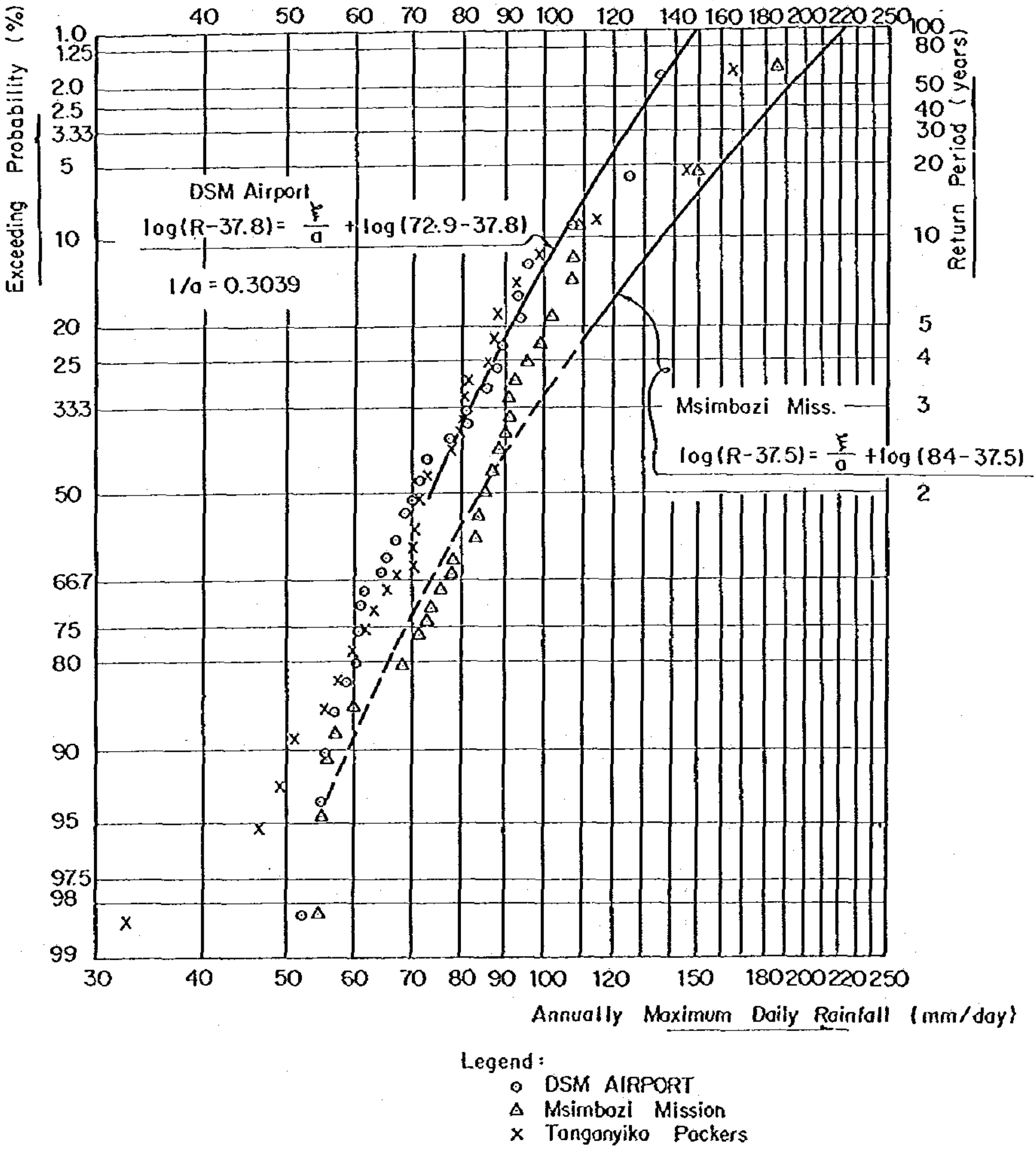
(More exactly speaking, the regression line itself, indicated in the figure, was drawn based on calculation conducted according to the positions of the plotted data, but as it was explained for the Msimbazi Mission data, if there is too much a deviation (or gap) between the(1st & 2nd largest data)and(3rd and subsequent data),there can be no simple regression line that can cover the deviation (or gap), smoothly.)

Contrary to these data of the annually maximum ones, total annual rainfall in respective rainfall gauging station is always smaller than DSM Airport, as indicated below.

	DSM Airport	Msimbazi Mission	Tanganyika Packers	Chemical Laboratory	Ubungo Maji
Period	'57-'82	'56-'82	'57-'82	'54-'82	'59-'82
Number of Years*	26	25	25	25	23
Average Rainfall	1,144mm	1,094mm	919mm	1,083mm	1,054mm

* Years, in which annual rainfall was not obtained, excluded.

Fig. 1 Exceeding Probability & Return Period of the Annually Maximum Daily Rainfall



In every gauging stations, the above average rainfall is the average for a period of 23 or more years, which is not a short period anyway. However, always the annual average rainfall is smaller than the DSM Airport, but with the tendency of annually largest rainfall being at least equal to, or often much larger than that of DSM Airport.

And further, excepting the DSM Airport, other gauging stations are not necessarily the organization in which the weather observation is the main item of their functions. (Msimbazi being a Christian mission, Tanganyika Packers being a factory, and Chemical Laboratory being a laboratory as its name implies.)

Therefore, it may not be an excessive guesswork if we consider that in these rainfall gauging stations on the day after a severe rainfall which recorded the largest (or 2nd largest) rainfall in the past, due to some confusion in the traffic etc., they could not carry out the rainfall measurement at exactly the same time of the day (say for instance, 9:00 a.m. everyday), with a few hours or possibly one day of delay unavoidably caused, so that their record in the past tends to be larger value than for the fixed time observation. In the Dar Es Salaam Airport, weather observation should occupy much more important portion of their routine work schedule than in other gauging stations, with more number of staff assigned on it, so that fixed time observation would be more easy.

Based on such consideration, the rainfall data of DSM Airport only was used to analyse the flood discharge from the Msimbazi Creek.

2) The Flood Experienced in 1978

During the investigation conducted this time, it was found that in 1978 there was a large flood which closed the Morogoro Road for a week or 10 days, as a result of "tracing of old floods" along the Msimbazi Creek. Therefore, we futher studied the rainfall data in DSM Airport in detail and found that in the second half of November, 1978, there was a series of rainfall that lasted for a week (or 10 days), though the largest daily rainfall recorded was only 70 mm/day, on 25th Nov. '78, but on other days 10-50 mm/day.

These rainfall data together with the tide level at that time obtained from the DSM Harbour Authority, are indicated in the table on the next page.

Therefore, it is very much probable that the traffic shut down in Nov. '78 took place sometime around 25th Nov. 1978. Since the rainfall continued for a week or more, the basin of the Creek should be very much wet, so that the coefficient of discharge, which was assumed to be 0.50 in section 4-2, 6), for purpose of estimating flood discharge for a single rainfall (but not sustained one), might possibly be a little bit large a figure, so that 0.60 is used for purpose of estimating flood discharge in Nov. 1978, as follow, for a daily rainfall of 70 mm/day, 25th Nov. '78.

$$T = 8.2 \text{ hrs.}$$

$$r = \frac{R24}{24}\left(\frac{24}{T}\right)^{2/3} = 0.0853\ R24$$

$$Qp = \frac{1}{3.6}\ f.r.A = \frac{0.60 \times 0.0853\ R24}{3.6} \times 240 = 239\ (m^3/sec)$$

Therefore, it is likely that the peak flood discharge at that time was something 240 (m^3/sec), which is about 80% of the peak flow discharge (296 ≒ 300 m^3/sec), which is anticipated to occur once in every 10 years period.

The information obtained from the flood tracing conducted on site said that the water level in the Creek at that time reached up to 1 ft. below the cross beam of the existing Msimbazi Bridge, an elevation corresponding to EL. +4.50 approximately. Since the existing road surface being at El. +3.70 approximately, the inundated depth of water above the road should be something 0.80 m or so, as follow.

$$4.50 \text{ m} - 3.70 \text{ m} = 0.80 \text{ m}$$

(It is regretted that, although the depth of inundation is approximately revealed as above, we can not convert it to a discharge from the Creek, because at that time the overflow of water over the existing road was in a condition of "submerged weir", of which discharge is not simple as ordinary "weir".)

As has been stated above, even under 80% of discharge of "once in 10-years period flood", the present Msimbazi Creek becomes impassable.

Table 1 A LONG SPELL OF RAINFALL, 15/11/'78 - 3/12/'78 INCLUDING TIDAL LEVEL

Date:	16 NOV.	17 NOV.	18 NOV.
Tide Level(m)	+1.9 -1.5 +1.6 -1.4	+1.8 -1.4 +1.5 -1.3	+1.7 -1.3 +1.3
Time	04:55 10:57 17:06 23:01	05:18 11:29 17:39 23:32	05:49 12:00 18:10
Daily Rain-fall	-	-	4.8 mm
Date:	**19 NOV.**	**20 NOV.**	**21 NOV.**
Tide Level(m)	-1.1 +1.5 -1.1 +1.2	-0.9 +1.2 -0.9 +1.0	-0.8 +1.1 -0.7 +0.9
Time	00:04 06:21 12:32 18:42	00:38 06:53 13:07 19:17	01:13 07:30 13:45 19:59
Daily Rain-fall	52.3 mm	42.7 mm	5.5 mm
Date:	**22 NOV.**	**23 NOV.**	**24 NOV.**
Tide Level(m)	-0.6 +0.9 -0.6 +0.7	-0.4 +0.7 -0.4 +0.7	-0.3 +0.7 -0.4 +0.7
Time	01:58 08:16 14:36 20:56	02:58 09:21 15:46 22:19	04:34 10:55 17:20 23:50
Daily Rain-fall	9.1 mm	37.7 mm	29.8 mm
Date:	**25 NOV.**	**26 NOV.**	**27 NOV.**
Tide Level(m)	-0.4 +0.7 -0.5	+1.0 -0.7 +0.9 -0.7	+1.2 -0.9 +1.1 -0.9
Time	06:12 12:24 18:36	00:57 07:19 13:27 19:31	01:48 08:06 14:15 20:13
Daily Rain-fall	70.0 mm	48.7 mm	17.5 mm
Date:	**28 NOV.**	**29 NOV.**	**30 NOV.**
Tide Level(m)	+1.5 -1.2 +1.3 -1.1	+1.7 -1.4 +1.5 -1.3	+1.9 -1.2 +1.6 -1.4
Time	02:27 08:47 14:56 20:53	03:08 09:25 15:34 21:29	03:46 10:02 16:12 22:06
Daily Rain-fall	19.0 mm	-	-
Date:	**1 DEC.**	**2 DEC.**	**3 DEC.**
Tide Level(m)	+2.0 -1.7 +1.7 -1.5	+2.1 -1.7 +1.7 -1.5	+2.0 +1.6 -1.6
Time	04:24 10:40 16:49 22.45	05:02 11:18 17:29 23:25	05:43 11:58 18:11
Daily Rain-fall	-	-	-

Note: Above tidal levels have already been adjusted by reducing 1.4 m from their original values in the "Tidal Table in 1978", in order to represent the tidal level by ordinary elevation.

3) Effect of High Tide in the Outer Sea on the Discharge and Water Level in the Msimbazi Creek

(1) General

The Msimbazi Creek is a small river, having a catchment area of 240 km^2, which discharges into the Indian Ocean, however this ocean in the East African side there are relatively large differences in the tidal level, between those of flood tide and ebb tide that ensues, as exemplified as follow:

Example: <u>6th April, 1981</u>

(1) Time	(2) Tide Level (m)	(3) Difference in Successive Max. and Minimum	(4) Tidal level Expressed in Terms of Usual EL.
05:01	+ 3.4		+ 2.0
		) 3.9 m	
11:05	- 0.5		- 1.9
		) 4.2 m	
17:23	+ 3.7		+ 2.3
		) 4.1 m	
23:30	- 0.4		- 1.8

Therefore, it was afraid in the beginning of the study that whether this large difference in tidal level, or more exactly speaking, whether the higher tide leval in the outer ocean affects very much the discharge from the Creek resulting in a higher water table in the Msimbazi Creek, if the higher tide level coincides with the flood discharge from upstream area.

Speaking of the conclusion, firstly, the reply for above question is rather negative, in that the water level in the Creek may be affected by 10 cm or 20 cm at the maximum, possibly, but nothing more. And considering the general accuracy in calculation, all through this Hydrological & Hydraulic Analyses of the Project, this error of 10 or 20 cm is not so much an important factor.

(2) Difference Between Tidal Level and Usual Elevation

Going back to the study of the original question, the first thing we will have to do is to obtain the difference between;
the level indicated in the Tidal Table,
and usual level used in the ordinary civil engineering works.

The first level as indicated in the Tidal Table is determined from some Geo-Physical study, and there is no guarantee that the above two levels are in total agreement. Therefore, in order to make sure that how much difference there would be between the two, observation of tidal level at the Selander Bridge was conducted on 16th & 17th February, 1984, around 17:00 o'clock when the highest sea level was reached, defining the surface of the old Selander Bridge (presently foot-path bridge), to be at El. 4.01 m.

The result was that there was 1.40 m difference between them, or their inter-relationship is mathematically as follow:

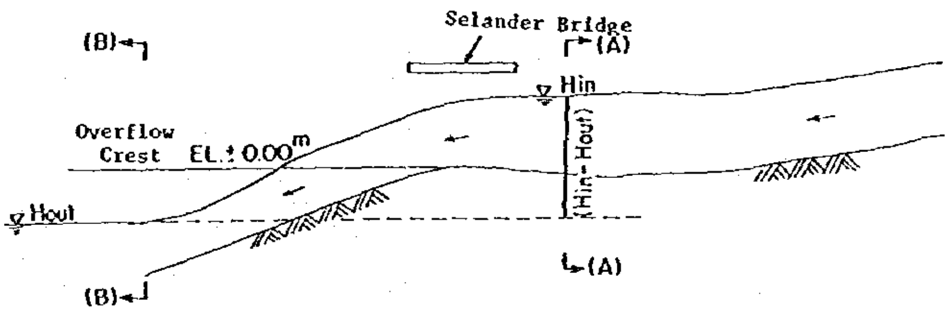
$$\left(\begin{array}{l}\text{El. used in the}\\ \text{Tidal Table}\end{array}\right) - 1.40\text{ m} = \left(\begin{array}{l}\text{Usual El. used in the civil}\\ \text{engineering work on the ground}\end{array}\right)$$

Based on this equation, column (4) of the previous table, in which tidal level for 6th April, 1981 was indicated, was derived from column (2) of the same.

(3) Overflowing Condition at the Salander Bridge

Thinking of the overflowing condition at the Selander Bridge, we can figure out something as illustrated in the following figure, wherein the discharge from the Msimbazi Creek (with its water level denoted by H_{in}) overflows over the crest of natural river bed beneath the Bridge (of which typical height was assumed to be at El. 0.00 m in the study as stated in Section 4-2, 6) of the Text).

Fig. 2 Relationship Between H_{in} & H_{out}



However, since the outer sea level (to be denoted by H_{out}) changes rapidly, totally free or independently from H_{in}, so that even for the given value of H_{in}, there may be varying discharge is likely to correspond causing us some umbiguity. At the same time, however, it can be possible that if we have sufficient difference between H_{in} and H_{out}, we can anticipate that the overflow formula

$$Q = C \times B \times H_{in}^{3/2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(a)}$$

can hold. And it is reasonable theoretically to assume that if the value of $(H_{in} - H_{out})$ satisfies the following condition as indicated by equation (1), the above ordinary overflow formula will hold. However, if only equation (2) is satisfied, the above overflow formula does not hold.

$$\frac{(V_c)^2}{2g} = \frac{1}{2g}\left(\frac{Q}{H_c x B}\right)^2 \leqq (H_{in} - H_{out}) \quad \cdots\cdots\cdots\cdots\cdots\cdots \quad (1)$$

$$\frac{(V_c)^2}{2g} = \frac{1}{2g}\left(\frac{Q}{H_c x B}\right)^2 > (H_{in} - H_{out}) \quad \cdots\cdots\cdots\cdots\cdots\cdots \quad (2)$$

where, V_c = Critical velocity of flow (Q m^3/sec) when the flow is under the critical depth, H_c, as represented by

$$H_c = \sqrt[3]{\frac{1.1 \times Q^2}{g \times B^2 \cdot \cos Q}} = \sqrt[3]{\frac{1.1 \times Q^2}{g \cdot B^2}}$$

Q = $C \cdot B \cdot H^{3/2}$ = (Discharge from Selander Bridge)

H_{in} = Water level directly upstream of Selander Bridge

H_{out} = Water level in the sea (varying with time), but the value in the Tidal Table has to be deducted by 1.40 m so as to give ordinary El. value.

C = Overflow coefficient (only for the case of 1.30 was calculated)

B = Length of overflow weir = 30.0 m

g = Acceleration due to gravity = 9.80 m/sec^2

cos θ = Cosine for θ, when θ indicates slope of beach angle, however, in the actual calculation cos θ can be regarded to be 1.0000, because of very gentle slope of the beach.

The reason for adopting the equation (1) (and (2)) for identifying whether the equation (a) holds or not is that:

If the equation (1) holds, even if we assume that at Section A-A in the previous figure the speed of overflowing water is assumed to be zero (but in the actual case this speed can not be zero at all, because all the water in this section is in movement), at the Section B-B in the same figure, the discharged water should reach the critical velocity, so far as friction losses between the two Sections could be neglected as usually assumed in hydraulics, as inferred from comparison of energy between the two Sections, so that the flow at Section B-B should be in a state of "super-critical flow" in which the effect of down stream (that is the sea side) does not climb up toward the upstream (impounded water upstream of the Selander Bridge).

Contrary to the above, if only the equation (2) holds, the overflow over the weir until it reaches the sea level is in a state of "ordinary flow" so that between the sea water level and that of the impounded water, there should be a backwater curve is to exist, that can be calculated by ordinary flow equation.

Therefore, we can conclude that if there is any umbiguity of the quantity of discharge from the Selander Bridge, this is only restricted to a case where equation (2) holds, and equation (1) does not hold. Based on this type of consideration, following table was prepared in which values of equation (a), H_c, V_c, $V_c^2/2g$ etc.were tabulated for various values of H_{in}.

(1) H_{in} (EL.m)	(2) Eq. (a) (m^3/sec)	(3) H_c (m)	(4) V_c (m/sec)	(5) $V_c^2/2g$ (m)	(6) Boundary Sea Level (1)-(5) (EL.m)	(7) V mean (m/sec)
0.80	27.91	0.460	2.024	0.21	0.59	1.40
1.00	39.00	0.575	2.261	0.26	0.74	1.30
1.50	71.65	0.861	2.774	0.39	1.11	1.59
1.80	94.18	1.034	3.036	0.47	1.33	1.74
2.00	110.3	1.149	3,200	0.52	1.48	1.84
2.30	136.0	1.321	3.431	0.600	1.70	1.97
2.50	154.2	1.436	3.579	0.65	1.85	2.06
2.80	182.7	1.609	3.786	0.73	2.07	2.18
3.00	202.7	1.724	3.919	0.78	2.22	2.25

What is meant by the above table is that the Column (6) in the table indicates the * value of H_{out}, for a given value of H_{in}, that the outer sea level if lower than the figure indicated in the Column (6) the equation (a) as follow, (Note: * boundary)

$$Q = C \times B \times H_{in}^{3/2} \quad \cdots\cdots \quad (a)$$

will hold. Say for instance, for a given value of H_{in} = 1.80 m, if outer sea elevation, H_{out}, is lower than the Column (6), 1.33 m, equation (a) does hold, but if higher than 1.33 m, equation (a) does not hold.

Column (7) also indicates the average velocity at the overflow weir of the Selander Bridge, since this was calculated based on the following fomula,

$$V_{mean} = \frac{Q}{B\ H_{in}}$$

- - - - - - - - - - - - - - - - - -

Note: * Because the top elevation of overflow creast at the Selander Bridge was supposed to be at EL. 0.00, the above formular gives directly the average velocity, below the bridge.

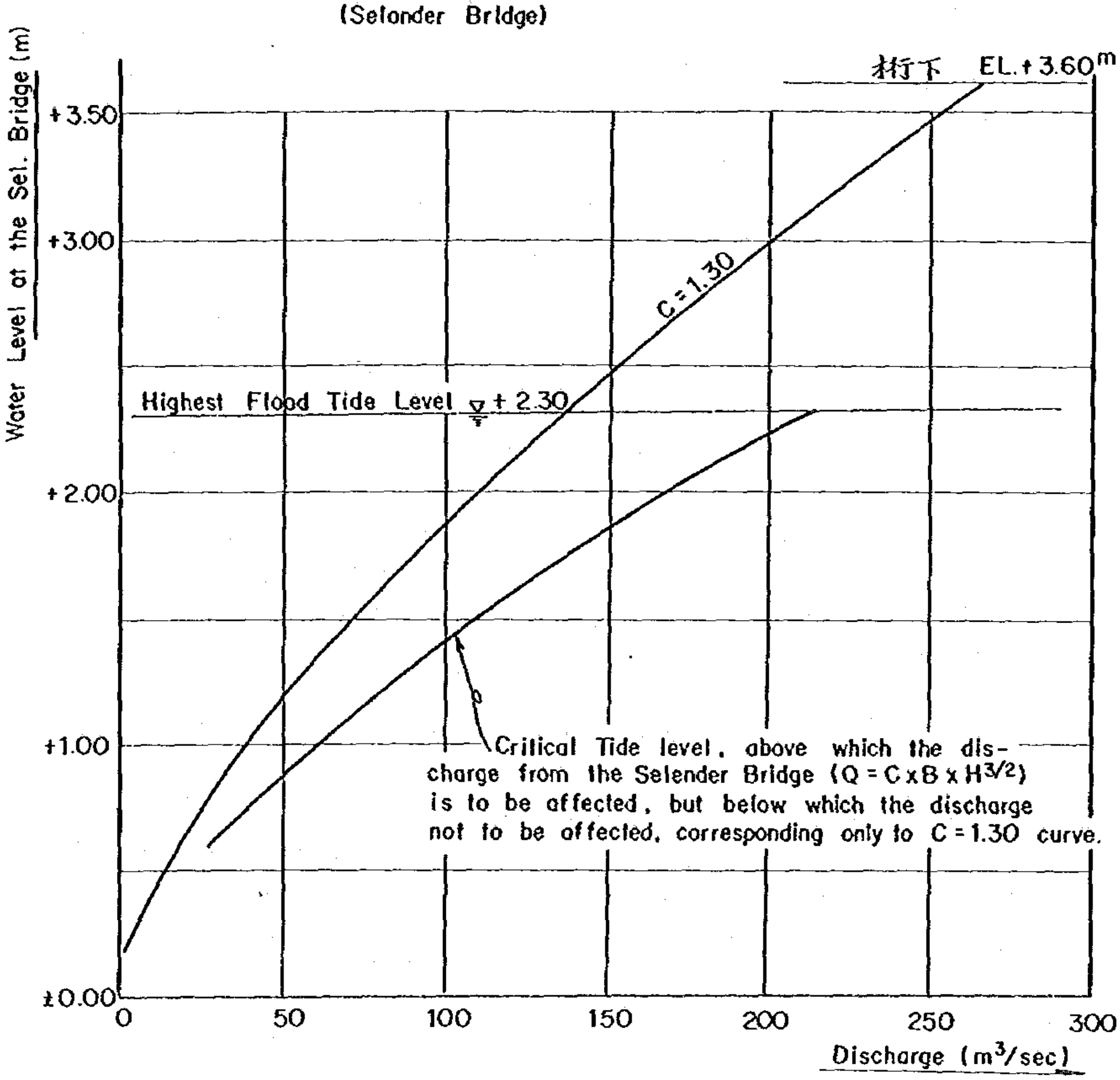
- - - - - - - - - - - - - - - - - -

Therefore, the value in Column (6) was plotted in relation with discharge curve, which is in itself only a graphical representation of Columns (1) & (2), for a case of C = 1.30, to obtain theoretical limit of discharge to be (or not to be) affected by H_{out}. However, since it was revealed that no higher tide level than + 3.70 exists in terms of Tidal Table Level, this was converted to ordinary EL. by deducting 1.40 m as has been explained, obtaining + 2.30 m at the Selander Bridge.

After above provisional consideration and calculation, another study was conducted for a hypothetical flood flow conditions as follow, in order to estimate what is the "magnitude" of approximate difference in water level at the Selander Bridge, if the effect of high tidal level (is taken into account) and (if this effect is neglected totally).

Fig. 3 Discharge Rating Curve

(Selander Bridge)



Inflow from upstream area: 250 m^3/sec (constant value)

C (coeficient of overflow): 1.30

Initial Water Level at Selander Bridge: EL + 1.00 m

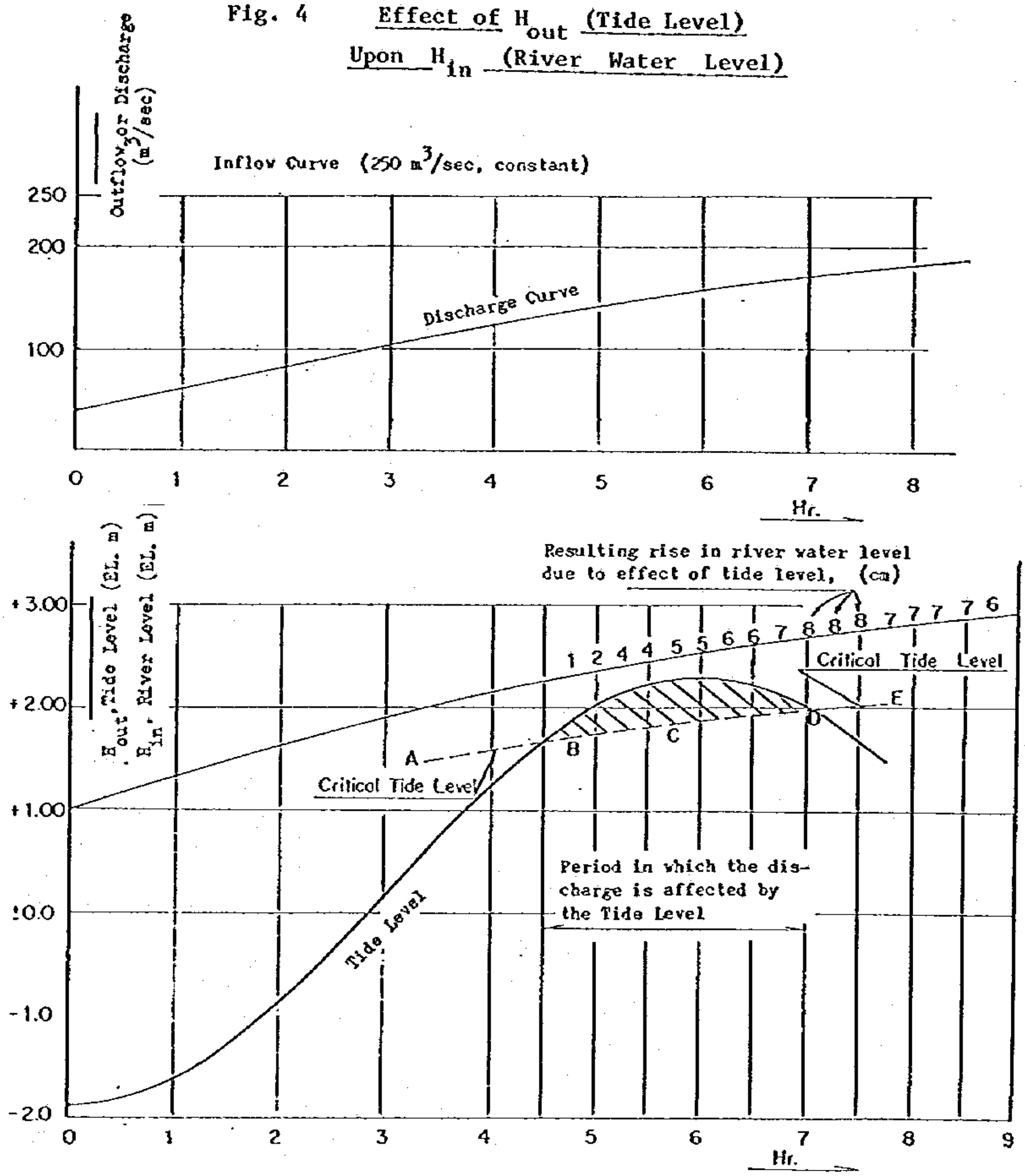
Tide Level:	Time	EL. (m)	Difference in Tidal Level
	0:00	-1.90	4.20 m
	6:00	+2.30	

The attached figure indicates the result of calculation, in which the change in the outer sea water level is indicated by a sine-curve. After calculation started at time 0:00, the water level, H_{in}, gradually increases, but outer sea level, H_{out}, rises more rapidly than H_{in}, of course. The line A-B-C-D-E indicates the values in Column (6), corresponding to the respective value of H_{in} at respective time, calculated for this case. Therefore, we can say that after time 4:30 until about 7:00, the outer sealevel should affect the discharge.

It was assumed in the calculation for purpose of simpler calculation, that in the above time period of 2 and a half hours approximately, 20 % of discharge from the Msimbazi Creek is reduced due to the effect of H_{out}, and the difference in H_{in}, (the one effect of the sea neglected, and the other 20 % reduction in discharge), was calculated. The results were that at about 7:00 to 8:00, about 8 cm higher water level was found, but later this difference was diminishing slowly with time.

Though the assumed discharge was 250 m^3/sec, being not so much large, but this flow continued for many hours with the highest tide level (EL. + 2.30 m) also assumed, so that if we conclude based on the above calculation that the effect of outer sea tide level upon H_{in} is within 10 - 20 cm range at its maximum, this conclusion can be reasonable, it is believed.

Fig. 4 **Effect of H_{out} (Tide Level) Upon H_{in} (River Water Level)**



4) Rainfall

Annual Rainfall Near Dar Es Salaam

Year	DAR AIRPORT	CHEMICAL LABORATORY	MSIMBAZI MISSION	TANGANYIKA PACKERS	UBUNGO MAJI
			ANNUAL Rainfall		
1954		1,083.0			
1955		1,371.0			
1956		968.0	958.0		
1957	1,462.0	1,498.0	1,690.0	1,320.0	
1958	823.0	–	792.0	–	
1959	902.0	–	676.0	729.0	752.0
1960	1,029.0	801.0	787.0	713.0	1,021.0
1961	1,732.7	1,531.0	1,369.0	1,031.0	1,779.0
1962	1,013.2	911.1	782.8	728.0	787.5
1963	1,606.8	1,343.2	1,540.2	1,041.6	1,286.2
1964	907.9	906.7	1,483.6	838.8	1,012.7
1965	731.3	626.3	801.7	644.1	760.3
1966	1,057.5	1,106.1	1,446.5	859.2	1,058.0
1967	1,514.2	1,148.5	1,618.2	1,032.2	1,393.7
1968	1,565.9	993.9	1,315.0	1,085.1	1,123.8
1969	1,134.9	–	953.5	737.9	944.2
1970	879.0	819.5	902.5	883.6	849.9
1971	812.6	–	933.8	1,024.0	908.5
1972	1,429.1	1,367.8	1,326.8	1,048.0	1,286.4
1973	774.4	869.2	798.1	899.0	860.4
1974	782.9	701.1	734.3	611.5	645.2
1975	1,089.4	1,001.8	606.6	841.7	980.3
1976	1,010.2	1,087.1	901.8	881.6	941.6
1977	1,283.4	971.1	–	889.0	1,057.5
1978	1,490.7	1,496.8	–	1,125.4	1,375.1
1979	1,315.2	1,305.2	1,567.3	1,146.8	–
1980	913.4	993.8	862.1	875.3	1,094.2
1981	1,048.6	1,006.5	1,266.6	950.1	1,083.1
1982	1,424.0	1,160.3	1,234.2	1,033.6	1,250.3
TOTAL	29,733.3	27,068.0	27,347.6	22,965.5	24,250.9
Years of Obs.	26	25	25	25	23
AVERAGE	1,143.6	1,082.9	1,093.9	918.8	1,054.4

DIRECTORATE OF METEOROLOGY

(Maximum Rainfall and Date)

YEAR	DAR AIRPORT		TANGNYIKA PACKERS		CHEMICA LABORATORY		MSIMBAZI MISSION		UBUNGO MAJI		PUGU FOREST	
1982	81.0	8/5	82.0	17/11	111.1	9/5	90.7	23/4	67.3	8/5	120.3	17/11
1981	61.1	3/5	148.0	14/12	82.4	14/12	107.7	14/12	71.5	14/12	54.2	3/5
1980	94.1	20/11	88.0	19/4	66.0	13/4	55.0	21/5			85.5	20/11
1979	70.1	4/5	81.0	4/5	87.0	4/5	96.6	28/3			20.6	24/5
1978	72.4	7/4	80.0	25/11	66.0	13/4	55.0	2/5			-	-
1977	68.2	26/11	50.6	30/10	80.0	27/11	89.0	26/11			72.6	20/4
1976	55.4	15/3	67.0	8/3	61.0	16/3	68.5	9/7			-	-
1975	108.4	13/11	112.5	15/5	137.0	15/5	60.0	18/4			70.0	14/5
1974	59.1	14/1	47.2	14/1	90.7	19/1	71.8	24/1			-	-
1973	70.2	28/4	71.2	28/4	80.8	28/4	86.2	27/4			69.7	4/12
1972	80.5	16/4	57.5	21/3	70.6	9/12	99.9	17/11			60.4	11/5
1971	35.8	8/5	88.9	23/12	46.7	25/12	56.2	19/1			41.2	19/5
1970	52.7	4/5	73.1	2/4	102.3	2/4	73.5	1/4			65.5	2/12
1969	69.1	25/4	66.8	2/2	68.8	2/2	76.5	2/2			57.1	22/5
1968	136.9	6/4	99.6	7/4	61.0	12/4	103.0	6/11			71.9	18/11
1967	55.8	21/12	56.1	22/12	77.5	23/4	78.0	24/11			106.7	8/11
1966	57.4	11/4	-	-	86.1	2/5	187.0	22/6			67.1	18/1
1965	65.4	16/4	49.8	27/5	54.6	16/4	93.0	16/12			71.4	24/12
1964	66.8	28/4	70.6	19/10	57.4	2/3	107.2	26/3			104.1	5/4
1963	126.5	10/11	92.7	20/11	104.7	19/11	91.4	4/3			102.1	19/2
1962	62.0	10/4	-	-	71.1	11/4	-	-			88.9	4/3
1961	88.1	4/2	70.6	20/12	70.1	23/10	85.3	22/10			88.9	19/10
1960	77.7	12/4	32.5	21/3	76.2	12/4	73.2	12/4			31.7	7/1
1959	86.4	10/12	62.7	13/2	56.1	21/8	56.6	22/8			58.9	9/12
1958	61.7	20/4	59.9	18/8	68.8	28/3	83.8	19/2			66.0	22/4
1957	94.0	3/5	79.8	3/5	85.3	30/4	87.9	17/11			99.1	28/10
1956	61.2	25/1	166.6	5/4	50.0	5/4	91.4	5/4			60.8	5/4
1955	95.5	2/5	78.0	7/2	215.9	2/5	150.1	2/5			58.4	8/4
1954	89.7	22/5	70.1	7/5	86.4	9/5	78.2	25/3			84.5	22/5
1953			61.5	16/11			95.3	16/11			127.6	16/11
1952			85.6	28/3							58.9	16/11
1951											-	-
1950											34.5	12/4

Daily Rainfall in 1978

Date	MARCH			APRIL			MAY			NOV.		DEC.	
	DSM A/P	C.L.	M.M.	DSM A/P	C.L.	M.M.	DSM A/P	C.L.	M.M.	DSM A/P	C.L.	DSM A/P	C.L.
1	3.4			TQ		3.4				0.0		0.0	17.7
2		0.8	1.3	15.0	3.7	0.1	T.R			0.0	0.2	18.2	
3			5.6	7.2	2.3	8.7	0.0			0.0	3.3	21.5	53.2
4			2.0	37.8	1.2		T.R			0.8		24.1	1.9
5	11.2	10.8		6.7			0.0			36.2	46.3	2.3	0.4
6	T.R	0.1		72.4	52.9	75.2	0.0			13.0		11.2	
7	T.R	0.2		29.5	30.0	32.8	4.1	15.0		4.8		0.7	
8	1.3	0.4	4.4	13.1		9.9	9.9	11.2		8.3		0.0	
9	1.1			1.7	22.2		12.2	16.5		7.2	4.8	17.5	
10				1.0			1.0			0.0		3.4	81.2
11				0.0	12.1		0.9			1.2		1.8	
12	0.5			20.6		14.4	T.R			T.R	6.6	0.0	
13				T.R	0.1		0.0			5.7	12.1	0.0	62.2
14	0.2			37.0	1.4	20.0	0.0			10.8		22.5	10.3
15		0.8		18.0			1.0			0.0		7.0	3.0
16	T.R			6.3	26.8	5.4	0.0			0.0		3.8	
17	39.8	38.1	15.8	15.7	33.0	40.0	0.0			T.R	0.1	11.0	0.8
18	2.7			T.R	0.1	36.2	0.3			4.8		0.0	
19	4.1	3.5		25.7	29.1		1.7	6.0		52.3	11.7	0.2	6.2
20	1.6	0.6	10.0	45.8	33.3	40.0	27.4			42.7	21.0	11.9	3.9
21	19.9	8.5	7.5	27.4	34.0	7.8	1.3	26.4		5.5		1.9	0.5
22	4.3	2.0	2.7	1.2		2.4	0.0		165.4	9.1	44.6	0.0	
23	0.6			0.0	3.3		0.0			37.7	9.4	0.0	
24	19.1	4.1		0.0		10.3	0.0			29.8	90.0	0.0	
25	10.0			0.0			0.0			70.0		0.0	
26	8.7			23.1	20.3		0.0			48.7	51.2	0.0	
27	1.0	3.7	5.2	22.9	16.0		1.2			17.5	7.6	T.R	
28	0.7	8.6	2.5			20.2	21.2	21.1		19.0		0.0	
29	T.R	2.8	3.1				27.9	6.0	23.3	T.R		0.4	
30	T.R	0.1	6.2				0.2	0.8		0.0		0.0	
31	2.9	2.2					1.0	3.5		0.0		0.0	
TOTAL	133.1	87.3	66.3	427.4	341.8	326.8	110.3	106.5	188.7	425.1	308.9	159.4	241.3

APPENDIX VI

BENEFIT CALCULATION

APPENDIX VI BENEFIT CALCULATION

There are two types of direct benefit conceivable that are to be derived from the implementation of the Project, the one, saving in the vehicle operating costs and the other, passengers time saving.

1) Saving in the Vehicle operating costs

Vehicle operating costs consist of the following components:

- Depreciation and insterest cost
- Overhead cost
- Crew cost
- Fuel cost
- Oil cost
- Tyre and tube cost
- Repair and maintenance cost

Because the fuel cost in the above components being the largest item of saving to be anticipated, the fuel cost saving is adopted for the purpose of direct benefit evaluation of the Project.

Fuel cost saving, due to the Project implementation, is divided into the following three categories:

- Saving due to total cancellation of diverted traffic, that has to travel a longer distance if the Project not implemented.

- Saving due to vanishing of the existing traffic congestion.

- Saving due to decrease in rise in the longitudinal alignment.

(1) Saving due to total cancellation of diverted traffic

In case, if the Project is not implemented, because the capacity of the existing Morogoro Road has already been filled up, the excess traffic due to future traffic increase will have to be diverted to other two roads, either Kigogo Road or Bagamoyo

Road, which have longer distance to go to the centre of the city than the Morogoro Road. However, if the Project is implemented, because of the capacity increase in the New Morogoro Road, diverted traffic will not occur at all, but all the traffic will go through the Morogoro Road. Thus fuel saving can be expected due to the shorter length through the Morogoro Road than through the other two roads. Distribution of the diverted traffic between these two roads was decided in proportion to the inverse ratio of these excess lengths, which are 4.5 km for Morocco Road and 2.3 km for Kigogo Road, or more briefly (Morocco Road : Kigogo Road) = (1 : 2).

Assuming that opening of the project is in January, 1987, the project life of fifteen (15) years and the growth rate of the traffic from 1986 to 2001 being 3.5 percent per annum, taking into consideration present socio-economic situation in Tanzania, future traffic on the Morogoro Road and diverted traffic to Morocco Road and Kogogo Road, if the Project not implemented, were estimated as indicated in the following table.

Traffic Volume on Morogoro Rd., Kigogo Rd., and Morocco Rd.

Year	(1) Traffic Volume Required (3.5%)	(2) Diverted Traffic (1)-14,000	Kigogo Road		Morocco Road	
			(3) (2)x2/3 x0.8 Passenger Car	(4) (2)x2/3 x0.2 Large Vehicle	(5) (2)x1/3 x0.8 Passenger Car	(6) (2)x1/3 x0.2 Large Vehicle
	(ADT)	(ADT)	(ADT)	(ADT)	(ADT)	(ADT)
1982	14,000	-	-	-	-	-
83	14,490	(490)	(261)	(65)	(131)	(33)
84	14,997	(997)	(532)	(133)	(266)	(66)
85	15,522	(1,522)	(812)	(203)	(406)	(101)
86	16,065	(2,065)	(1,107)	(275)	(551)	(138)
1987	16,628	2,628	1,402	350	701	175
88	17,210	3,210	1,712	428	856	214
89	17,812	3,812	2,033	508	1,017	254
90	18,435	4,435	2,365	591	1,183	296
91	19,081	5,081	2,710	678	1,355	338
92	19,749	5,749	3,066	767	1,533	383
93	20,440	6,440	3,435	859	1,717	429
94	21,155	7,155	3,816	954	1,908	477
95	21,895	7,895	4,211	1,053	2,105	526
96	22,661	8,661	4,619	1,155	2,310	577
97	23,454	9,454	5,042	1,261	2,521	630
98	24,275	10,275	5,480	1,370	2,740	685
99	25,125	11,125	5,933	1,483	2,967	742
2000	26,004	12,004	6,402	1,601	3,201	800
1	26,915	12,915	6,888	1,722	3,444	861

Note: Figures in parentheses are not contained in the calculation of benefit, because the project will not be completed until October, 1986.

Based on the number of diverted traffic, the additional length to travel, fuel consumption and fuel prices, additional fuel cost was calculated as shown in the following table. Fuel consumption of passenger car (petrol) and large vehicle (diesel) on level tangent road was assumed to be 0.111 ℓ/km and 0.222 ℓ/km respectively, and prices of petrol and diesel were also assumed to be 12.5 T.Shs./ℓ and 5.5 T.Shs./ℓ, respectively.

(2) Saving due to vanishing of traffic congestion

The Morogoro Road indicates traffic convestion in the morning peak hours of every weekday in which following two types of additional fuel consumption would occur; both of which need not occur if the Project is implemented.

- idling for some time, (in this calculation it was assumed that the congestion take 30 minutes of additional time for each vehicle to pass the congested area, and also that each vehicle is forced to have 10 minutes of engine idling in this 30 minutes period.)

- repeated start in uphill position, 5 times in average for each vehicle.

Following fuel consumption rate for this case was introduced in the calculation, from some reference book on automotive engineering.

Type of vehicles	Passenger Car & Taxi	Large Vehicles
Kind of Fuel	Petrol	Diesel oil
Idling (10 minutes)	200 mℓ/vehicle	400 mℓ/vehicle
Start in Uphill Position (5 times)	50 mℓ/vehicle	100 mℓ/vehicle

After this assumption, saving due to vanishing of traffic congestion was calculated as shown in following table. The traffic that yields this type of benefit is restricted to the vehicle toward city centre in the morning peak hours from 7:00 to 9:00 a.m., and this benefit accrue all through the project life, though constant in its amount, every year.

(3) Saving due to decrease in rise

If the Project implemented, fuel cost saving due to raing the embankment across the Msimbazi Creek by 3.0 m and lowering of United Nations junction (by 0.5 m) can be expected.

Based on the condition that decrease of rise toward the direction of city centre (and Morocco Road) are 3.5 m (and 3.0 m) respectively, fuel consumption and weight of passenger car and large vehicle are 1.34 mℓ/t.m* and 1.14 mℓ/t.m* respectively, and the weights are 1.3 ton and 5.0 ton respectively, saving due to decrease in rise was calculated as in the following table. (Please refer to the page after the next one, for explanation of * in the above sentence.)

SUMMARY OF BENEFIT

Unit : T.Shs.1,000

Year	Fuel Saving			
	(1) Saving in Detour Road (Kigogo & Morocco Road)	Saving in Improved Section		Total Fuel Saving
		(2) Idling, etc.	(3) Decrease in Rise	
1982				
1983				
1984				
1985				
1986				
1987	3,940	900	466	5,306
1988	4,812	900	482	6,194
1989	5,715	900	499	7,114
1990	6,649	900	516	8,065
1991	7,617	900	534	9,051
1992	8,618	900	553	10,071
1993	9,655	900	572	11,127
1994	10,728	900	592	12,220
1995	11,836	900	613	13,349
1996	12,985	900	635	14,520
1997	14,173	900	657	15,730
1998	15,405	900	680	16,985
1999	16,679	900	704	18,283
2000	17,997	900	728	19,625
2001	19,364	900	753	21,017

Note: * Assuming density of petrol & diesel oil is 0.70 g/mℓ and 0.82 g/mℓ, and amount of heat generated from them being 10 kcal/g, the fuel consumption required to do the physical work of 1.0 t.m is as follow for petrol and diesel oil, with 25% of thermal efficiency for both types of engines also assumed.

$$102 \text{ kg·m/sec} = 1 \text{ kW}$$

$$102 \text{ kg·m} = 1 \text{ kW,sec}$$

$$1 \text{ ton·m} = 1{,}000 \text{ kg·m}$$

$$1 \text{ ton.m} = \frac{1{,}000 \text{ kg.m}}{102 \text{ kg·m}} = 9.80 \text{ kW,sec}$$

Since 1 kW corresponds to 860 kcal/hr. of thermal energy, therefore,

$$1 \text{ kW} = 860 \text{ kcal/hr} = \frac{860}{3{,}600} \text{ kcal/sec}$$

$$= 0.2389 \text{ kcal/sec.}$$

Therefore,

$$1 \text{ ton.m} = 9.80 \text{ kw.sec} = 9.80 \times 0.2389 \text{ kcal}$$

$$= 2.341 \text{ kcal}$$

Since 25% of thermal efficiency as well as 10 kcal/g of heat generation were assumed for both types of engines and fuel, the weight of fuel required for (1.0 ton.m) of physical work is,

$$\frac{2.341 \text{ kcal}}{10 \text{ kcal/g}} \times \frac{1}{0.25} = 0.936 \text{ g.}$$

Being converted to volume, this weight of fuel give a volume of,

petrol, 0.936 g ÷ 0.70 g/mℓ = 1.34 mℓ

diesel, 0.936 g ÷ 0.82 g/mℓ = 1.14 mℓ

(4) Calculation of Internal Rate of Return (IRR)

Based on the benefit derived from the saving of fuel consumption and the project cost estimated, T.Shs.100 million (1,787 million yen), internal rate of return is calculated at 6.8%.

COST AND BENEFIT

(Unit: T.Shs. 1,000)

Year	Cost	Benefit	Discounted (5%)	
			Cost	Benefit
1985	50,000		50,000	
1986	50,000		47,619	
1987		5,306		4,813
1988		6,194		5,350
1989		7,114		5,853
1990		8,065		6,319
1991		9,051		6,754
1992		10,071		7,157
1993		11,127		7,531
1994		12,220		7,877
1995		13,349		8,195
1996		14,520		8,490
1997		15,730		8,759
1998		16,985		9,008
1999		18,283		9,239
2000		19,625		9,440
2001		21,017		9,628
Total			97,619	114,413

IRR : 6.8%

B/C : 1.17

2) Time Saving

According to the result of traffic survey conducted by Usafiri Dar Es Sallam which is the biggest bus company in Tanzania, passengers on the Morogoro Road in November, 1981 were 81,300 persons per day.

Number of Bus Passenger

Road	Passenger (persons/day)	Share (%)	Number of Bus (buses/day)
Bagamoyo Road	30,700	13.8	280
Morogoro Road	81,300	36.6	843
Uhuru Street	43,600	19.6	604
Pugu Road	46,500	20.7	392
Kilwa Road	20,300	9.1	260
Total	222,400	100.0	2,379

According to the result of traffic survey in March, 1982, peak hour ratio was calculated as follows.

- number of buses: 1,590
- number of buses toward city centre in the morning peak hours from 7:00 to 9:00 a.m. : 126
- peak hour ratio $= \frac{126}{1,590} \times 100 = 7.9$ (%)

Using above peak hour ratio, number of bus passenger in the morning peak hours were estimated as follows.

81,300 persons x 0.079 = 6,423 persons

Time saving of bus passenger were estimated at T.Shs.2,697,000 per year on the basis of the following assumption.

- average salary : T.Shs.800 per month
- working hour : 200 hours per month
- loss time due to traffic congestion : 30 minutes per day
- discount rate for time spent going to the office to normal working hour : 30 per cent
- time saving of bus passenger :

  $$\frac{30 \text{ minutes}}{60 \text{ minutes}} \times \frac{\text{T.Shs.800}}{200 \text{ hrs/month}} \times 0.7 \times 25 \text{ days/mon.} \times 12 \text{ month}$$

  $$\times\ 6{,}423 \text{ persons}$$

  $$\doteqdot \text{T.Shs.2,697,000 per year}$$

- numbers of passengers in other types of buses, such as buses of respective enterprises that transport their staff and work men, are not available.

According to the result of traffic survey in March, 1982, numbers of private car and taxi in the morning peak hours from 7:00 to 9:00 a.m. were counted of 479 cars and 292 taxies. Based on the occupancy of 2 persons per each cars, numbers of passenger were estimated at about 1,400 persons. Time saving of passengers of private cars and taxies were estimated by unit salary of T.Shs.6 per hour as follows:

$$\frac{30 \text{ minutes}}{60 \text{ minutes}} \times \text{T.Shs.6} \times 0.7 \times 25 \text{ day/month} \times 12 \text{ month/year}$$

$$\times\ 1{,}400 \text{ persons}$$

$$\doteqdot \text{T.Shs.882,000 per year}$$

Total time saving in 1982 of passengers of buses, private cars and taxies were estimated at T.Shs.3,579,000 per year.

Time saving during project life was estimated at T.Shs.82,020,000 using traffic growth rate of 3.5% per year as follows.

Time Saving

(Unit: T.Shs. 1,000)

Year	Time Saving
1987	4,250
1988	4,400
1989	4,553
1990	4,713
1991	4,878
1992	5,049
1993	5,225
1994	5,408
1995	5,597
1996	5,793
1997	5,996
1998	6,206
1999	6,423
2000	6,648
2001	6,881
Total	82,020

APPENDIX VII

DRAWING