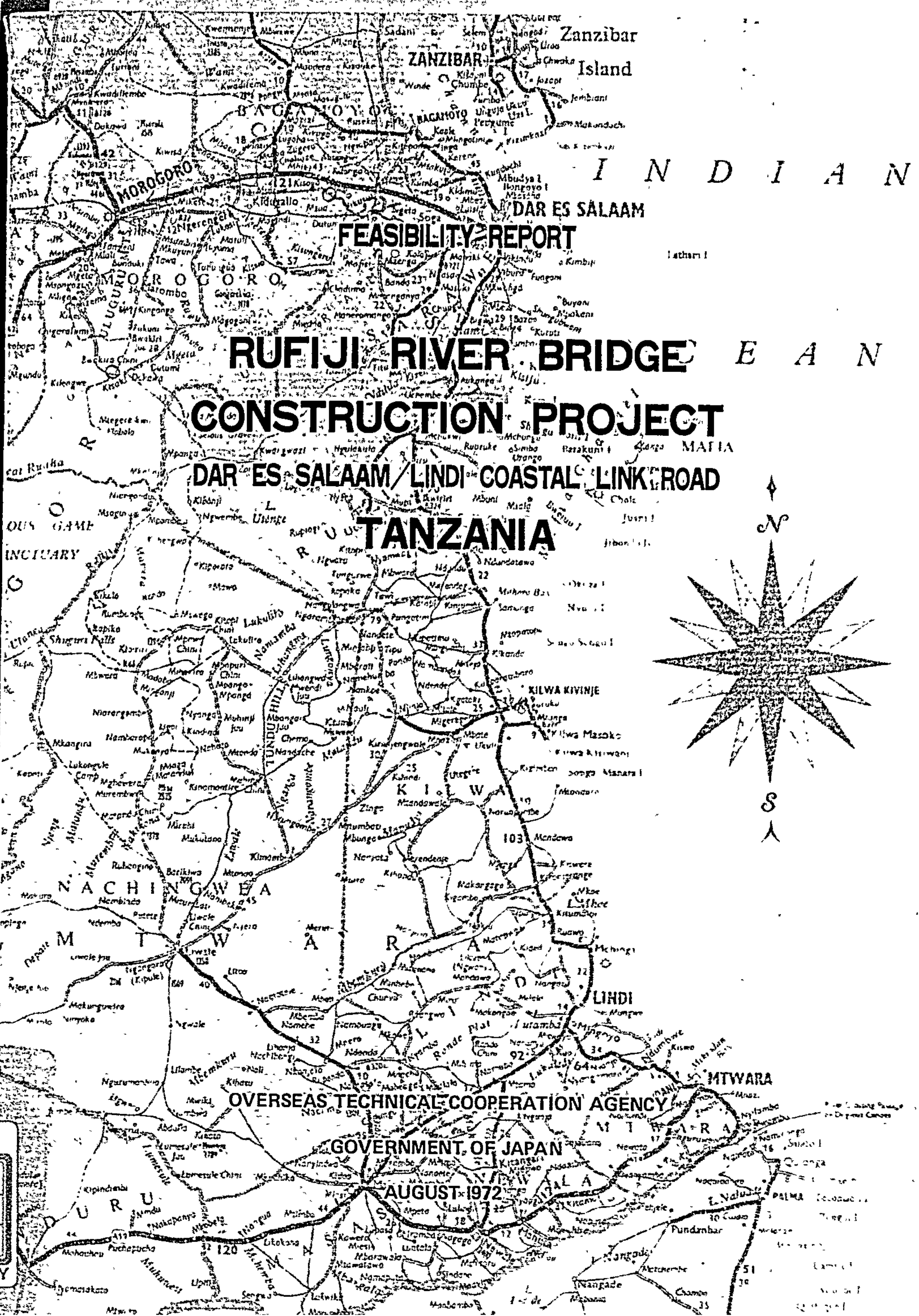


FEASIBILITY REPORT

RUFIJI RIVER BRIDGE CONSTRUCTION PROJECT

DAR ES SALAAM/LINDI COASTAL LINK ROAD

TANZANIA

OVERSEAS TECHNICAL COOPERATION AGENCY

GOVERNMENT OF JAPAN

AUGUST 1972

PREFACE

In response to the request of the Government of the United Republic of Tanzania, the Government of Japan entrusted the Overseas Technical Cooperation Agency (O. T. C. A.) to conduct a survey for the plan of constructing bridges over River Rufiji in the country.

The O. T. C. A., fully realizing a vital influence to be given by the planned bridges upon socio-economic development of the southern coastal region of the country, organized a Technical Survey Mission headed by Mr. Hiroshi Yamashita, Director of Niigata Laboratories, Public Works Research Institute, Ministry of Construction and dispatched the Mission to the country for a period of 65 days from Nov. 5, 1971 to Jan. 8, 1972.

The field investigations on the spot were conducted very smoothly through the immeasurable cooperation rendered by the authorities of the Government of the United Republic of Tanzania. After its return to Japan, the Mission has directed its efforts to and completed the examination and analysis of the results of the survey, and this Report is hereby submitted to the Government of the United Republic of Tanzania.

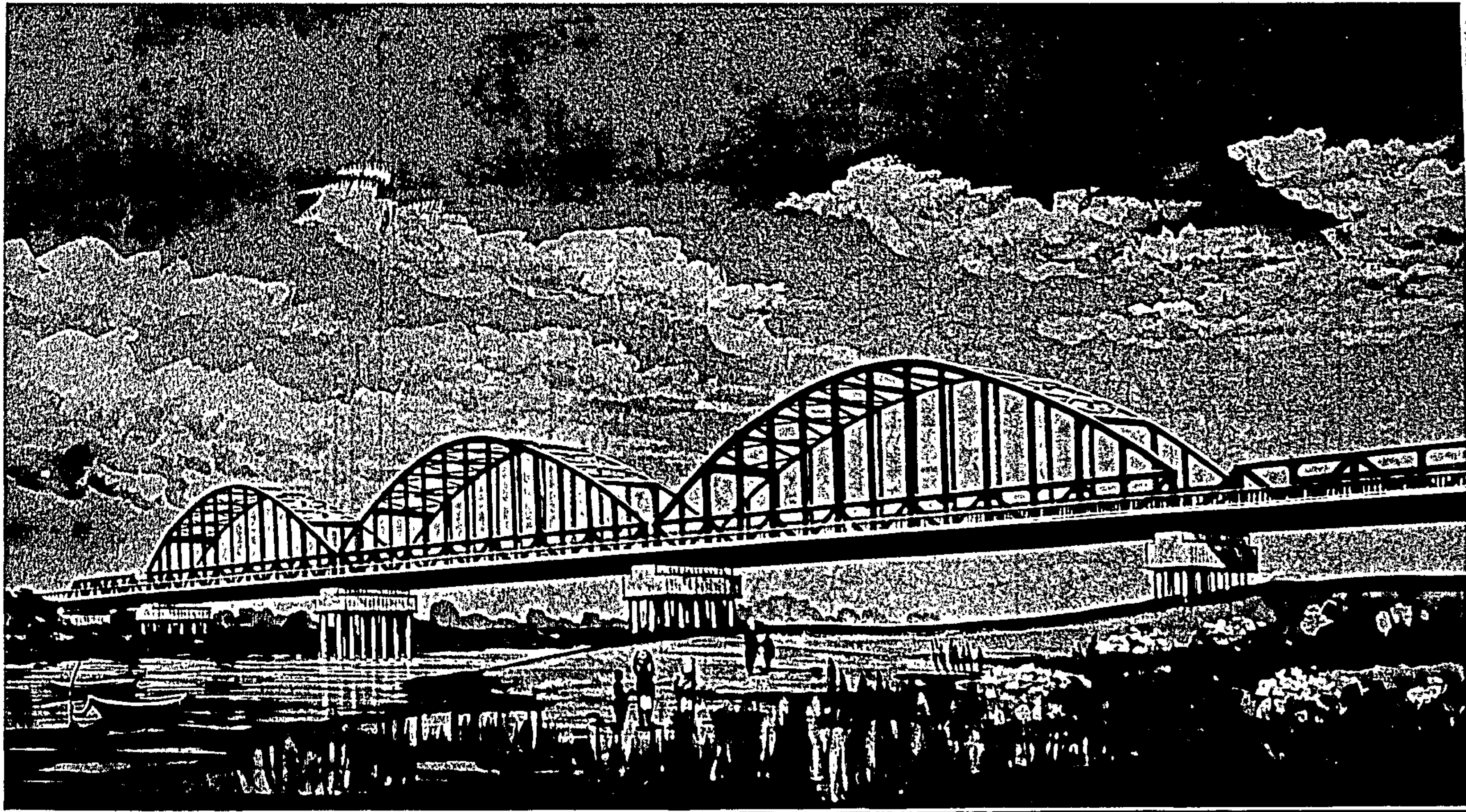
This Report discusses the technical feasibility and the estimated construction cost for the planned first-stage bridging works over River Rufiji, which is the largest river along the coast, of the road construction plan for the total length of about 320km between Dar-es-Salaam and Lindi, in consideration of the present situation that the road traffic is blocked for a long period in the southern coastal region of the country in the wet season, economic development of the region is delayed and the public welfare is menaced.

It would be the deepest pleasure if the results of the present survey be contributed to development of the southern coastal region of the country and to promotion of the friendship and amity between Japan and the United Republic of Tanzania.

In conclusion, I wish to take this opportunity to express my sincere gratitude to various authorities concerned of the Ministry of Communications, Transport and Labour of the Government of the United Republic of Tanzania.

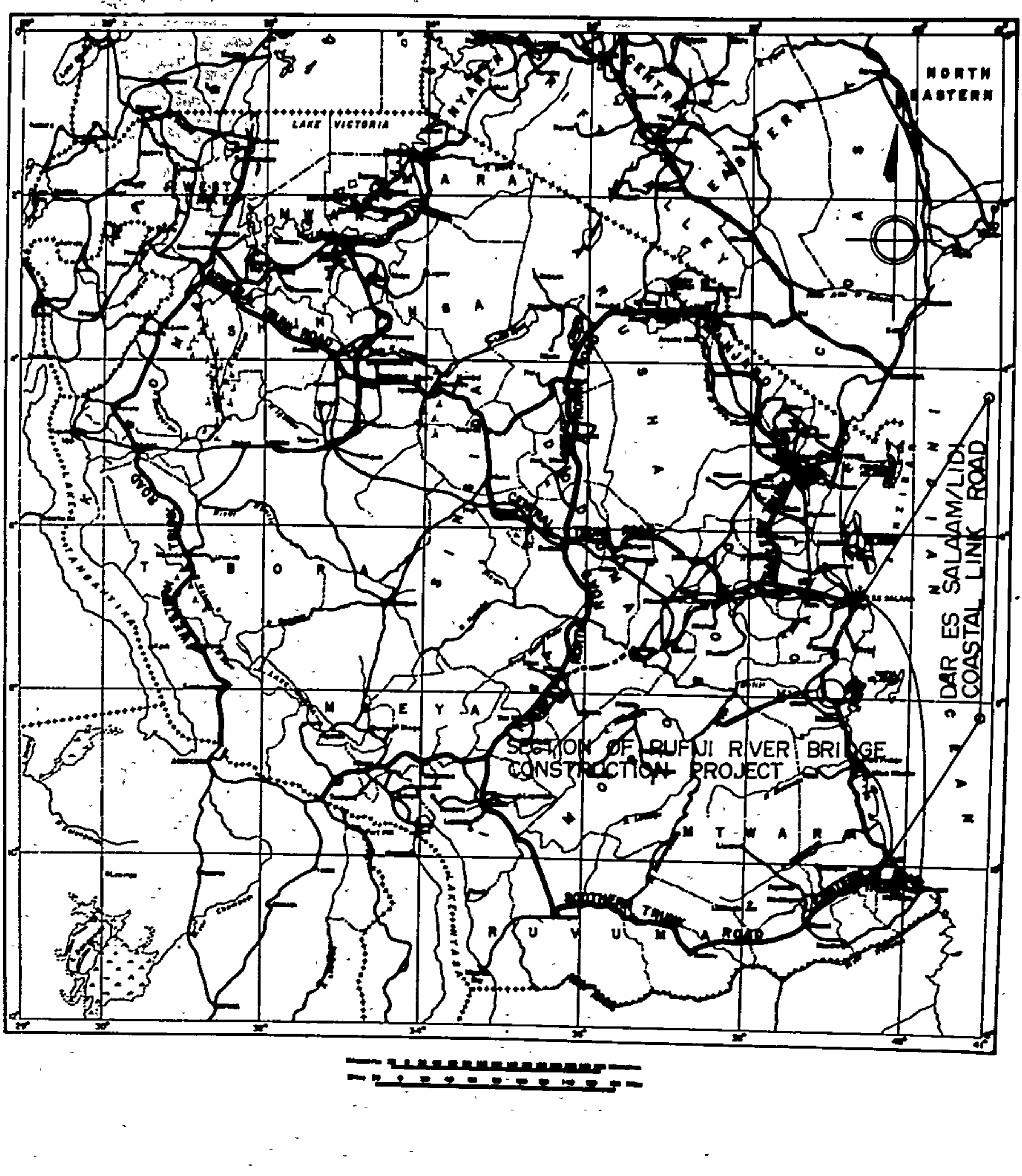
August 1972

Keiichi Tatsuke
Director General
Overseas Technical
Cooperation Agency

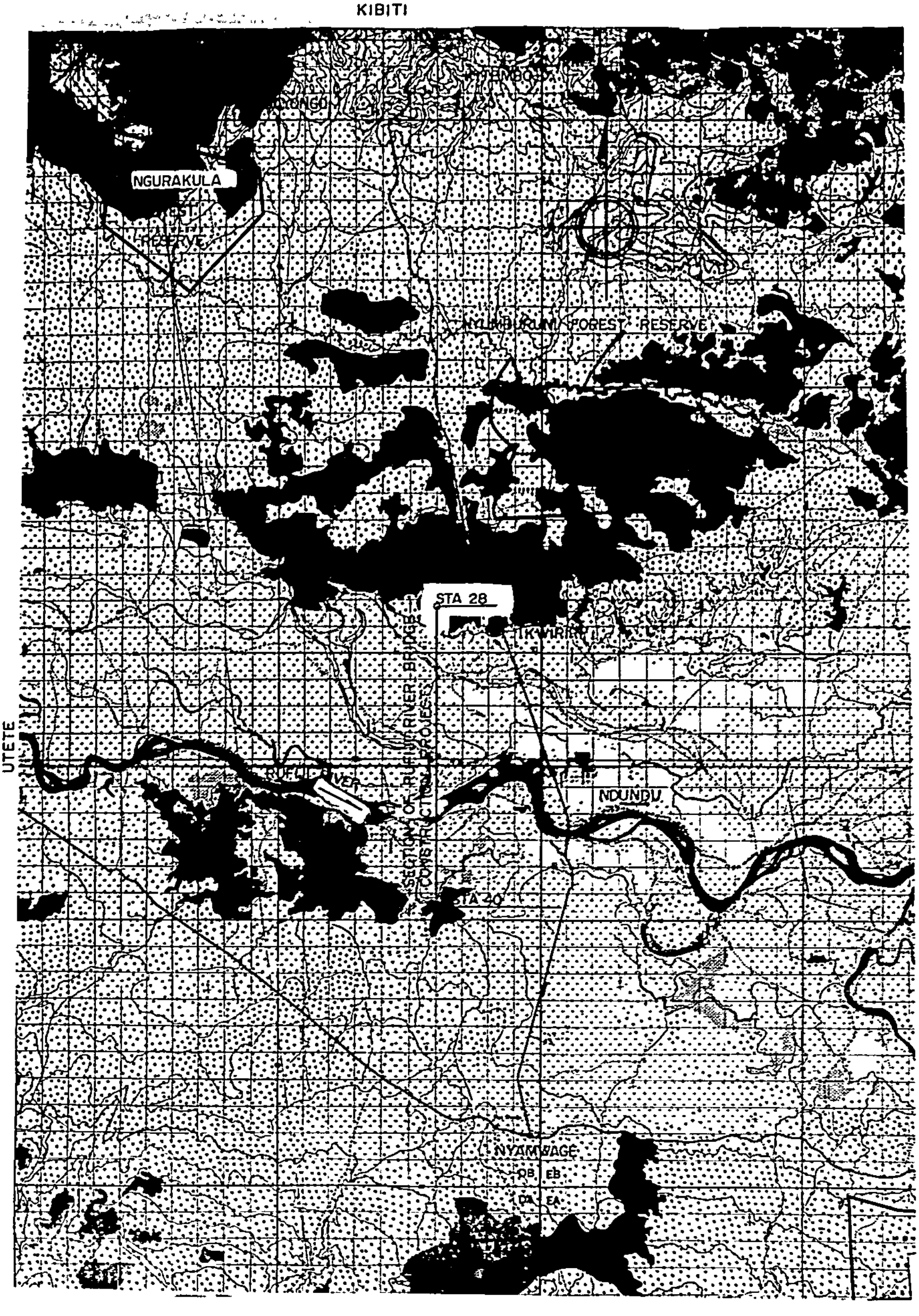


PROPOSED DESIGN OF RUFIJI RIVER BRIDGE

PROJECT LOCATION MAP (I)



PROJECT LOCATION MAP (II)



CONTENTS

SUMMARY

The Government of the United Republic of Tanzania requested the Government of Japan to conduct a survey for construction of the Dar-es-Salaam / Lindi Coastal Link Road as a all weather road along the southern coast of the country. In response to the request, the Government of Japan organized and dispatched the first Survey Mission in October 1970 for a period of about 40 days and the second Survey Mission to supplement the survey of the first Mission in November 1971 for a period of about 60 days to study about the road construction plan.

A total length of about 320km along Dar-es-Salaam/ Lindi Coastal Link Road is not improved yet, and a population of 1.033 million (in the year 1967) i.e. about 10% of the total population of Tanzania inhabits in the region that is influenced by the road. The present situation, however, is that rivers and streams including River Rufiji which is the largest river in Tanzania always bring floods on the region in the wet season, the traffic is blocked for a long period of two to six months every year and the inhabitants of the region are isolated. The Government of the United Republic of Tanzania, in reply to the fervent hope of the regional inhabitants, has taken up the improvement of the road to a weatherproof one as one of the Government's policies for a better welfare and future development of industry.

The first Survey Mission, based upon its field investigations, submitted the Feasibility Report to the Government of the United Republic of Tanzania in July 1971, advising that construction of the road would bring very good effects on administration, culture and welfare, the Construction plan should be positively promoted, particularly priority must be given to the construction work around River Rufiji which is the most difficult and further detailed surveys must be conducted.

The second Survey Mission, in reponse to the request of the Government of Tanzania and according to the survey items noted in the Feasibility Report for further investigations, conducted researches and surveys, along an extension of about 12km around River Rufiji, about surveying, the soil, geology and materials for the purpose of constructing bridges and road. This Report refers to the Pre-Detail Design for the plan necessary for execution of such works as bridge construction, banking and paving of the said section.

THE ESSENTIALS OF THE CONTENTS OF THE REPORT

1. Survey on the Foundation

A test boring for a depth of 15m was conducted at a point near the planned route on the left bank of the main stream of Rufiji River during the first survey. The second survey included seven test borings by means of machinery for the soil survey necessary for designing of the foundation for bridges and also 28 shallow test pits for the purpose of investigating the suitability of the soil for the material for banking and the stability for the basic foundation of banking.

The 7 test borings by means of machinery were made as follows: three on the left bank of River Rufiji, each one on the left and the right banks of the main stream and two on the right bank of River Rufiji. The bored depth was from 13m to 30m at various points.

The consistency and the relative density of the foundation were observed by standard penetration test for every meter of depth. For the test borings on the both banks of the main stream, pressure meter test (in-situ test) was conducted for the purpose of finding out the bearing capacity characteristic of the foundation for the main bridge. Twenty test pits were made on the planned banking area on the left bank of River Rufiji and eight on the right bank. Representative sample soils from the test pits were put to identification test, compaction test and laboratory CBR test, to be available for judgment of the suitability as materials for banking. As for the representative sample soil of black cotton clay scattered over the left bank, unconfined compression test was made for the sample soil that was held in its natural condition, fairly dried and rather hard, and also it was observed in its soaked condition.

The results of the second survey brought about several facts which were not found out by the first survey. Followings are main conclusions from the second survey:

(1) The bearing stratum sufficient to bear the load of the main bridge is observed in El. -12 to -14. This means that the foot depth of the deep foundation to bear the main bridge requires about 20m to 30m or more in accordance with the level of the surface of the earth above the sealevel. Therefore, though the report of the first survey recommended to bear the main bridge with an open caisson foundation of a foot depth of 15m, it is necessary to take the use of steel-pipe piles into consideration from economic and engineering viewpoints.

(2) As for the bridges over flood openings, on the right bank comparatively short piles of a foot depth of about 10m will be sufficient for bearing. For the left bank, however, though piles of the same scale as those for the right bank are sufficient for some part of the area, as shown in the result of Test Boring No. 2 (Sta. 33+802) some part of the area shall require piles longer than those planned for the right bank or piles of an increased number per foundation.

(3) The shallow section on the rc .e is covered by such five soils as black cotton clay, silty clay, sandy clay, silty sand and lateritic sand. It is not advisable to use black cotton clay and silty clay for banking work. It is recommended to utilize silty sand and lateritic sand for banking. Though it is better in general not to use sandy clay, it can be used for the lower part of the road (?) if it is of a better CBR characteristic.

(4) The foundation on which banking is made shall be stable against a load of a banking of four-meter thickness or less.

(5) As for aggregate, quartzite of Kitembo area and sand stone of Utete area are recommendable with their better quality.

(6) For detailed design, soil survey must be conducted to investigate distribution and boundary of strata and dynamic characteristics of clayey soils about the foundation for the bridges over flood openings on the left bank of the main Rufiji stream. Investigation and research must be made also on quality and quantity of aggregates.

2. Bridge Construction Plan

The Report of the First Survey discussed that, as for the flood of Rufiji River, the designed flood discharge and estimated high-water level at Ndundu, the crossing point, shall be 6,700m^3/sec. and 16.80m respectively by 15-year probability, and as for extraordinary floods a raised water level from the designed high-water level (16.80m) by

100-year probability flood of 9,900m^3/sec. shall be 0.70m and another level by 50-year probability flood of 8,700m^3/sec. be 0.50m.

Results of repeated calculation of the above items based upon the detailed survey results of the present survey are very similar to the above figures, and the bridge construction plan was prepared principally based upon the conception of the Report of the First Survey.

As for the extension of bridge, the face to face of parapet walls of Rufiji main bridge is 336.6m, 4.06m on the left bank of the bridges over flood openings and 1,000m on the right bank, to be 5,396.6m in total. The under-girder allowance of those bridges shall be 1.50m above the designed high-water level and the designed road surface level shall be 19.8m for both the main bridge and the bridge over flood opening.

As for design terms, design is drawn basically in accordance with the British Standard, and the effective width is 7.0m with two lanes.

A footway of a 1.5m width is planned for one side of the main bridge. For the bridge construction plan, several comparative designs were made according to some different methods (systems) to find out a construction system which is as standardized as possible for the purpose of curtailing the costs and expenses for materials, manufacturing, transport and constructing works.

2-1 Main Bridge of Rufiji River

Table-1 shows the elements of the Main Bridge of Rufiji River.

Table-1. Main Bridge Of Rufifi River

Width		Superstructure		Substructure		
Lane	Footway	Langer Truss	Pony Truss	Type of Foundation	Foot Depth	No. of Pile per Base
7.0m	1.5m	84mx3=252m	40mx2=80m	steel pile 80cm dia.	about 22m	10 or 12

The main bridge of Rufifi River is planned with three units of langer truss of 84.0m long span at the central part and each one set of pony truss of 40.0m long span on the left and the right hand sides. The footway of 1.5m width is planned to be installed to the outside of the main structure.

As for the substructure, steel pile shall be used according to the comparison with caisson about economy and engineering efficienty, and steel piles of 80cm diameter shall be used; 12 piles for Pier No. P2 and No. P3 which are subject to the worst base condition and 10 piles for other points.

2-2 Bridges Over Flood Openings

Table-2. shows the elements of Bridges Over Flood Openings.

Table-2. Bridges Over Flood Opening

Extension			Superstructure			
left bank	right bank	total	Main Beam	Floor Plate	Pavement	Span Length
4,060m	1,000m	5,060m	H-steel	corrugated steel plate (steel deck)	asphalt concrete	20m

Substructure		
Type of Foundation	Foot Depth	No. of Pile per Base
H-pile	10m in average	6 or 9

The width of the bridge for bridges over flood openings is 7.0m with two lanes. The superstructure shall be made with standard beams consisting mainly of H-steel of 20m span. The floor shall be made with corrugaged steel plates (steel deck) and paved with 5cm-thick asphalt concrete.

The substructure shall be made in two ways, with 6 H-piles or 9 H-piles per base according to the results of the soil test, and the foot depth shall be 10m in average.

3. Banking and Paving of Road and Related Structures

Design of road was prepared principally according to the standards of the Government of Tanzania, and as for the items that are not provided in the standards, AASHO and Japanese Road Design Standards were applied. Main design standards are shown in Table-3.

Table-3. Road Structure

Designed Speed (km/h)	Width (m)		
	Total Width	Lane	Shoulder
80	9.6	6.0	1.8

The section of 12km for which the road is planned is geographically very flat with five plane curves, two of which are with very small angle of intersection and it is no need to plan curved lines. Other curves were planned in two different systems, R=1,500m and also 24,000m.

As for the banking structure, its grade is planned to be 1:2.0 according to the nature of soil, flood and engineering system. Volume of soil for banking shall be 210,000m^3 in total, about 100,000m^3 for the left bank and 110,000m^3 for the right bank, and besides, soil of about 50,000m^3 shall be required for excavation and consolidation of the section where the bridge for flood relief is planned.

As the joint section between the banking and the bridge for flood relief is subject to the velocity of flow of floods, it is protected with the slope by means of frame blocks.

4. Construction Cost

The first Survey Mission (October 1970) was aimed at sounding the feasibility and estimating the construction cost about the road and bridge construction plan for the route of about 320km between Dar es Salaam and Lindi. Therefore, it was necessary to conduct a further detailed survey for implementation of the plan.

According to the results of the investigations made by the second Survey Mission, it was found out that the bridge foundation works for weak foundation must be further reinforced and the change in the international currency conversion rates produced a difference in estimated construction costs between the first Feasibility Report and the second Survey Report.

Table-4. International Currency Fluctuation in December 1971

	Tanzania Shilling	U.S. Dollar	Japanese Yen	Ratio
Before Dec. '71	1	0.14	50.4	$\frac{50.4}{43.12} = 1.1688$
After Dec. '71	1	0.14	43.12	

As shown in the above Table-4, the currency ratio was changed with about 16% in December 1971 and this change produced an effect on the estimation of construction cost.
Furthermore, based upon the results of the foundation survey and other surveyings, it was planned in the Feasibility Report that caisson base of 15m foot depth should be applied to the foundation of Rufiji main bridge and piles of 5m foot depth should be used for the foundation of the bridge for flood relief, however, the plan was changed to use steel pipe piles of foot depths of 22m and 10m, respectively. Due to the above two problems and materials for paving works, the construction costs are estimated as follows:

Table-5. Estimated Construction Costs

		Shilling	¥	Remarks
Direct Construction Cost	Rufiji Main Bridge	13,616,000	585,490,000	
	Bridges Over Flood Opening	49,609,000	2,133,130,000	
	Sub-total	63,224,000	2,718,620,000	
	Access Road	5,591,000	240,420,000	
	Total	68,815,000	2,959,040,000	
Contingency		24,559,000	1,055,990,000	Tax, detailed design, field control & work-site administration, compensation
Total		93,374,000	4,015,030,000	

5. Period of Construction Work

In this Report, the period of construction work was set for three years. As the period of the construction is influenced by the time of contract or order of the work before or after the wet season or the flood season, the construction plan and the working schedule must be prepared in due consideration of this point.

6. Estimation of Traffic Volume and Economic Evaluation of the Project

Outline

On the basis of the plan which calls for the construction of 12 km Rufiji River bridge section leaving the remaining sections unimproved, the future traffic volume has been estimated by the Gravity Model method (using α') for 1978 when the bridge section is to be opened to traffic and for 2007 when the redemption of construction cost is to be completed.

The estimated traffic volume is shown in the following table.

Table-6.1 Traffic Volume on the Coastal Link Road (Vehicle/day)

Link No.	Section \ Year	Actual traffic volume counted by COMWORKS	Estimated traffic volume		
		1971	1971	Year when bridge is opened to traffic	Year of completion of repayment
				1978	2007
1	D.S.M. ~ Ndundu	50 ~ 130	85	125	403
2	Ndundu~Nangurukuru	50	53	77	236
3	Nangurukuru~Lindi	40	53	78	233
4	Lindi~Mtwara	100	105	154	454

Using the estimated traffic volume the five items of benefits shown below have been calculated for 1978 and 2007 and the total benefits of 30-year period accumulated on the assumption that the annual change of these benefits will keep the linear relation.

The items of benefits calculated are,

(1) Travelling benefit after the completion of bridge;

(2) Time benefit after the completion of bridge;

(3) Saving of ferry charges (for passenger and vehicle);

(4) Benefits from the direct land transportation to be enabled by the completion of bridge from the southern regions to Dar es Salaam that are presently connected through Songea and Iringa during

the rainy season without a bridge to cross the Rufiji River.

(5) Benefits from the diversion of sea to land transportation to be enabled by the completion of Rufiji River bridge during four months in the rainy season when the traffic becomes impossible to cross the Rufiji River.

Basing on the values worked out by the above process the cost benefit ratio and internal rate of returns have been calculated as shown in the following table.

Table-6.4 Completion Year of Redemption and B/C of 30-Year Period to Interest Rates

Interest rate (%)	Case 1		Case 2	
	Completion year of redemption	B/C of 30-year period (1978 - 2007)	Completion year of redemption	B/C of 30-year period (1978 - 2007)
0.5	2005	1.11	2003	1.25
1.0	2007	1.02	2004	1.15
1.5	2009	0.93	2006	1.05
2.0	2012	0.86	2009	0.96
2.5	2015	0.79	2011	0.89
3.0	2020	0.73	2015	0.82
3.5	2026	0.67	2019	0.76
4.0		0.62	2026	0.70
Internal rate of returns	Case 1		r = 1.10%	
	Case 2		r = 1.79%	

Note: Case 1 - Plan in which footway of 1.5 m wide is provided on one side for the entire bridge and viaduct section.

Case 2 - Plan in which footway of 1.5 m wide is provided on one side for only the main bridge section.

As a-result of the above investigation and analysis, the cost benefit ratios against various interest rate in Cases 1 and 2 will be as shown in Table-6.4.

The interest rate for a 30-year redemption plan will be as follows:

Case 1	r = 1.10 %	$\frac{B}{C} = 1.00$
Case 2	r = 1.79 %	$\frac{B}{C} = 1.00$

So far as the above values are concerned, the cost benefit ratios are relatively small and it is due to the characteristics of this project which requires the construction costs to be concentrated as there are long bridge sections in proportion to the length of road. The construction of Rufiji River bridge is of major significance in that it is carried out as one of the stages of Dar es Salaam-Lindi Coastal Link Road project, and as such its overall economic effects seem to be great indeed (see the first feasibility report).

Thus the Rufiji River bridge project should be evaluated from this point of view.

Since the duration of traffic interruption across of the Matandu, Mavudyi and Mbemkuru Rivers excluding the Rufiji River due to floods is about one month at maximum, it may be said that the construction of Rufiji River bridge alone will almost achieve the objective to provide the all-weather road.

The completion of the project will not only bring about the direct economic benefits analyzed in this report but also actualize potential traffic demand restrained during the four-month period of the rainy season, thus stimulating economic activities in the coastal region, which in turn will prompt further development of this region.

It is a promising project which will also bring about the sufficient indirect benefits that cannot be measured by monetary value such as the increase of income, improvement of cultural standard, furtherance of over-all development, stabilization of the feeling and promotion of well-being of the people in the coastal districts as a result of integration of the southern regions with Dar es Salaam.

7. Surveys to be Conducted in the Future

(1) Boring must be made for the purpose of confirming the nature of the basic foundation for bridges, particularly the bridge for flood relief on the left bank of River Rufiji.
It is advisable to conduct this boring before preparation of detailed design, however, a survey on the foundation can be contracted with the conctractor at the time of contract and according to the result of the survey the number of piles for each point can be decided by consultation with the overseer.

(2) A further detailed survey must be made about places for collection of aggregates for cement and asphalt concrete.

Fig. 3-3. 1 Standard Cross-sectional View Of Main Bridge

Fig. 3-3. 2 Standard Cross-sectional View Of Bridge For Flood Relief

ACKNOWLEDGEMENT

It owes wholly to the generous coopration by the Ministry of Communications, Transport and Labour, the Government of the United Republic of Tanzania, that the Japanese Survey Team for the Rufiji River Bridge Project could accomplish its task without any troulble. We express our profound gratitude especially to Mr. I.M. Kaduma, Principal Secretary, Mr. Kassamia, Director of Roads and Aerodromes Division, and Mr. R.M. Minja, Executive Engineer of Planning Unit, of the Ministry. We express our sincere thanks to Messrs. A.K. Fuko and G. Gulamali, Technical Assistants of the ministry who joined us for the field survby conducted around the Rufiji River as Liaison Officers to keep in contact and coordinate our working groups and Messrs. J.B. Mzoo, C.K. Ndungulu, A. Halahara and G. Mgimwa, the technicians of Material Laboratory, who cooperated us in carrying out the geological survey.

We also received instructive advices and useful assistances from the officials of the ministry of Finance as well as other officials of the ministry of Communications, Transport and Labour. We record their names below and express our sincere gratitude to them.

The Ministry of Finance

Mr. C.D. Msuya,	Principal Secretary
Mr. Mbago.	Director of External and Technical Co-operation Dvision
Mr. B. Chahali	Assistant Secretary

The Ministry of Communications, Transport and Labour

Mr. L.R. Mcginnis	Chief, Planning Unit
Mr. A.J. Philbert	Executive Engineer, Roads and Aerodromes Division
Mr. Dotta	"
Dr. H.L. Uppal	Chief, Material Laboratory
Mr. D.V. Sikka	Soil Analyst, Material Loboratory
Mr. E.P. Mosha	Technical Assistant, Material Loboratory

CHAPTER 1

INTRODUCTION

Chapter 1

List of Figures & Tables

CHAPTER 1 INTRODUCTION

1-1 Purpose and Content of the Survey

The Dar es Salaam/Lindi Coastal Link Road located in the southern coastal region of Tanzania and its parts of about 320 km in length remain unimproved. There live 1,033 thousand peoples (as of 1967) in the areas influenced by this road, and the large and small rivers including the Rufiji River which is the largest in Tanzania, flood these areas in the rainy season without exception, interrupting traffic on the existing road with a resultant isolation of the areas. This interrupting of traffic continues at least for two months, sometimes exetending over as long as six months, and the inhabitants feel very isolated during the rainy season. Thus the construction of the Dar es Salaam/Lindi Coastal Link Road as in all-weather road is demanded keenly in view of the administration, transportation, communication, culture, welfare and industrial development.

At the request of Tanzanian Government, the Japanese government sent the survey Team for the Dar es Salaam/Lindi Coastal Link Road Project (the First Survey Team) who stayed in Tanzania for about fourty days from October, 1970, to carry out the field survey. The works for compiling a feasibility report was performed in Japan based on the results of the field survey and the report was submitted to the Tanzanian Government in July, 1971. In that report the Survey Team recommended to promote the Construction of this Road vigorously since it produces a sufficient investment effect in the form of various benefits as well as a very high degree of indirect effects on administration culture and welfare and showed that is technically quite feasible to construct the Link Road along the existing road from Kibiti to Lindi. In particular, as for the crossing of the Rufiji River which constitutes the place hardest to pass on the proposed route, the above report stated that the construction of a bridge of 300m long over the main stream and bridges over flood openings of 5,000m in length together with embankments extending about 6,600m will permit the vehicle traffic cross over the Rufiji River even during a flood time, judging from the results of the analysis of data on the past floods and the field survey of flood-marks in this area, and that the first priority should be given to the construction of this section especially. (For details, see Feasibility Report, DAR ES SALAAM / LINDI COASTAL LINK ROAD PROJECT, TANZANIA, July, 1971.)

Having received the above report, the Tanzanian Government again requested the Japanese Government to make more detailed survey and the latter government organized the Survey Team for the Rufiji River Bridge Project (the second Survey Team) to send to Tanzania. The Survey Team who stayed there for about 60 days from November, 1971, engaged in various activities such as bridge planning, surveying, geological and soil survey, and material investigation over the area extending about 12 km around the Rufiji River. Planning and designing for the project was carried out in Japan to prepare this report using the data obtained from the field survey. However, this report should be regarded as prescribing the preliminary steps for a detailed design necessary for the implementation of works, or pre-detailed design. In particular, as the satisfactory confirmation of foundation soil necessary for designing the substructures of bridge was not made in this field survey, more thorough investigation is needed for the detailed designing. Other problems and the items of survey required in future are described in the relevant chapters.

1-2 Organization of Survey Team

Members of the Japanese Survey Team for the Rufiji River Bridge Project

YAMASHITA, Hiroshi	Chief of the Team	Chief, Niigata Branch Laboratory of Public Works Institute, Ministry of Construction
SUMIYOSHI, Yukihiko	Bridge planning	Section Chief, Kinki Regional Construction Bureau, Ministry of Construction
FUKUYAMA, Toshiro	Economic Analysis	Director, Japan Overseas Consultants Co., Ltd.
SHIRAISHI, Yasuo	Highway planning	Engineer, Mitsui Consultants Co., Ltd.
HORIBE, Shiro	Surveying	Surveyor, Mitsui Consultants Co., Ltd.
SAKAMOTO, Hazime	- do -	- do -
ABE, Tokizo	- do -	- do -
TANIGAWA, Kumpei	Soil Survey	Engineer, Japan Overseas Consultants Co., Ltd.
KANEKO, Susumu	Boring Survey	- do -
KASAHARA, Tsuneo	- do -	- do -

Resident Japanese Expert on highway planning who joined the Survey Team in the field -survey

KOMURO, Akira	Executive Engineer, Roads and Aerodromes Div. Ministry of Communications, Transport & Labour.

Liaison Officers from the Government of Tanzania who joined the Survey Team in the field survey

Mr. A. K. Fuko	Technical Assistant, Roads and Aerodromes Div. Ministry of Communications, Transport & Labour
Mr. G. Gulamali	- do -

In addition to the above members, four Technicians from the Material Laboratory and six Chain Boys from the Regional Engineer COAST joined the Survey Team.

1-3 Outline of Survey

1-3-1 Carrying Out of Survey

The Survey Team was divided into three groups according to the contents of works, which were allotted to each group as follows. The camp of Comworks, R. E. COAST at Ikwiriri was used in carrying out the field survey of the Rufiji River.

Group A

YAMASHITA, Hiroshi	Chief of the Team
SUMIYOSHI, Yukihiko	Bridge planning
FUKUYAMA, Toshiro	Economic analysis

Group B (in Charge of Surveying)
SHIRAISHI, Yasuo — Highway planning and surveying
HORIBE, Shiro — Surveying
SAKAMOTO, Hazime — - do -
ABE, Tokizo — - do -
Six Chain Boys and many local labours joined this group.

Group C (in charge of Boring and Soil Survey)
TANIGAWA, Kumpei — Soil and material survey
KANEKO, Susumu — Boring
KASAHARA, Tsuneo — Boring
Four Technisians from the material Laboratory joined this group

Mr. KOMURO, Akira, Resident Japanese Expert, and Messre. A. K. Fuko and G. Gulamali, Liaison Officers, joined the group on occasion to keep in contact and coordinate the groups with each other.

Table 1-1 Period of Survey

Group	Various preparations for field survey (at Dar es Salaam)	Field survey of the area around the Rufiji River (Base Camp-Ikwiriri)	Works at Dar es Salaam	Remarks
A	From Nov. 5, 1971 to Nov. 13	From Nov. 13 to Nov. 27	From Nov. 27 to Dec. 3	
B	"	From Nov. 13 to Dec. 17	From Dec. 17 to Dec. 25	
C	"	From Nov. 13 to Dec. 23	From Dec. 23 to Jan. 15, 1972	Soil test and others were conducted at the Material Laboratory in Dar es Salaam.

1-3-2 Outline of Each Survey

A. Surveying

The following surveyings were conducted for the section of 12km from Sta. No. 28 near Ikwiriri to Sta. No. 40 on the right hand bank of Rufiji River.

A-1 Center Line Setting

The center lines of the bridge over the main stream of the Rufiji River were established first, then the center line of the whole route was selected so that the abandoned embankment of washed out road can be used as far as possible. The pegs were provided at intervals of 50m together with I. P., B. C. and E. C. pegs to conduct the center line surveying.

A-2 Profile Levelling

Based on the established center line the profile levelling was conducted at intervals of 50m and at the changing point of topography. The profiles of the main stream of Rufiji River and the ponds were obtained by taking soundings.

A-3 Cross-sectioning

The cross-sectioning was conducted at the survey points at intervals of 50m for the width of 50m on each side of the point, that is, for the width of 100m in all.

A-4 Topographical Survey

The Topographical survey was conducted for the area of about 200m in width along the established center line (and for the area of about 500m in width adjacent to the main stream of Rufiji River). The scale is 1:1000.

B. Boring Survey

The boring was conducted at seven locations with the hole of 260.5m in total depth drilled, of which detail is shown in Table 1-2.

The standard penetration test was performed at every 1 or 2m in depth, the horizontal loading test was conducted at every 3m with PRESSURE METER only for the test holes bored for the bridge over the main stream.

Table 1-2 Details of Boring Survey

	No. or locations	Depth of bored hole		Standard ponetra-tion test	Horizontal loading test
		Depth of each borea hole	Total		
Bridge section over the main stream of the Rufiji River	2	30m 30m	60m	42times	18times
Bridge section over flood opening	5	51m, 57.5m, 40m, 27m, 25m,	200.5m	168times	-
Total	7		260.5m	210times	18times

C. Soil Survey

The test pits were hand excavated at 28 locations in all at intervals of about 200m over the section planned for enbankment; the subsurface conditions of ground were observed and the samples taken. The tests were conducted to determine 1 Specific Gravity, 2 Moisture Content, 3 Gradation, 4 Liquid Limit, 5 Plastic Limit, 6 Compaction, and 7 California bearing ratio of the samples obtained, in cooperation with the Material Laboratory.

Also the samples for testing the filling material, were taken from 2 test pits excavated in laterite lying near Ikwiriri and the same tests as above were performed on these samples.

D. Other Survey

D-1 Survey for quarry

In order to secure aggregates for concrete and asphalt, the survey was done at the area around the Rufiji River where produces aggregates available for the purpose.

CHAPTER 2

SOIL SURVEY

Chapter 2

List of Figures & Tables

CHAPTER 2 SOIL SURVEY

2-1 Outline

In order to survey the underground condition the borings were conducted at 7 points and the test pits were excavated at 28 points between Sta. No. 28 and Sta. No. 40 shown in the first phase survey report. The most important fact ascertained by this survey is the existence of soil layers softer than expected from the information obtained from the one test hole bored in the first phase survey. It was found that a relatively soft cohesive soil having N-value of about 5 of the standard penetration test deposits thickly on the left bank side of the Rufiji River (to the direction of Ikwiriri, the origin) bounded approximately by the left bank of this river. It was found that the thickness of this layer is as much as 43 m in the borehole No. 2.

Another important fact is that in the first phase survey the bearing stratum was supposed to deposit uniformly beneath the loose sand layer all over the vicinity of this section but in the present survey it was found that the said stratum lies in the deeper place than expected. It was found that the consistency of clay layer distributed over the entire section is not uniform and some portions are soften than expected from the results of the first phase survey. Some portions showed N-value of more than 25 while others indicated N-value of less than 10 of the standard penetration test.

In the first phase survey report, it was proposed that both main bridge and bridges for flood relief is recommendable to be supported by caissons and piles, of which the bearing capacity depends essentially on their point resistance given by the said bearing stratum. According to the result of the present survey, however, it is recommendable that the main bridge is supported by the bearing piles reaching the said bearing stratum and that the bridges for flood relief are beared by the frictional piles.

2-2 Deep Soil Condition (Bridge Section)

The soil stratification are shown in Fig. - 2, 1, Soil Profile, as classified on the basis of the result of standard penetration test and identification soil test at seven bore holes.

In this figure, the stratification, except the embankment of existing abandoned road (B-layer), may be explained from upper to lower layers roughly as follows:

- Cu layer = upper cohesive soil layer, of which colour ranging from brown to dark bluish grey.
- Su layer = upper sandy soil layer, of which colour varying from light bluish grey to light brown.
- Cl-S layer = lower cohesive soil layer (soft), of which colour varying from dark grey to light brown.
- Cl-h layer = lower cohesive soil layer (hard), of which coulour varying from dark grey to light brown.
- Sl layer = lower sandy soil layer dense and stable), of which colour varying from light yellowish brown to light greenish grey.

The characteristics of these soil layers are as described below.

Cu layer: This layer is from 5m to 8m in thickness, principally composed of silt with some sandy soil or black cotton clay depositing locally, and does not form an uniform deposit. N-value of the standard penetration test may be regarded to range from 5 to 10.

Su layer: This layer has a thickness of about 10m. The soil grading varies from fine to coarse sand by place and a silt layer is intercalated in it at Borehole No. 2. N-value of the standard penetration test ranges approximately between 10 and 30.

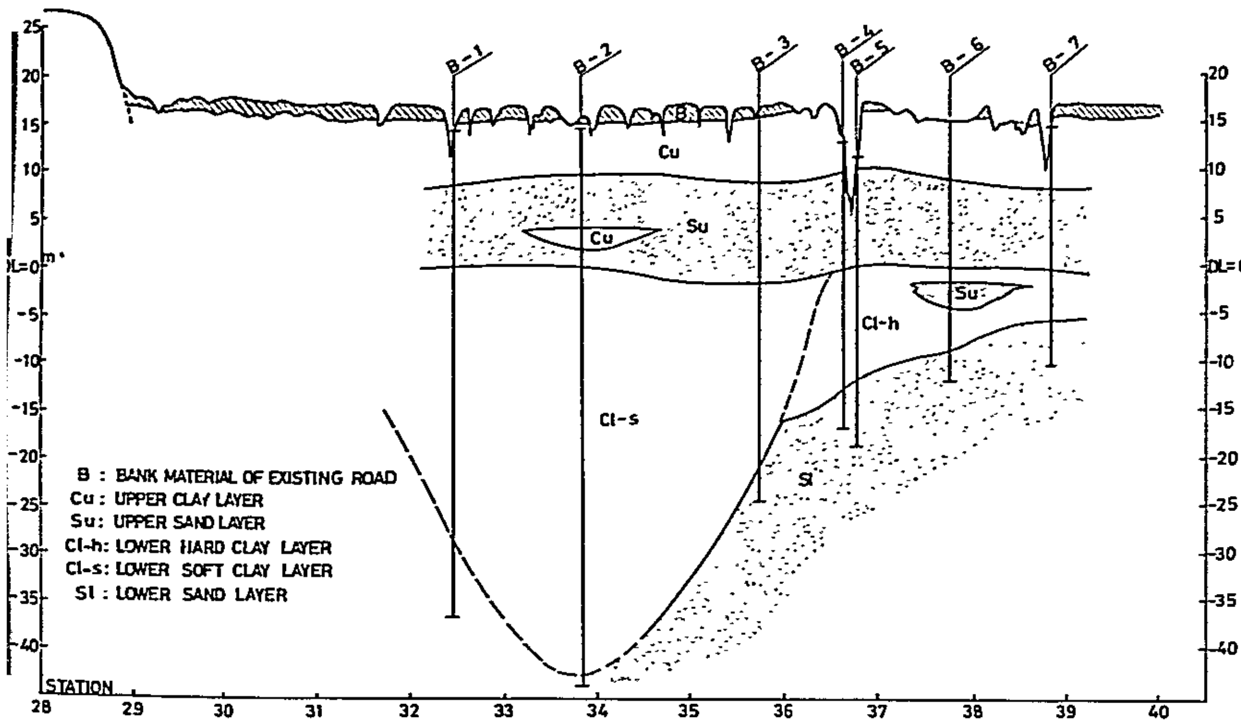
Ce-S Layer: This is a silt layer having the maximum thickness of about 40m, and some wooden pieces and organic material not decomposed are contained in it. N-value of the standard penetration test shows an appoximately constant figure of 5 regardless of the depth. Judging from the application to this layer of the co-relation between the result of pressure meter test and standard penetration tests for Ce-h layer, this layer of cohesive soil seems to be in a normally consolidated condition.

Ce-h layer: This layer of cohesive soil is rather sandy without wooden pieces or organic material. N-values of the standard penetration test, ranging from 12 to 25, are greater than those of Ce-S layer and so far as P_f-values of the pressure meter test concern, it is presumed that this layer is somewhat in an over-consolidated condition.

Se layer: It is the substratum for the present survey. At the location of main bridge, it is encountered at the elevation of about-12 to-14. The layer on the left bank side is composed of medium-grained sand and on the right bank side of fine-grained sand. The layer is very dense with N-values of the standard penetration test ranging over 50. Se layer is considered suitable as bearing stratum of main bridge foundations.

Fig-2·1 LOCATION OF TEST BORING AND SOIL PROFILE

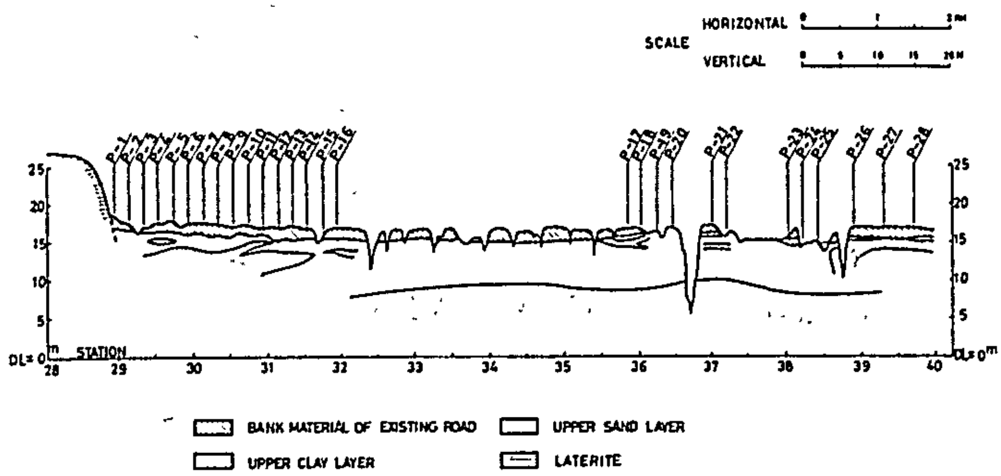
SCALE HORIZONTAL 0 1 2KM
VERTICAL 0 5 10 15 20M



2-3 Shallow Soil Condition (Embankment Section)

The condition of surface soil was investigated by means of the test pits excavated at 28 points over the embankment section of about 6.6km, of which results are described below. (Fig. - 2.2.)

Fig-2·2 LOCATION OF TEST PIT



Section from P-1 to P-3

The surface soil of this section is principally composed of black cotton clay and at the time when the survey was made it was dry and shrinked with innumerable cracks occurring on its surface. Though the soil is stiff and its strength is about 5kg/cm^2 in the unconfined compression test, it has a character to swell when it absorbs water and decreases its strength to an extreme extent.

Section from P-4 to P-16

The surface portion, from 0.5m to 2m in depth, of this section is composed of black cotton clay or silt and the layer of fine-grained sand lies beneath it.

Section from P-17 to P-20

It is a deposit of cohesive soil layers primcipally composed of silt with sand layers of 50cm thick intervening in some places.

Vicinity of P-21

In general the cohesive soil predominates in this area and thin sand layers intervene in place.

Section from P-22 to P-25

The cohesive soil prevails in the subgrade of this section. At P-23, P-24 and P-25, the cohesive soil is so stiffly solidified with calcareous gravel mixing in that it took one and half days to excavate 1m³ by hand.

Section from P-26 to P-28

In this section, the surface portion from 0.2m to 0.6m deep is composed of cohesive soil and beneath it lie the layers of fine-and medium-grained sand with silt mixing in.

The results of the soil test stated in the first phase survey report and those of the present test were generalized to examine the stability of embankment against the sliding failure; on the basis of which it may be concluded that in the section surveyed the embankment of up to 4m high is stable even at a site of comparatively poor soil condition.

2-4 Filling Material

Conceivable mathods to obtain the filling material for the road embankment is to use the earth produced by excavating the soil mass lying around the route or to carry in a suitable material obtained elsewhere.

The soil tests were conducted of the soil sarrples taken from the excavation of test pits, of which results are shown in Table-2.1. The samples of soils of which the soil tests were conducted are as follows.

(a) Black cotton clay

(b) Silty clay

(c) Sandy clay

(d) Silty sand

(e) Laterite

As a result of the soil tests the following facts were ascertained for each sample, (a) Black cotton clay is not quite suitable for the filling material because of its very low CBR-value in the soaked condition. (b) Silty clay has much the same quality as black cotton clay and therefore it is undesirable to use it for filling material as for as possible. (c) Sandy clay having a high soaked CBR-value can be used as the material of lower portion of embankment. (d) Silty sand may be regarded suitable for the material of embankment. (e) Laterite has a soaked CBR-value as large as 14% at the lowest and is a suitable soil as filling material.

Judging generally from the above, the silty sand and laterite should be used as filling materials, avoiding the use of black cotton and silty clays distributed over the area along the route.

2-5 Investigation of aggregats

In order to study the possibility of obtaining aggregates for the work, the field investigations were conducted for the rock mountains at the four sites of Kitembo, Wingayongo, Utete and Namakutwa, of which results are shown on Table-2.2.

Table - 2.1.1

SUMMARY OF SOIL TEST

Item	Pit No.1	Pit No.2	Pit No.3	Pit No.4	Pit No.5	Pit No.6	Pit No.7	Pit No.8	Pit No.9	Pit No.10	Pit No.11	Pit No.12	Pit No.13	Pit No.14	Pit No.15
U: Undisturbed Sample / D: Disturbed Sample	D.	D.	D.	D.	D.	D.	D.	D.	D.	D.	D.	D.	D.	D.	D.
Sample Depth (m)	1.00m 1.20m	0.50m 0.70m	1.00m 1.20m	1.70m 2.00m	1.10m 1.20m	1.30m	2.00m	1.80m	1.50m	0.70m	1.50m	0.80m	0.90m	1.00m	0.90m
Natural Water Content Wc (%)	12.6	17.2	6.7	2.5	4.5	4.5	17.6	5.60	6.30	17.60	1.30	13.10	3.10	27.80	7.40
Specific Gravity of Soil Particles Gs	2.65	2.61	2.60	2.65	2.64	2.65	2.73	2.74	2.68	2.70	2.64	2.65	2.65	2.64	2.70
Wet Density γ_t (t/m³)															
Dry Density γ_d (t/m³)															
Natural Void Ratio e															
Degree of Saturation S (%)															
Liquid Limit L.L. (%)	82.0	79.0	30.0				30.0			47.0				56.0	23.0
Plastic Limit P.L. (%)	19.0	21.0	15.0				20.0			16.0				18.0	16.0
Plasticity Index P.I.	63.0	58.0	15.0				10.0			31.0				38.0	7.0
Grain Size Analysis – Gravel (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0				0.0	0.0
Grain Size Analysis – Sand (%)	3.0	17.0	38.0	99.0	87.0	91.0	45.0	92.0	77.0	13.0	89.0	90.0	97.0	16.0	58.0
Grain Size Analysis – Silt (%)	30.0	56.0	35.0	1.0	7.0	2.0	37.0	8.0	12.0	61.0	5.0	4.0	3.0	61.0	27.0
Grain Size Analysis – Clay (%)	67.0	27.0	27.0	0.0	6.0	7.0	18.0	0.0	11.0	26.0	6.0	6.0	0.0	23.0	15.0
Grain Size Analysis – Colloid (%)															
Grain Size Analysis – Percentage No.200 Sieve (%)															
Classification – Field Identification	Cotton Clay	Heavy Cotton Clay	Wet Fine Sand	Fine Sand	Sand	Fine Sand	Sandy Silt	Fine Sand	Fine Sand	Silty	Fine Sand	Silty Sand	Fine Sand	Sandy Clay	Sand silt
Classification – Unified Classification	CH	CH	CL	SP	(SC)	SP-SM	CL	SP-SM	(SC)	CL	SP-SM	SP-SM	SP	CH	SC
British Standard Method – Compaction Test – Maximum Dry Density (lb/ft³)	86.6	102.6	103.7	100.9	105.3	100.2	116.5	95.0	103.9	108.0	97.2	95.8	99.2	107.8	113.4
British Standard Method – Compaction Test – Optimum Moisture Content (%)	28.0	17.5	18.0	23.0	16.0	18.2	14.2	20.5	16.7	17.0	17.0	17.5	20.0	18.0	14.0
British Standard Method – CBR Test – Soaked – Dry Density (lb/ft³)	87.8	103.4	103.8	101.1	106.2	101.3	116.4	95.7	104.5	108.2	102.8	96.8	99.2	107.8	113.4
British Standard Method – CBR Test – Soaked – CBR (%)	7.0	8.1	5.9	12.7	20.3	7.8	22.2	16.0	29.6	25.0		14.0	18.7	14.3	32.2
British Standard Method – CBR Test – Un Soaked – Dry Density (lb/ft³)		103.4	103.8	101.1	106.2	97.3	114.2	94.4	106.0	107.7		95.1	99.0	107.6	113.7
British Standard Method – CBR Test – Un Soaked – CBR (%)	1.0	1.2	1.5	10.4	10.4	4.5	16.3	12.0	27.4	3.0	9.0	12.8	20.0	13.8	30.3
Japan Industrial Standard Method – Compaction Test – Maximum Dry Density (g/cm³)	1.415				1.681				1.659			1.570		1.685	
Japan Industrial Standard Method – Compaction Test – Optimum Moisture Content (%)	26.2				15.6				15.5			16.3		16.0	
Japan Industrial Standard Method – Compaction for CBR Test – Maximum Dry Density (g/cm³)	1.662				1.895				1.820			1.657		1.920	
Japan Industrial Standard Method – Compaction for CBR Test – Optimum Moisture Content (%)	21.4				11.0				14.6			13.6		10.6	
Japan Industrial Standard Method – CBR Test (soaked 4 days) – 17* – Dry Density (g/cm³)	1.301				1.659				1.588			1.493		1.625	
Japan Industrial Standard Method – CBR Test (soaked 4 days) – 17* – CBR (%)	0.7				13.8				11.0			16.7		1.71	
Japan Industrial Standard Method – CBR Test (soaked 4 days) – 42* – Dry Density (g/cm³)	1.403				1.753				1.690			1.546		1.780	
Japan Industrial Standard Method – CBR Test (soaked 4 days) – 42* – CBR (%)	0.8				35.9				17.1			26.5		5.90	
Japan Industrial Standard Method – CBR Test (soaked 4 days) – 92* – Dry Density (g/cm³)	1.515				1.841				1.820			1.634		1.907	
Japan Industrial Standard Method – CBR Test (soaked 4 days) – 92* – CBR (%)	1.2				51.7				22.0			27.3		11.1	
Japan Industrial Standard Method – CBR Coresponding to 95% of Yd max (%)	1.4				44.5				18.5			26.8		7.6	

Notes; * Number of Blows for each of three Layers

Table - 2.1.2

SUMMARY OF SOIL TEST

Sample No.	Pit No.16	Pit 1 No.17	Pit 2 No.17	Pit No.18	Pit No.19	Pit No.20	Pit No.21	Pit No.22	Pit No.23	Pit No.24	Pit No.25	Pit No.26	Pit No.27	Pit No.28	[illegible] No.1
U: Undisturbed Sample / D: Disturbed Sample	D.	D.	D.	D.	D.	D.	D.	D.	D.	D.	D.	D.	D.	D.	D.
Sample Depth (m)	1.00m	1.40m 1.50m	1.60m 1.70m	1.20m	1.00m 1.20m	1.00m 1.20m	0.50m 0.70m	0.50m	0.50m	1.50m	1.00m	1.40m	0.40m 0.60m	0.80m	1.00m 1.20m
Natural Water Content Wc (%)	12.9	26.5	12.6	7.0	23.0	3.6	10.7	34.3	4.6	5.5	13.6	5.2	4.9	5.4	2.2
Specific Gravity of Soil Particles Gs	2.61	2.62	2.68	2.61	2.53	2.63	2.67	2.60	2.65	2.56	2.65	2.62	2.63	2.62	2.66
Wet Density γ_t (t/m³)															
Dry Density γ_d (t/m³)															
Natural Void Ratio e															
Degree of Saturation S (%)								77.0		61.0	49.0			30.0	
Liquid Limit L.L. (%)	80.0	34.0		39.0	78.0			25.0		13.0	10.0			13.0	
Plastic Limit P.L. (%)	13.0	16.0		16.0	22.0			52.0		48.0	39.0			17.0	
Plasticity Index P.I.	67.0	18.0		23.0	56.0	0.0	0.0	0,0	0.0	0,0	0.0	0.0	0.0	0.0	
Grain Size Analysis: Gravel (%)	2.0	0.0	0.0	0.0	0.0	66.0	94.0	2.0	76.0	23.0	40.0	77.0	92.0	69.0	82.0
Grain Size Analysis: Sand (%)	6.0	37.0	97.0	11.0	2.0	25.0	6.0	16.0	10.0	16.0	17.0	15.0	2.0	13.0	7.0
Grain Size Analysis: Silt (%)	23.0	47.0	3.0	57.0	27.0	9.0	0.0	82.0	14.0	56.0	43.0	8.0	6.0	18.0	11.0
Grain Size Analysis: Clay (%)	69.0	16.0	0.0	32.0	71.0										
Grain Size Analysis: Colloid (%)															
Grain Size Analysis: Percentage No.200 Sieve (%)															
Classification: Field Identification	Silty Clay	Sandy Silt	Medium Sand	Sandy Silt	Cotton Clay	Clay Silty	Very FineSand	Cotton Clay	Sandy Silt	Clay	Silty Clay	Sandy Silts	Medium FineSand	Silty Sand	Laterite
Classification: Unified Classification	CH	CL	SP	CL	CH	(SC)	SP-SM	CH	(SC)	CH	CL	(SC)	SP	SC	(SC)
British Standard Method: Compaction Test: Maximum Dry Density (lb/ft³)		108.8	102.9	99.1	86.4	110.2	105.8		108.0	101.6	109.8	121.6	106.2	119.4	123.0
British Standard Method: Compaction Test: Optimum Moisture Content (%)		15.5	15.0	19.5	26.0	14.5	15.5		16.0	20.0	14.5	12.0	14.0	11.5	10.0
British Standard Method: CBR Test: Soaked: Dry Density (lb/ft³)		110.6			100.3	110.9	106,1		107.9	102.0	109.8	122.3	106.5	119.9	123.0
British Standard Method: CBR Test: Soaked: CBR (%)		15.6		5.3		14.9	6.7		15.0	10.0	15.9	23.7			29.7
British Standard Method: CBR Test: Un Soaked: Dry Density (lb/ft³)		109.0		99.8		110.3	104.7				115.5	121.1			121.3
British Standard Method: CBR Test: Un Soaked: CBR (%)		1.7		0.2		14.3	2.7		7.0		1.2	17.3	11.0	9.0	19.3
Japan Industrial Standard Method: Compaction Test: Maximum Dry Density (g/cm³)							1.681		1.730	1.590					1.975
Japan Industrial Standard Method: Compaction Test: Optimum Moisture Content (%)							15.0		15.7	14.4					9.6
Japan Industrial Standard Method: Compaction for CBR Test: Maximum Dry Density (g/cm³)							1.903		1.900	1.906					2.105
Japan Industrial Standard Method: Compaction for CBR Test: Optimum Moisture Content (%)							10.5		12.8	11.8					8.0
Japan Industrial Standard Method: CBR Test (soaked 4 days): 17: Dry Density (g/cm³)							1.581		1.756	1.598					1.869
Japan Industrial Standard Method: CBR Test (soaked 4 days): 17: CBR (%)							14.7		20.0	0.7					9.5
Japan Industrial Standard Method: CBR Test (soaked 4 days): 42: Dry Density (g/cm³)							1.648		1.838	1.609					2.019
Japan Industrial Standard Method: CBR Test (soaked 4 days): 42: CBR (%)							26.6		22.4	1.0					38.2
Japan Industrial Standard Method: CBR Test (soaked 4 days): 92: Dry Density (g/cm³)							1.863		1.900	1.735					2.078
Japan Industrial Standard Method: CBR Test (soaked 4 days): 92: CBR (%)							33.8		23.8	1.7					53.3
Japan Industrial Standard Method: CBR Corresponding to 95% of γ_d max (%)							32.0		21.0	2.1					34.0

Table - 2.1.3

SUMMARY OF SOIL TEST

				Ikwiriri No.2	Rufiji Sand														
Sample No.				Ikwiriri No.2	Rufiji Sand														
U:Undisturbed Sample D: Disturbed Sample				D.	D.														
Sample Depth (m)				1.00m 1.20m	0.80m 1.00m														
Natural Water Content W_c (%)				2.4	0.4														
Specific Gravity of Soil Particles G_s				2.63	2.64														
Wet Density γ_t (t/m³)																			
Dry Density γ_d (t/m³)																			
Natural Void Ratio e																			
Degree of Saturation S (%)																			
Liquid Limit L.L. (%)																			
Plastic Limit P.L (%)																			
Plasticity Index P.I.																			
Grain Size Analysis	Gravel (%)			0.0	2.0														
	Sand (%)			85.0	98.0														
	Silt (%)			3.0	0.0														
	Clay (%)			12.0	0.0														
	Colloid (%)																		
	Percentage No.200 Sieve (%)																		
Classification	Field Identification			Laterite	Sand														
	Unified Classification			(SC)	SP														
British Standard Method	Compaction Test		Maximum Dry Density (lb/ft³)	117.9															
			Optimum Moisture Content (%)	12.0															
	CBR Test	Soaked	Dry Density (lb/ft³)	119.2															
			CBR (%)																
		Un Soaked	Dry Density (lb/ft³)																
			CBR (%)	14.0															
Japan Industrial Standard Method	Compaction Test		Maximum Dry Density (g/cm³)	1.880															
			Optimum Moisture Content (%)	12.0															
	Compaction for CBR Test		Maximum Dry Density (lb/ft)	2.026															
			Optimum Moisture Content (%)	7.3															
	CBR Test (soaked 4 days)	17*	Dry Density (g/cm³)	1.820	1.582														
			CBR (%)	19.1	28.6														
		42*	Dry Density (g/cm³)	1.950	1.644														
			CBR (%)	57.1	31.9														
		92*	Dry Density (g/cm³)	2.040	1.706														
			CBR (%)	61.5	44.3														
		CBR Corresponding to 95% of γ_d max		51.0	41.0														

Notes; * Number of Blows each of three Layers

Favourable materials as aggregates include quartzite at Kitembo and sandstone at Utete. The possible quantity of production of these materials should be ascertained by a detailed investigation in future.

Table-2. 2 Summary on Reconnaisance Survey for the Material Availability

Site	Distance from NDUNDU	Material	COLOUR	REMARKS
KITEMBO	Northern, about 30km	soft sandy deposit (ground surface)	brown	slightly solidified
		hard sandy Quartzite (basement complex)	bluish grey	jointed slightly
WINGAYONGO	Northern, about 38km	sandstone	white	slightly solidified crushable with finger smell of dead animals
UTETE	Western, about 30km (upper reaches of the Rufiji river)	soft sandstone	brown	very hard block
NAMAKUTWA	Southern, about 30km	conglomerate	bluish grey	slightly solidified
		soft sandy deposite	brown	looks like solidified

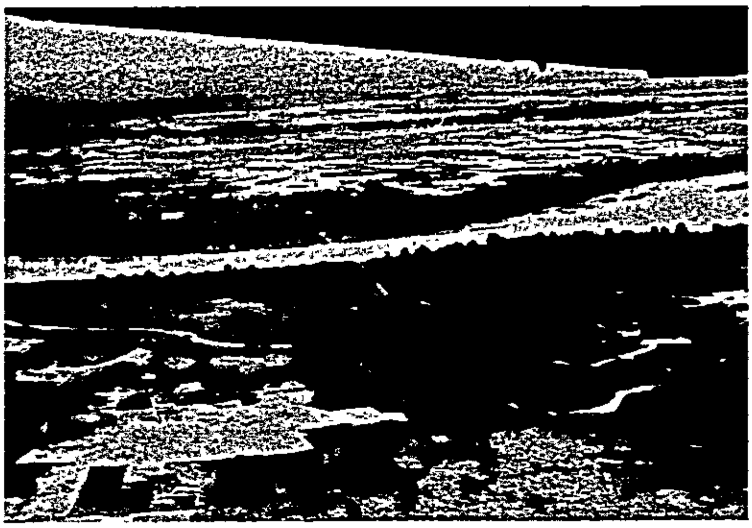
2-6 Supplements of Investigation Necessary for Detailed Design

The items of investigation necessary for the detailed designing of the foundation of the bridges over flood openings include, the confirmation of (1) the extent of distribution and the strength of cohesive soil which was found in Borehole No. 2 intervening in Su layer, (2) the consolidation settlement characteristic of Cl-S layer which was found in Borehole No. 1 to No. 3 and the boundary between this Cl-S layer and Cl-h layer. In this, it is necessary to carry out the test boring again at several or about ten points and at the same time to conduct the soil tests, mainly the consolidation tests, of the undisturbed samples taken from such test boring.

As for aggregate, it is necessary to conduct the core boring for the rocks at Wingayongo and Utete for testing the fitness as aggregate by the strength and abration tests of the core, and at the same time to carry out the surveying to ascertain the possible quantity of production of such materials.

CHAPTER 3

BRIDGE PLANNING



Chapter 3

List of Figures & Tables

CHAPTER 3 BRIDGE PLANNING

3-1 Relation to First Phase Survey Report

The principal matters related to this report and the Report on the Dar es Salaam/ Lindi Coastal Link Road Construction Project (the first phase survey report) are described below.

3-1-1 Design-Flood Discharge of the Rufiji River

In the first phase survey report the flood discharge of the Rufiji River was estimated by the analysis of past hydrological data and the investigation of flood-marks. That is, the design-flood discharge at Ndundu, the bridging site, was estimated at 6,700m^3/sec. (of 15 years probable flood) with the flood stage at that time put at 16.8m; of which 2,960m^3/sec. are to run down through the main stream portion of the Rufiji River and 3,740m^3/sec. through the flood openings (of about 5 km in total length). Since the rises of water level above the design high water level at the abnormal flood are 0.7m and 0.5m respectively for 9,900m^3/sec of 100 years and 8,700m^3/sec of 50 years probable floods, the bridge was planned with the clearance below girder of 1.5m and the embankment planned with its road surface height of 1.0m, respectively above the design high water level of 16.8m. Based on the way of thinking for bridging of the river as above described, the same calculation as that made in the first phase report was made to use the results of detailed profile levelling performed for the present survey, the results of which are shown in Tables-3.1.1 and -3.1.2.

Table-3.1.1 Floodwater Discharge through the Main Stream of Rufiji River

Watercourse	A	n	R	V	Q
Low water sole	1,247	0.03	9.10	2.03	2,530
Flood sole	415	0.035	2.87	0.81	330
Total	1,662				2,860

Where;

Design high water level = 16.80m Surface slope, I = 1/5,100

A = Cross-sectional area, in m^2

n = Coefficient of roughness

R = Hydraulic mean depth, in m

V = Average flow velocity, in m/sec

Q = Discharge, in m^3/sec

Table-3.1.2 Flood Discharge through Bridges over Flood Openings

Length and location of bridge over flood opening	A	N	R	V	Q
L = 4,000m Left bank of Rufiji River	6,890	0.045	1.47	0.46	3,150
L = 700m Right bank of Rufiji River	1,146	0.045	1.41	0.44	500
L = 300m Right bank of Rufiji River	581	0.045	1.59	0.50	290
Total	8,617				3,940

The total discharge through the main stream and flood openings are 6,800m³/sec. approximating the design-flood discharge, the planning was made fundamentally in accordance with the way of thinking and the length of bridges over flood openings (about 5,000m) shown in the first phase report. However, the fills of abandoned road lying in the planned section for the bridges over flood openings will be excavated to back-fill the dents in the vicinity to the same level as the ground surface and thus the cross-sectional area of river will be secured for the said section.

At present there is a culvert of about 10m in the rivercourse at Sta. No. 30 + 600 near Ikwiriri Chini; for which a new bridge of about 60m long is planned because the discharge is estimated to increase to 100m³/sec at a flood time and the construction height of road is increased.

3-1-2 Sidewalk of Bridge

The width of bridges being 7.0m as compared with 9.6m in total width of the embankment portion, it is preferable to provide a sidewalk on the bridges in view of the safety of pedesrians. The form of sidewalk will depend on whether it is provided on one side or both sides and the type of bridge, with a resultant difference in the construction cost. Though any conclusion cannot be absolutely drawn, it is desirable to provide a sidewalk, if practicable, on the bridge as well as the embankment portion. In this plan, it has been planned from the first to construct the sidewalk of 1.5m wide on the bridge over the main stream of the Rufiji River only on its one side taking into account the increase in construction costs. The reasons for this are that the bridge is of through bridge type of Langer and pony trusses and a considerable number of pedestrians is expected to use the bridge from the first.

The increase in construction costs due to the sidewalks to be constructed on the bridges over flood openings is described in Chapter 5. On the assumption that the sidewalks are to be provided, if practicable, on the bridges over flood openings the method of their construction will be examined thoroughly in preparing the detailed design so that the increase in construction costs may be minimized.

3-1-3 Survey of Foundation Soil and Design of Substructure

In the first phase survey, each one test hole was bored respectively for Utete route and Ndundu route which was proposed as the final route. The latter test hole locates near and its depth is smaller than that of Borehole No. 4 drilled for the main stream postion or Rufiji River in the present survey, from which the condition of foundation soil was deduced to plan the substructures for the first phase survey. In the second phase survey, the test holes were bored at two points for the main stream portion and five points for the bridges over flood openings and the soil condition of bridging section could be grasped pretty well as described in detail in Chapter 2. Therefore, the substructures of respective bridges have been designed in conformity with the conditions of foundation soil clarified by this survey.

For preparing the detailed design, it is necessary to conduct a survey which can grasp the condition of foundation soil more accurately. In particular as the foundation soil of the flood opening portions of 4 km in length is relatively poor and the extent of poorness is not defined yet, an additional number of test holes will be necessary for further investigation.

3-2 Design Condition

The design conditions for planning the bridge over the main stream of Rufiji River and the bridges over flood openings of 5,060m in total length on the both banks of river are as follows:

1. The design specifications will be basically in accordance with the latest British Standard. However, of live loads, 80% of knife edge load is adopted.

2. The effective width will be 7.0m for two lanes and a sidewalk of 1.5m wide will be provided on one side only of the main bridge.

3. The clearance below bridge girder will be 1.5m as against the design high water level.

4. All of the steel materials for the bridges will be in compliance with the Japanese Industrial Standards (JIS).

3-3 Bridge Structure

3-3-1 Main Bridge

The main bridge has 3 series of Langer truss of 84.0m in span length arranged on its center portion and each one series of pony truss of 40.0m in span length provided on the both sides of them. This plan is completely the same as that proposed in the first phase report, and the length of face to face of parapet walls is 336.6m. The arragement of each one series of pony truss on the both sides is to provide some allowances for the both banks tending to crumble year by year. The main structure of stiffening trusses of Langer trusses for the main spans and the pony trusses for the both side spans are designed by the same height of 4.5m from the aesthetic point of view.

The standard cross sections of both spans for the main bridge are shown in Fig. – 3.1 and the sidewalk of 1.5m wide is to be attached to the outside of main truss on the downstream side.

In the first phase report, it was planned to use the caissons embeded to the depth of 15m for the substructures of main bridge. As a result of the second phase survey of subgrade it was bound to be necessary to embed the caissons deeper by about 7m (or 22m in total penetration). Therefore, an examination was made to compare various construction methods, upon which the conclusion was reached that the following method is more advantageous in view of the execution of works and the economy. That is, the steel pipe piles, instead of caissons, driven in as the foundations are erected upward to connect their uppen parts with cap beams of reinforced or steel-frame concrete, and the superstructures are supported on these cap beams.

The piers, P3, located in the most unfavourable condition require 12 steel pipe piles of 80cm in diameter which should be driven to the depth of about 22m below GL (+ 5.000). The upper and lower halves of these steel pipe piles are of plates respectively of 18mm and 14mm thick with allowance of 2mm provided for corrosion; further, the inside of steel pipe at the pile heat part is filled with reinforced concrete to increase the stiffness of pile as a composite column, in order to decrease as far as possible any displacement of pile head due to earthquake or wind load.

3-3-2 Bridges Over Flood Openings

The total length of the bridges over flood openings is 5,060m which is longer by 60m than that shown in the first phase survey report by reason referred above.

Actually, it includes 4,060m on the left bank side and 1,000m on the right bank side of Rufiji River. This total length of the bridges over flood openings is approximately equal to that of the present broken portion of embankment.

The bridges over flood openings are of standard beam bridge with the superstructures composed of main H-beams spanning 20m (distance between centers of piers) and their standard cross section is shown in Fig. - 3.2.

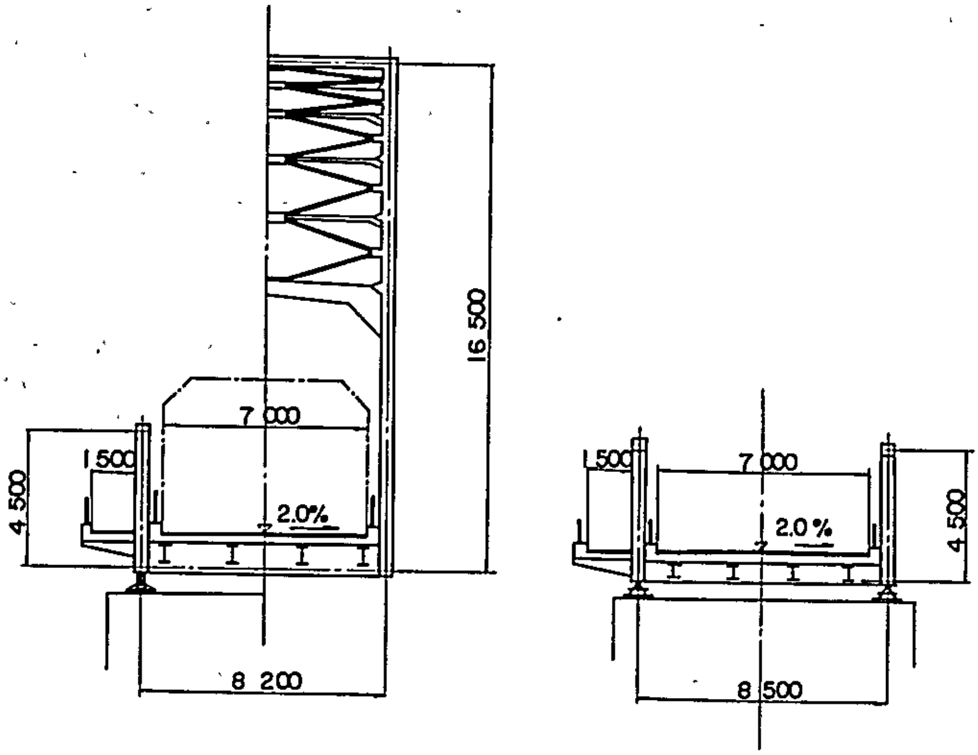
The floor system is composed of cross beams of corrugated steel plate fastened to the upper flanges of main beams with high tensile bolts, upon which concrete floor slabs are placed. The concrete slab and the corrugated steel forming cross beam are locked with stud dowels. Though the load is born by the cross beam, it is necessary to take a measure to prevent the floor slab concrete from cracking. The pavement is applied on the concreate floor slab by asphalt concrete of 5cm thick.

The substructures of bridge over flood opening are composed of foundation piles of H-beam as shown in Fig. - 3.2 and these piles are extended upward to connect their heads with cap beams on which the superstructures are supported. The construction methods were examined comparing the H-beam and reinforced concrete piles, upon which it was ascertained that the H-beam pile method is more advantageous in view of both the execution of work and the economy.

In the first phase survey the planning was made with the length of foundation piles assumed at 10m in average because of insufficient geological survey, while it was found as a result of the second phase survey that such length required is 15m in average (or penetration of from 10m to 11m).

As described in paragraph 3.1, the condition of subgrade on the both sides of Borehole No. 2 in particular on the left bank of Rufiji River is not satisfactory and there

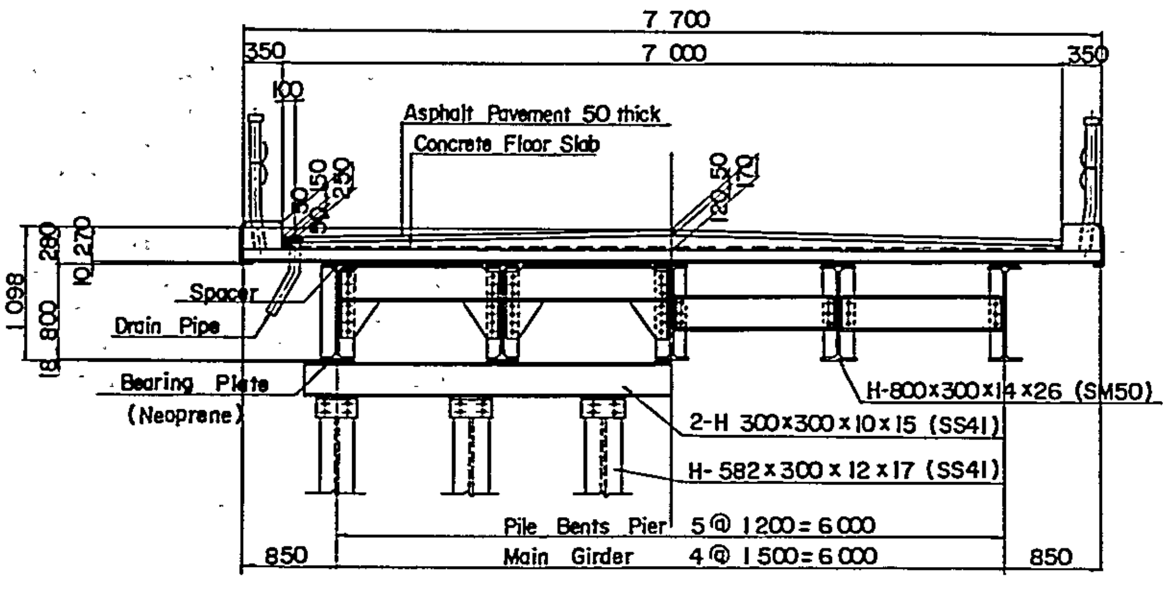
Fig.-3·1 STANDARD CROSS SECTION OF MAIN BRIDGE



LANGER TRUSS

PONY TRUSS

Fig.-3·2 STANDARD CROSS SECTION OF BRIDGES OVER FLOOD OPENINGS



END

INTER

seems to be some questions in estimating the bearing capacity of foundation piles. However, in the present planning, the number of necessary piles per one pier is classified based on the results of various examinations for designing purpose as shown in Table 3. 3. 1.

Table 3. 3. 1 Materials for Piers of Bridge over Flood Opening

	No.30^{k}560 No.30^{k}670 L=60m	No.31.^{k}7114 No.35.^{k}7114 L = 4,000 m			No.37.^{k}192 No.37^{k}892 L=700m	No.38^{k}500 No.38,800 L=300m
Section for which determination is made in accordance with soil quality	The same for whole section	1,000m	2,000m	1,000m	The same for whole section	The same for whole section
No. of test holes bored	Bore Hole No. 1	Bore Hole No. 1	Bore Hole No. 2	Bore Hole No. 3	Bore Hole No. 6	Bore Hole No. 7
No. of piles per pier	6 piles	6 piles	9 piles	6 piles	6 piles	6 piles
No. of piers	2	49	101	49	34	14

3-4 Bridging Work Plan

3-4-1 Main Bridge

As either of trussed for the side spans of main bridge are on the land part they may be easily erected by installing a staging and operating a truck-crane on it.

As for the Langer-trusses for the main spans, it seems reasonable to adopt the cable erection method which is usually applied to the construction of this type of bridge, in view of various conditions including topography and river flow. In case where the cable erection method is adopted, it is essential to pay a sufficient attentin to the regulation of camber of truss.

The greatest problem in the construction of substructures of main bridge is the driving of foundation piles for the piers standing in water even in the dry season. The conceivable method for driving the foundation piles is to provide a platform vessel or to install a stage for pile driving. Any way, the working method should be determined upon the thorough examination of working conditions at the site.

The driving of steel pipe piles on the land part is easier compared with that in the flowing water part. In this, however, it is necessary to effect a sufficient control over the penetration of pile by preparing the working specifications.

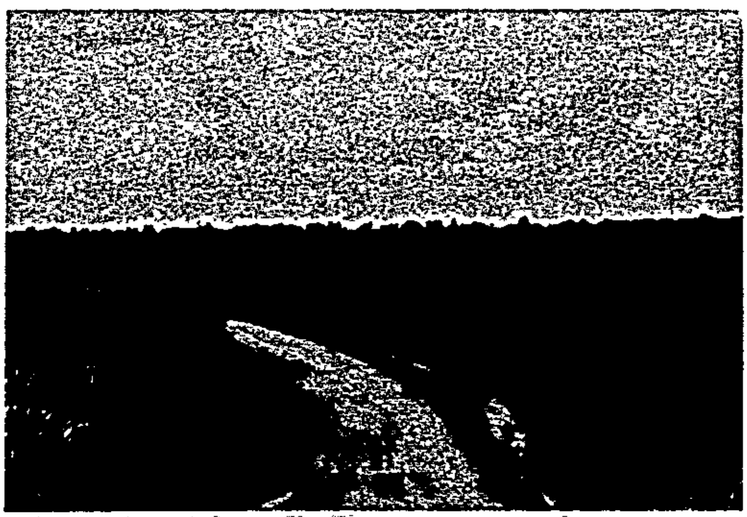
3-4-2 Bridge Over Flood Opening

As the substructures of bridge over flood opening, except the abutments on the both sides, are composed of foundation piles of H-beam and the length of piles is estimated at 15m in average the erection works are not particularly difficult. While, because the cap beams at the pile tops are of H-beam so constructed as to be joined with by bolts, it is necessary to drive the piles so as to aligne accurately and to deal with the pile tops very carefully.

After the pile driving for the substructures having been completed, the erection of superstructures is to be started in order. The steel weight per one main beam of superstructures is very small and, therfore, the erection work is easy. First the main beams are fastened in place to the top of cap beam and connected with each other by sway bracings to prevent traversal shaking, then the cross beams of corrugated steel are fixed to the main beams which have been fastened. The floor slab concrete is placed on the cross beams of corrugated steel and the pavement is applied on this concrete.

CHAPTER 4

ROAD DESIGN



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CHAPTER 4 ROAD DESIGN

4-1 Design Criteria

The road has been designed, in principle, in accordance with the provisions of Road Design Criteria, Typical Cross Section for Bitumen Roads prescribed by the Ministry of Communications, Transport and Labour of Tanzania, referring to the criteria of AASHO and the road design criteria in Japan.

Table-4.1 Design Criteria

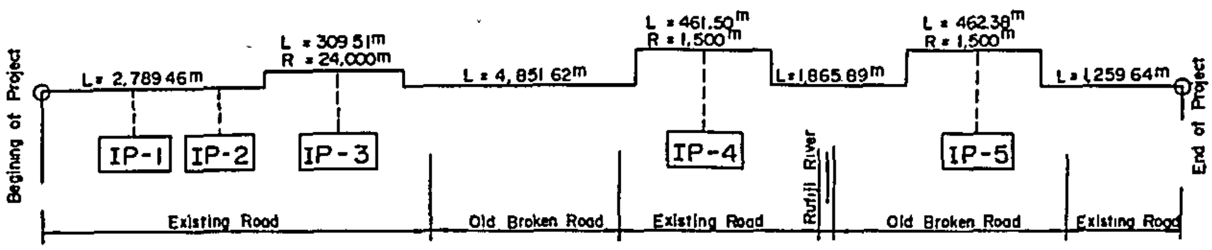
<table>
<tr><th colspan="3">Design Element</th><th colspan="2">Level & Rolling</th><th colspan="2">Hilly</th></tr>
<tr><td colspan="3">Design Speed (km/h)</td><td colspan="2">80</td><td colspan="2">80</td></tr>
<tr><td colspan="3">Road Width (m)</td><td colspan="2">9.6</td><td colspan="2">9.6~8.4</td></tr>
<tr><td colspan="3">Carriageway (m)</td><td colspan="2">6</td><td colspan="2">6</td></tr>
<tr><td colspan="3">Verge (m)</td><td colspan="2">1.8</td><td colspan="2">1.8~1.2</td></tr>
<tr><td colspan="3">Minimum Radius of Curvature (m)</td><td colspan="2">610</td><td colspan="2">305</td></tr>
<tr><td rowspan="4">*1 Surperelevation (%)</td><td colspan="2">Radius of Curve (m)</td><td>330~380</td><td>380~450</td><td>450~540</td><td>540~670</td></tr>
<tr><td colspan="2">Superelevation (%)</td><td>8</td><td>7</td><td>6</td><td>5</td></tr>
<tr><td colspan="2">Radius of Curve (m)</td><td>670~870</td><td>870~1240</td><td>1240~3500</td><td>over 3500</td></tr>
<tr><td colspan="2">Superelevation (%)</td><td>4</td><td>3</td><td>2</td><td>2</td></tr>
<tr><td colspan="3">Maximum Grade to Design Speed (%)</td><td colspan="2">5</td><td colspan="2">6</td></tr>
<tr><td colspan="3">Critical Length of Grade (m)</td><td colspan="2">370</td><td colspan="2">270</td></tr>
<tr><td rowspan="4">Minimum Radius Of Vertical Curve (m)</td><td rowspan="2">Summit</td><td>Desirable</td><td>4,500</td><td>*1</td><td>4,500</td><td>*1</td></tr>
<tr><td>Critical</td><td>2,600</td><td>*2</td><td>2,600</td><td>*2</td></tr>
<tr><td rowspan="2">Sag</td><td>Desirable</td><td>3,000</td><td>*1</td><td>3,000</td><td>*1</td></tr>
<tr><td>Critical</td><td>2,300</td><td>*2</td><td>2,300</td><td>*2</td></tr>
<tr><td colspan="3">Stopping Sight Distance (m)</td><td colspan="2">115</td><td colspan="2">115</td></tr>
<tr><td colspan="3">Passing Sight Distance (m)</td><td colspan="2">600</td><td colspan="2">600</td></tr>
</table>

Note: *1 = Road design criteria of Japan.
*2 = Criteria of AASHO.

4-2 Horizontal Plan

The alignment of the proposed road has been planned on the following principles that the connection to the existing road can be made smoothly at the both ends of the proposed road; that the section of 3 km across the main stream of Rufiji River is so aligned that the main bridge crosses the river at right Angles as far as practicable; that the Viaduct of 700m over flood opening in the right bank side of Rufiji River is included in a straight section; and that the embankment of old broken road can be used as far as possible. The alignment elements planned on the above principles are shown below.

Fig-4·1 ALIGNMENT ELEMENT OF PROPOSED ROUTE



IP-1 and IP-2 are provided to fit the center of the proposed road to that of the existing road, respectively making a bend without curvature because of very small intersection angle. Though the angle at IP-3 requires a curvature, it is as small as $0^{\circ}44'23''$; the minimum curve length of 300m is provided with the radius of curve, R=24,000m, in compliance with the criteria of AASHO.

The radius of curve, R=1,500m, is selected for IP-4 and IP-5, which permits to omit the transition curves.

4-3 Profile Plan

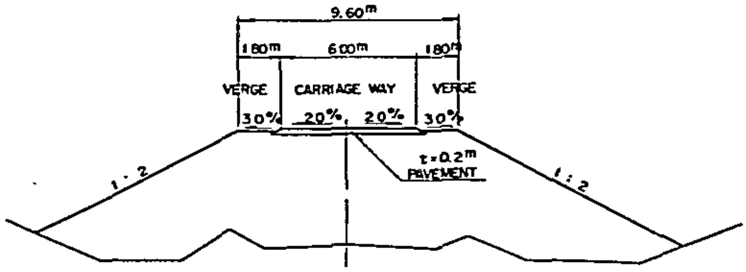
The proposed height of the road has been determined against the design high-water level of 16.80m; a clearance of 1.5m is provided below bridge girders for the bridge sections and the road surface is higher by 1.0m above the high-water level for the earthwork sections. The clearance below girder has been determined taking into account the rise of 0.70m above the design high-water level at the time of abnormal flood (100 years probable flood).

The maximum longitudinal grade is 3.75% since the proposed road is connected to the existing road at the vicinity of Ikwiriri and the flat sections are inclined somewhat to provide drainage in the longitudinal direction.

4-4 Cross Section

The cross section of the proposed road has been formed in compliance with the design criteria.

Fig - 4·2 CROSS SECTION OF ROAD



The surface of carriage way is roof-shaped with an incline of 2% for the sections of straight line and curve of R=24,000m and the superelevation of 2% is provided for the curve sections of R=1,500m; all of the verges have superelevation of 3% down to the outside direction. The slope gradient of embankment has been fixed at 1:2, taking into account the results of stability calculation made by the data from the test of soil sample obtained, the actual conditions of old road remaining after inundation, and the compaction to be insured in executing the work.

4-5 Eearthwork Plan

The embankment materials of good quality indicated by the results of soil survey are laterite deposited near Ikwiriri, the beginning of project, and sandy soils deposited near the end of project and another sandy soil existing below the cohesive soil layer of about 1 m thick lying in the section (STA. NO. 29~32, STA. NO. 38~40). If the cohesive soil covering the area along the road does not contain black cotton clay, it can be used for the embankment material of lower course.

The volume of fills is 100 thousand m^3 to be placed on the left bank side and 110 thousand m^3 to be placed on the right bank side of the Rufiji River.

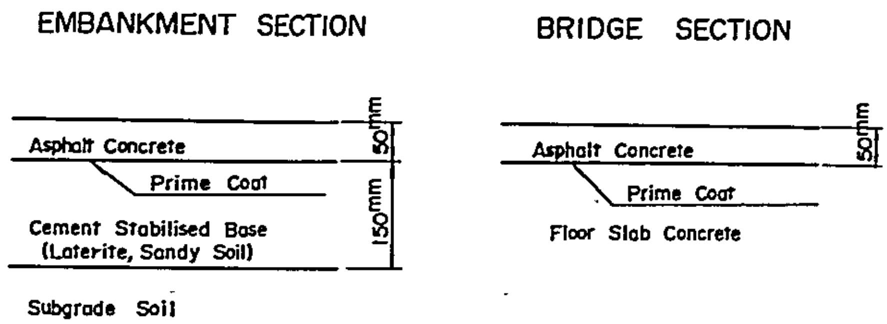
Table 4-2 Volume of Earthwork

Fills (in m^3)	Left bank side	103,400
	Right bank side	111,700
	Total	215,100
Excavation of soil beneath flood openings (in m^3)	Left bank side	49,600
	Right bank side	2,200
	Total	51,800

4-6 Pavement Plan

The structure of pavement is as shown in Fig 4-3.

Fig - 4-3 STRUCTURE OF PAVEMENT



The modified CBR of laterite taken from the Ikwiriri hill is 34% for the sample No. 1 and 51% for the sample No. 2 and these values being the result of CBR test at the optimum water content, the value of about 20% has been used as CBR for the designing of filling materials. The volume of commercial traffic has been estimated to range from 450 to 1,000 vehicles per day on the assumption of 66% accounted for by lorries and buses, which percent calculated from the estimates made by the first phase survey, with the design target year set at 1990-2000; this corresponds to E curve on C.B.R. Design Chart shown as Fig. 4-4. The thickness of pavement is 8^{inch} (200^{mm}) at 20% of the design C.B.R., composed of surface course of 50^{mm} thick and subbase course of 150^{mm} thick.

Fig - 4.4 CBR DESIGN CHART
(ROAD RESEACH LABORATORY)

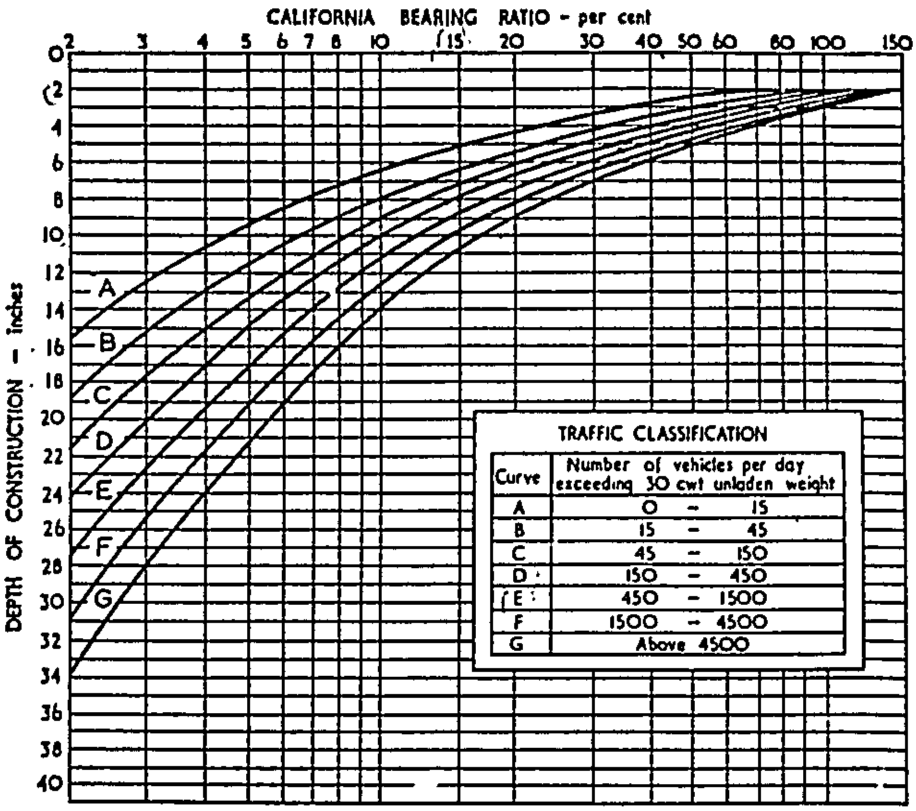


Fig. 9.11. C.B.R. design curves for different classes of road.

The subbase course is planned to be composed of laterite or sandy soil and cement of about 3.5%, and prior to the execution of works, it is necessary to determine the quantity of cement to be added by a laboratory test. It is also desirable to add crushed stones of about 30%, if practicable.

Asphalt concrete is applied to the surface course. Quartzite from Kitembo and sandstone from Uete may be used for the coarse aggregates but their volume of deposits is unknown, for which a survey is necessary in future.

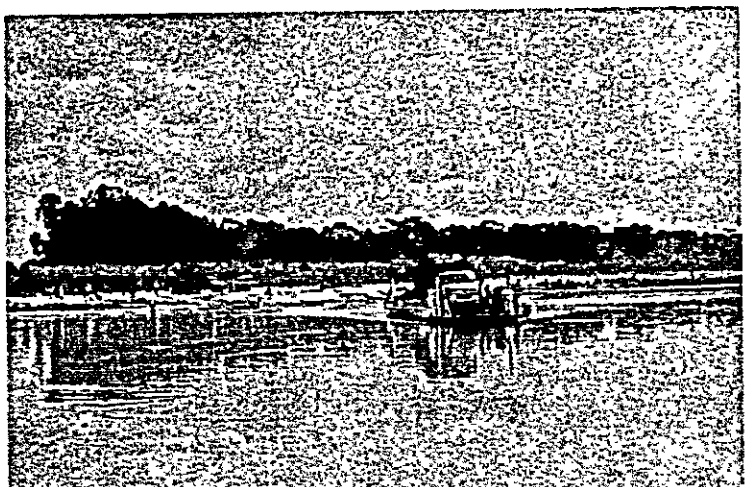
4-7 Slope Protection and Others

At the time of flood the areas around the embankment section are inundated with water for a long period and the embankments near by openings through which the flood discharge flows down are subjected to a strong imfluence of flowing water. Therefore, a concrete retaining walls are provided to the access portions of bridges and embankments and the side slopes of embankment adjacent to it are protected with precast concrete grids (Noriwaku). Other parts of embankment are protected by the Grass planting method using the local grass.

The drainage facilities for the low land areas include two box culverts and nine corrugated metal pipes respectively laid at needed locations. Besides, it is necessary to provide the access roads to the proposed road at several locations in order to keep connection to the cultivated lands along the road.

CHAPTER 5

CONSTRUCTION COST AND PLAN OF WORKING SCHEDULE



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CHAPTER 5 CONSTRUCTION COST AND PLAN OF WORKING SCHEDULE

5-1 Construction Cost

Table-5. 1 shows the construction cost for the extension of 12km between Sta. No. 28 near Ikwiriri and Sta. No. 40 on the right bank of the Rufiji River. The construction cost is estimated according to the following prerequisites:

(1) The rate of exchange between Japanese Yen and Tanzanian shilling is made as follows according to the IMF parity of 1972: One Tanzanian Shillings = 43 Japanese Yen

(2) Machineries and plant facilities for the use of the construction work shall be provided from Japan and the residual prices of these machinery and plant facilities after completion of the works shall be 40% of initial cost (price on arrival in Japan).

(3) Cost estimation is made in consideration of the necessary quantity for every type of work according to the results of field survey and the unit construction cost based upon the actual situation and conditions of the site.

(4) As shown in Diagram-5. 1, the period required for the construction work shall be two years and nine months.

According to Table-5. 1, the total construction cost is 93, 374, 000 Shillings (4, 015, 030, 000 Yen), of which 63, 173, 000 Shillings (2, 716, 400, 000 Yen) is of foreign currency and 30, 201, 000 Shillings (1, 298, 300, 000 Yen) is of local currency.
These figures are estimated for the case where a footway is constructed for only the section of the main bridge, and Table-5. 2 shows the estimated construction cost for a construction work including footways for whole bridge sections.
According to Table-5. 2, the total construction cost shall be 105, 412, 000 Shillings (4, 532, 720, 000 Yen), an increase of 12, 038, 000 Shillings (517, 690, 000 Yen) i. e. an increase of about 12%.

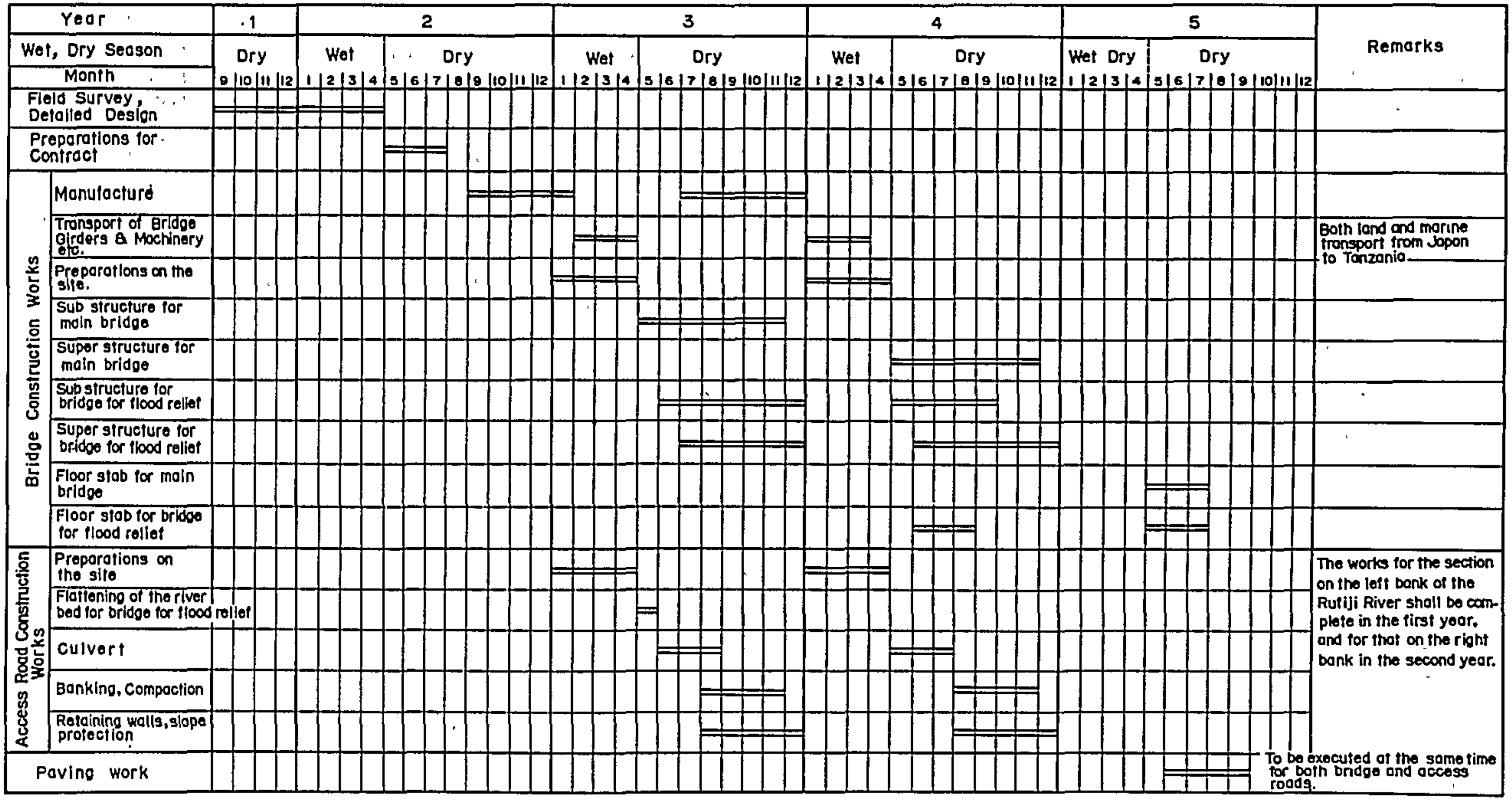
Table-5.1 Total Construction Cost

Footway of 1.5m width in one side is planned for only the main bridge.

	Item	Local Shs.	Local ¥	Foreign Shs.	Foreign ¥	Total Shs.	Total ¥	Remarks
A	Direct Construction Cost	20,644,000	887,710,000	48,171,000	2,071,330,000	68,815,000	2,959,040,000	
	%	30		70		100		
B	Contingency	4,129,000	177,540,000	9,634,000	414,270,000	13,763,000	591,810,000	A x 20%
	%	30		70		100		
C	Sub Total	24,773,000	1,065,250,000	57,805,000	2,485,600,000	82,578,000	3,550,850,000	A + B
	%	30		70		100		
	Tax	2,890,000	124,280,000	2,890,000	124,280,000	5,780,000	248,560,000	C x 7%
	%	50		50		100		
E	Detailed Survey & Design	1,239,000	53,260,000	1,239,000	53,260,000	2,478,000	106,520,000	C x 3%
	%	50		50		100		
F	Field Control & Work-Site Administration	1,239,000	53,260,000	1,239,000	53,260,000	2,478,000	106,520,000	C x 3%
	%	50		50		100		
G	Right of Way & Compensation	60,000	2,580,000			60,000	2,580,000	
	%	100		0		100		
	Total	30,201,000	1,298,630,000	63,173,000	2,716,400,000	93,374,000	4,015,030,000	

Direct Construction Cost (Bridges and Access Roads) ¥2,718,620,000+240,420,000=2,959,040,000
Shs. 63,224,000+ 5,591,000= 68,815,000

Diagram-5.1 Work Schedule For The Rufiji River Bridge Construction Project



Direct construction cost for bridges is shown in Table-5.3, and that for access roads in Table-5.4.

Table-5.2 Total Construction Cost

Footway of 1.5m width in one side is planned for wholebridge sections.

	Item	Local Shs.	Local ¥	Foreign Shs.	Foreign ¥	Total Shs.	Total ¥	Remarks
A	Direct Construction Cost	23,308,000	1,002,230,000	54,384,000	2,338,550,000	77,692,000	3,340,780,000	
	%	30		70		100		
B	Contingency	4,662,000	220,450,000	10,876,000	467,710,000	15,538,000	668,160,000	A x 20%
	%	30		70		100		
C	Sub Total	27,970,000	1,202,680,000	65,260,000	2,806,260,000	93,230,000	4,008,940,000	A + B
	%	30		70		100		
D	Tax*	3,263,000	140,320,000	3,263,000	140,320,000	6,526,000	280,640,000	C x 7%
	%	50		50		100		
E	Detailed Survey & Design	1,399,000	60,140,000	1,399,000	60,140,000	2,798,000	120,280,000	C x 3%
	%	50		50		100		
F	Field Control & Work-Site Administration	1,399,000	60,140,000	1,399,000	60,140,000	2,798,000	120,280,000	C x 3%
	%	50		50		100		
G	Right of Way & Compensation	60,000	2,580,000			60,000	2,580,000	
	%	100		0		100		
	Total	34,091,000	1,465,860,000	71,321,000	3,066,860,000	105,412,000	4,532,720,000	

Direct Construction Cost (Bridges and Access Roads) ¥3,100,360,000+240,420,000=3,340,780,000
Shs. 72,101,000+5,591,000=77,692,000

Table-5.3.1 Direct Construction Cost For Bridges

- Footway of 1.5m width in one side is planned for the main bridge -

Item		Quantity etc.	Amounts Shs.	Amounts ¥
Main Bridge	Super Structure	Langer truss 3 @84m, Pony truss 2 @40m	7,795,000	335,190,000
	Sub Structure	two abutments, four piers	5,821,000	250,300,000
	Total		13,616,000	585,490,000
Bridge for Flood Relief	Super Structure	Plate girder 253 @20m	31,337,000	1,347,480,000
	Sub Structure	8 abutments, 249 piers	18,271,000	785,650,000
	Total		49,609,000	2,133,130,000
Grand Total			63,224,000	2,718,620,000

Table-5.3.2. Direct Construction Cost For Bridges

- Footway of 1.5m width in one side is planned for the whole bridge sections -

Item		Quantity etc.	Amounts	
			Shs.	¥
Main Bridge	Super Structure	Langer truss 3 @84m Pony truss 2 @40m	7,795,000	335,190,000
	Sub Structure	2 abutments 4 piers	5,821,000	250,300,000
	Total		13,616,000	585,490,000
Bridge for Flood Relief	Super Structure	Girder 253 @20m	37,817,000	1,626,120,000
	Sub Structure	8 abutments 249 piers	20,668,000	888,750,000
	Total		58,485,000	2,514,870,000
Grand Total			72,101,000	3,100,360,000

Table-5.4 Direct Construction Cost For Access Road

Item		Quantity	Unit Price		Amounts	
			Shs.	¥	Shs.	¥
Pavement		39,600 m^2	47.4	2,040	1,878,000	80,780,000
Earth Work	Banking	215,100 m^3	9.8	420	2,101,000	90,340,000
	Compaction	"	2.9	125	625,000	26,890,000
	Excavation	51,800 m^3	5.	215	259,000	11,140,000
Slope Protection		70,400 m^2	1.2	50	82,000	3,520,000
Box Culvert		2PC			95,000	4,070,000
Pipe Culvert		9PC			89,000	3,820,000
Retaining Wall, Precast Concrete Grids etc.					462,000	19,860,000
Total					5,591,000	240,420,000

5-2 Plan of Work Schedule

The wet season is the most important factor in determination of the work schedule. The planned section including the Rufiji River is inundated with water for a distance of 6-9km every year and traffic by vehicles is impossible during the season. According to the experience in the past, the wet season lasts for two to six months. Accordingly, construction work is entirely impossible on the site during the wet season, and the whole work schedule is planned in accordance with the wet and the dry seasons. Followings are prerequisites for the work schedule on the site:

(1) The four months (from January to the end of April) shall be the wet season of the year, and no other works than preparatory works are possible during the season.

(2) For the main bridge, works of super structure and sub structure shall be conducted in each dry season.

(3) For bridge for flood relief, both works of super and sub structure constructed together.

(4) Access roads shall be completed for the section on the left bank of the Rufiji River in the first year and for that on the right bank in the second year except pavement.

(5) Pavement shall be executed for both bridges and access roads at the same time in the final year.

According to Diagram-5. 1, field work shall require about three dry seasons (21 months), and in total the plan requires three years and two months after contract and two years and nine months after the start of field work.

It is very important to adjust the whole work schedules so that dry seasons be fully utilized. In the work schedule, manufacture and transport of girders and parts of bridges shall be made in two periods in accordance with the plans of field work in dry season.

As shown in the work schedule, eitht months are required for field surveys for boring test etc. and three months for preparations ıor contract before the construction work starts.

CHAPTER 6

ESTIMATE OF TRAFFIC VOLUME AND ECONOMIC EVALUATION OF THE PROJECT

Chapter 6

List of Figures & Tables

CHAPTER 6 ESTIMATE OF TRAFFIC VOLUME AND ECONOMIC EVALUATION OF THE PROJECT

6-1 Introduction

In the report of first survey the economic feasibility study was made on two alternative plans, one calling for construction of an all-weather bitumen road for the entire Dar es Salaam-Lindi section (Approximately 470 km) and the other for construction of a bitumen road up to 3 km south of Kibiti and engineered gravel treatment of the remaining section.

In this report, however, the economic feasibility study was made on a plan which calls for construction of only Rufiji River bridge leaving the remaining sections intac in other words, the scheme calls for construction of Rufiji River bridge as a part of stage construction for the future construction of a complete all-weather road for the entire section.

6-2 Estimate of Future Traffic Volume

6-2-1 Years for Which Traffic Volume is Estimated

Start of investigation, suveying and designing 1973

Period of field servey, land surveying detailed designing and preparation of contract etc...................... 1.5 years

Period of manufacture and erection of bridge and construction of access roads .... 3.5 years.

From the above assumption, opening of the bridge section to public traffic will be in 1978.

Assuming repayment is to be made in 30 years, repayment will be completed in the year 2007.

6-2-2 Method of Estimation

(1) Basic Formula of Estimate

The Gravity Model Method is used for estimating the future traffic volume.

The parameters α and γ of the Gravity Model Formula are calculated using the method of least squares on the basis of the results of O D survey conducted by COMWORKS Planning Unit in 1968 and 1969 (Refer to the first feasibility report) and surveys on the population in each district within the sphere of coastal link road travelling time between zones.

(2) Modification of α to α' in Respect to the Rate of Vehicle Ownership

The annual growth rate of population in Tanzania for the years 1960 - 1970 was 2.6% on the average.

The annual growth rate in the ownership of vehicle for the years 1960 - 1970 varied with the type of vehicles, such as 3.3% for passenger car, 4.0% for lorry, 2.4% for van and 5.7% for bus. The growth rates of all types of vehicle except van exceed the growth rate of population indicating an annual increase in the ownership of vehicle.

The estimate of future traffic volume on the basis of natural increase of population alone is not considered appropriate as it does not take into account the increase in the future traffic volume with the increase in the ownership of vehicle.

The number of vehicle of various types respectively for the year 1978 when the proposed bridge is expected to be completed and for the year 2007 when the repayment is expected to be completed is calculated by the method of least squares on the basis of the available data on the various types of vehicles and the population both for the years 1960 - 1970 as follows.

1978 .... $\alpha' = 4.89 \times 10^{-9}$

2007 .... $\alpha' = 5.08 \times 10^{-9}$

The above values of α' are used for estimating the future traffic volume.

6-2-3 Estimate of Future Traffic Volume

O D traffic volume and link traffic volume for the years 1971, 1978 and 2007 respectively can be obtained using the Gravity Model Method (Using α') on the basis of the future population in each district and travelling time between zones.

Table-6.1 Traffic Volume on Coastal Link Road (vehicle/day)

Link No.	Section / Year	Actual traffic volume surveyed by COMWORKS	Estimated traffic volume		
		1971	* 1971	Year when bridge is opened to traffic 1978	Year of completion of repayment 2007
1	D.S.M.~Ndundu	50 ~ 130	85	125	403
2	Ndundu~Nangurukuru	50	53	77	236
3	Nangurukuru~Lindi	40	53	78	233
4	Lindi ~ Mtwara	100	105	154	454

* As the travelling time Tij used for the estimation of traffic volume for the year 1971 is based on the estimated travelling time after completion of the bridge, addition of the time required for ferry service (about 40 minutes) to the travelling time will make the traffic volume for the year 1971 slightly smaller than that shown in Table-6.1.

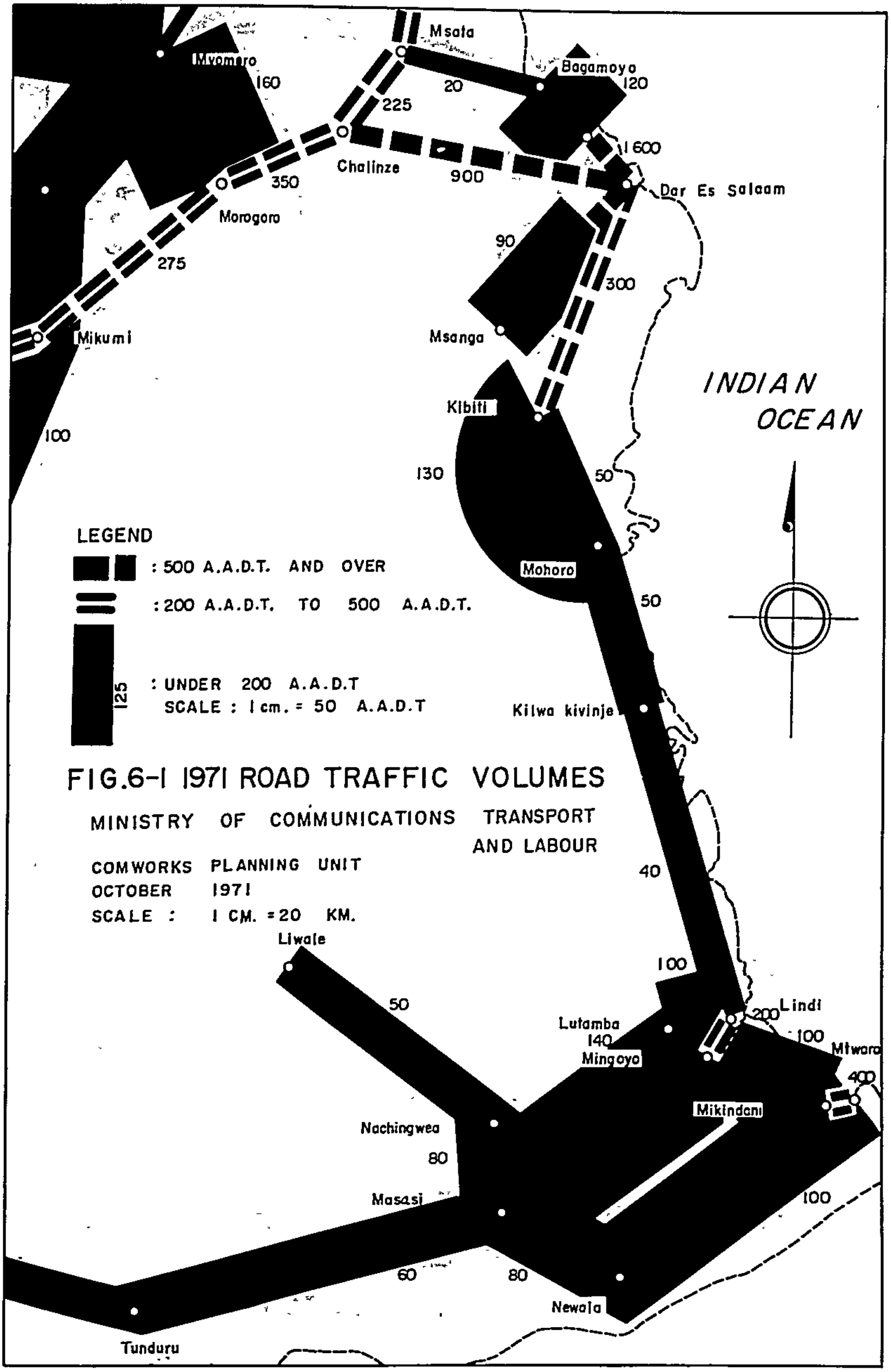
Traffic volume for the year 1971 calculated with the Gravity Model formula shows slight difference in some links but is almost identical with the results of actual survey conducted by COMWORKS in October 1971 (Refer to Fig. 6-1). For this reason, estimated traffic volume for the years 1978 and 2007 respectively is also considered reasonable.

The estimated traffic volume (vehicle/day) is shown in Figs.-6.2 and 6.3 for these years.

6-3 Diversion of Traffic Volume from Coastal Link Road to Coastal Shipping Line

The regular and more reliable service of the coastal shipping line to be inaugurated between the port of Dar es Salaam and the ports of Kilwa, Lindi and Mtwara is expected to become competitive to the coastal link road.

At present, the following passenger fares of bus and ship are in effect between Dar es Salaam and Mtwara.


Msata
Bagamoyo
Mvomero
160
20
120
225
1600
Chalinze
900
350
Dar Es Salaam
Morogoro
90
275
300
Mikumi
Msanga
INDIAN
OCEAN
Kibiti
100
130
50
LEGEND
: 500 A.A.D.T. AND OVER
: 200 A.A.D.T. TO 500 A.A.D.T.
Mohoro
50
125
: UNDER 200 A.A.D.T
SCALE : 1 cm. = 50 A.A.D.T
Kilwa kivinje
FIG.6-1 1971 ROAD TRAFFIC VOLUMES
MINISTRY OF COMMUNICATIONS TRANSPORT AND LABOUR
COMWORKS PLANNING UNIT
OCTOBER 1971
SCALE : 1 CM. = 20 KM.
40
Liwale
100
50
Lutamba
140
Mingoyo
200
Lindi
100
Mtwara
400
Mikindani
Nachingwea
80
Masasi
100
60
80
Newala
Tunduru

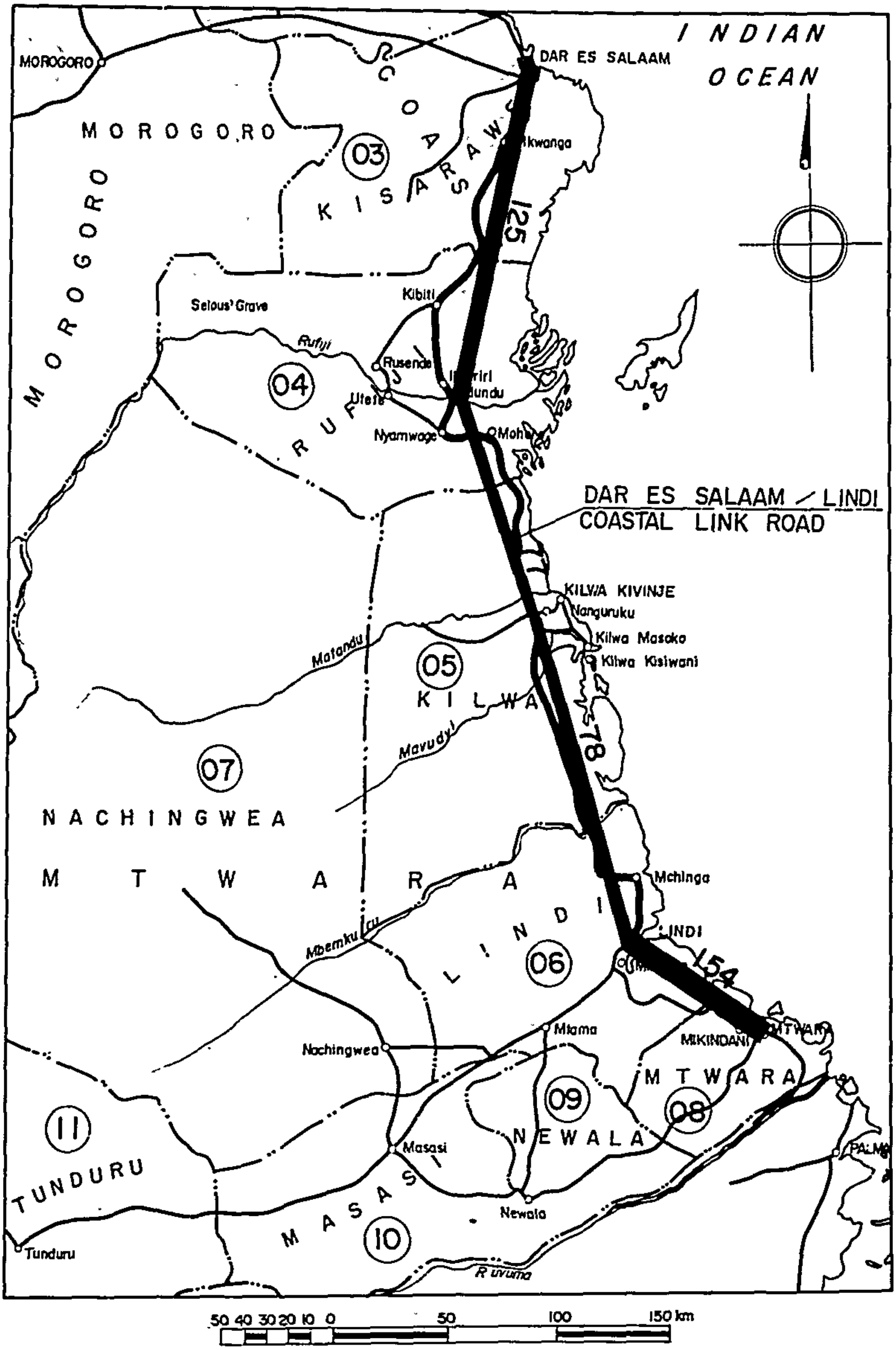


FIG. 6-2 FUTURE DAILY TRAFFIC VOLUME
1978

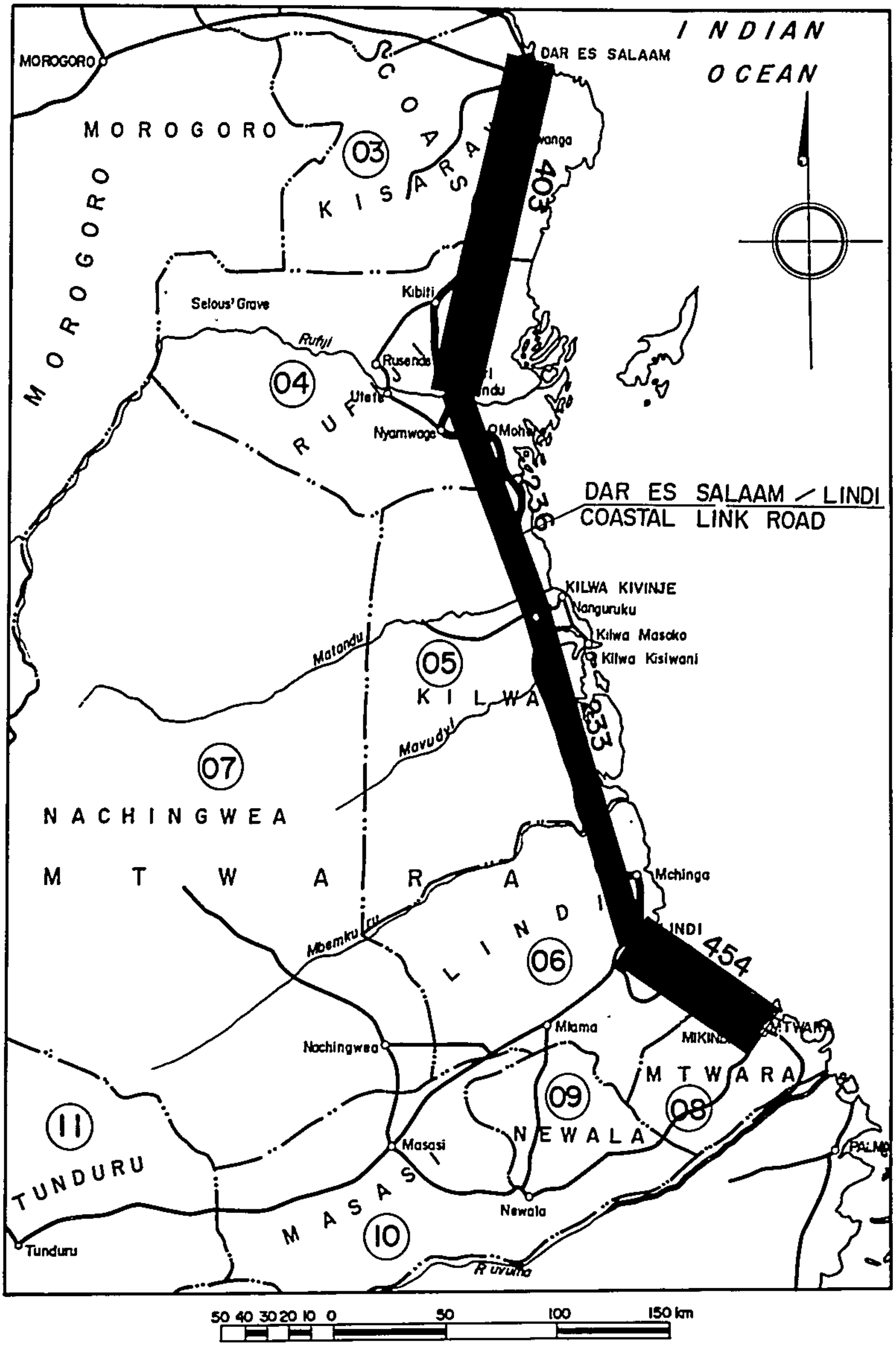


FIG. 6-3 FUTURE DAILY TRAFFIC VOLUME 2007

Bus:	1st class ~ 50 Shs/person	
	3rd class ~ 35 Shs/person	
Ship:	1st class ~ 315 Shs/person	
	2nd class ~ 190 Shs/person	
	3rd class ~ 64 Shs/person	

Even when the new fare of coastal shipping line is reduced to the level of bus fare, the diversion of passengers from bus to ship is not considered expectable except for the case of tourists because of such factors as the difference in travelling time and the frequency of operation. That is, as for the passengers, it is presumed that the present pattern of transportation by road and ship in the dry season will continue also in the wet season after the bridge has been completed.

The rate of cargo diverting from land transport to sea transport will be determined mainly by transport cost and transport time.

However, the diversion rate will vary with the type of cargo and such items as perishable foods will tend to prefer land transport which requires a shorter transport time.

Comparison of transport costs between trucks and pallet ships shows apparent differences between the two and for this reason, some of the cargo may divert from land transport to sea transport in the future, though the extent will differ according to the distances to be transported.

In order to obtain a reasonable figure for the diversion rate, accurate data on the monthly volume of cargo of various types, freight and transport time for the routes between Dar es Salaam and the three southern ports classified by type of transport facilities are necessary. Since these data are difficult to obtain at present, the diversion rate of cargoes from land transport to sea transport was assumed by converting per-ton freight by truck and pallet ship to the time value and also by comparing transport time between the two.

The estimated percentages of cargo likely to be diverted are as follows:

D.S.M. ~ Kilwa:	10% of lorry cargo is likely to divert to sea transport.
D.S.M. ~ Lindi:	20% of lorry cargo is likely to divert to sea transport.
D.S.M. ~ Mtwara:	35% of lorry cargo is likely to divert to sea transport.

With the increase of trade with foreign countries in the future, the increase in the rate of utilization of Mtware port favoured with natural conditions as a good port is expected in place of Dar es Salaam port which lacks a sufficient capacity at present, resulting in the possible diversion of cargo traffic to land from Mtwara to to Dar es Salaam after the coastal link road has been constructed and improved.

6-4 Evaluation of Project

Calculation of benefit resulting from the planned project has been made for the year 1978 when the project is expected to be completed and the year 2007 when the repayment is expected to complete. Assuming that the annual change of benefit keeps a linear relation, the total benefits have been accumulated over a period of 30 years which corresponds to the repayment period.

6-4-1 Unit Cost

(1) Unit Travelling Cost

The unit travelling cost adopted is the unit cost estimated with the Weille Method on the basis of the data analyzed by United Research Incorporated by taking into account the prevailing unit cost and local factors in Tanzania.

(2) Unit Time Cost

The values of unit time cost used are those shown in Table-6.2.

Table 6 2 Unit Time Cost

	Type of vehicle	Unit time cost (Shs/vehicle,hr.)
1	Passenger car	0.18
2	Lorry	0.28
3	Van	0.24
4	Bus.	1.04

6-4-2 Benefits

Items that have been used for the calculation of benefits are as follows.

(1) Travelling benefit after completion of bridge.

(2) Time benefit after the completion of bridge.

(3) Saving of ferry charges (for passenger and vehicle).

(4) Benefits resulting from the direct land transportation to be enabled by the completion of bridge from the southern regions to Dar es Salaam that are presently connected through Songea and Iringa during the rainy season without a bridge to cross the Rufiji River.

(5) Benefits from the diversion of sea to land transportation to be enabled by the completion of Rufiji River bridge during four months in the rainy season when the traffic becomes impossible to cross the Rufiji River.

Since the Matandu, Mavudyi and Mbemkuru rivers become impassable during a period of one month in the rainy season, the above benefits for the years 1978 and 2007 have been calculated as shown in Table-6.3 on the assumption that the land transport between Dar es Salaam and the southern region is available only for 11 months over a year even after the completion of Rufiji bridge.

Table - 6.3 Benefits Broken Down into Year (Shs/year)

Description \ Year			Year when bridge is opened to traffic 1978	Completion year of repayment 2007	Remarks
Travelling benefit after completion of bridge			135,900	421,800	
Time Benefit	Reduction in travelling time as a result of the change of earth road to bitumen road for the 12 km section near Rufiji River bridge.		1,000	3,000	
	Reduction in travelling time as a result of the change from ferry service to bridge. (For vehicle)		5,300	16,000	A reduction of 40 minutes because of the availability of bridge.
	Reduction in travelling time as a result of the change from ferry service to bridge. (For passenger)		13,400	24,100	A reduction of 30 minutes because of the availability of bridge.
Saving of charges	Rufiji ferry	Vehicle	108,600	344,000	Ferry charge at Rufiji River 5 Shs/vehicle
		Passenger	11,200	20,100	5 sent /vehicle
Benefit from direct travelling	Difference in travelling cost between detour course and direct course.		862,200	1,665,400	
	Difference in time value between detour course and direct course.		8,800	18,200	
Benefit from the diversion of sea to land transportation for 4 months.			1,199,600	3,935,700	
Total			2,346,000	6,448,300	

6-4-3 Cost Benefit Ratio

The years when the repayment will complete, cost benefit ratios (B/C) and internal rates of returns are calculated against various interest rates as shown in Table-6.4 and Fig. -6.4

Table-6.4 Completion year of Repayment and B/C of 30-year Period to Interest Rates

Interest rate (%)	Case 1		Case 2	
	Completion year of repayment	B/C of 30-year period (1978~2007)	Completion year of repayment	3/C of 30-year period (1978~2007)
0.5	2005	1.11	2003	1.25
1.0	2007	1.02	2004	1.15
1.5	2009	0.93	2006	1.05
2.0	2012	0.86	2009	0.96
2.5	2015	0.79	2011	0.89
3.0	2020	0.73	2015	0.82
3.5	2026	0.67	2019	0.76
4.0		0.62	2026	0.70
Internal rate of returned		Case 1	= 1.10 %	
		Case 2	= 1.79 %	

Note: Case 1 - Plan in which footway of 1.5 m wide is provided on one side for the entire bridge and viaduct section.

Case 2 - Plan in which footway of 1.5 m wide is provided on one side for only the main bridge section.

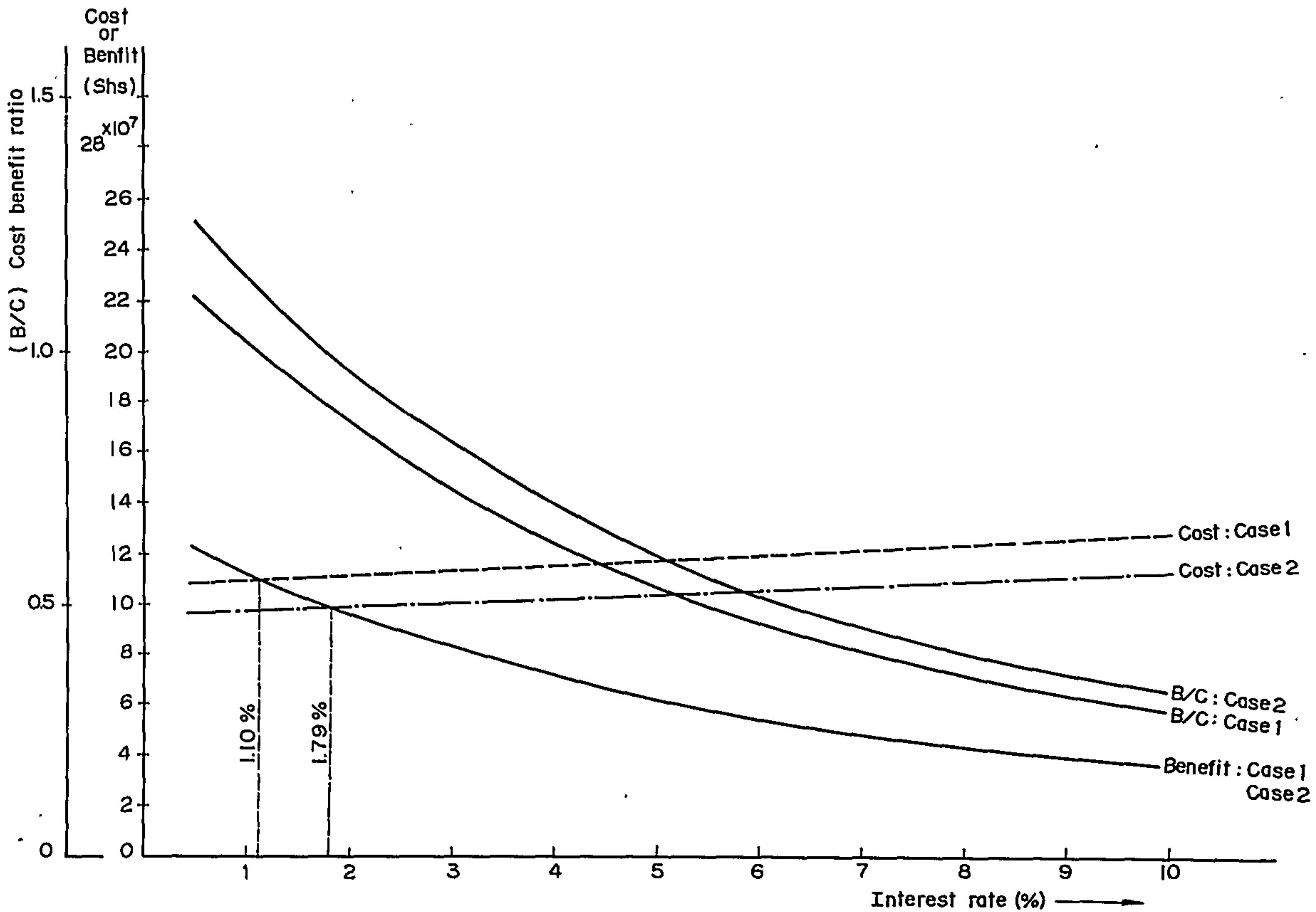


Fig. 6-4 Cost, Benefit and Cost Benefit Ratio (In Case 1 and Case 2)

6-4 Conclusions

As a result of the afore-mentioned investigation and analysis, the cost benefit ratio for each interest rate in Case 1 and Case 2 will be as shown in Table-6.4.

Interest rate for a 30-year repayment plan will be as follows:

Case 1: $r = 1.10\ \% \ldots\ldots\ldots\ldots \frac{B}{C} = 1.00$

Case 2: $r = 1.79\ \% \ldots\ldots\ldots\ldots \frac{B}{C} = 1.00$

So far as the above values are concerned, the cost benefit ratios are relatively small and it is due to the characteristics of this project which requires the construction costs to be concentrated as there are long bridge sections in proportion to the length of road. The construction of Rufiji River bridge is of major significance in that it is carried out as one of the stage construction of Dar es Salaam/Lindi Costal Link Road project, and as such its overall economic effects seem to be great indeed (see the first feasibility report).

Thus the Rufiji River bridge project should be evaluated from this point of view.

Since the duration of impassability of the Matandu, Mavudyi and Mbemkuru Rivers excluding the Rufiji River due to floods is about one month at maximum, it may be said that the construction of Rufiji River bridge alone will almost achieve the objective to provide the all-weather road.

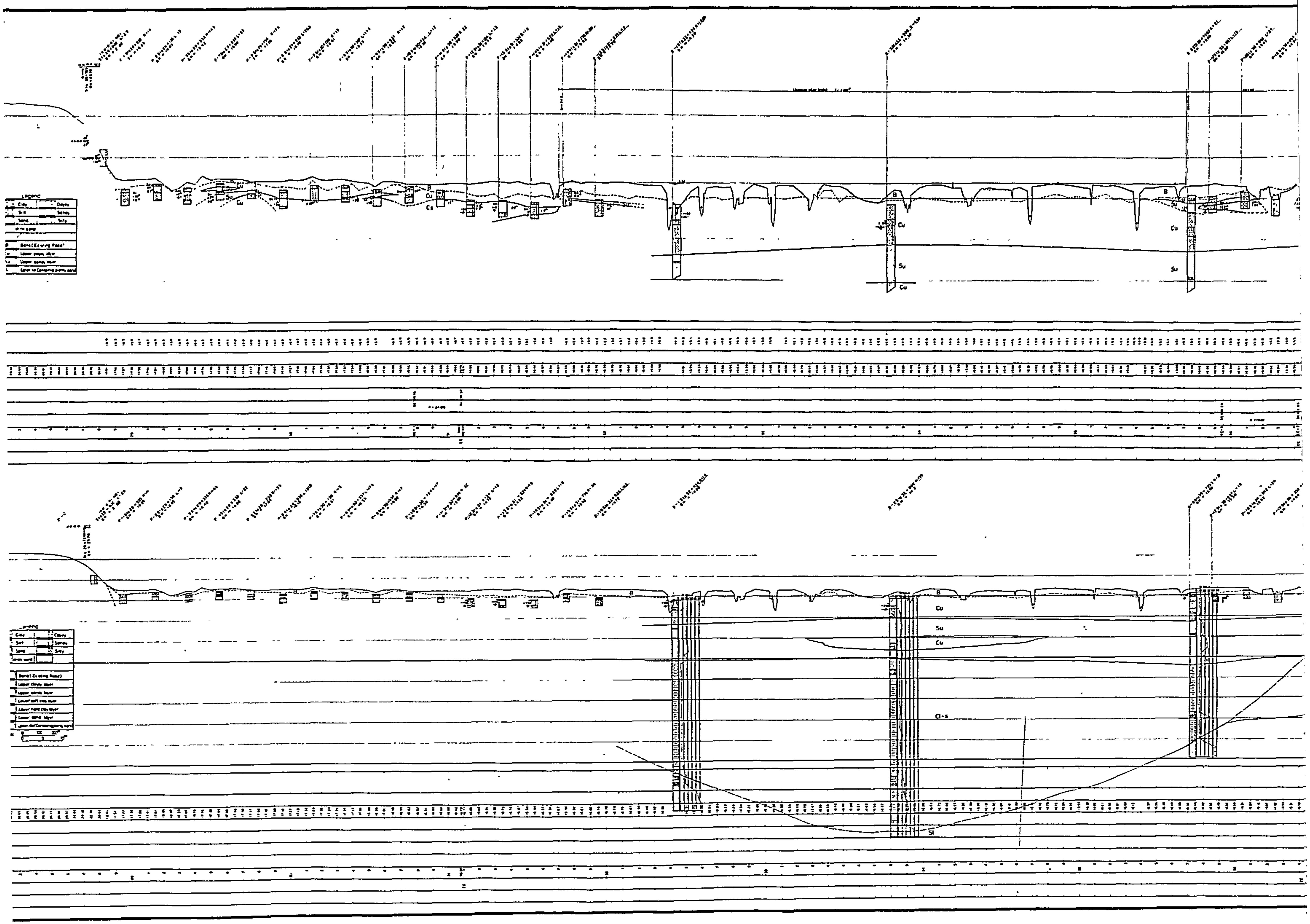
Since the duration of impassability of the Matandu, Mavudyi and Mbemkuru rivers excluding the Rufiji river due to floods is about one month at maximum, it may be said that the construction of Rufiji bridge alone will almost fulfill the objective of the all-weather road.

Completion of the project will not only bring about direct economic benefits analyzed in this report but also actualize potential traffic demand restrained during the four-month period of the rainy season, thus stimulating economic activities in the coastal region, which in turn will prompt further development of this region. This is a promising project which will also bring about sufficient indirect benefits that cannot be measured by monetary value such as the increase of income, improvement of cultural standard, furtherance of over-all development, stabilization of the feeling, and promotion of well-being of the people in the coastal regions as a result of integration of the southern region with Dar es Salaam.

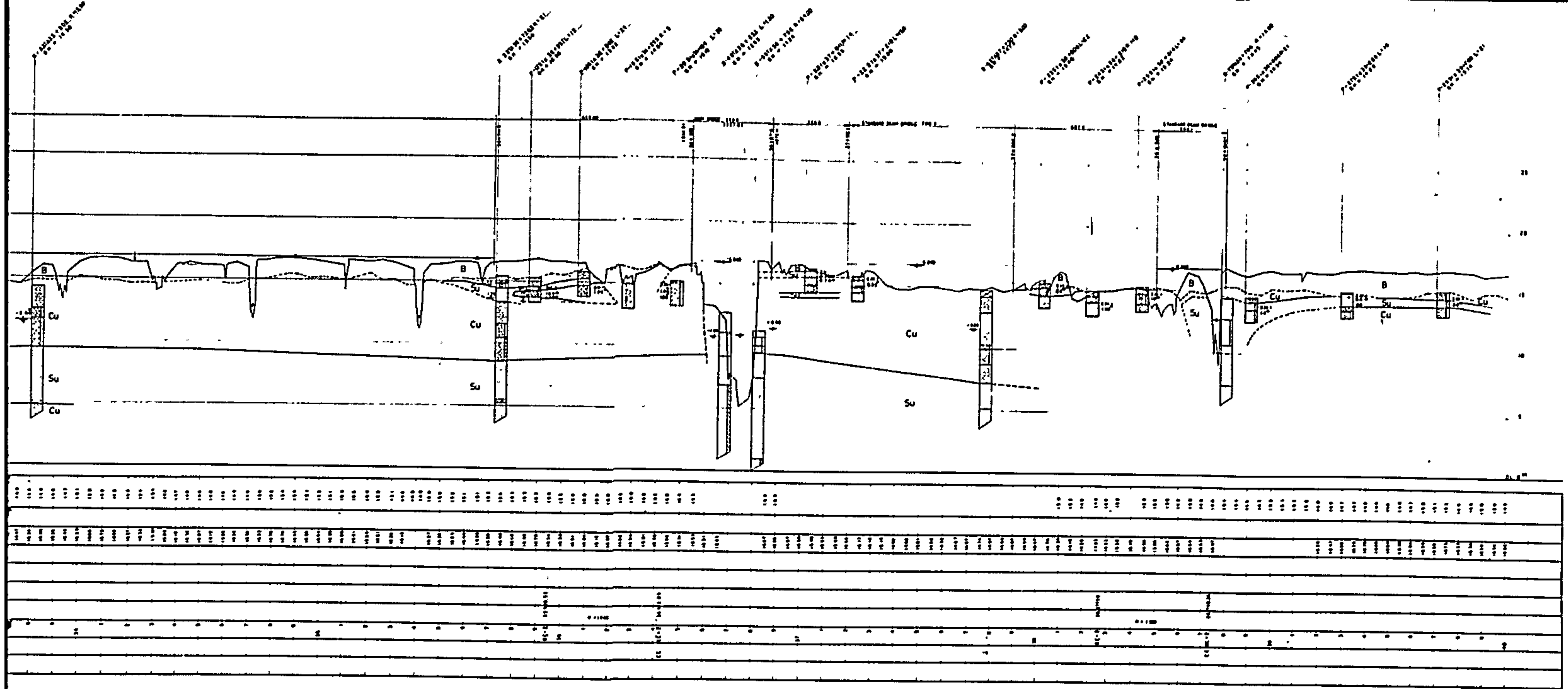
CHAPTER 7

ADDITIONAL DRAWINGS

LIST OF DRAWINGS



Clay
Clayey
Sandy
Sand
Silty
Cu
Su
B
Cl-s

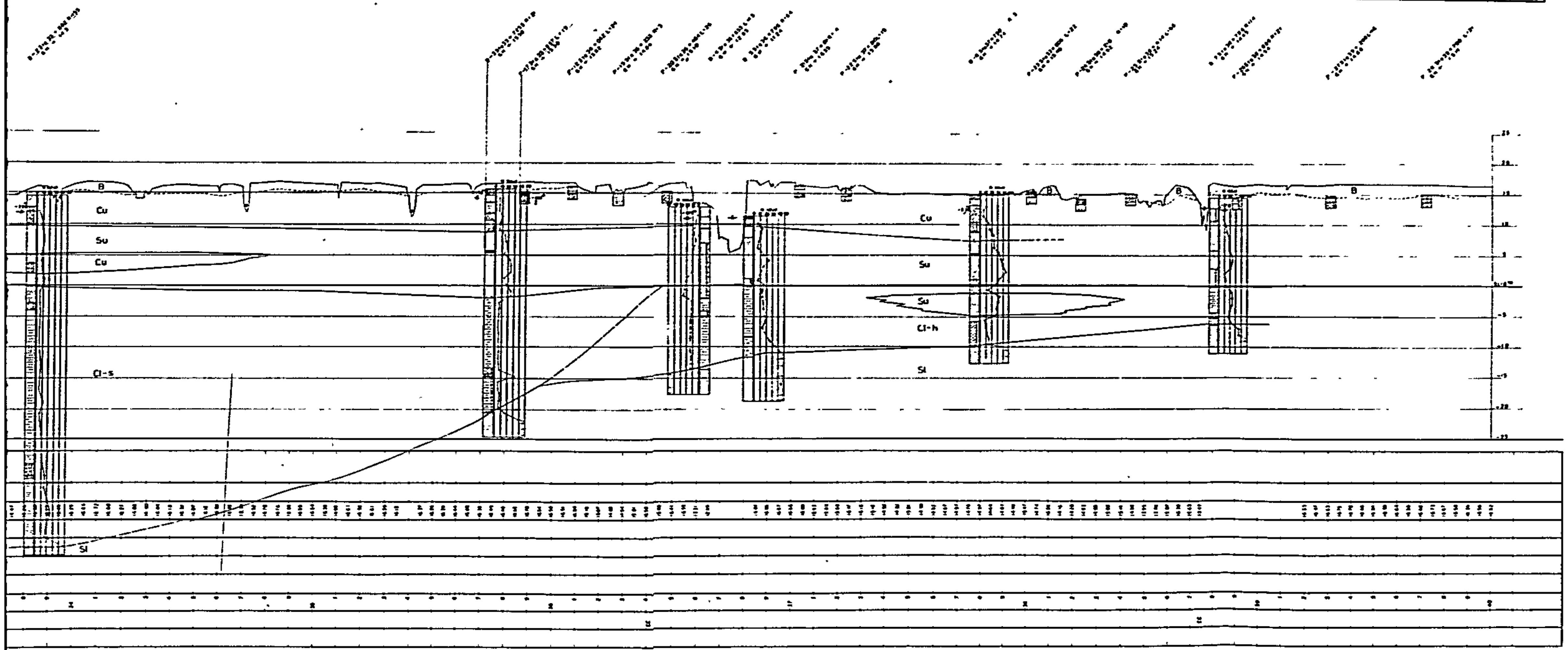


RUFIJI RIVER BRIDGE CONSTRUCTION PROJECT

(DAR ES SALAAM-LINDI COASTAL LINK ROAD)

SOIL PROFILE (1)

DRAWN BY	CHECKED BY
DATE JUN 1972	DWG NO 1



RUFIJI RIVER BRIDGE CONSTRUCTION PROJECT

(DAR ES SALAAM-LINDI COASTAL LINK ROAD)

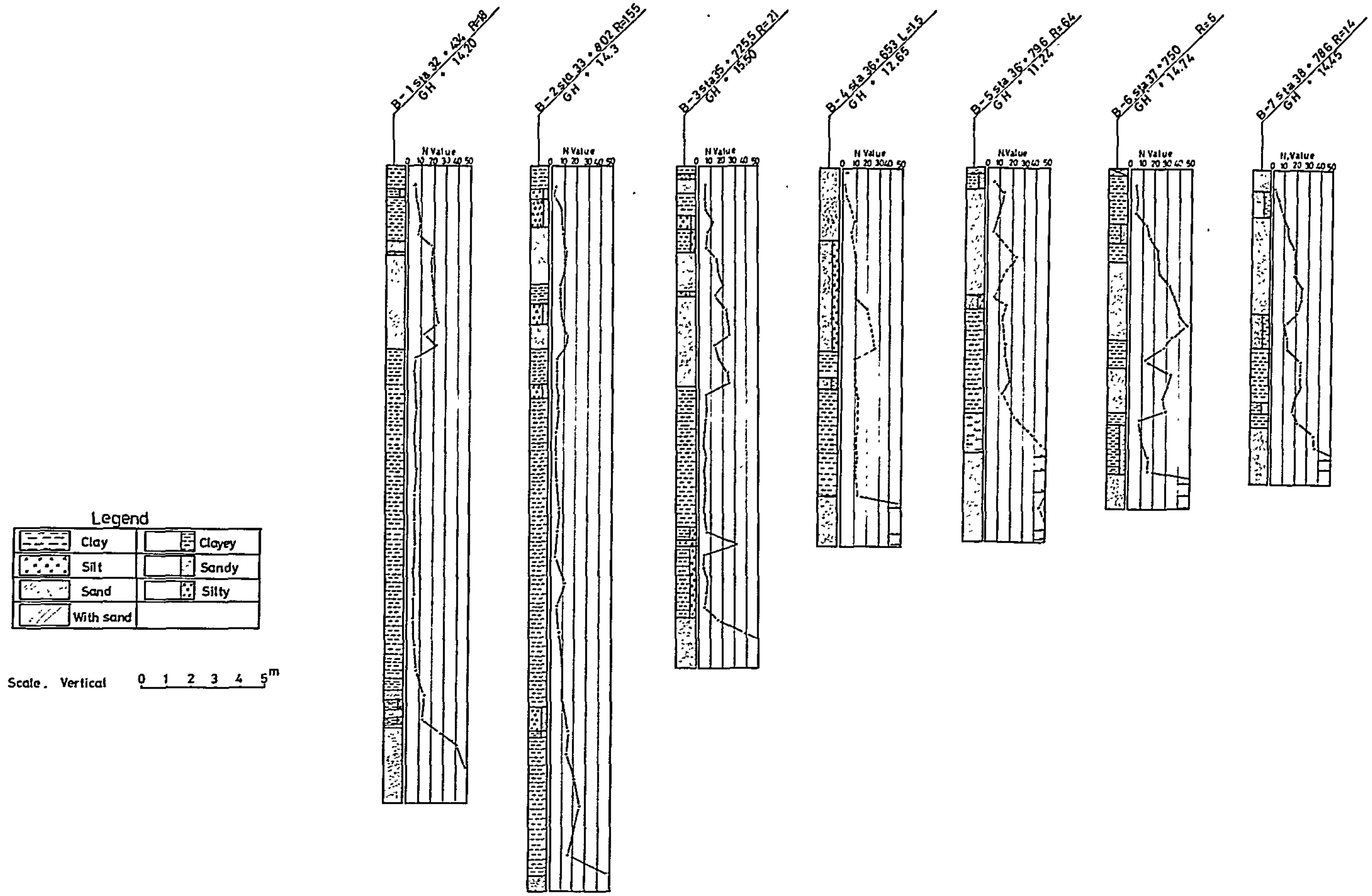
SOIL PROFILE (2)

DRAWN BY	CHECKED BY
DATE JUN 1972	DWG NO 2

RUFUI RIVER BRIDGE CONSTRUCTION PROJECT
(DAR ES SALAAM UNDI COASTAL LINK ROAD)

BORING LOGS

DRAWN BY	CHECKED BY
DATE : JUN 1972	DWG NO 3



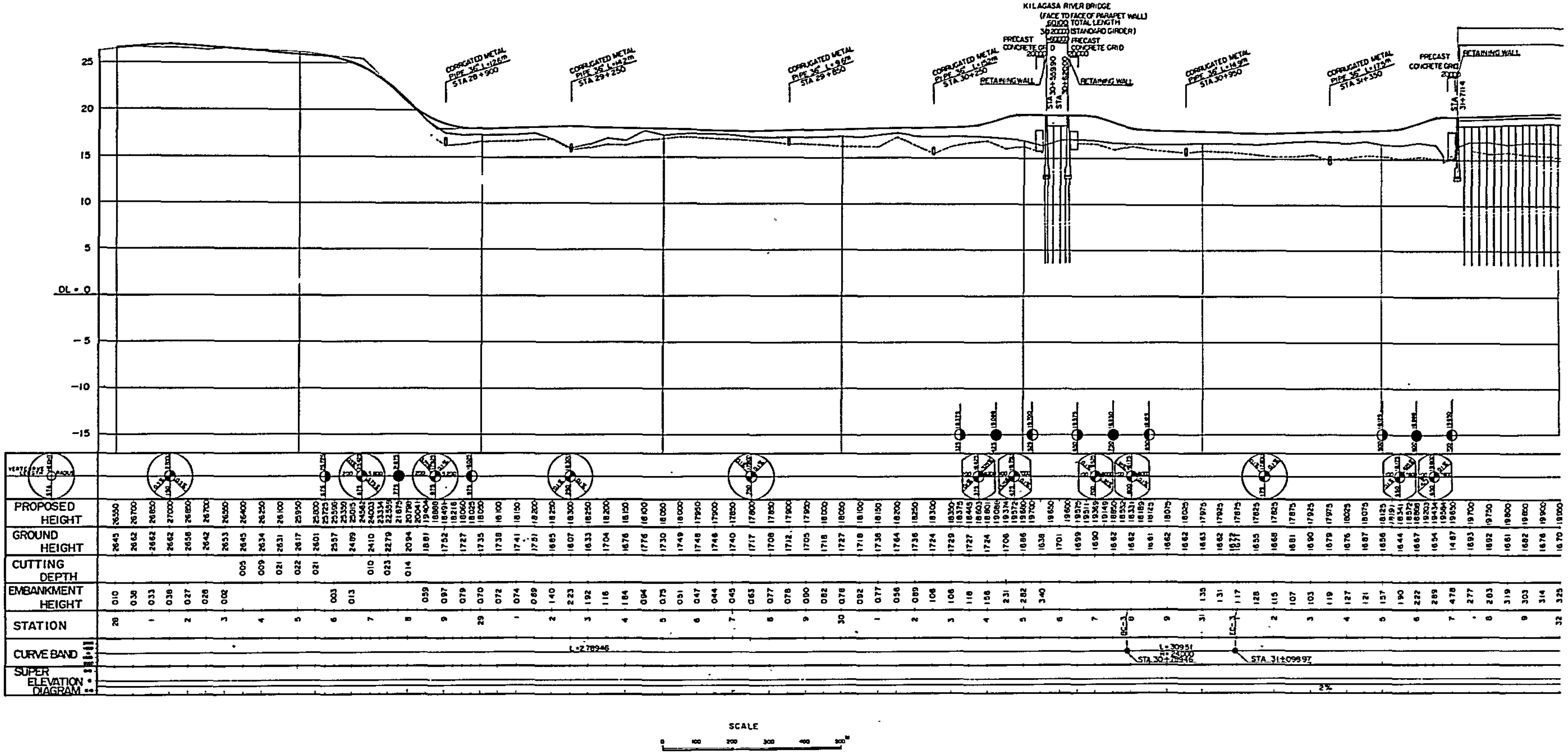
RUFIJI RIVER BRIDGE CONSTRUCTION PROJECT
(DAR ES SALAAM–LINDI COASTAL LINK ROAD)

APPROACH ROAD

PROFILE — I

DRAWN BY		CHECKED BY	
DATE	JUNE 1972	DWG NO	4

PROFILE-I



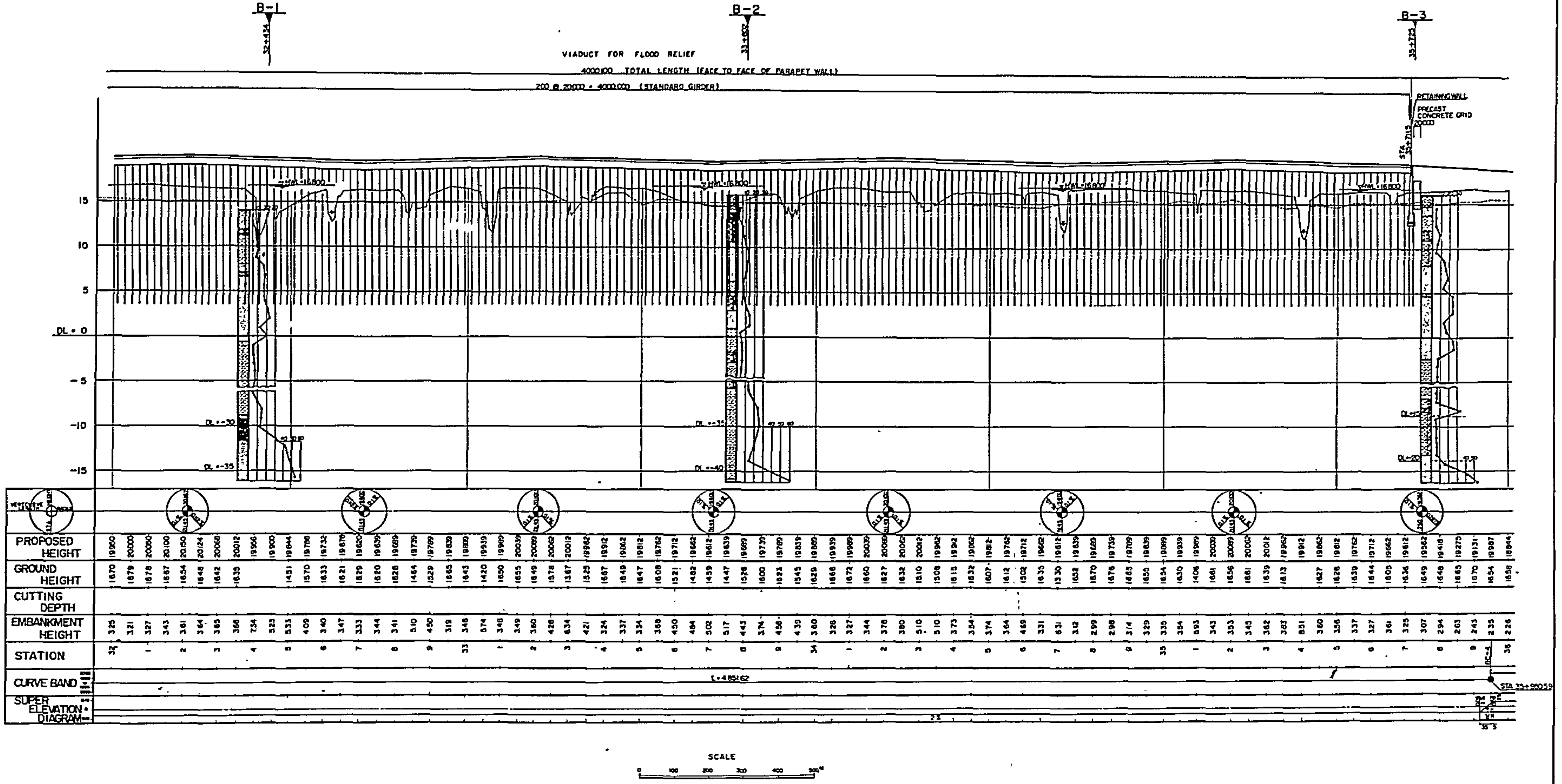
RUFIJI RIVER BRIDGE CONSTRUCTION PROJECT
(DAR ES SALAAM-LINDI COASTAL LINK ROAD)

APPROACH ROAD

PROFILE – 2

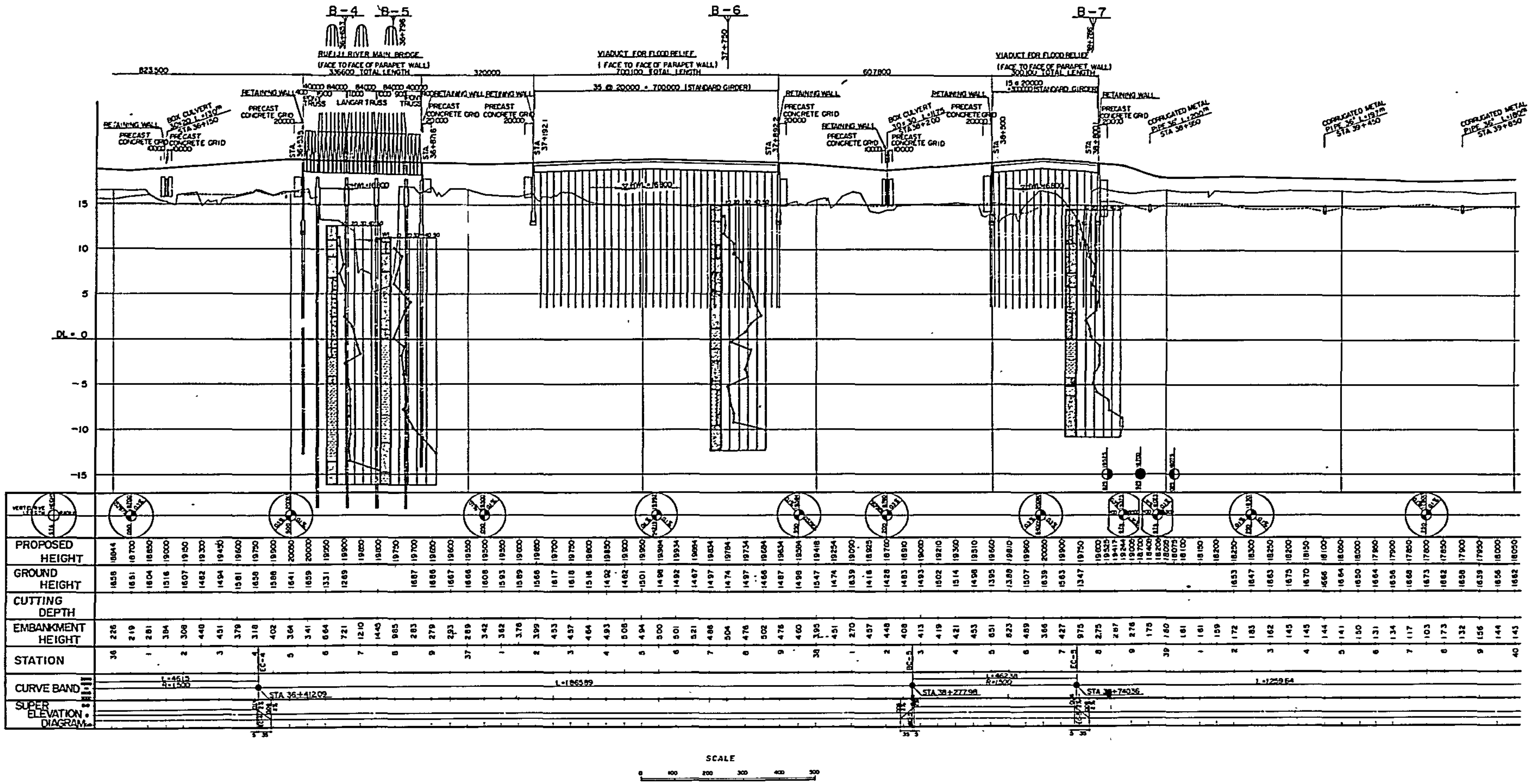
DRAWN BY		CHECKED BY	
DATE	JUNE 1972	DWG NO	5

PROFILE – 2



RUFIJI RIVER BRIDGE CONSTRUCTION PROJECT (DAR ES SALAAM-LINDI COASTAL LINK ROAD)	
APPROACH ROAD	
PROFILE — 3	
DRAWN BY	CHECKED BY
DATE JUNE 1972	DWG NO 6

PROFILE — 3

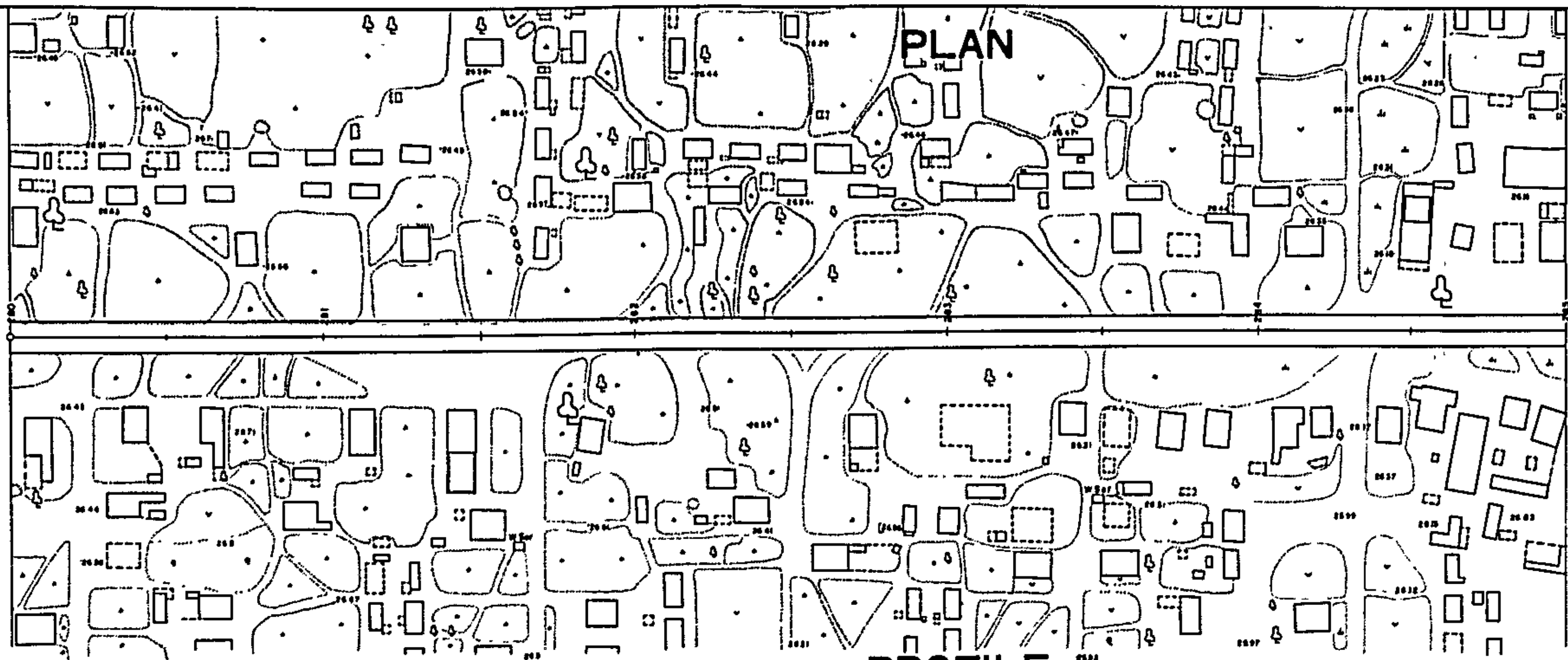


RUFIJI RIVER BRIDGE CONSTRUCTION PROJECT (DAR ES SALAAM-LINDI COASTAL LINK ROAD)	
APPROACH ROAD	
PLAN	
DRAWN BY	CHECKED BY
DATE: JUNE 1972	DWG. NO 7

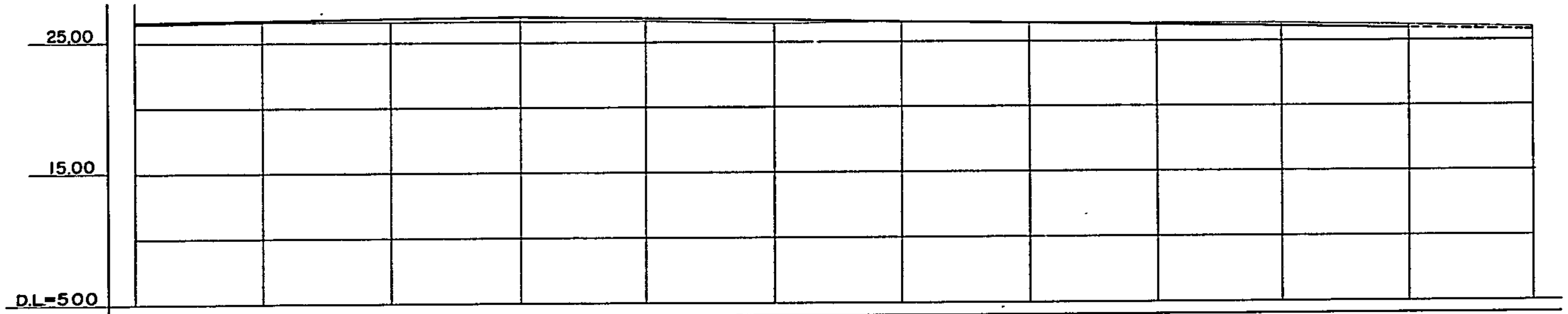
1	2

SCALE

PLAN



PROFILE



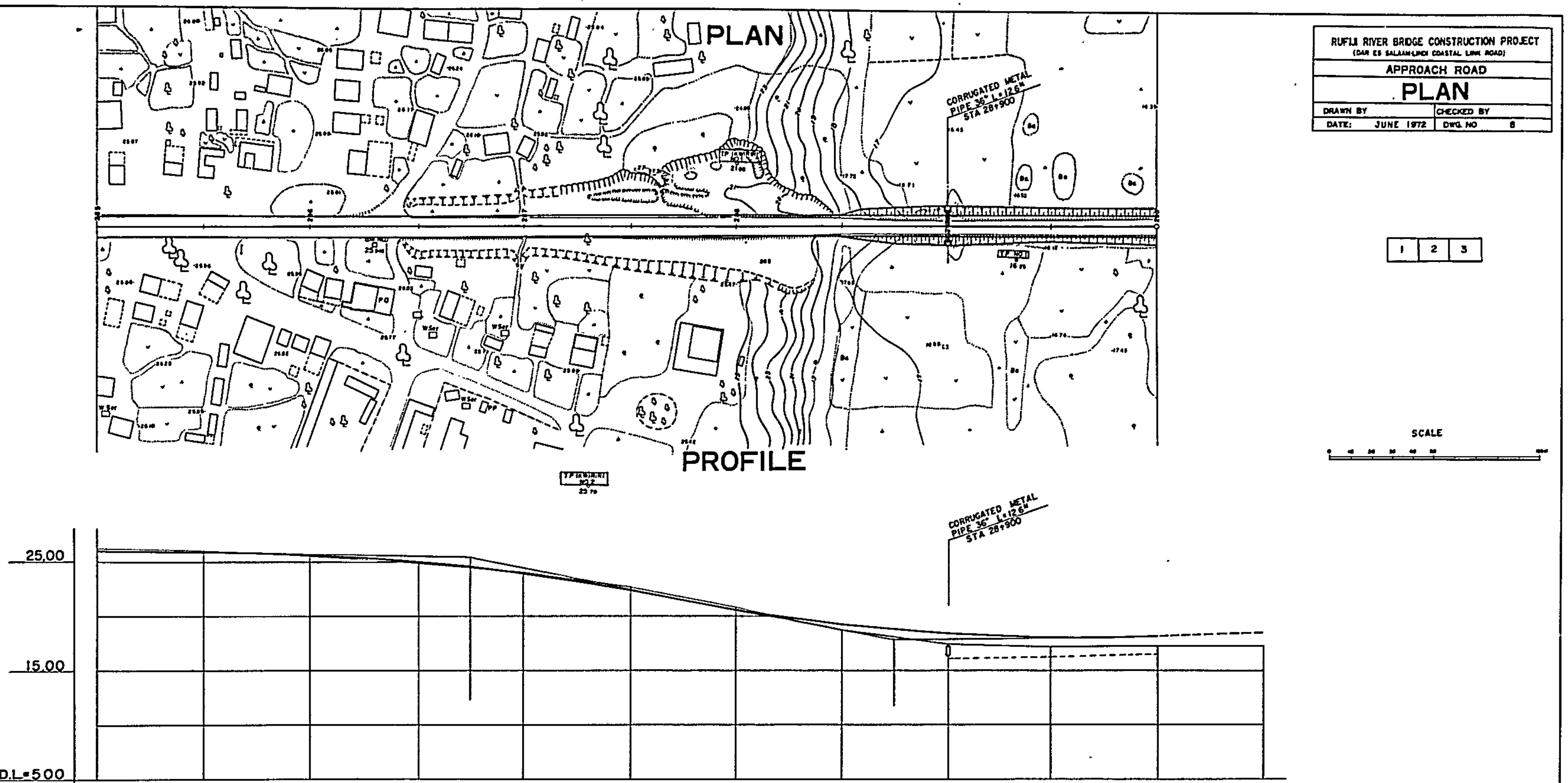
PROPOSED HEIGHT	26.550	26.700	26.850	27.000	26.850	26.700	26.550	26.400	26.250	26.100	25.950	25.800
GROUND HEIGHT	26.45	26.62	26.62	26.62	26.58	26.42	26.53	26.45	26.34	26.31	26.17	26.01
CUTTING DEPTH								0.05	0.09	0.21	0.22	0.21
EMBANKMENT HEIGHT	0.10	0.38	0.23	0.38	0.27	0.28	0.02					
ACCUMULATIVE DISTANCE	28000	28050	28100	28150	28200	28250	28300	28350	28400	28450	28500	28550
DISTANCE	0.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
STATION	280+00	280+50	281+00	281+50	282+00	282+50	283+00	283+50	284+00	284+50	285+00	285+50
CURVE BAND 1000 2000 ∞ 2000 1000												
SUPER ELEVATION DIAGRAM 0.0 0 0.0												

RUFIJI RIVER BRIDGE CONSTRUCTION PROJECT
(DAR ES SALAAM-LINDI COASTAL LINK ROAD)

APPROACH ROAD

PLAN

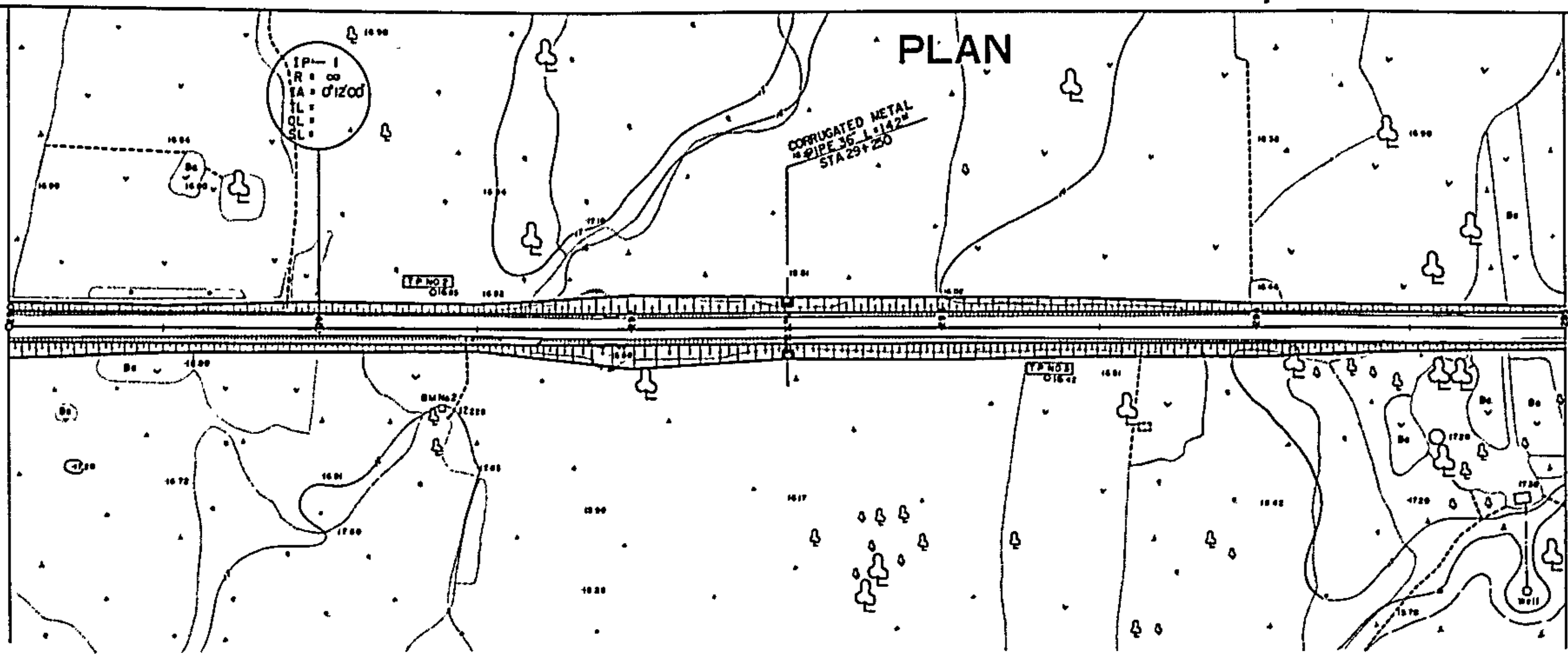
DRAWN BY	CHECKED BY
DATE: JUNE 1972	DWG. NO 8



VERT. CURVE L, STA., R.L.(RADIUS)			25.725				24.642				21.875					18.868				18.025		
PROPOSED HEIGHT	25.950	25.900	25.725	25.596	25.339	25.015	24.642	24.003	23.334	22.939	21.875	20.790	20.041	19.404	18.868	18.491	18.214	18.050	18.025	18.050	18.100
GROUND HEIGHT	26.17	26.01		25.57		24.88		24.10		22.78		20.94		18.81		17.52		17.27		17.38	17.38
CUTTING DEPTH	0.22	0.21						0.10		0.23		0.14									
EMBANKMENT HEIGHT				0.03		0.13								0.58		0.97		0.79		0.70	0.72
ACCUMULATIVE DISTANCE	28500	28550	28575	28600	28625	28650	28675	28700	28725	28750	28775	28800	28825	28850	28875	28900	28925	28950	28975	29000	29050
DISTANCE	50.00	50.00		50.00		50.00		50.00		50.00		50.00		50.00		50.00		50.00		50.00	50.00
STATION	285+00	285+50	285+75	286+00	286+25	286+50	286+75	287+00	287+25	287+50	287+75	288+00	288+25	288+50	288+75	289+00	289+25	289+50	289+75	290+00	290+50
CURVE BAND																					
SUPER ELEVATION DIAGRAM																					

RUFIJI RIVER BRIDGE CONSTRUCTION PROJECT (DAR ES SALAAM-LINDI COASTAL LINK ROAD)	
APPROACH ROAD	
PLAN	
DRAWN BY	CHECKED BY
DATE: JUNE 1972	DWG. NO 9

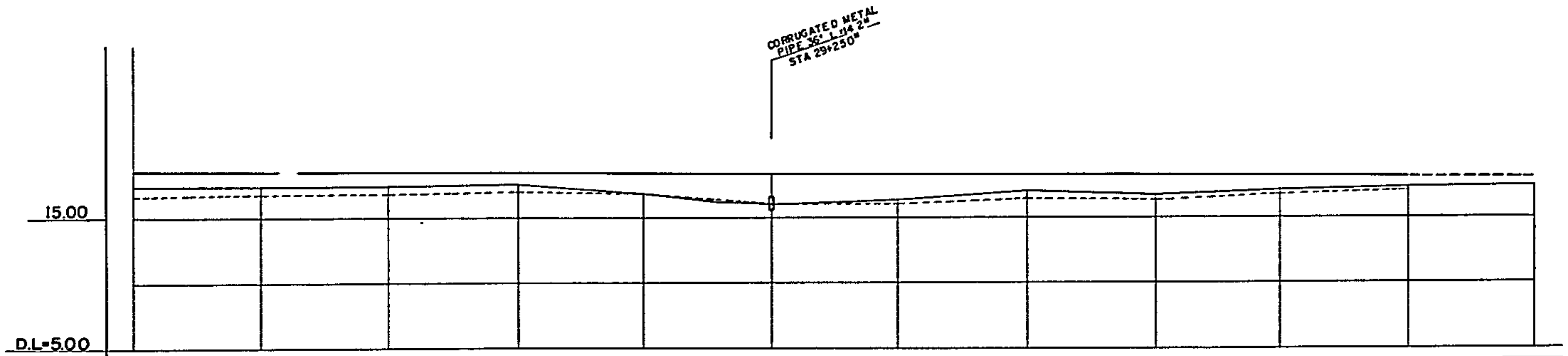
PLAN



2	3	4

SCALE

PROFILE



VERT. CURVE LENGTH / HEIGHT / STA. / RADIUS						18.300 / 0.1% / 0.1% / 250						
PROPOSED HEIGHT	18.050	18.100	18.180	18.200	18.250	18.300	18.250	18.200	18.180	18.100	18.050	18.000
GROUND HEIGHT	17.35	17.38	17.41	17.51	16.85	16.07	16.33	17.04	16.71	17.16	17.30	17.49
CUTTING DEPTH												
EMBANKMENT HEIGHT	0.70	0.72	0.74	0.69	1.40	2.23	1.92	1.16	1.64	0.94	0.75	0.51
ACCUMULATIVE DISTANCE	29000	29050	29100	29150	29200	29250	29300	29350	29400	29450	29500	29550
DISTANCE	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
STATION	290+00	290+50	291+00	291+50	292+00	292+50	293+00	293+50	294+00	294+50	295+00	295+50
CURVE BAND (1000 / 2000 / ∞ / 2000 / 1000)												
SUPER ELEVATION DIAGRAM (0.10 / 0 / 0.10)												

RUFIJI RIVER BRIDGE CONSTRUCTION PROJECT
(DAR ES SALAAM-LINDI COASTAL LINK ROAD)

APPROACH ROAD

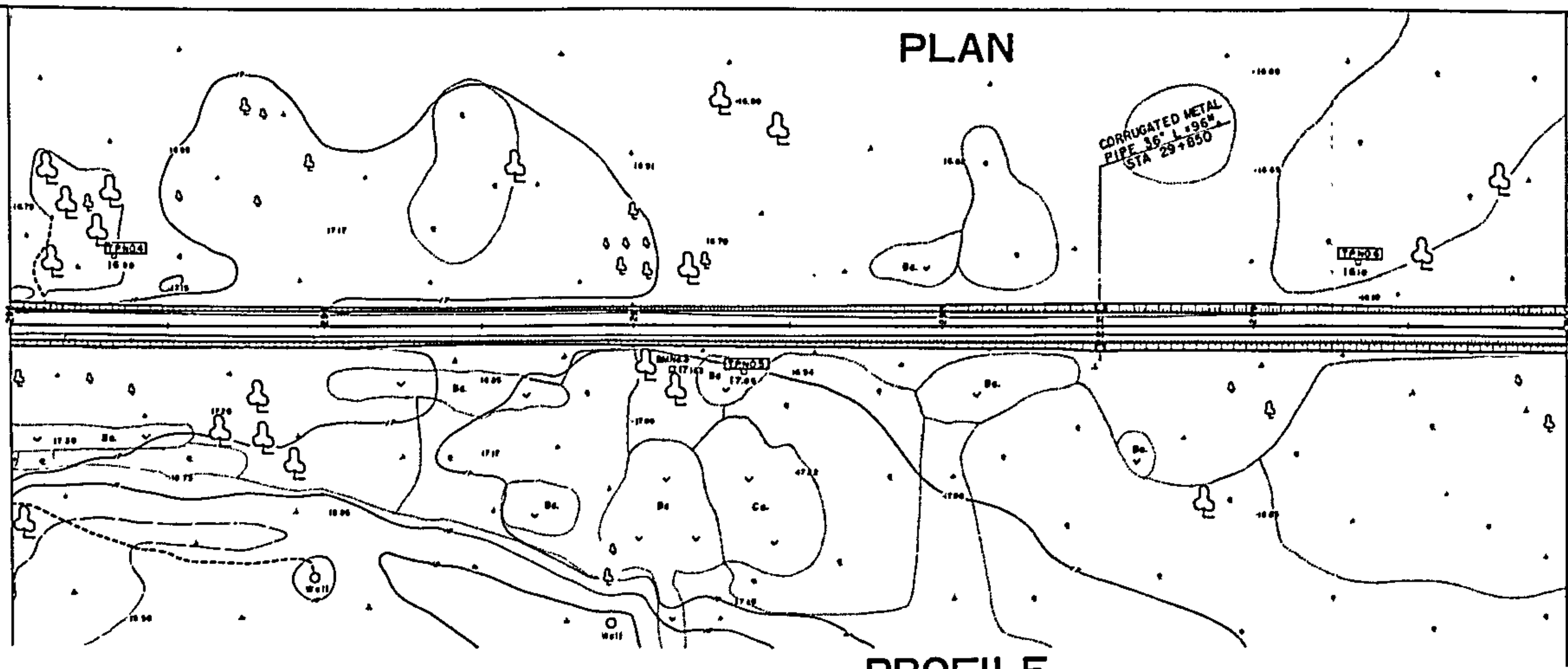
PLAN

DRAWN BY	CHECKED BY
DATE: JUNE 1972	DWG. NO 10

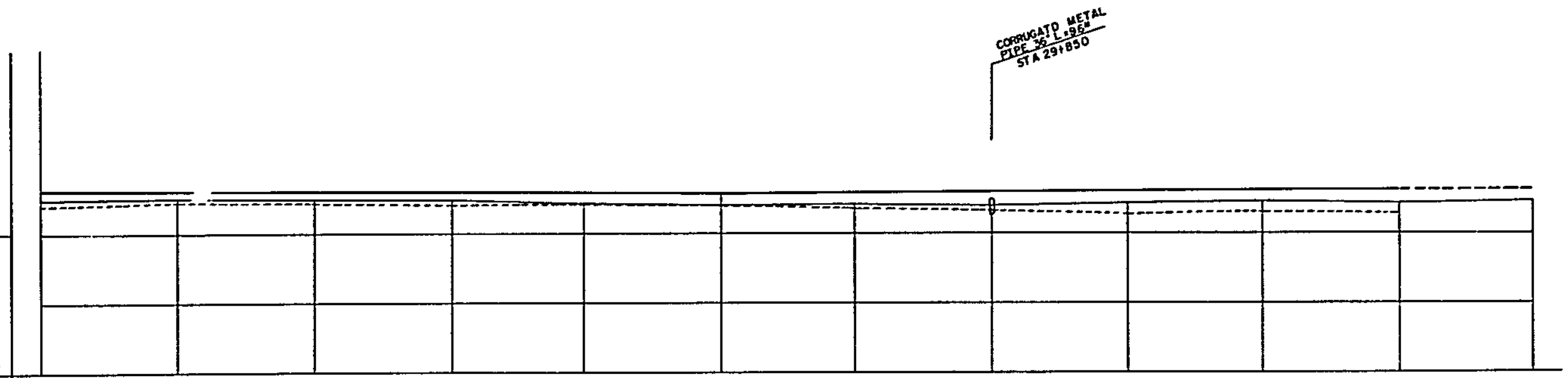
3	4	5

SCALE

PLAN



PROFILE



PROPOSED HEIGHT	18.050	18.000	17.950	17.900	17.850	17.800	17.850	17.900	17.950	18.000	18.050	18.100
GROUND HEIGHT	17.30	17.49	17.48	17.46	17.40	17.17	17.08	17.12	17.05	17.18	17.27	17.18
CUTTING DEPTH												
EMBANKMENT HEIGHT	0.78	0.51	0.47	0.44	0.48	0.63	0.77	0.78	0.90	0.82	0.78	0.92
ACCUMULATIVE DISTANCE	29500	29550	29600	29650	29700	29750	29800	29850	29900	29950	30000	30050
DISTANCE	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
STATION	295+00	295+50	296+00	296+50	297+00	297+50	298+00	298+50	299+00	299+50	300+00	300+50
CURVE BAND												
SUPER ELEVATION DIAGRAM												

RUFIJI RIVER BRIDGE CONSTRUCTION PROJECT
(DAR ES SALAAM-LINDI COASTAL LINK ROAD)

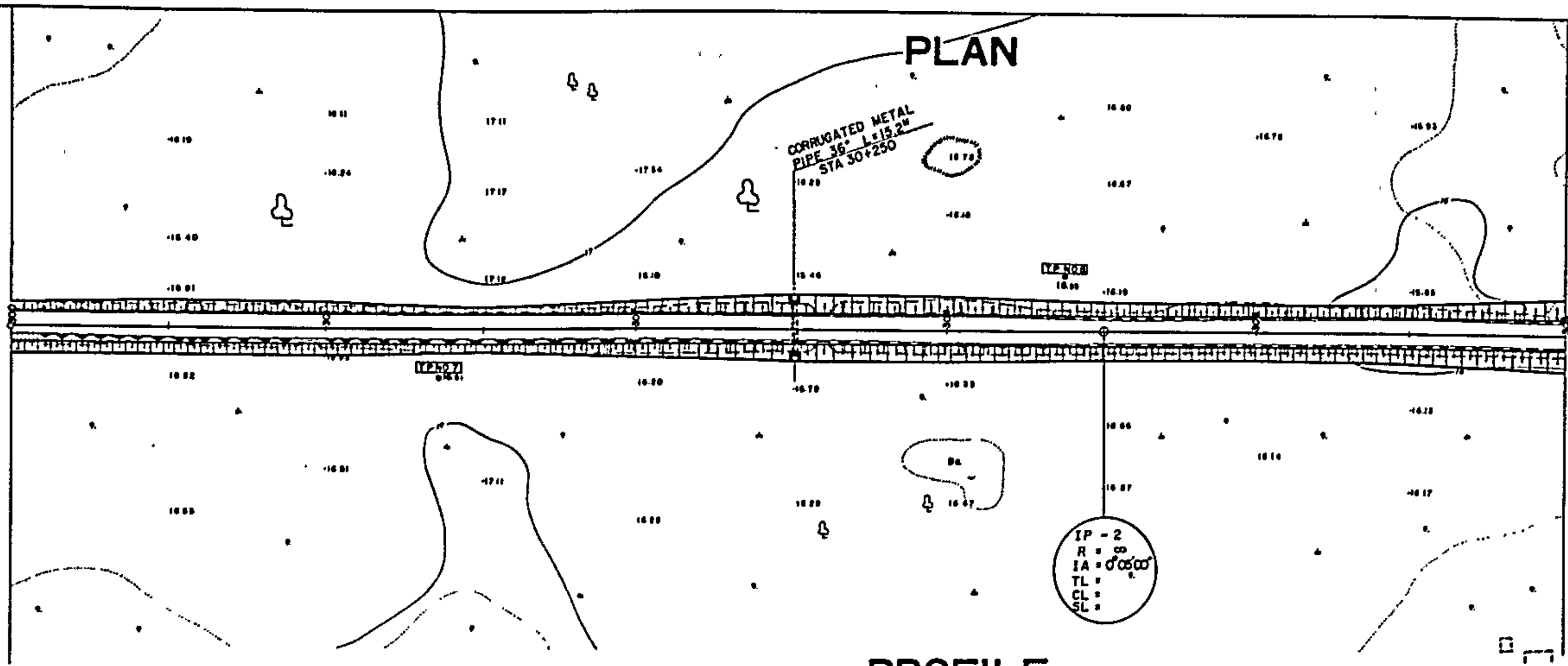
APPROACH ROAD

PLAN

DRAWN BY	CHECKED BY
DATE: JUNE 1972	DWG. NO 11

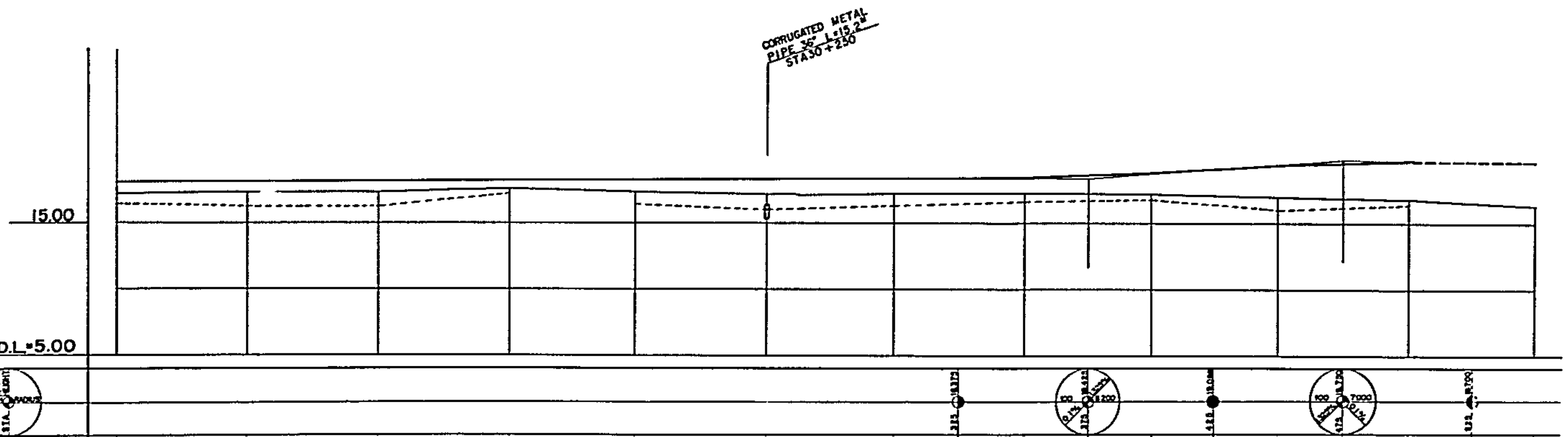
4 | 5 | 6

PLAN

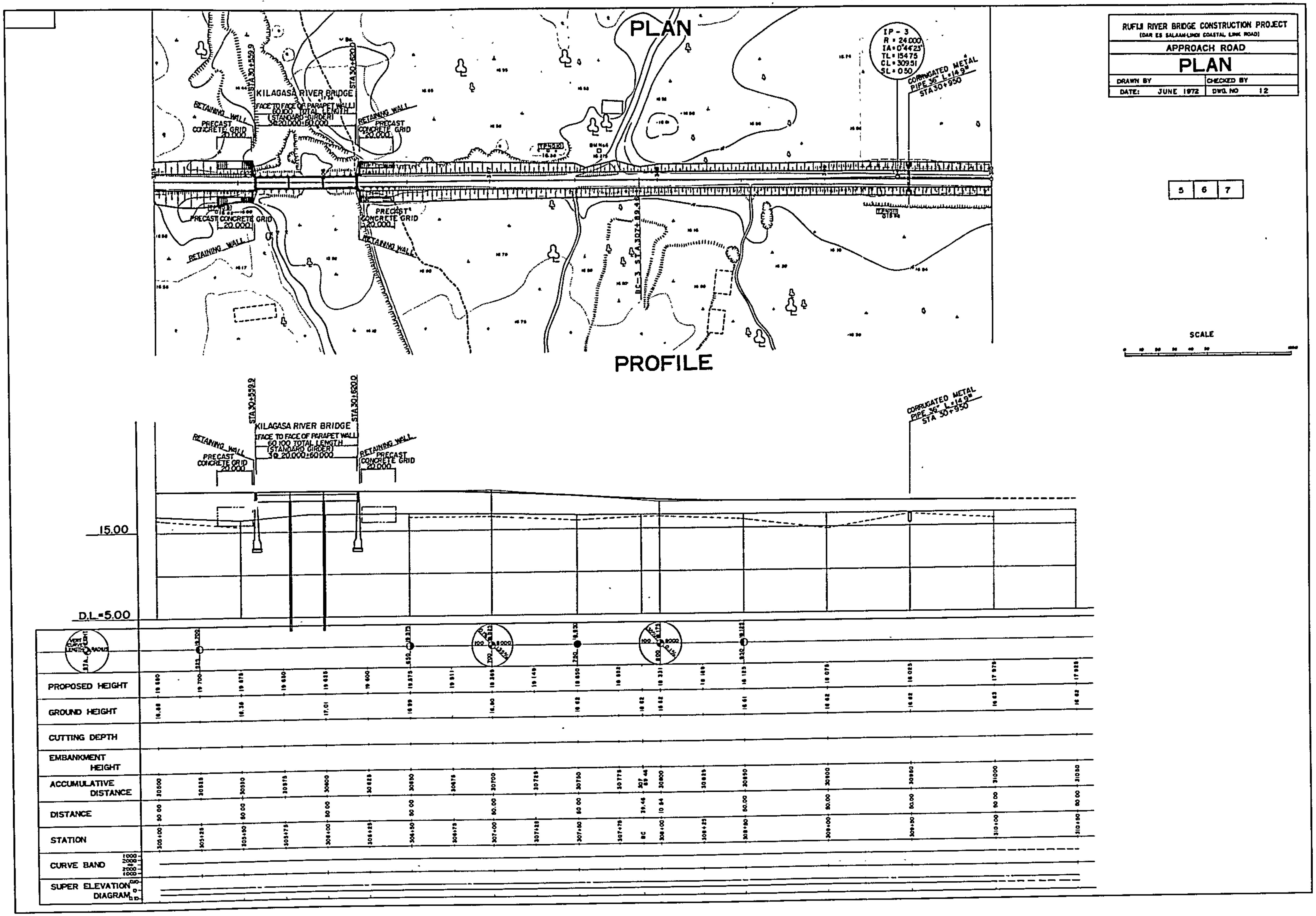


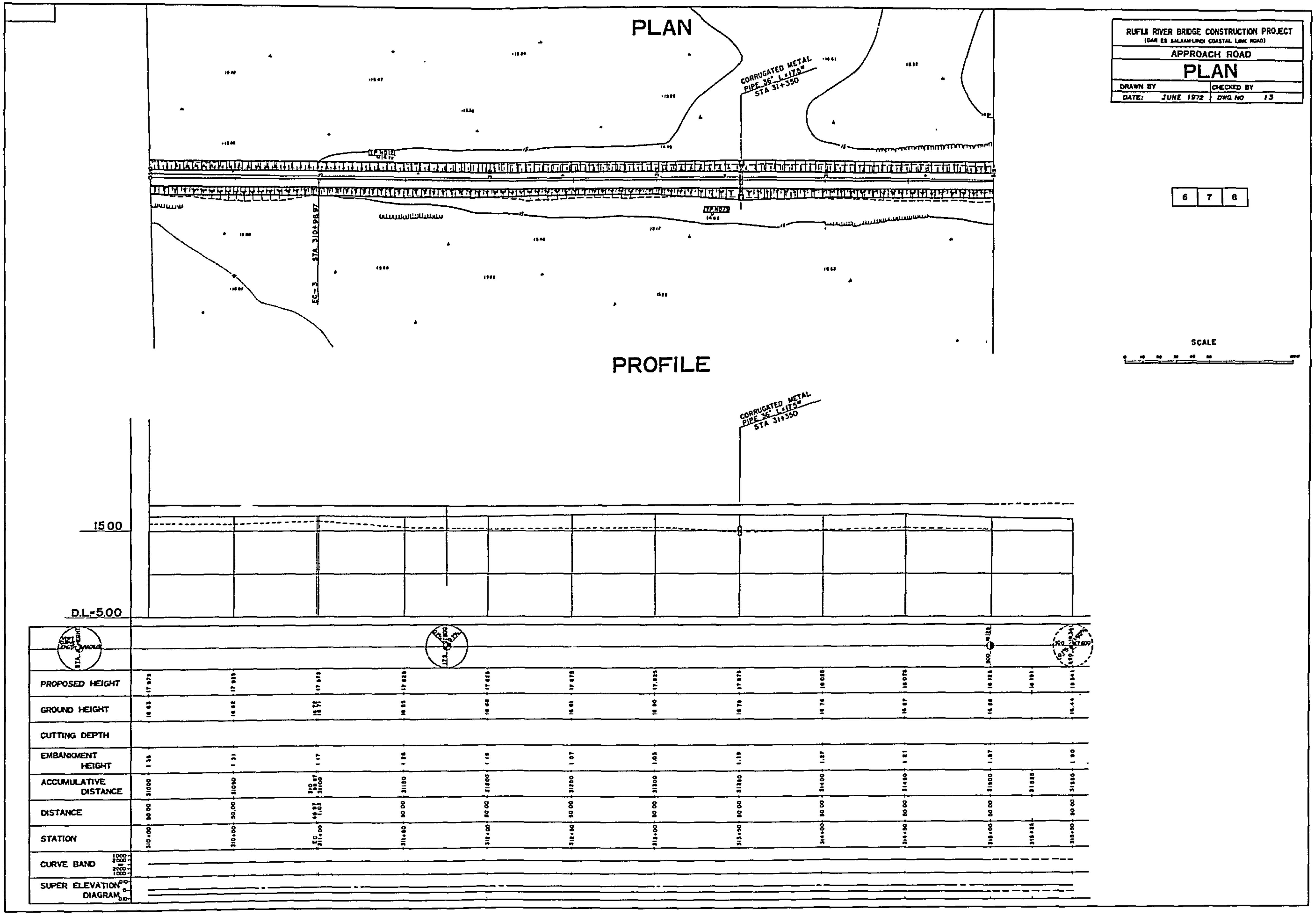
SCALE

PROFILE

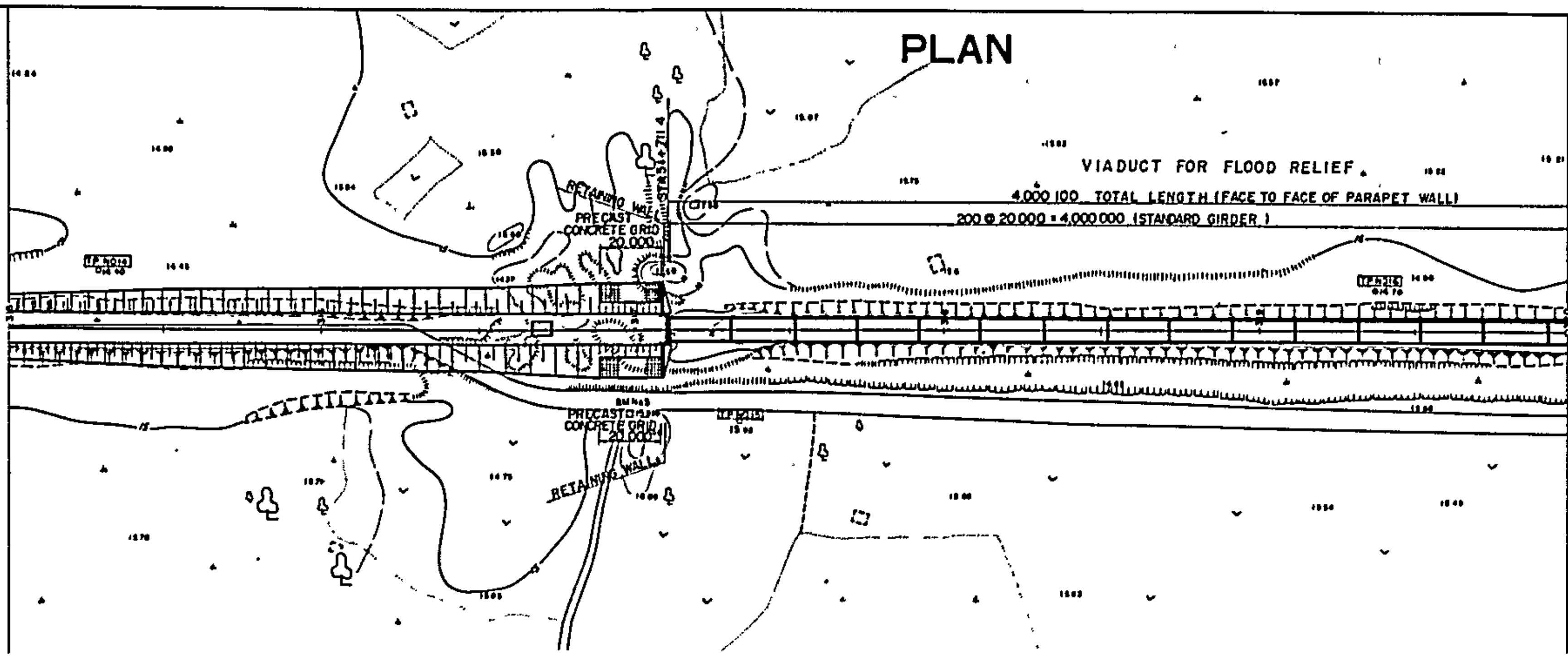


PROPOSED HEIGHT	18.050	18.100	18.150	18.200	18.250	18.300	18.350	18.375	18.448	18.603	18.801	19.068	19.374	19.873	19.680	19.700	19.678
GROUND HEIGHT	17.27	17.18	17.38	17.64	17.36	17.24	17.29		17.27		17.24		17.04		16.86		16.34
CUTTING DEPTH																	
EMBANKMENT HEIGHT	0.78	0.92	0.77	0.88	0.89	1.06	1.06		1.18		1.56		2.31		2.82		3.40
ACCUMULATIVE DISTANCE	30000	30050	30100	30150	30200	30250	30300	30325	30350	30375	30400	30425	30450	30475	30500	30525	30550
DISTANCE	50.00	50.00	50.00	50.00	50.00	50.00	50.00		50.00		50.00		50.00		50.00		50.00
STATION	300+00	300+50	301+00	301+50	302+00	302+50	303+00	303+25	303+50	303+75	304+00	304+25	304+50	304+75	305+00	305+25	305+50
CURVE BAND																	
SUPER ELEVATION DIAGRAM																	


PLAN
PROFILE
KILAGASA RIVER BRIDGE
(FACE TO FACE OF PARAPET WALL)
60.100 TOTAL LENGTH
(STANDARD GIRDER)
3@20.000=60.000
STA.30+559.9
STA.30+620.0
RETAINING WALL
PRECAST CONCRETE GRID 20.000
IP-3
R = 24000
IA = 0°44'23"
TL = 15.475
CL = 309.51
SL = 0.50
CORRUGATED METAL PIPE 36" L=14.9m STA.30+950
BC-3 STA.307+89.46
15.00
D.L.=5.00
PROPOSED HEIGHT
GROUND HEIGHT
CUTTING DEPTH
EMBANKMENT HEIGHT
ACCUMULATIVE DISTANCE
DISTANCE
STATION
CURVE BAND
SUPER ELEVATION DIAGRAM
RUFIJI RIVER BRIDGE CONSTRUCTION PROJECT
(DAR ES SALAAM-LINDI COASTAL LINK ROAD)
APPROACH ROAD
PLAN
DRAWN BY
CHECKED BY
DATE: JUNE 1972
DWG. NO 12
5 6 7
SCALE


PLAN
CORRUGATED METAL PIPE 36" L=17.5" STA 31+350
STA. 310+98.97
EC-3
RUFIJI RIVER BRIDGE CONSTRUCTION PROJECT
(DAR ES SALAAM-LINDI COASTAL LINK ROAD)
APPROACH ROAD
PLAN
DRAWN BY
CHECKED BY
DATE: JUNE 1972
DWG NO 13
6
7
8
SCALE
PROFILE
CORRUGATED METAL PIPE 36" L=17.5" STA 31+350
15.00
D.L.=5.00
PROPOSED HEIGHT
GROUND HEIGHT
CUTTING DEPTH
EMBANKMENT HEIGHT
ACCUMULATIVE DISTANCE
DISTANCE
STATION
CURVE BAND
SUPER ELEVATION DIAGRAM

PLAN

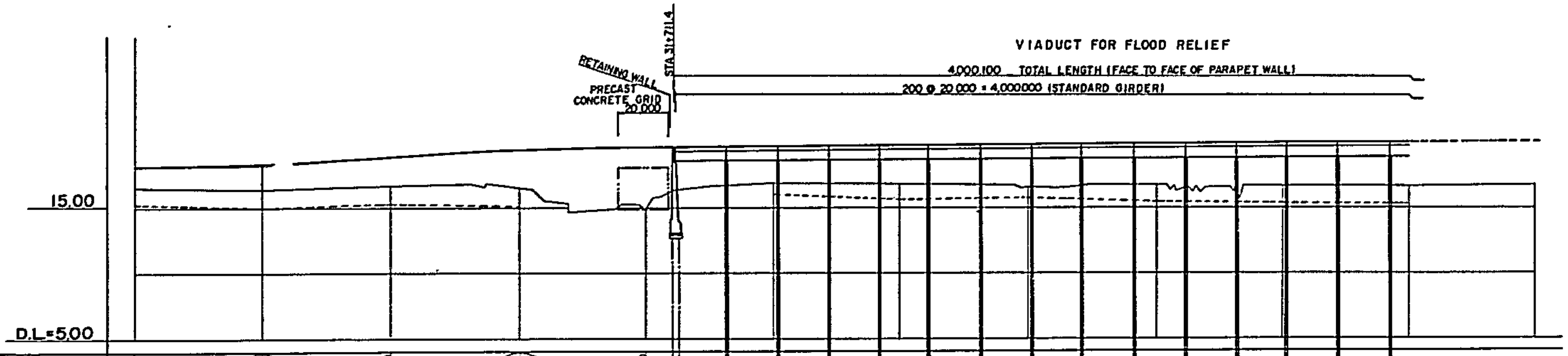


RUFIJI RIVER BRIDGE CONSTRUCTION PROJECT (DAR ES SALAAM-LINDI COASTAL LINK ROAD)	
APPROACH ROAD	
PLAN	
DRAWN BY	CHECKED BY
DATE: JUNE 1972	DWG. NO 14

7	8	9

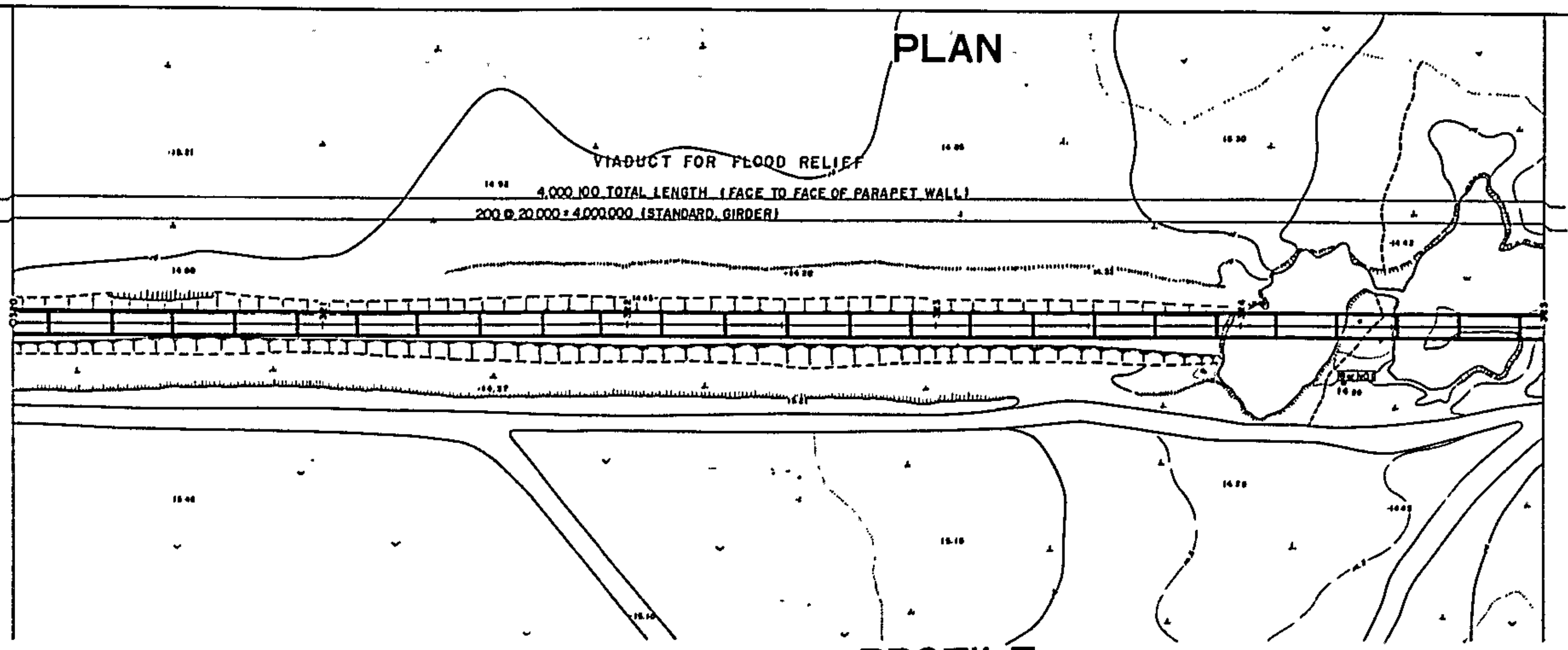
SCALE

PROFILE

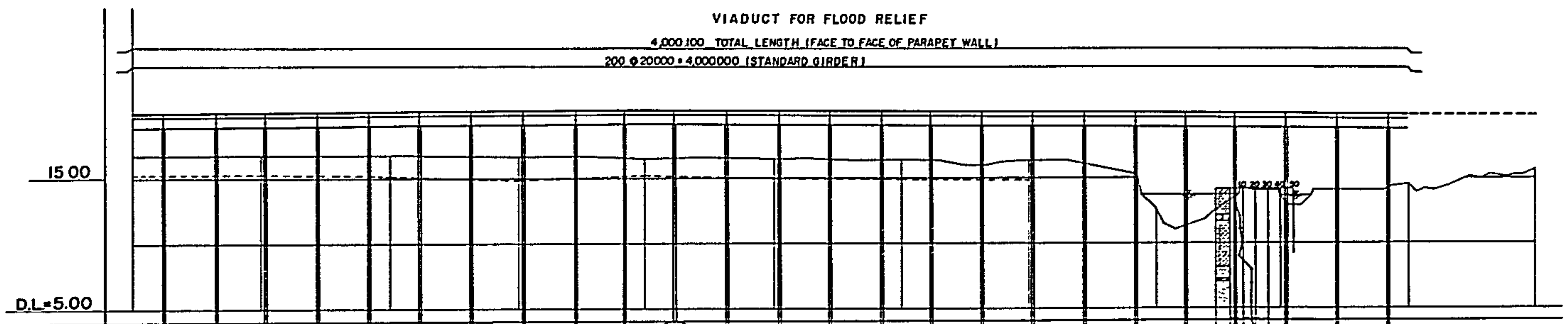


PROPOSED HEIGHT	18 129	18 181	18 341	18 872	18 668	18 203	18 434	18 804	18 650	19 700	19 750	19 800	19 850	19 900	19 950	20 000
GROUND HEIGHT	16 56		16 44		16 67		16 54		14 87	16 93	16 92	16 61	16 88	16 76	16.70	16.79
CUTTING DEPTH																
EMBANKMENT HEIGHT	1 57		1.90		2 22		2 89		4.78	2.77	2 83	3 19	3 03	3.14	3.25	3.21
ACCUMULATIVE DISTANCE	31500	31525	31550	31575	31600	31625	31650	31675	31700	31750	31800	31850	31900	31950	32000	32050
DISTANCE	50 00		50 00		50 00		50 00		50 00	50 00	50 00	50.00	50 00	50.00	50 00	50 00
STATION	315+00	315+25	315+50	315+75	316+00	316+25	316+50	316+75	317+00	317+50	318+00	318+50	319+00	319+50	320+00	320+50
CURVE BAND																
SUPER ELEVATION DIAGRAM																

PLAN



PROFILE



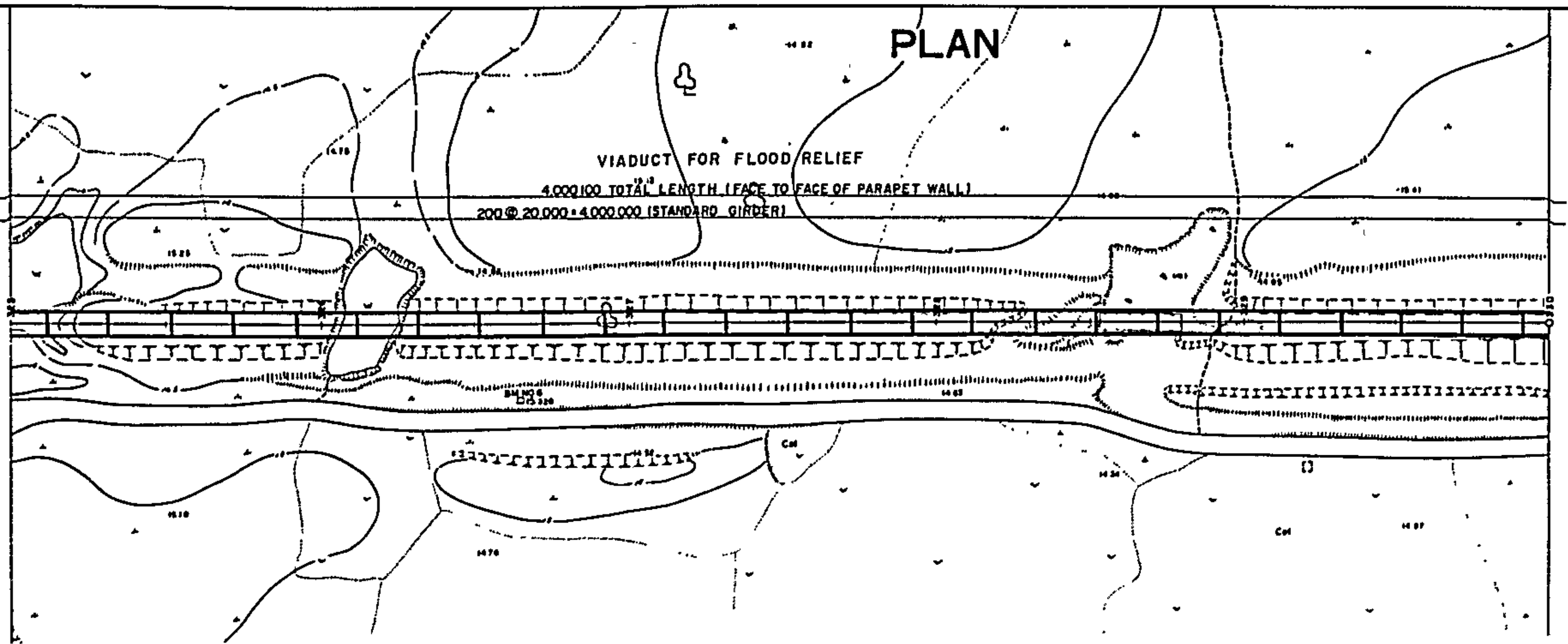
PROPOSED HEIGHT	19.950	20.000	20.050	20.100	20.180	20.124	20.068	20.012	19.956	19.900	19.844	19.788
GROUND HEIGHT	16.70	16.79	16.78	16.67	16.54	16.48	16.42	16.35	12.62	13.67	14.51	15.70
CUTTING DEPTH												
EMBANKMENT HEIGHT	3.25	3.21	3.27	3.43	3.61	3.64	3.65	3.66	7.34	6.23	5.33	4.09
ACCUMULATIVE DISTANCE	32000	32050	32100	32150	32200	32250	32300	32350	32400	32450	32500	32550
DISTANCE	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
STATION	320+00	320+50	321+00	321+50	322+00	322+50	323+00	323+50	324+00	324+50	325+00	325+50
CURVE BAND												
SUPER ELEVATION DIAGRAM												

RUFIJI RIVER BRIDGE CONSTRUCTION PROJECT (DAR ES SALAAM-LINDI COASTAL LINK ROAD)	
APPROACH ROAD	
PLAN	
DRAWN BY	CHECKED BY
DATE: JUNE 1972	DWG. NO 15

8	9	10

SCALE

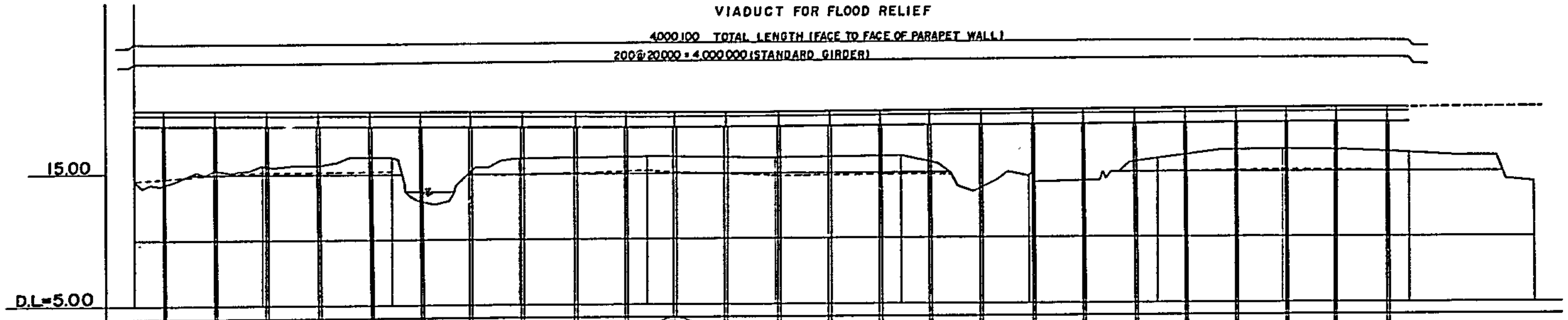
PLAN



9	10	11

SCALE

PROFILE



PROPOSED HEIGHT	19.844	19.796	19.732	19.676	19.620	19.839	19.689	19.739	19.789	19.639	19.489	19.939
GROUND HEIGHT	14.61	15.70	16.33	16.21	16.28	16.30	16.28	14.64	15.29	16.65	16.43	14.20
CUTTING DEPTH												
EMBANKMENT HEIGHT	5.33	4.09	3.40	3.47	3.33	3.44	3.41	5.10	4.50	3.19	3.46	5.74
ACCUMULATIVE DISTANCE	32500	32550	32600	32650	32700	32750	32800	32850	32900	32950	33000	33050
DISTANCE	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
STATION	325+00	325+50	326+00	326+50	327+00	327+50	328+00	328+50	329+00	329+50	330+00	330+50
CURVE BAND												
SUPER ELEVATION DIAGRAM												

RUFIJI RIVER BRIDGE CONSTRUCTION PROJECT (DAR ES SALAAM-LINDI COASTAL LINK ROAD)	
APPROACH ROAD	
PLAN	
DRAWN BY	CHECKED BY
DATE: JUNE 1972	DWG. NO 16

RUFLI RIVER BRIDGE CONSTRUCTION PROJECT
(DAR ES SALAAM-LINDI COASTAL LINK ROAD)

APPROACH ROAD

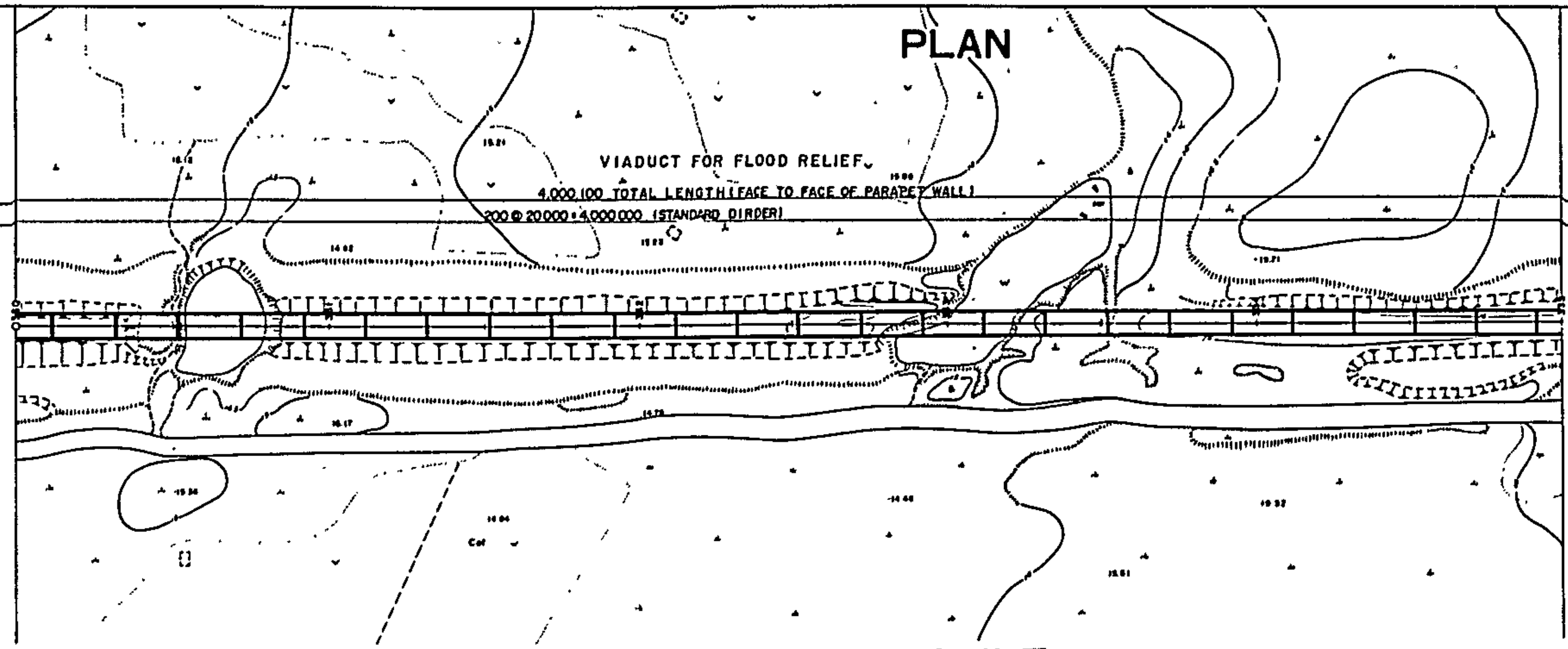
PLAN

DRAWN BY	CHECKED BY
DATE: JUNE 1972	DWG. NO 17

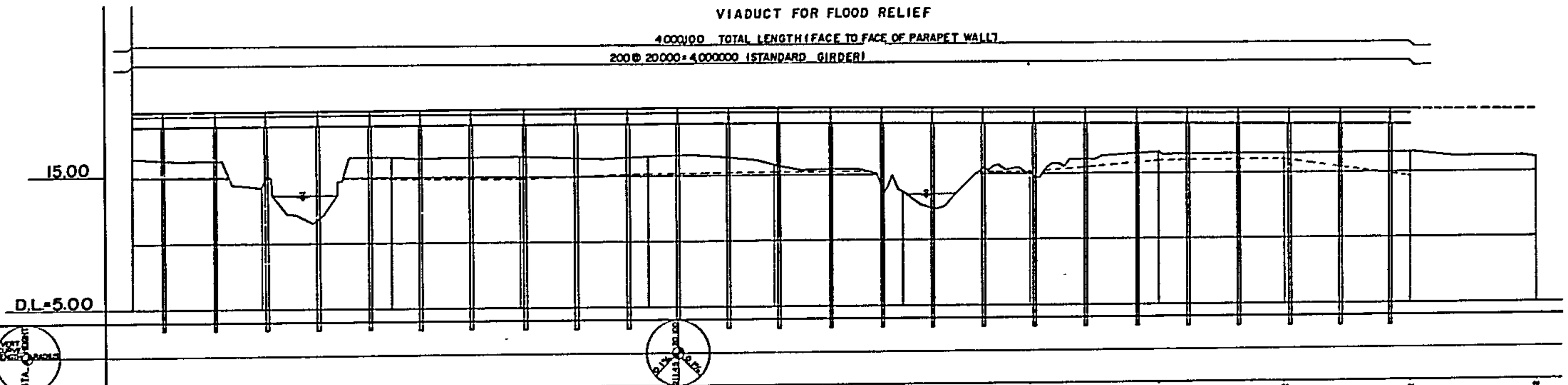
10	11	12

SCALE

PLAN



PROFILE

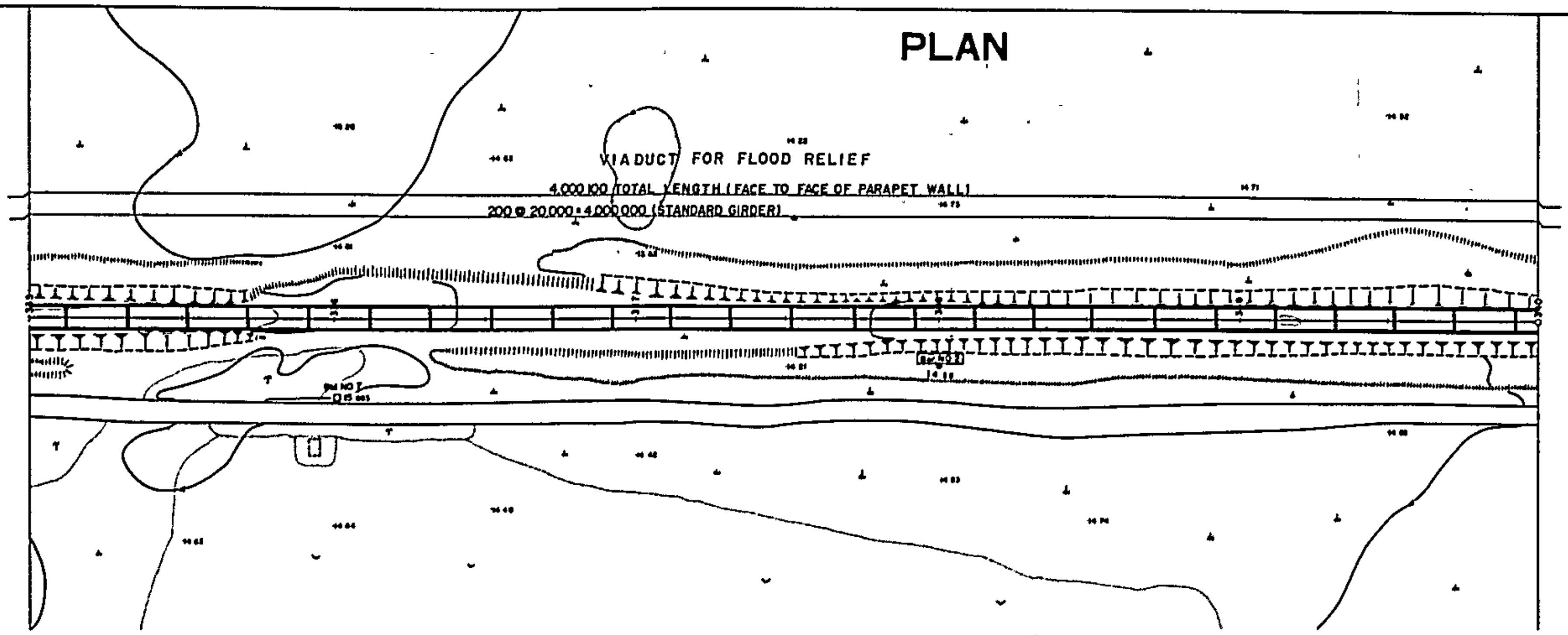


PROPOSED HEIGHT	19.889	19.938	19.989	20.039	20.089	20.062	20.012	19.962	19.912	19.862	19.812	19.762
GROUND HEIGHT	16.43	14.20	16.50	16.55	16.40	15.70	13.67	15.75	16.67	16.48	16.47	16.08
CUTTING DEPTH												
EMBANKMENT HEIGHT	3.46	5.74	3.49	3.49	3.60	4.36	6.34	4.21	3.24	3.37	3.34	3.68
ACCUMULATIVE DISTANCE	33000	33050	33100	33150	33200	33250	33300	33350	33400	33450	33500	33550
DISTANCE	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
STATION	330+00	330+50	331+00	331+50	332+00	332+50	333+00	333+50	334+00	334+50	335+00	335+50
CURVE BAND												
SUPER ELEVATION DIAGRAM												

RUFIJI RIVER BRIDGE CONSTRUCTION PROJECT (DAR ES SALAAM-LINDI COASTAL LINK ROAD)	
APPROACH ROAD	
PLAN	
DRAWN BY	CHECKED BY
DATE· JUNE 1972	DWG. NO 18

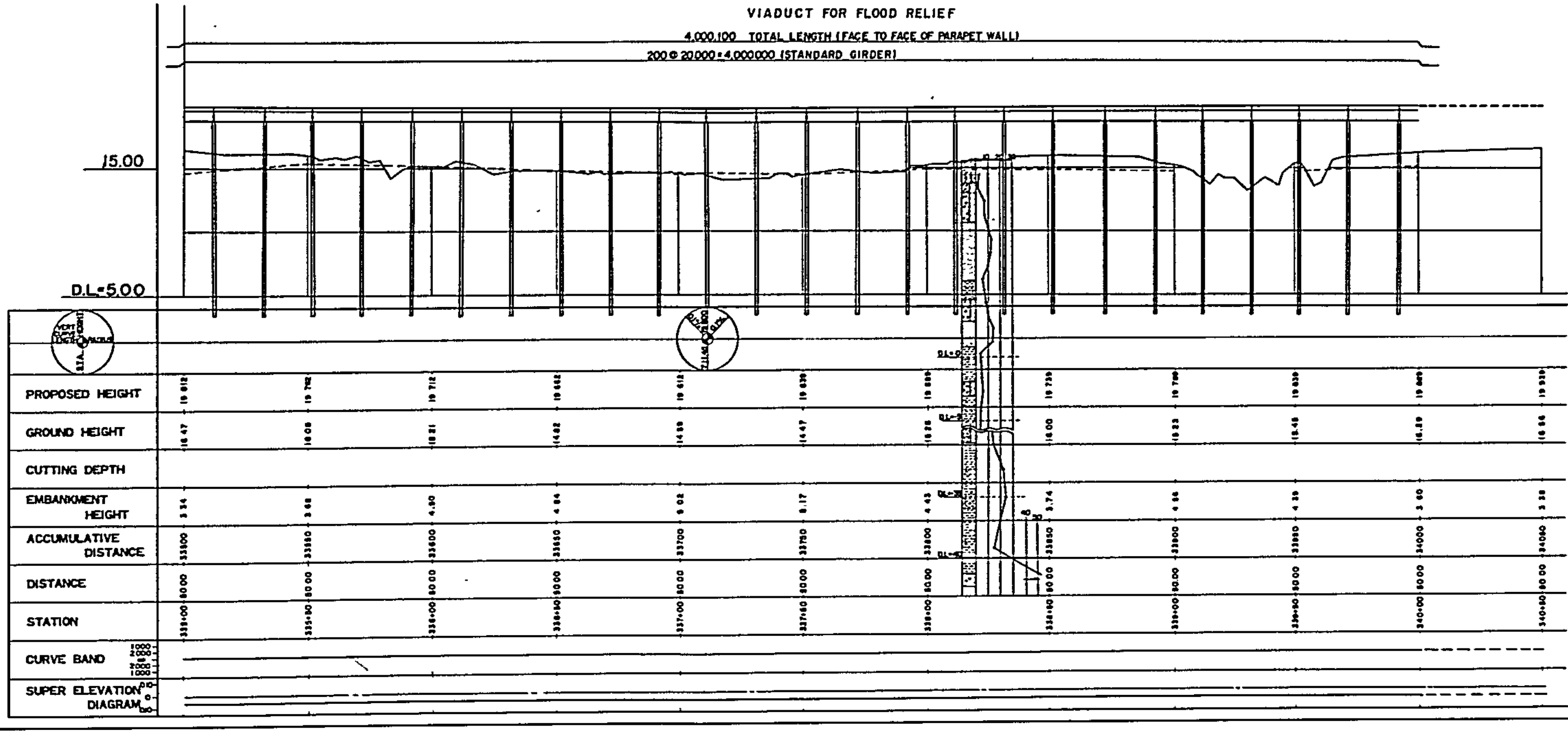
11	12	13

PLAN



SCALE

PROFILE



RUFIJI RIVER BRIDGE CONSTRUCTION PROJECT
(DAR ES SALAAM-LINDI COASTAL LINK ROAD)

APPROACH ROAD

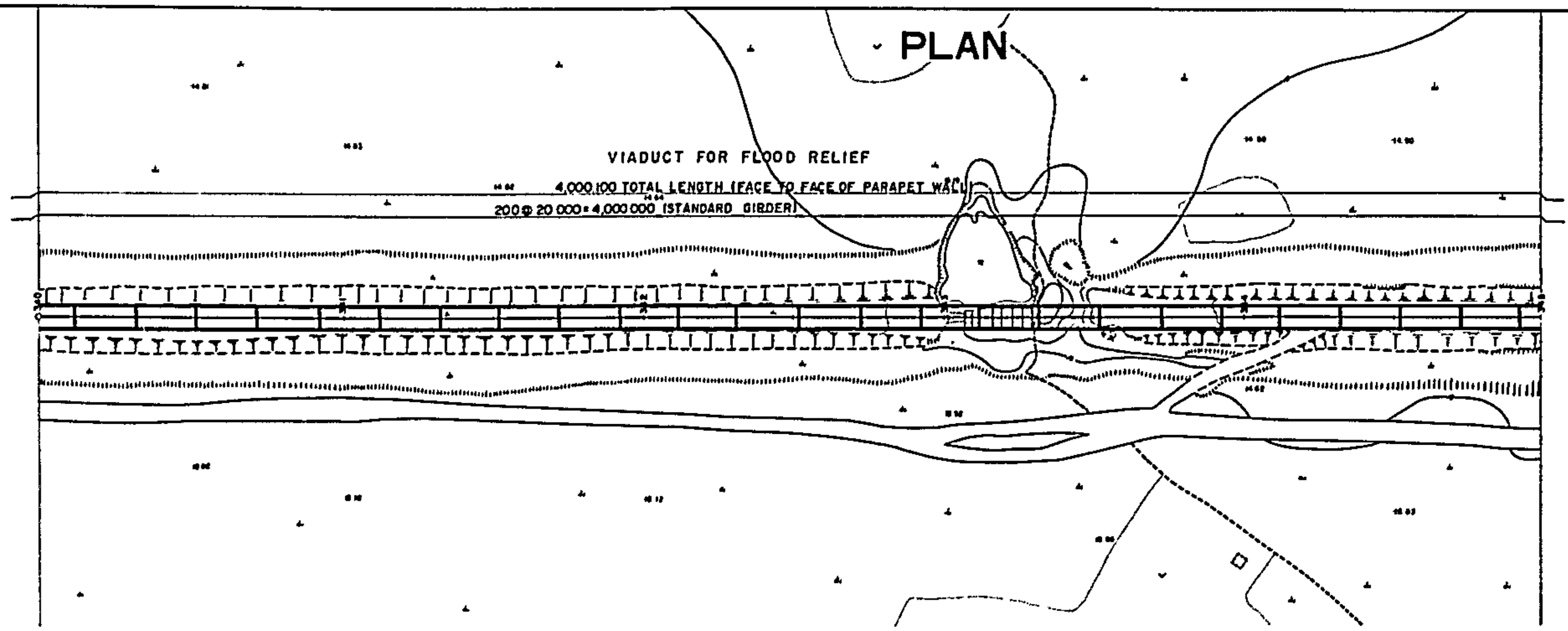
PLAN

DRAWN BY		CHECKED BY	
DATE:	JUNE 1972	DWG. NO	19

12	13	14

SCALE

PLAN



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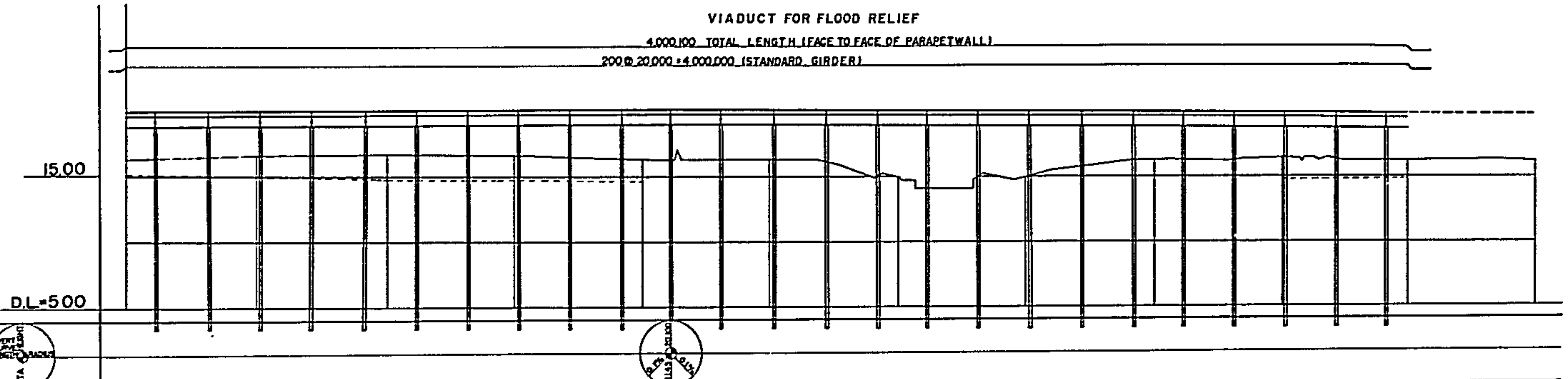
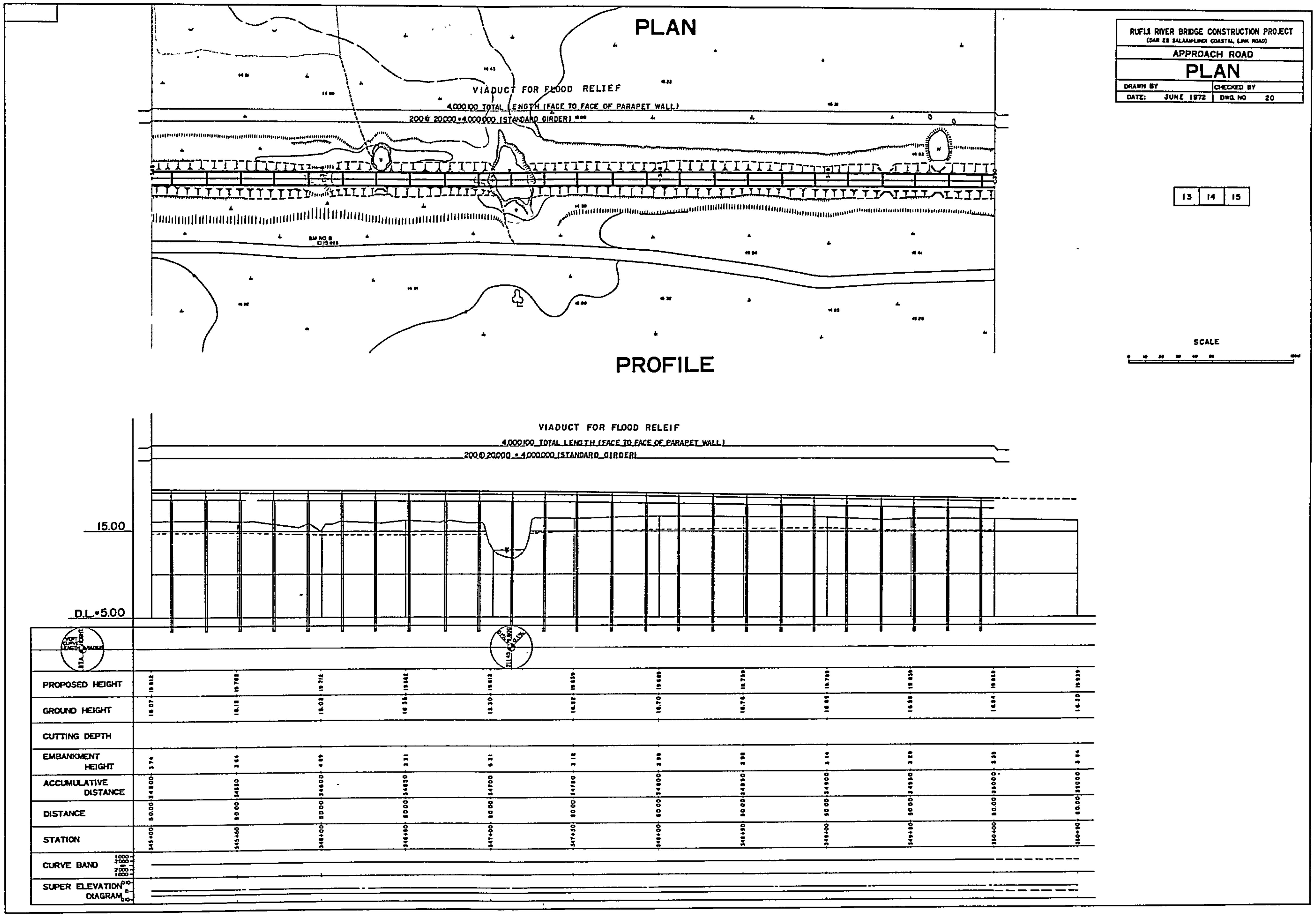
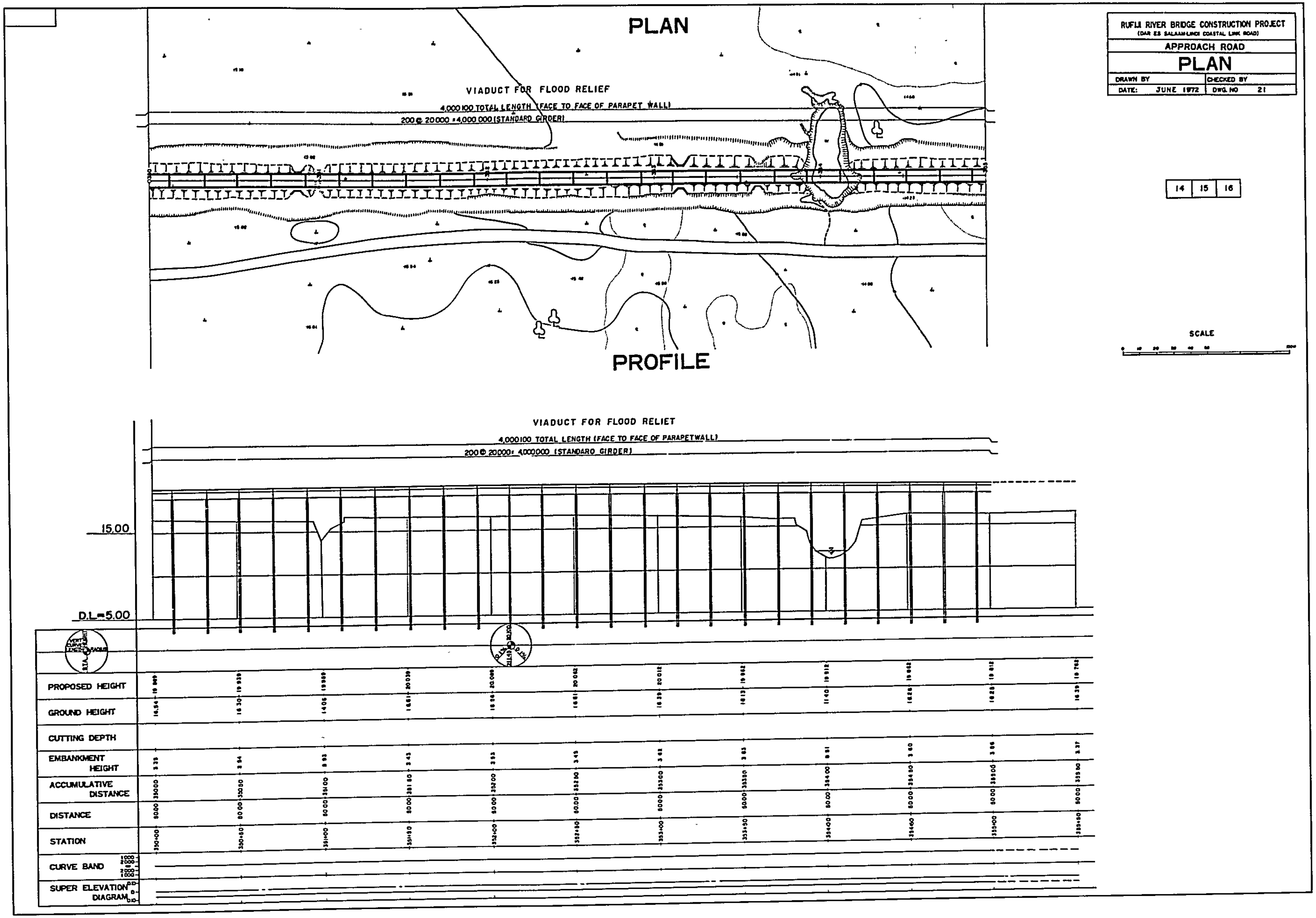


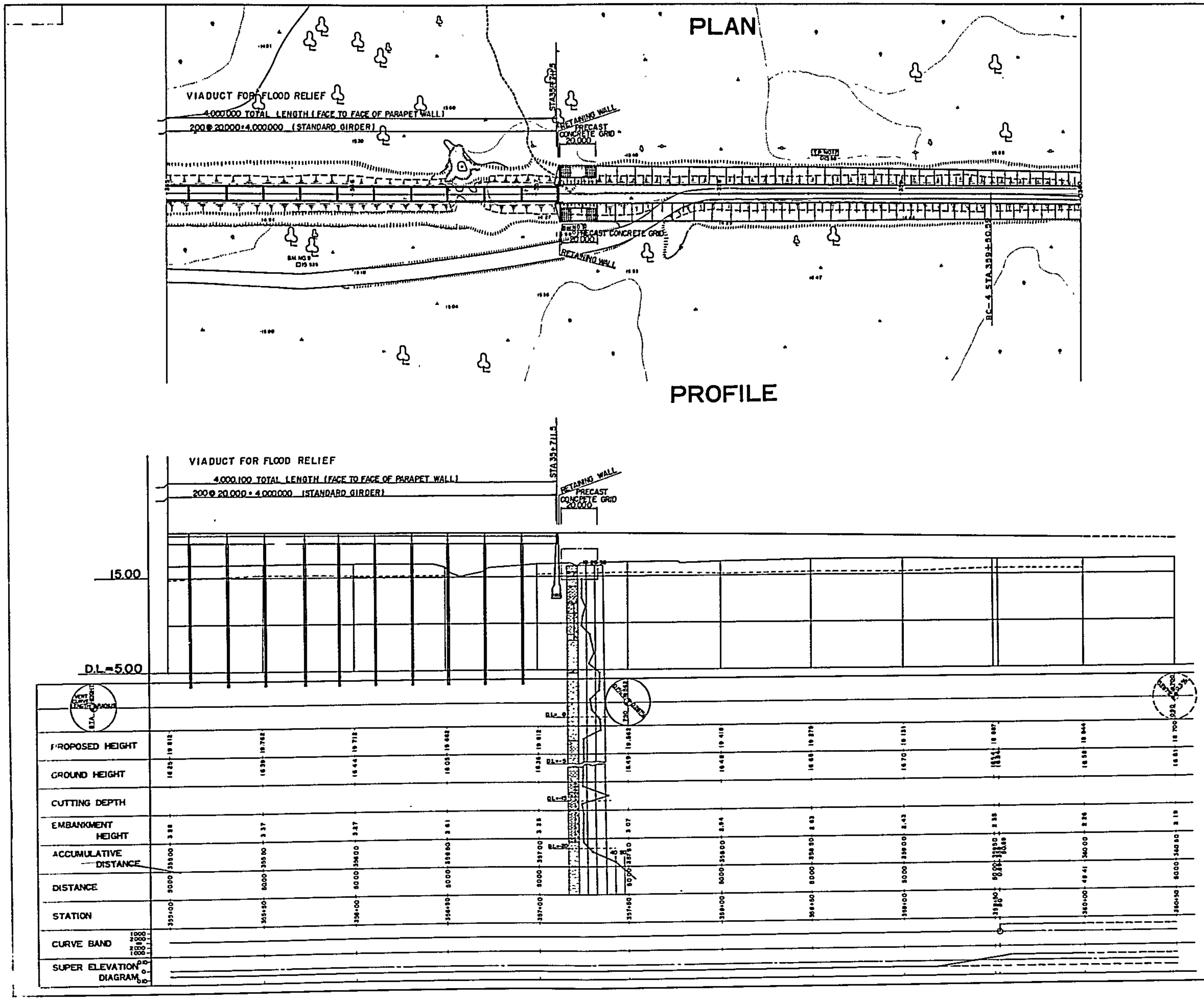
PROPOSED HEIGHT	19.889	19.939	19.989	20.039	20.089	20.062	20.012	19.962	19.912	19.862	19.812	19.762
GROUND HEIGHT	16.29	16.66	16.72	16.60	16.31	16.26	14.91	14.86	16.18	16.38	16.07	16.12
CUTTING DEPTH												
EMBANKMENT HEIGHT	3.60	3.28	3.27	3.44	3.78	3.80	5.10	5.10	3.73	3.84	3.74	3.64
ACCUMULATIVE DISTANCE	34000	34050	34100	34150	34200	34250	34300	34350	34400	34450	34500	34550
DISTANCE	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
STATION	340+00	340+50	341+00	341+50	342+00	342+50	343+00	343+50	344+00	344+50	345+00	345+50
CURVE BAND												
SUPER ELEVATION DIAGRAM												



PLAN
VIADUCT FOR FLOOD RELIEF
4,000.100 TOTAL LENGTH (FACE TO FACE OF PARAPET WALL)
200 @ 20.000 = 4,000.000 (STANDARD GIRDER)
PROFILE
VIADUCT FOR FLOOD RELEIF
4,000.100 TOTAL LENGTH (FACE TO FACE OF PARAPET WALL)
200 @ 20.000 = 4,000.000 (STANDARD GIRDER)
15.00
D.L.=5.00
PROPOSED HEIGHT
GROUND HEIGHT
CUTTING DEPTH
EMBANKMENT HEIGHT
ACCUMULATIVE DISTANCE
DISTANCE
STATION
345+00
345+50
346+00
346+50
347+00
347+50
348+00
348+50
349+00
349+50
350+00
350+50
CURVE BAND
SUPER ELEVATION DIAGRAM
RUFIJI RIVER BRIDGE CONSTRUCTION PROJECT
(DAR ES SALAAM-LINDI COASTAL LINK ROAD)
APPROACH ROAD
PLAN
DRAWN BY
CHECKED BY
DATE: JUNE 1972
DWG. NO 20
13
14
15
SCALE


RUFIJI RIVER BRIDGE CONSTRUCTION PROJECT
(DAR ES SALAAM-LINDI COASTAL LINK ROAD)
APPROACH ROAD
PLAN
DRAWN BY
CHECKED BY
DATE: JUNE 1972
DWG. NO 21
14 15 16
SCALE
PLAN
VIADUCT FOR FLOOD RELIEF
4,000.100 TOTAL LENGTH (FACE TO FACE OF PARAPET WALL)
200 @ 20.000 = 4,000.000 (STANDARD GIRDER)
PROFILE
VIADUCT FOR FLOOD RELIET
4,000.100 TOTAL LENGTH (FACE TO FACE OF PARAPETWALL)
200 @ 20.000 = 4,000.000 (STANDARD GIRDER)
15.00
D.L=5.00
VERT. CURVE LENGTH
HEIGHT
RADIUS
STA.
PROPOSED HEIGHT
GROUND HEIGHT
CUTTING DEPTH
EMBANKMENT HEIGHT
ACCUMULATIVE DISTANCE
DISTANCE
STATION
CURVE BAND
SUPER ELEVATION DIAGRAM

PLAN



15 | 16 | 17

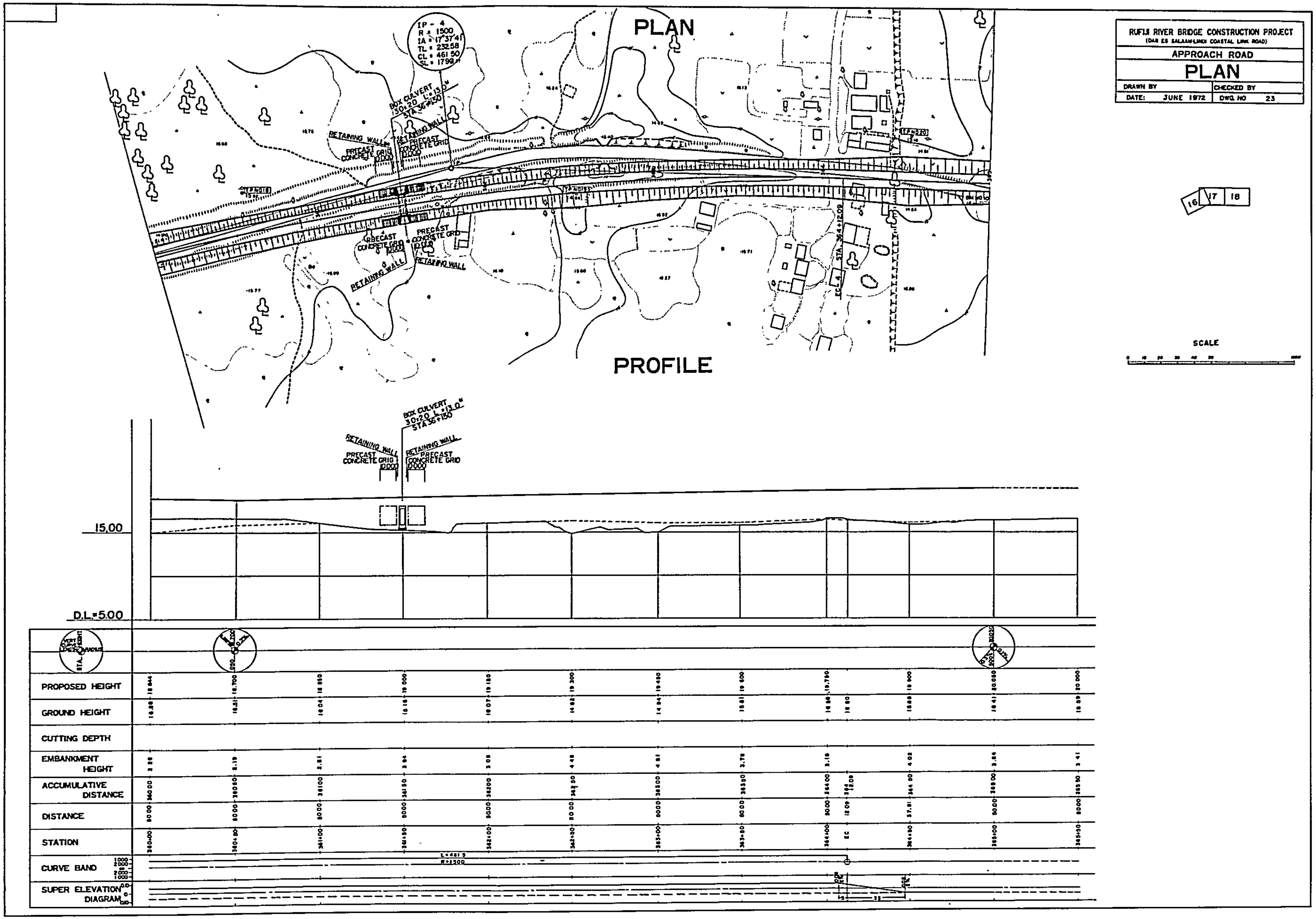
SCALE

RUFIJI RIVER BRIDGE CONSTRUCTION PROJECT
(DAR ES SALAAM-LINDI COASTAL LINK ROAD)

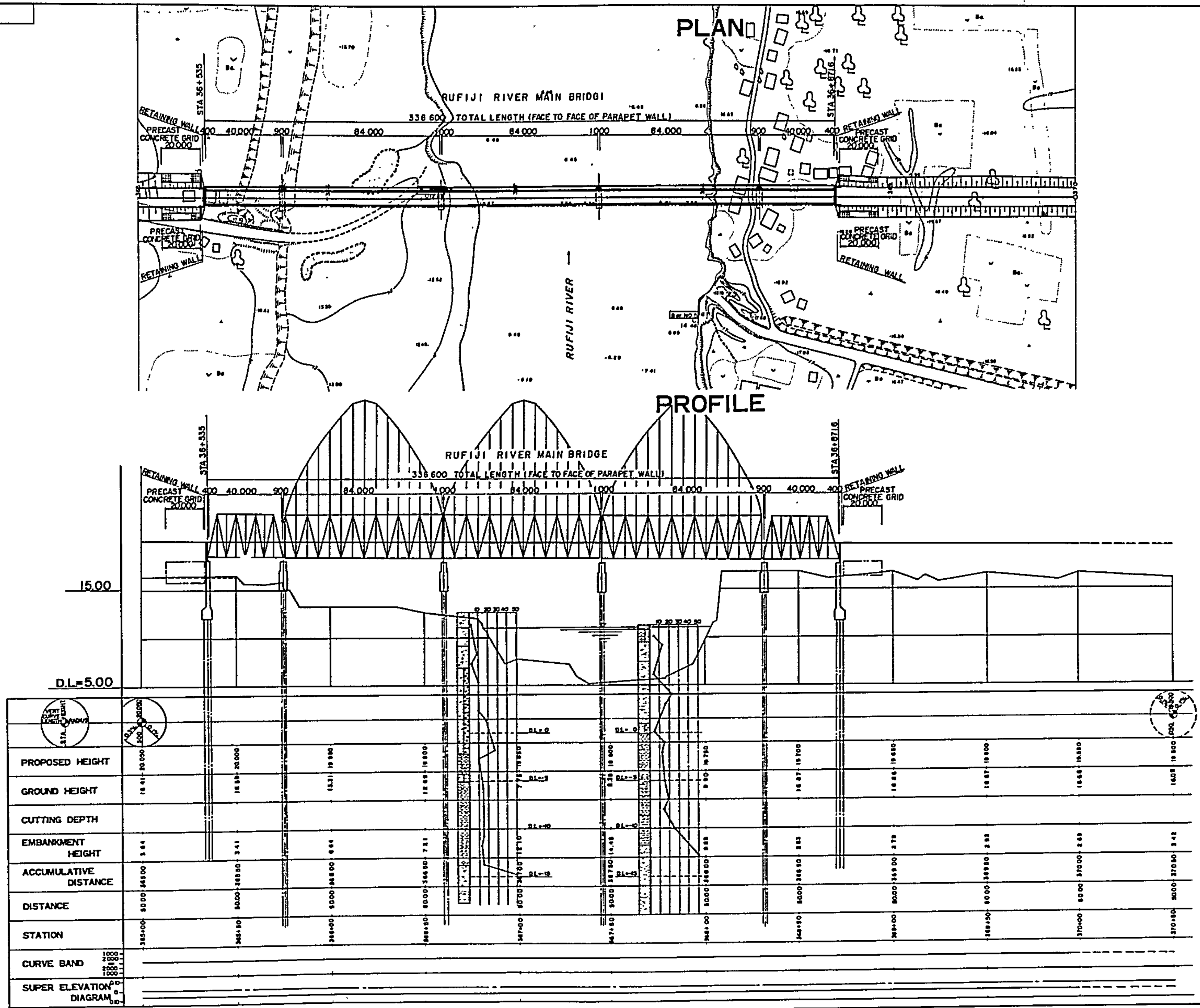
APPROACH ROAD

PLAN

DRAWN BY	CHECKED BY
DATE: JUNE 1972	DWG. NO 22



RUFIJI RIVER BRIDGE CONSTRUCTION PROJECT
(DAR ES SALAAM-LINDI COASTAL LINK ROAD)
APPROACH ROAD
PLAN
DRAWN BY
CHECKED BY
DATE: JUNE 1972
DWG. NO 23
PLAN
PROFILE
IP - 4
R = 1500
TL = 232.58
CL = 461.50
BOX CULVERT
30×20 L=13.0m
STA 36+150
RETAINING WALL
PRECAST CONCRETE GRID
SCALE
15.00
D.L.=5.00
PROPOSED HEIGHT
GROUND HEIGHT
CUTTING DEPTH
EMBANKMENT HEIGHT
ACCUMULATIVE DISTANCE
DISTANCE
STATION
CURVE BAND
SUPER ELEVATION DIAGRAM

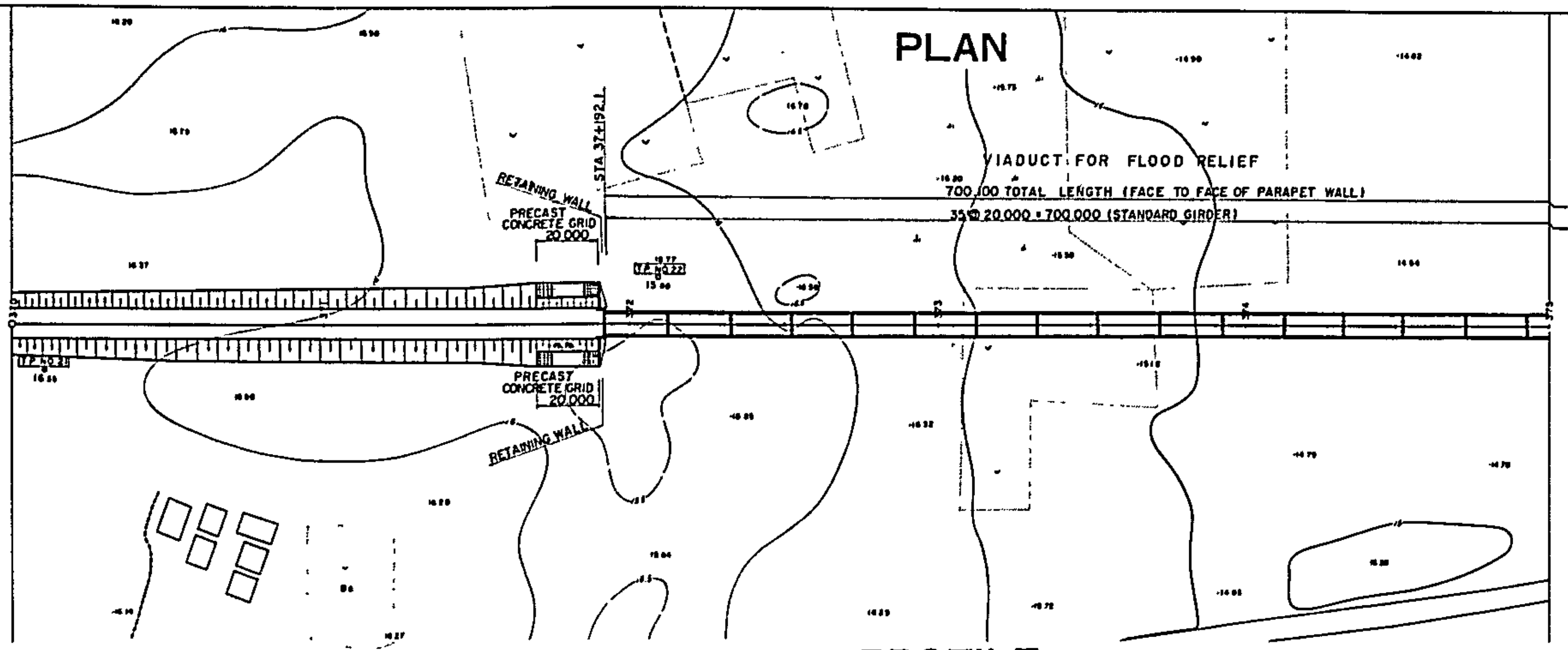


RUFIJI RIVER BRIDGE CONSTRUCTION PROJECT (DAR ES SALAAM-LINDI COASTAL LINK ROAD)	
APPROACH ROAD	
PLAN	
DRAWN BY	CHECKED BY
DATE: JUNE 1972	DWG. NO 24

17 | 18 | 19

SCALE

PLAN

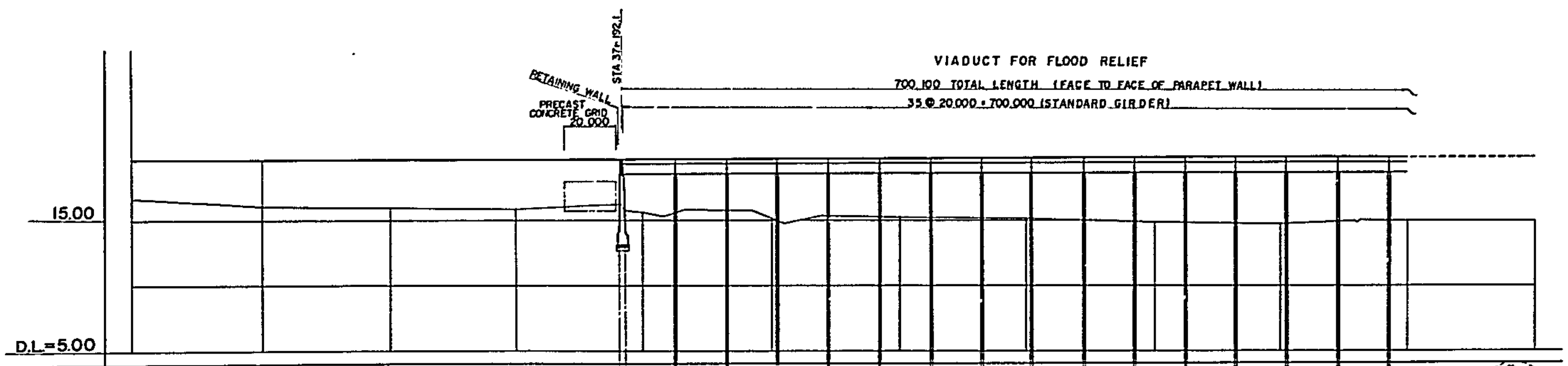


RUFIJI RIVER BRIDGE CONSTRUCTION PROJECT (DAR ES SALAAM-LINDI COASTAL LINK ROAD)	
APPROACH ROAD	
PLAN	
DRAWN BY	CHECKED BY
DATE. JUNE 1972	DWG. NO 25

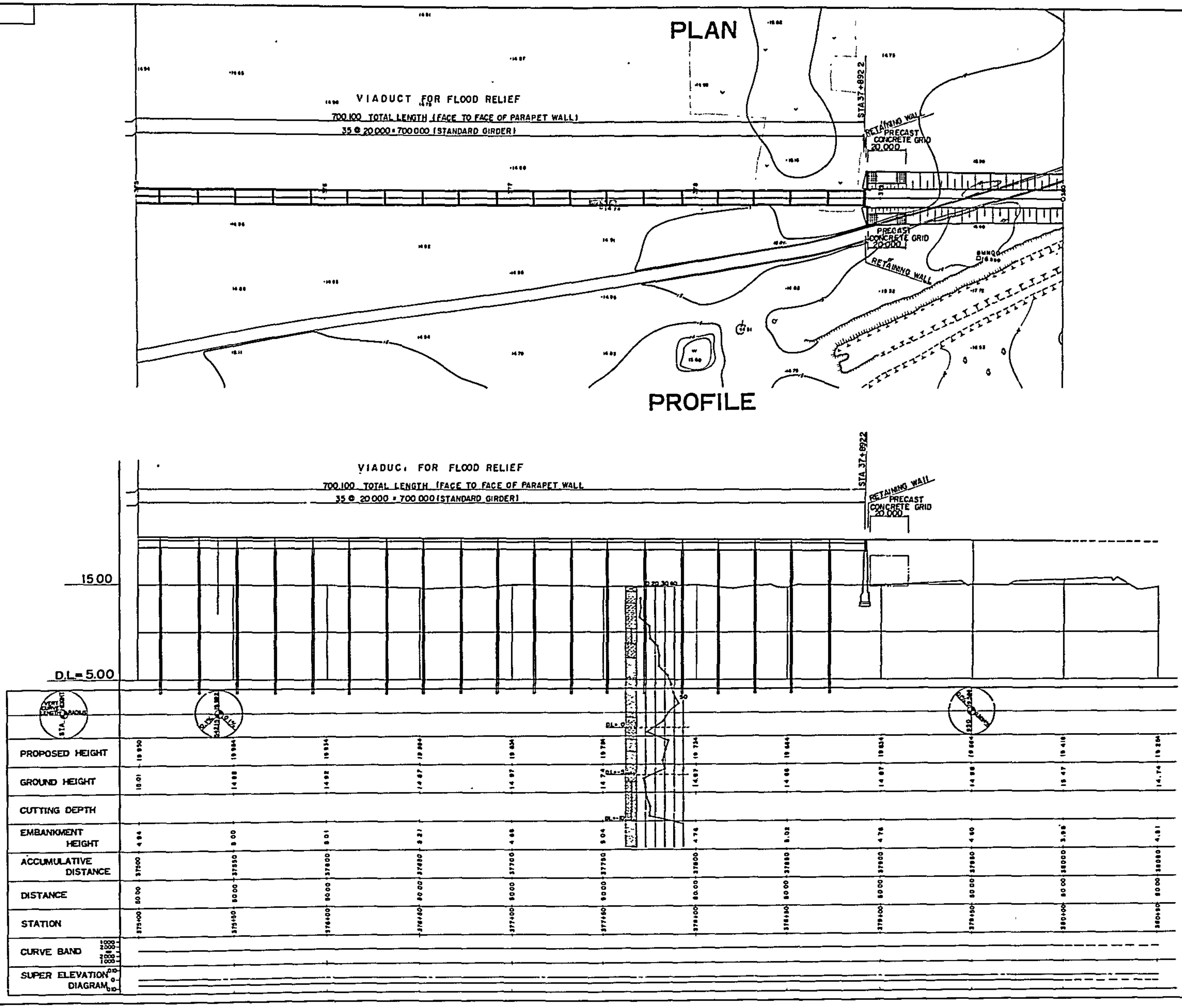
18	19	20

SCALE

PROFILE



PROPOSED HEIGHT	19 550	19 500	19 650	19 600	19 650	19.700	19 750	19 800	19 850	19 900	19 950	19 984
GROUND HEIGHT	16.66	16 08	15 83	15 84	15 66	15 17	15 18	15 16	14 92	14 82	15 01	14 98
CUTTING DEPTH												
EMBANKMENT HEIGHT	2 89	3.42	3 82	3 76	3 99	4 53	4 57	4 64	4 93	5 08	4 94	5 00
ACCUMULATIVE DISTANCE	37000	37050	37100	37150	37200	37250	37300	37350	37400	37450	37500	37550
DISTANCE	50 00	50 00	50 00	50 00	50 00	50 00	50 00	50 00	50 00	50 00	50 00	50.00
STATION	370+00	370+50	371+00	371+50	372+00	372+50	373+00	373+50	374+00	374+50	375+00	375+50
CURVE BAND												
SUPER ELEVATION DIAGRAM												



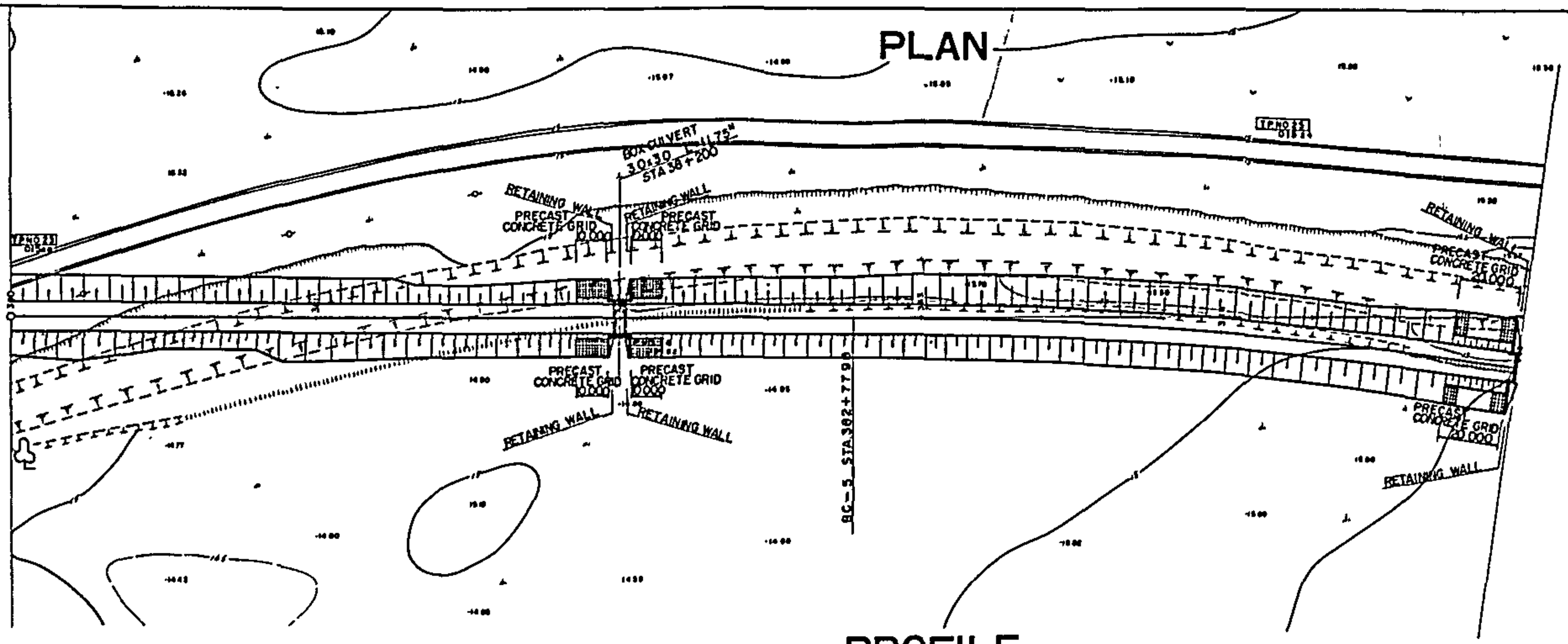
19	20	21

SCALE

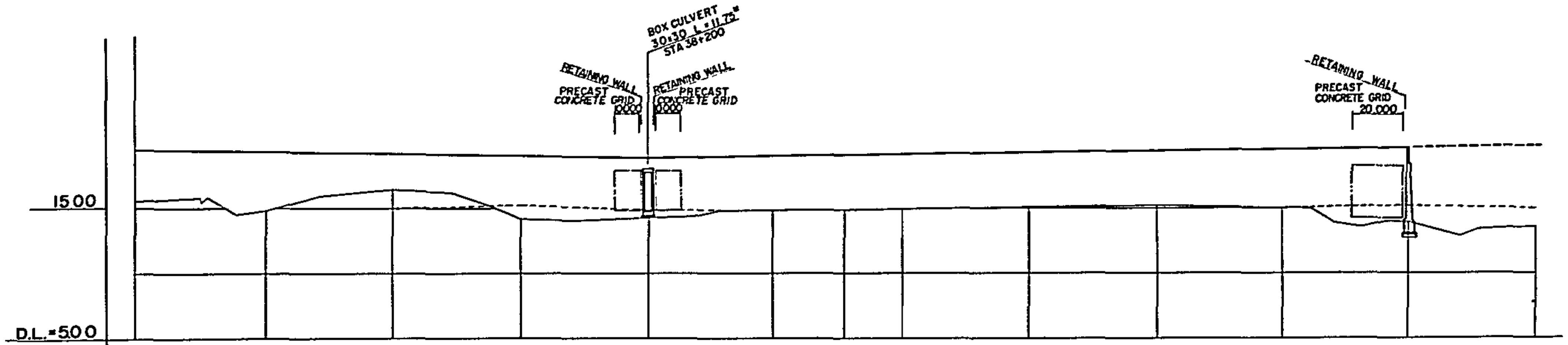
RUFIJI RIVER BRIDGE CONSTRUCTION PROJECT (DAR ES SALAAM-LINDI COASTAL LINK ROAD)	
APPROACH ROAD	
PLAN	
DRAWN BY	CHECKED BY
DATE JUNE 1972	DWG. NO 26

RUFIJI RIVER BRIDGE CONSTRUCTION PROJECT (DAR ES SALAAM-LINDI COASTAL LINK ROAD)	
APPROACH ROAD	
PLAN	
DRAWN BY	CHECKED BY
DATE: JUNE 1972	DWG. NO 27

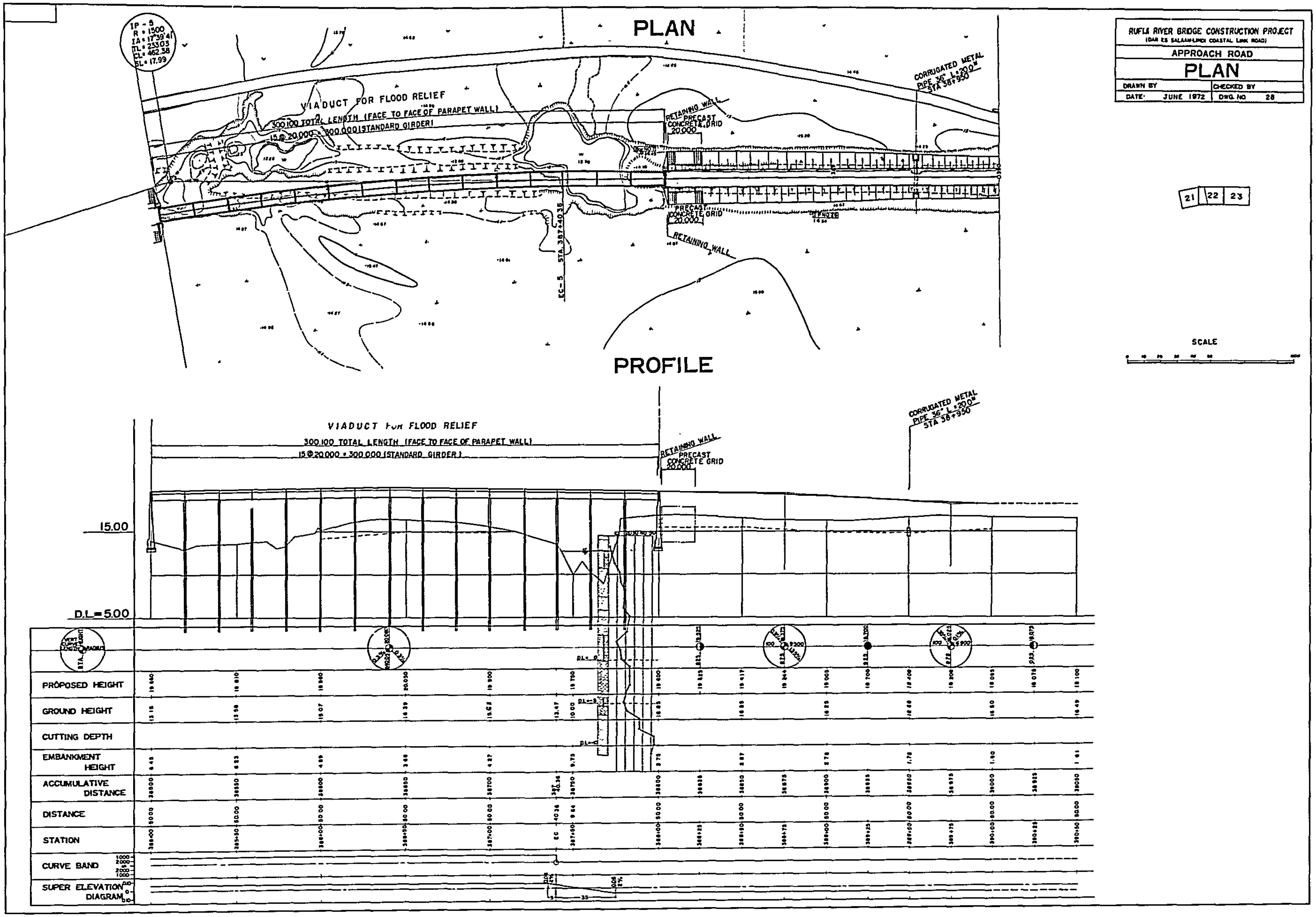
PLAN



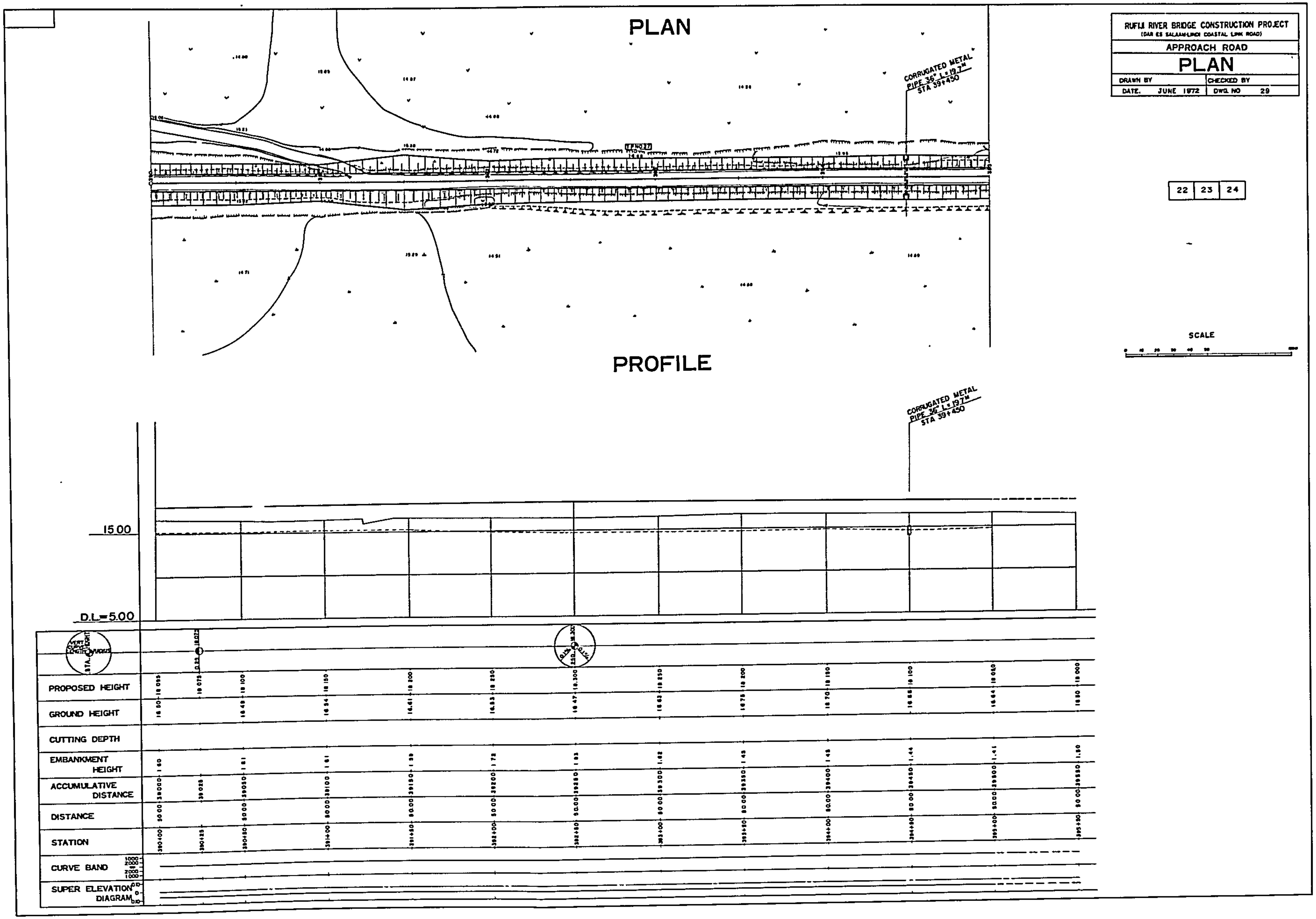
PROFILE



PROPOSED HEIGHT	19.416	19.234	19.090	18.925	18.760	18.910		19.050	19.210	19.360	19.510	19.660	19.810
GROUND HEIGHT	15.47	14.74	16.39	14.36	14.28	14.83	14.88	14.93	15.02	15.15	14.98	13.18	13.58
CUTTING DEPTH													
EMBANKMENT HEIGHT	3.95	4.51	2.70	4.57	4.48	4.08		4.13	4.19	4.21	4.53	6.51	6.23
ACCUMULATIVE DISTANCE	38000	38050	38100	38150	38200	38250	38297.98	38300	38350	38400	38450	38500	38550
DISTANCE	50.00	50.00	50.00	50.00	50.00	50.00	47.98	2.02	50.00	50.00	50.00	50.00	50.00
STATION	380+00	380+50	381+00	381+50	382+00	382+50	BC	383+00	383+50	384+00	384+50	385+00	385+50
CURVE BAND													
SUPER ELEVATION DIAGRAM													



RUFIJI RIVER BRIDGE CONSTRUCTION PROJECT
(DAR ES SALAAM-LINDI COASTAL LINK ROAD)
APPROACH ROAD
PLAN
DRAWN BY
CHECKED BY
DATE: JUNE 1972
DWG. NO 28
PLAN
PROFILE
IP - 5
R = 1500
IA = 17°39'41"
TL = 233.03
CL = 462.38
SL = 17.99
VIADUCT FOR FLOOD RELIEF
300.100 TOTAL LENGTH (FACE TO FACE OF PARAPET WALL)
15@20.000 = 300.000 (STANDARD GIRDER)
RETAINING WALL
PRECAST CONCRETE GRID
20.000
CORRUGATED METAL PIPE 36" L=20.0m STA 38+950
SCALE
21
22
23
15.00
D.L=5.00
PROPOSED HEIGHT
GROUND HEIGHT
CUTTING DEPTH
EMBANKMENT HEIGHT
ACCUMULATIVE DISTANCE
DISTANCE
STATION
CURVE BAND
SUPER ELEVATION DIAGRAM



PLAN
CORRUGATED METAL PIPE 36" L=19.7M STA 39+450
PROFILE
CORRUGATED METAL PIPE 36" L=19.7M STA 39+450
15.00
D.L=5.00
PROPOSED HEIGHT
GROUND HEIGHT
CUTTING DEPTH
EMBANKMENT HEIGHT
ACCUMULATIVE DISTANCE
DISTANCE
STATION
CURVE BAND
SUPER ELEVATION DIAGRAM
RUFIJI RIVER BRIDGE CONSTRUCTION PROJECT
(DAR ES SALAAM-LINDI COASTAL LINK ROAD)
APPROACH ROAD
PLAN
DRAWN BY
CHECKED BY
DATE. JUNE 1972
DWG. NO 29
22
23
24
SCALE

RUFIJI RIVER BRIDGE CONSTRUCTION PROJECT
(DAR ES SALAAM-LINDI COASTAL LINK ROAD)

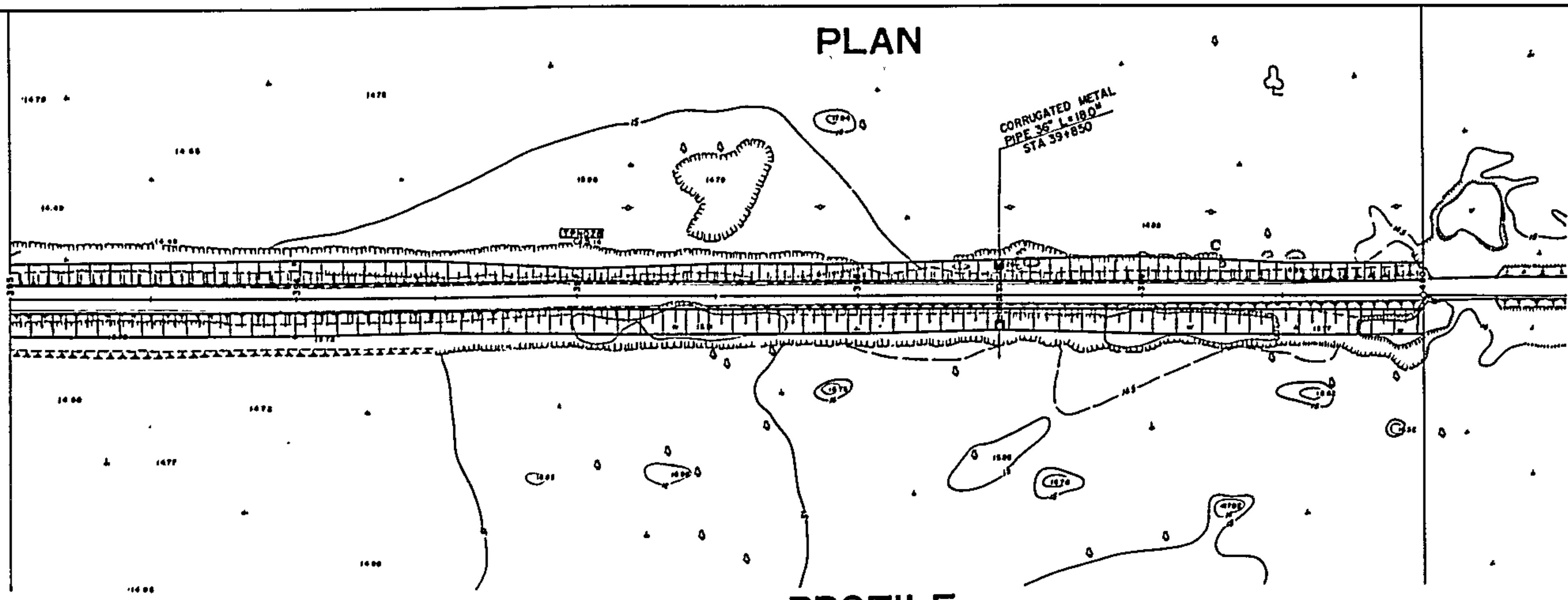
APPROACH ROAD

PLAN

DRAWN BY		CHECKED BY	
DATE:	JUNE 1972	DWG. NO	30

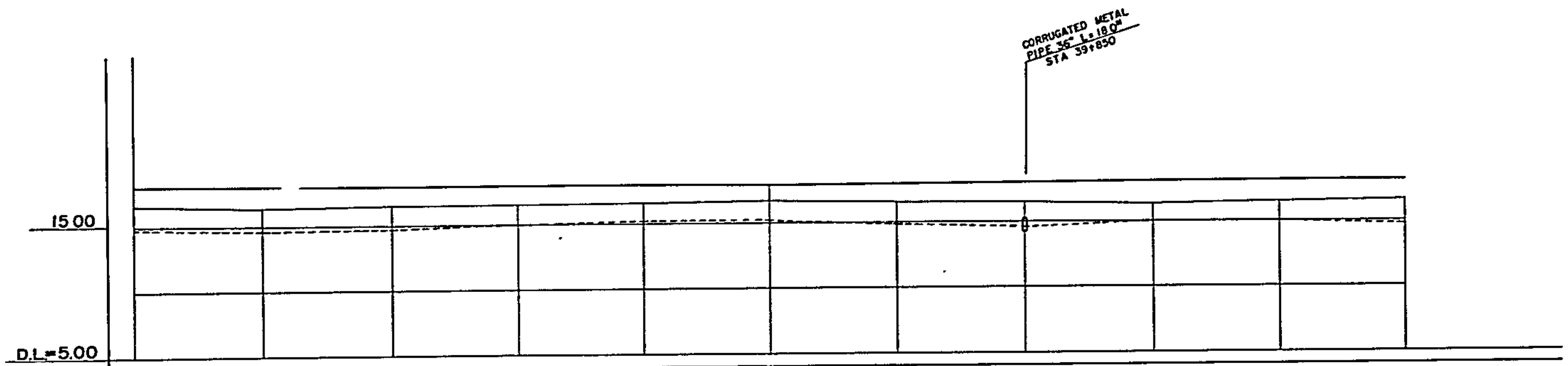
23 | 24

PLAN



SCALE

PROFILE



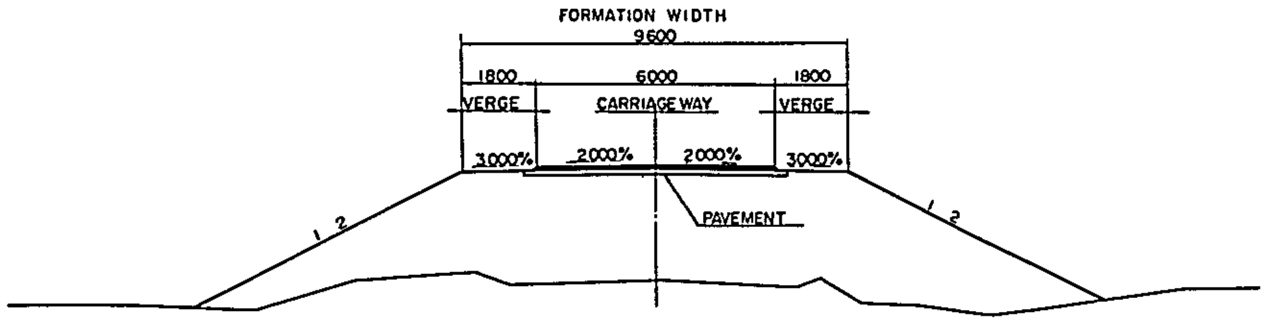
PROPOSED HEIGHT	18.050	18.000	17.950	17.900	17.850	17.800	17.850	17.900	17.950	18.000	18.050
GROUND HEIGHT	16.64	16.50	16.64	16.56	16.68	16.73	16.12	16.58	16.39	16.56	16.62
CUTTING DEPTH											
EMBANKMENT HEIGHT	1.41	1.50	1.31	1.34	1.17	1.03	1.73	1.32	1.56	1.44	1.43
ACCUMULATIVE DISTANCE	39500	39550	39600	39650	39700	39750	39800	39850	39900	39950	40000
DISTANCE	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
STATION	395+00	395+50	396+00	396+50	397+00	397+50	398+00	398+50	399+00	399+50	400+00
CURVE BAND											
SUPER ELEVATION DIAGRAM											

RUFIJI RIVER BRIDGE CONSTRUCTION PROJECT
(DAR ES SALAAM-LINDI COASTAL LINK ROAD)
APPROACH ROAD
TYPICAL CROSS SECTION

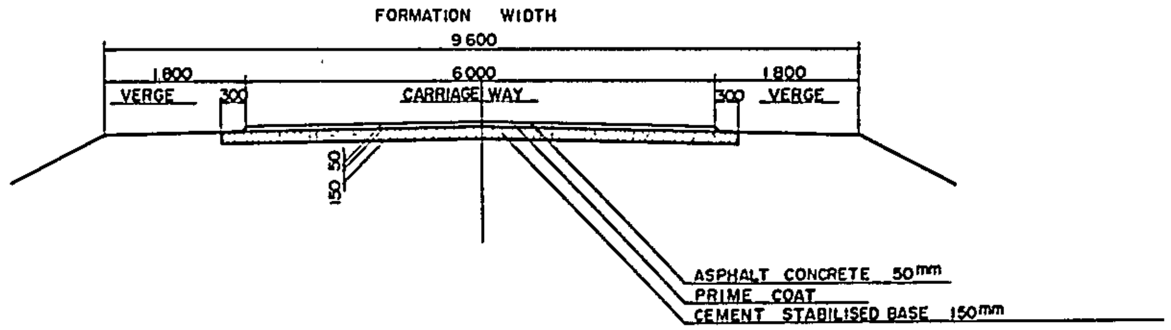
DRAWN BY		CHECKED BY	
DATE	JUNE 1972	DWG NO	31

TYPICAL CROSS SECTION

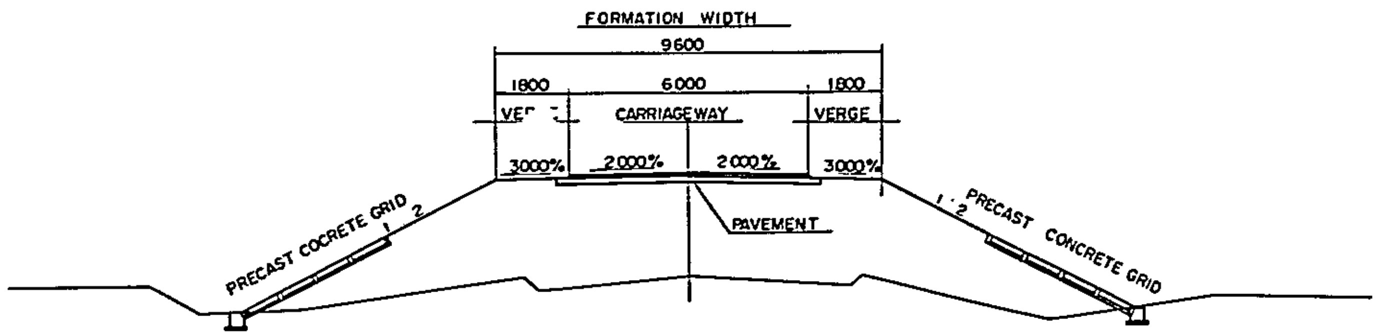
NORMAL FILL SECTION
STA. 30+500



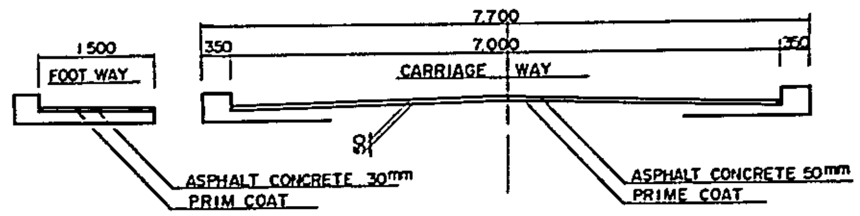
TYPICAL TYPE OF CONSTRUCTION FOR 20cm DEPTH OF PAVEMENT



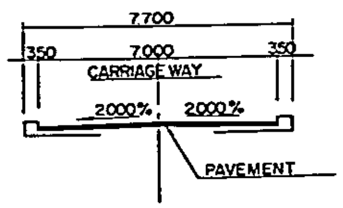
FILL SECTION WITH SLOPE PROTECTION
STA. 30+650



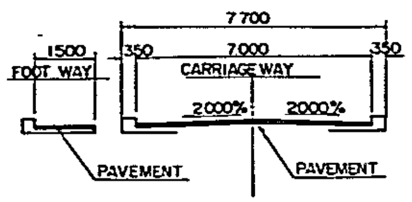
TYPICAL TYPE OF CONSTRUCTION FOR 5cm OR 3cm DEPTH OF PAVEMENT



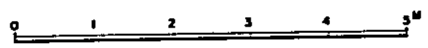
VIADUCT SECTION



RUFIJI RIVER MAIN BRIDGE SECTION



SCALE



RUFIJI RIVER BRIDGE CONSTRUCTION PRJECT
(DAR ES SALAAM-LINDI COASTAL LINK ROAD)

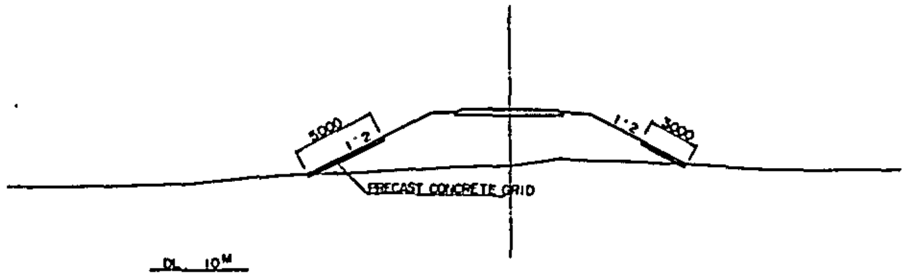
APPROACH ROAD

CROSS SECTION (I)

DRAWN BY	CHECKED BY
DATE JUNE 1972	DWG NO 32

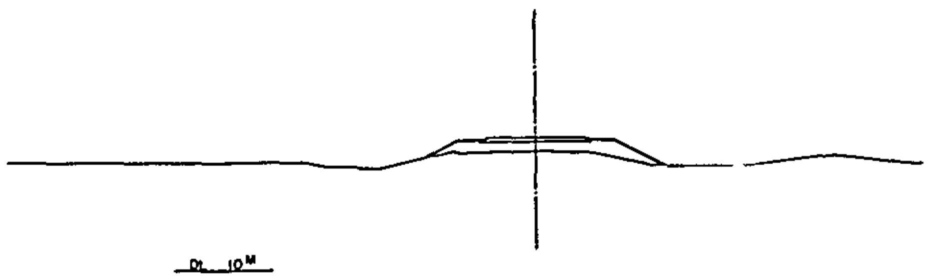
SCALE

STA. 305+50



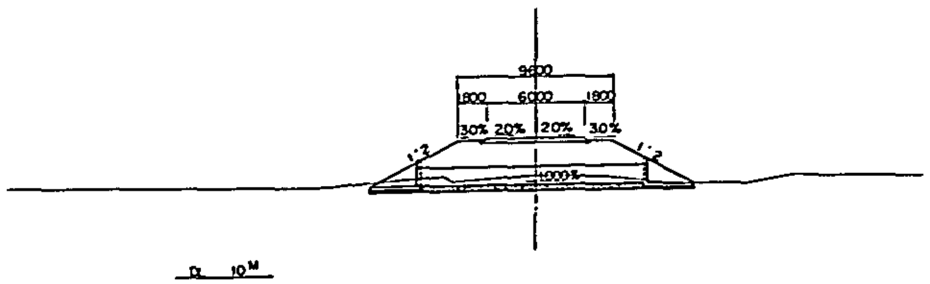
STA. 305+50		
G H		16380m
P H		19657m
Cut A		
EMBANK-MENT A		492m²
PAVEMENT A		
GRASS PLANTING	L	33m
	R	37m
PRECAST CONCRETE GRID	L	50m
	R	30m

STA. 300+00



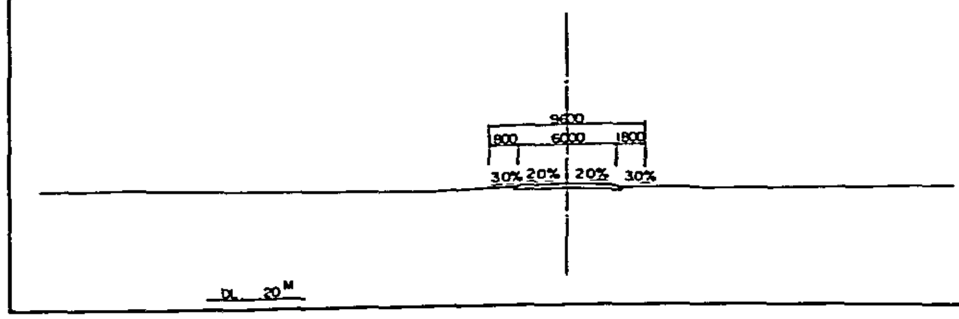
STA 300+00		
G H		17270m
P H		18050m
Cut A		
EMBANK-MENT A		87m²
PAVEMENT A		
GRASS PLANTING	L	25m
	R	34m
PRECAST CONCRETE GRID	L	
	R	

STA. 292+50



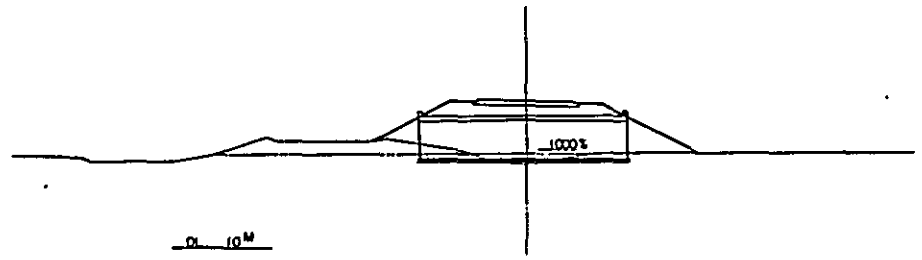
STA 292+50		
G H		16070m
P H		18300m
Cut A		
EMBANK-MENT A		297m²
PAVEMENT A		
GRASS PLANTING	L	54m
	R	56m
PRECAST CONCRETE GRID	L	
	R	

STA. 280+00



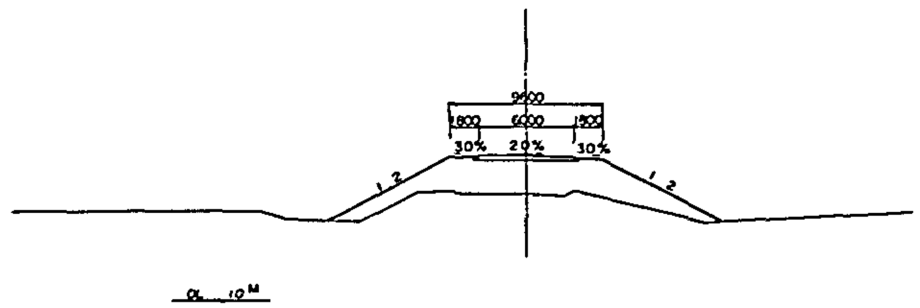
STA 280+00		
G H		26450m
P H		26550m
Cut A		18m²
EMBANK-MENT A		00m²
PAVEMENT A		
GRASS PLANTING	L	
	R	
PRECAST CONCRETE GRID	L	
	R	

STA. 361+50



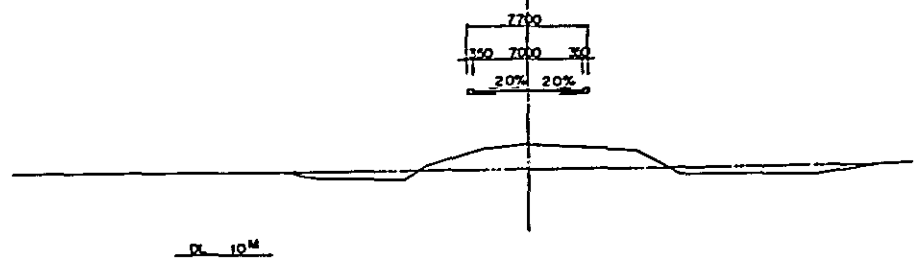
STA.361+50		
G H		15160m
P H		19000m
Cut A		
EMBANK-MENT A		465m²
PAVEMENT A		
GRASS PLANTING	L	53m
	R	67m
PRECAST CONCRETE GRID	L	
	R	

STA. 360+00



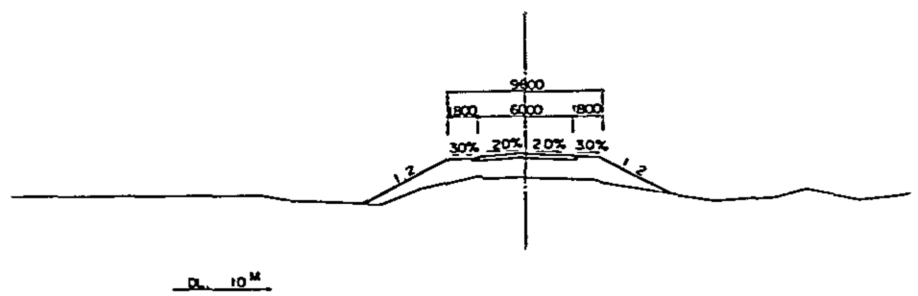
STA. 360+00		
G H		16580m
P H		18844m
Cut A		
EMBANK-MENT A		389m²
PAVEMENT A		
GRASS PLANTING	L	86m
	R	85m
PRECAST CONCRETE GRID	L	
	R	

STA. 320+00



STA. 320+00		
G H		16700m
P H		19960m
Cut A		164m²
EMBANK-MENT A		
PAVEMENT A		
GRASS PLANTING	L	
	R	
PRECAST CONCRETE GRID	L	
	R	

STA. 310+00

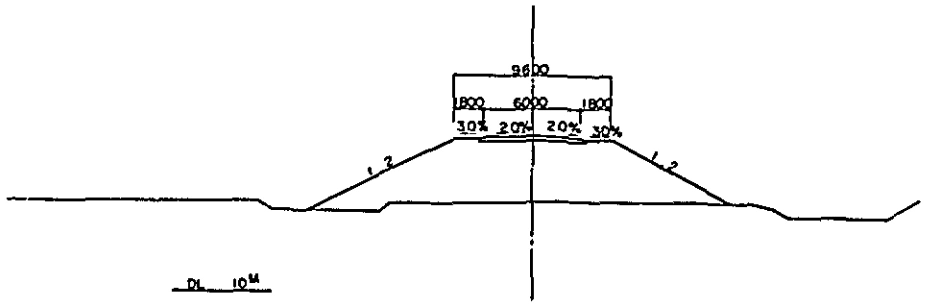


STA. 310+00		
G H		16630m
P H		17975m
Cut A		
EMBANK-MENT A		197m²
PAVEMENT A		
GRASS PLANTING	L	59m
	R	50m
PRECAST CONCRETE GRID	L	
	R	

SCALE

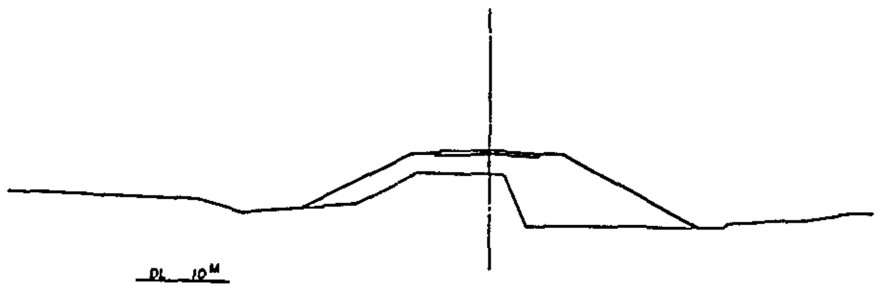
RUFIJI RIVER BRIDGE CONSTRUCTION PROJECT (DAR ES SALAAM-LINDI COASTAL LINK ROAD)	
APPROACH ROAD	
CROSS SECTION(2)	
DRAWN BY	CHECKED BY
DATE' JUNE 1972	DWG. NO 33

STA. 380 +00



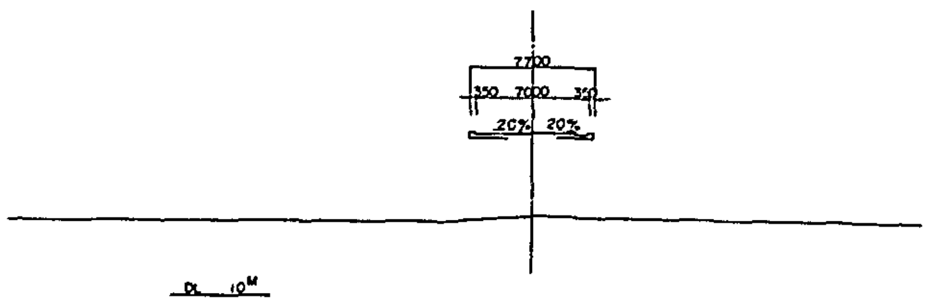
STA. 380+00		
G H		15.470m
P H		19418m
Cut A		
EMBANK--MENT A		675m²
PAVEMENT A		
GRASS PLANTING	L	98m
	R	83m
PRECAST CONCRETE GRID	L	
	R	

STA. 400+00



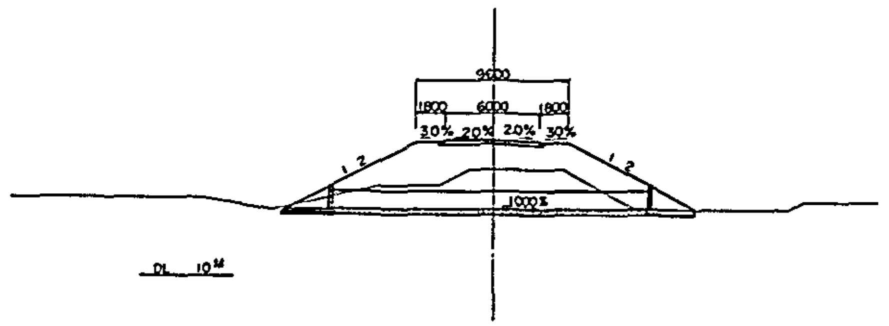
STA 400+00		
G H		16620m
P H		18050m
Cut A		
EMBANK--MENT A		457m²
PAVEMENT A		
GRASS PLANTING	L	96m
	R	76m
PRECAST CONCRETE GRID	L	
	R	

STA. 375 +00



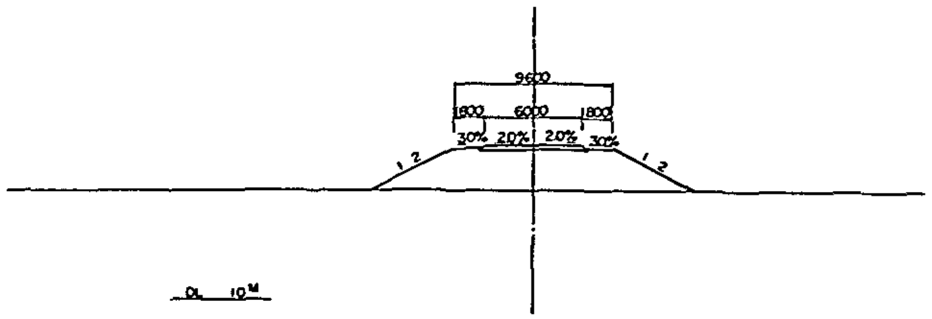
STA 375+00		
G H		15010m
P H		19950m
Cut A		
EMBANK--MENT A		
PAVEMENT A		
GRASS PLANTING	L	
	R	
PRECAST CONCRETE GRID	L	
	R	

STA. 389+50



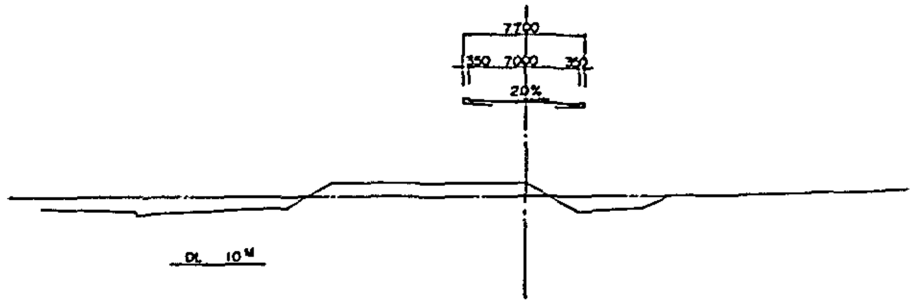
STA 389+50		
G H		16660m
P H		18408m
Cut A		
EMBANK--MENT A		367m²
PAVEMENT A		
GRASS PLANTING	L	82m
	R	88m
PRECAST CONCRETE GRID	L	
	R	

STA. 370 +00



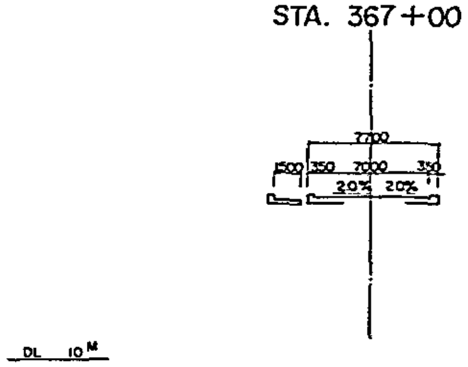
STA. 370+00		
G H		16660m
P H		19550m
Cut A		
EMBANK--MENT A		367m²
PAVEMENT A		
GRASS PLANTING	L	56m
	R	57m
PRECAST CONCRETE GRID	L	
	R	

STA. 386+00



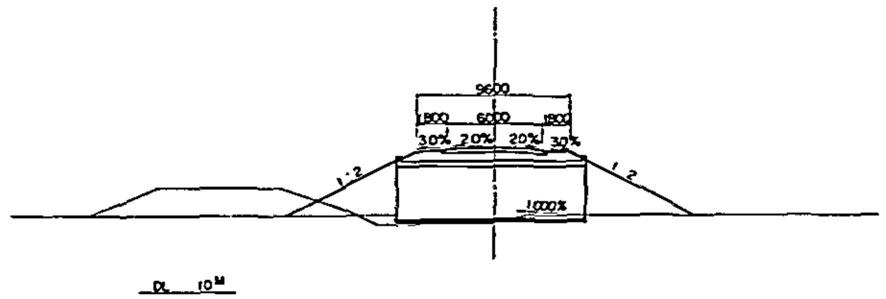
STA 386+00		
G H		15070m
P H		19960m
Cut A		107m²
EMBANK--MENT A		
PAVEMENT A		
GRASS PLANTING	L	
	R	
PRECAST CONCRETE GRID	L	
	R	

STA. 367+00



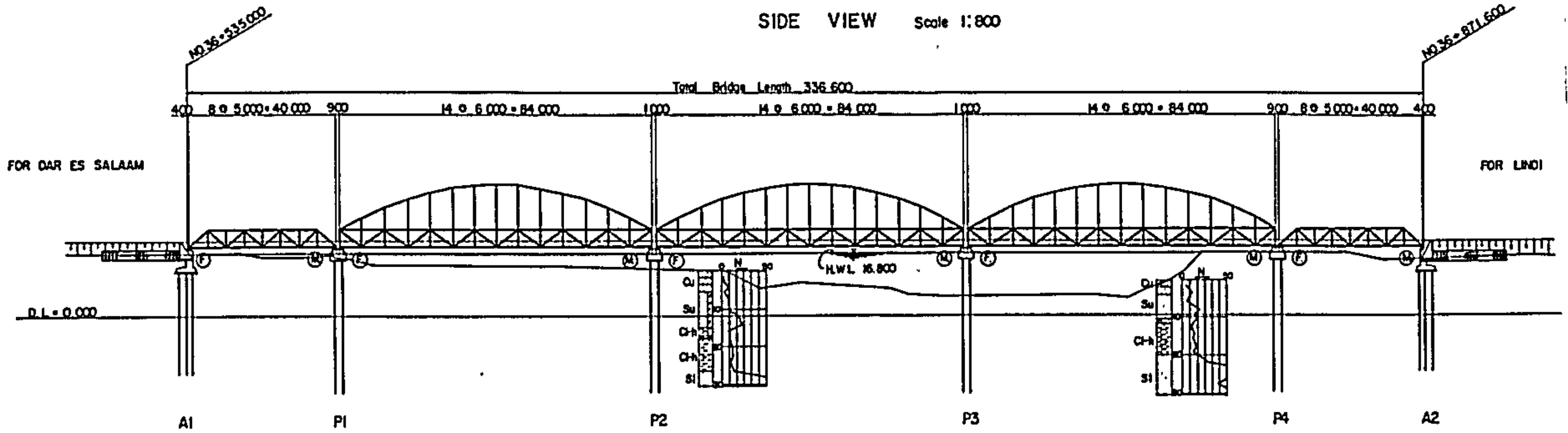
STA 367+00		
G H		7750m
P H		19850m
Cut A		
EMBANK--MENT A		
PAVEMENT A		
GRASS PLANTING	L	
	R	
PRECAST CONCRETE GRID	L	
	R	

STA. 382+00



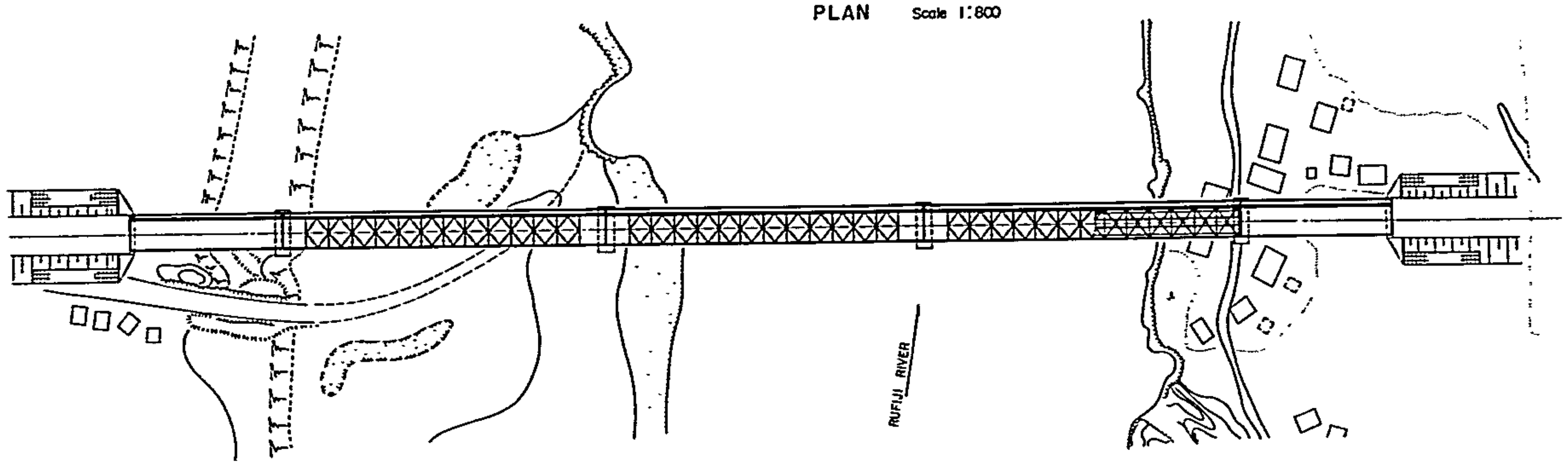
STA 382+00		
G H		14280m
P H		18760m
Cut A		
EMBANK--MENT A		693m²
PAVEMENT A		
GRASS PRANTING	L	67m
	R	86m
PRECAST CONCRETE GRID	L	
	R	

SIDE VIEW Scale 1:800



SLOPE	NO.36500.0 H=20.050				i=0.100 % L=550.0 m				NO.37000.0 H=19.500
PROPOSED HEIGHT	20.015	19.974	19.950	19.889	19.850	19.804	19.750	19.719	19.678
GROUND HEIGHT			13.310						
ACCUMULATIVE DISTANCE	36535.000	36575.850	36600.000	36660.800	36700.000	36745.800	36800.000	36830.750	36871.600
DISTANCE	35.000	40.850	24.150	60.800	39.200	45.800	54.200	30.750	40.850
STATION	(A1)	(P1)	NO.36 +600.000	(P2)	NO.36 +700.000	(P3)	NO.36 +800.000	(P4)	(A2)
CURVE BAND									

PLAN Scale 1:800



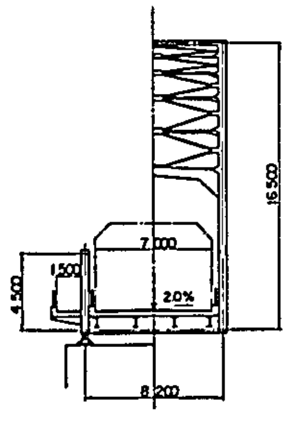
RUFIJI RIVER BRIDGE CONSTRUCTION PROJECT
(DAR ES SALAAM-LINDI COASTAL LINK ROAD)

RUFIJI RIVER MAIN BRIDGE

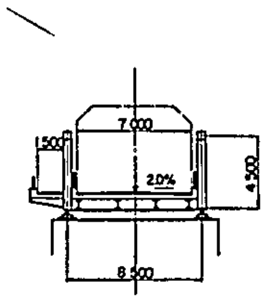
GENERAL VIEW

DRAWN BY	CHECKED BY
DATE : JUNE 1972	DWG NO. 34

CROSS SECTION
Scale 1:200

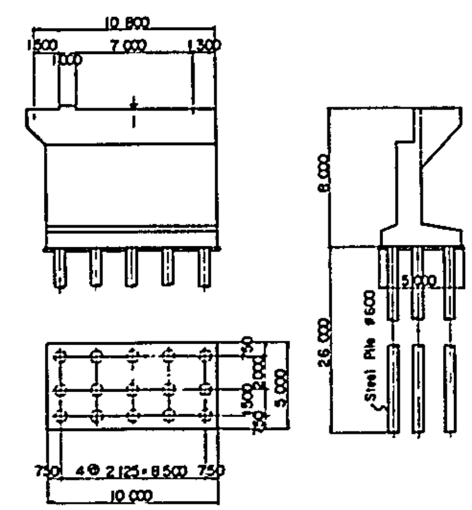


LANGER TRUSS

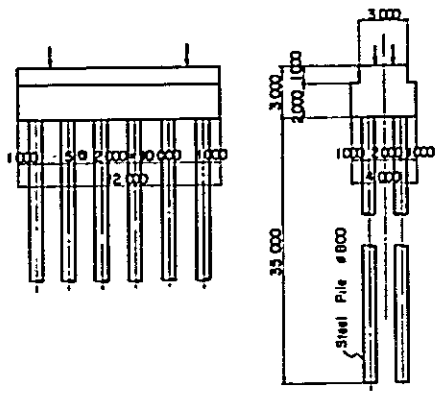


PONY TRUSS

VIEW OF ABUTMENT (A2)



VIEW OF PIER (P3)

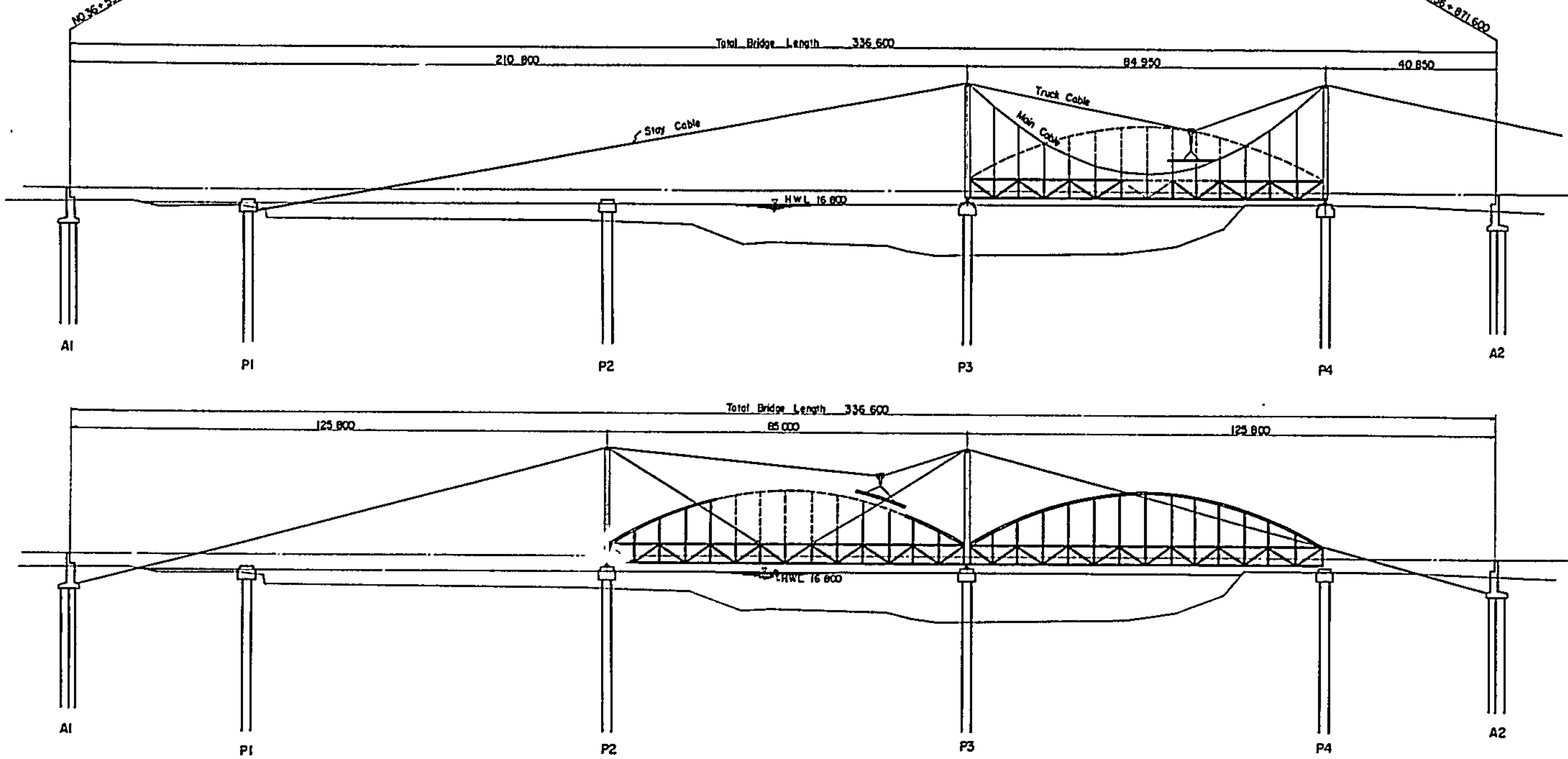


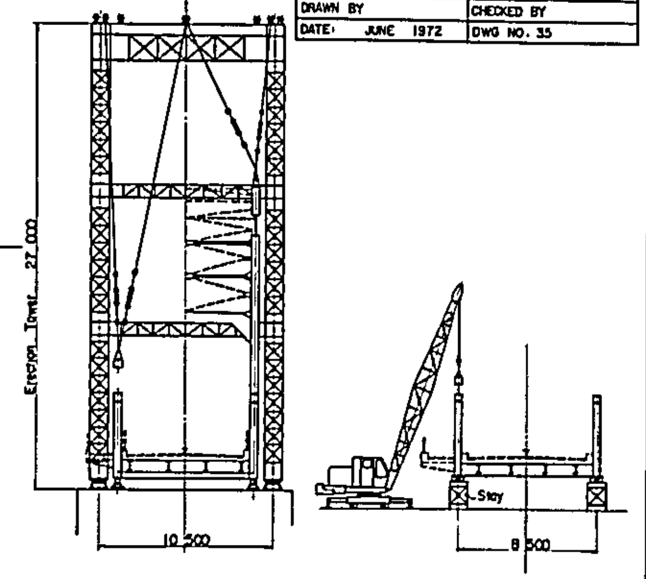
RUFIJI RIVER BRIDGE CONSTRUCTION PROJECT
(DAR ES SALAAM-LINDI COASTAL LINK ROAD)
RUFIJI RIVER MAIN BRIDGE

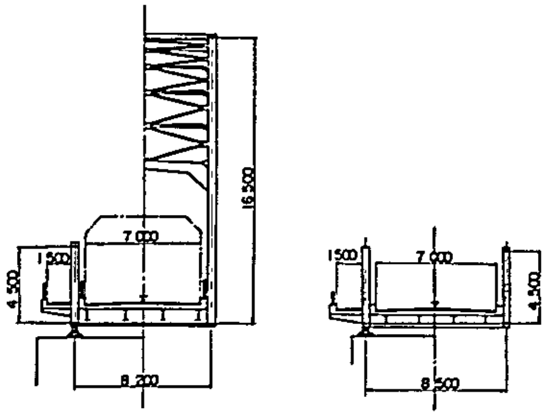
ERECTION WORKS

DRAWN BY	CHECKED BY
DATE: JUNE 1972	DWG NO. 35

PART 1. ERECTION OF LANGER TRUSS Scale 1:600

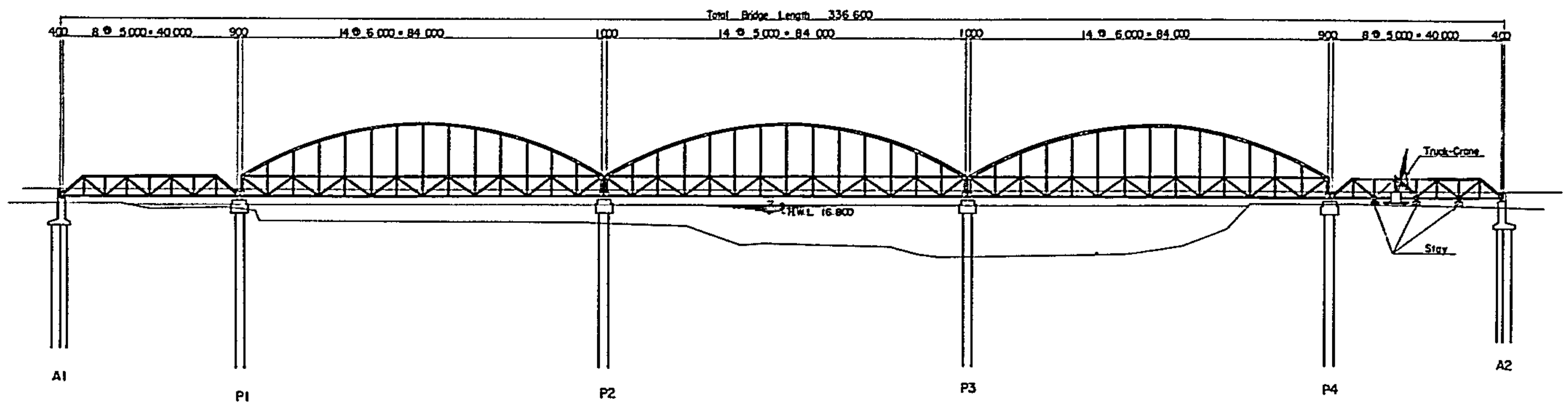






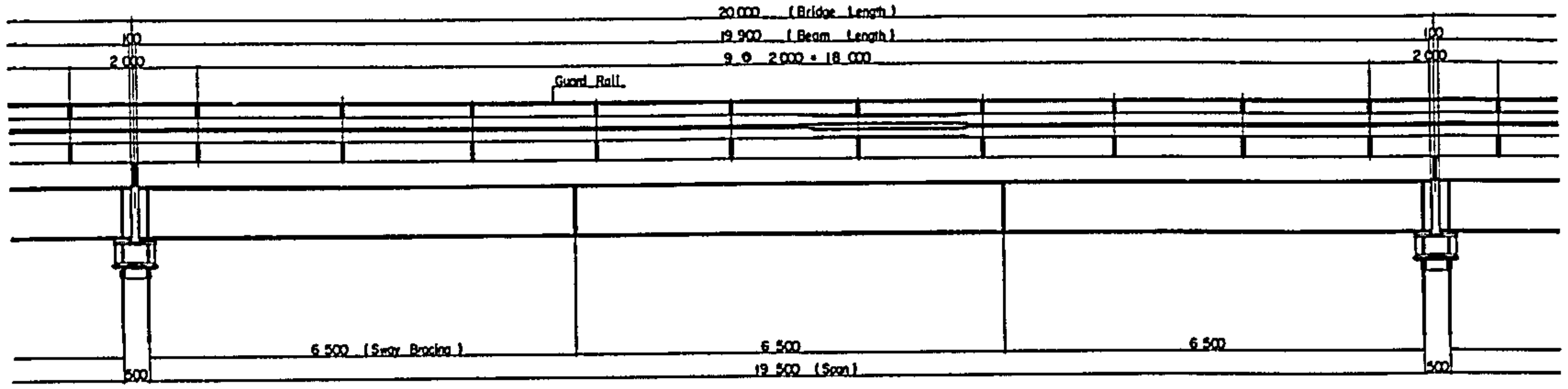
LANGER TRUSS PONY TRUSS

PART 2. ERECTION OF PONY TRUSS Scale 1:600

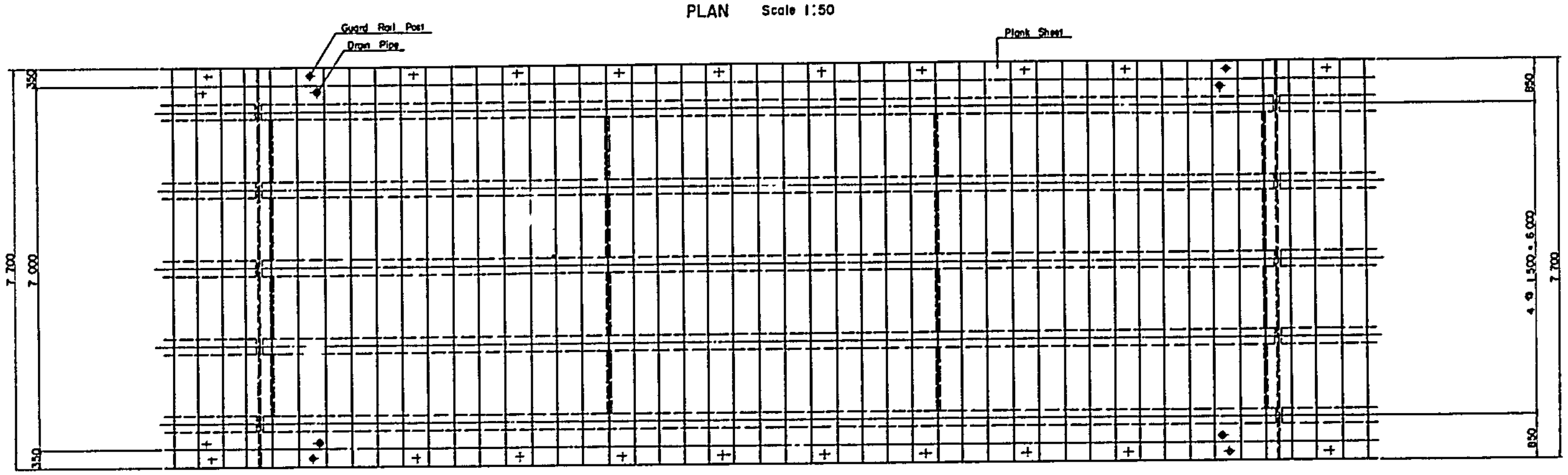


RUFIJI RIVER BRIDGE CONSTRUCTION PROJECT (DAR ES SALAAM-LINDI COASTAL LINK ROAD)	
STANDARD BEAM BRIDGE	
GENERAL VIEW (ROAD WAY ONLY)	
DRAWN BY	CHECKED BY
DATE : JUNE 1972	DWG NO. 36

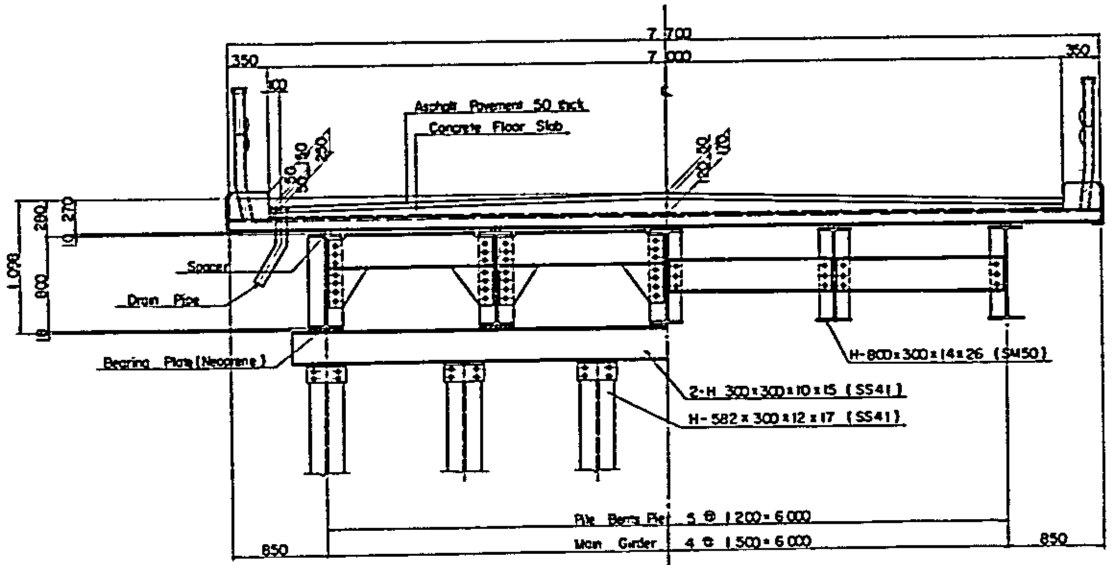
SIDE VIEW Scale 1:50



PLAN Scale 1:50

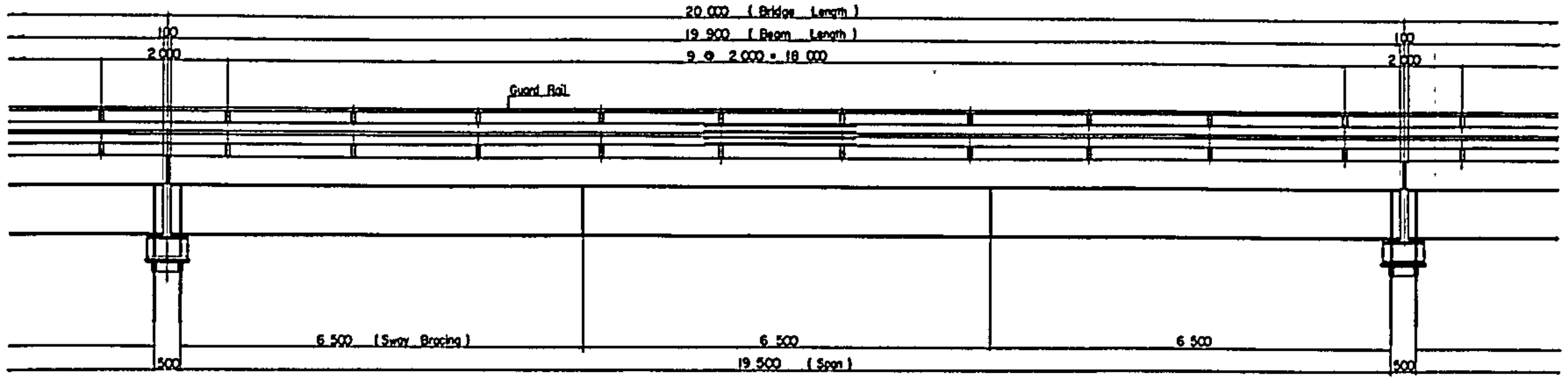


CROSS SECTION Scale 1:30

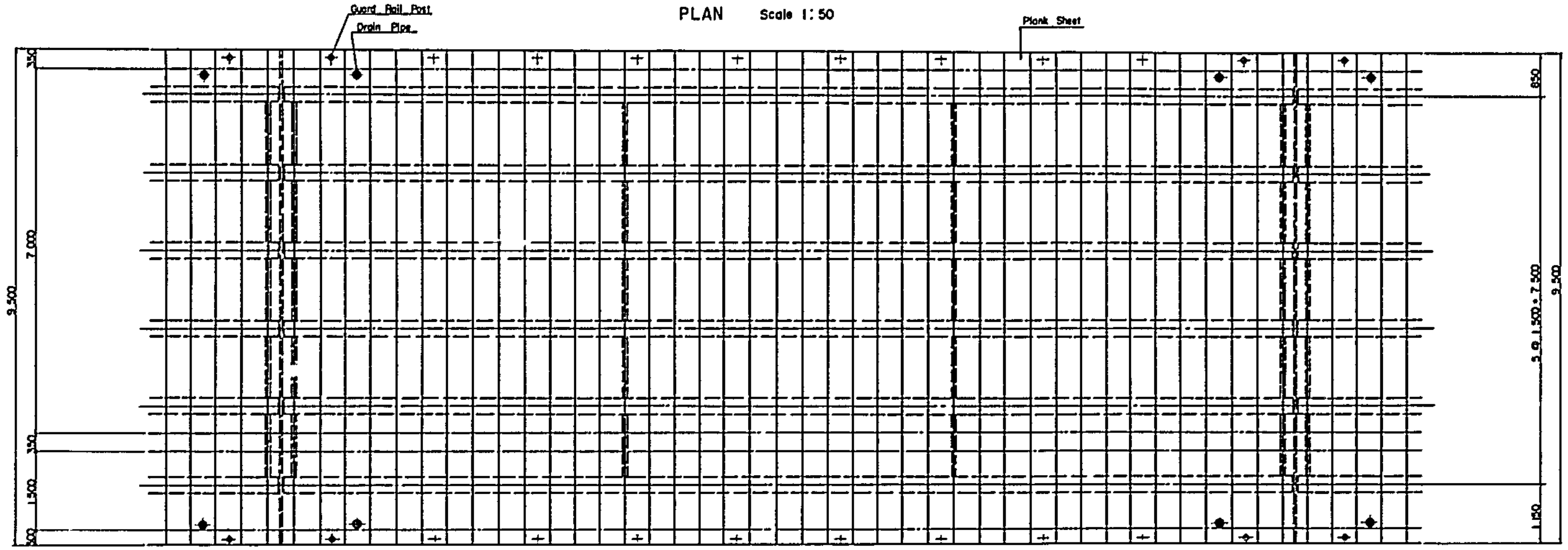


RUFIJI RIVER BRIDGE CONSTRUCTION PROJECT (DAR ES SALAAM-LINDI COASTAL LINK ROAD)	
STANDARD BEAM BRIDGE	
GENERAL VIEW (ADDITION TO FOOT-WAY)	
DRAWN BY	CHECKED BY
DATE: JUNE 1972	DWG. NO. 37

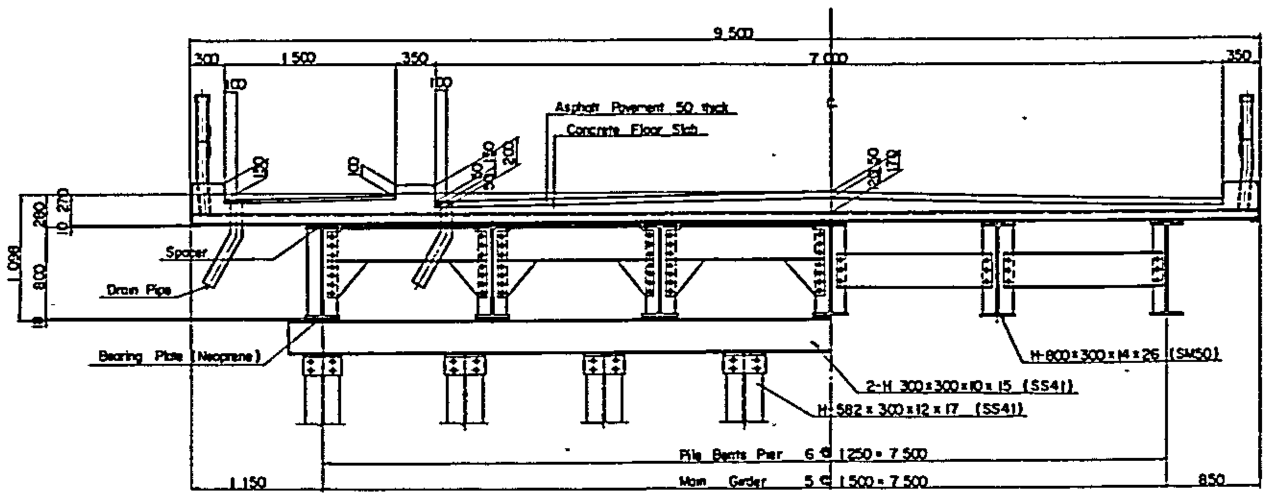
SIDE VIEW Scale 1:50



PLAN Scale 1:50



CROSS SECTION Scale 1:30

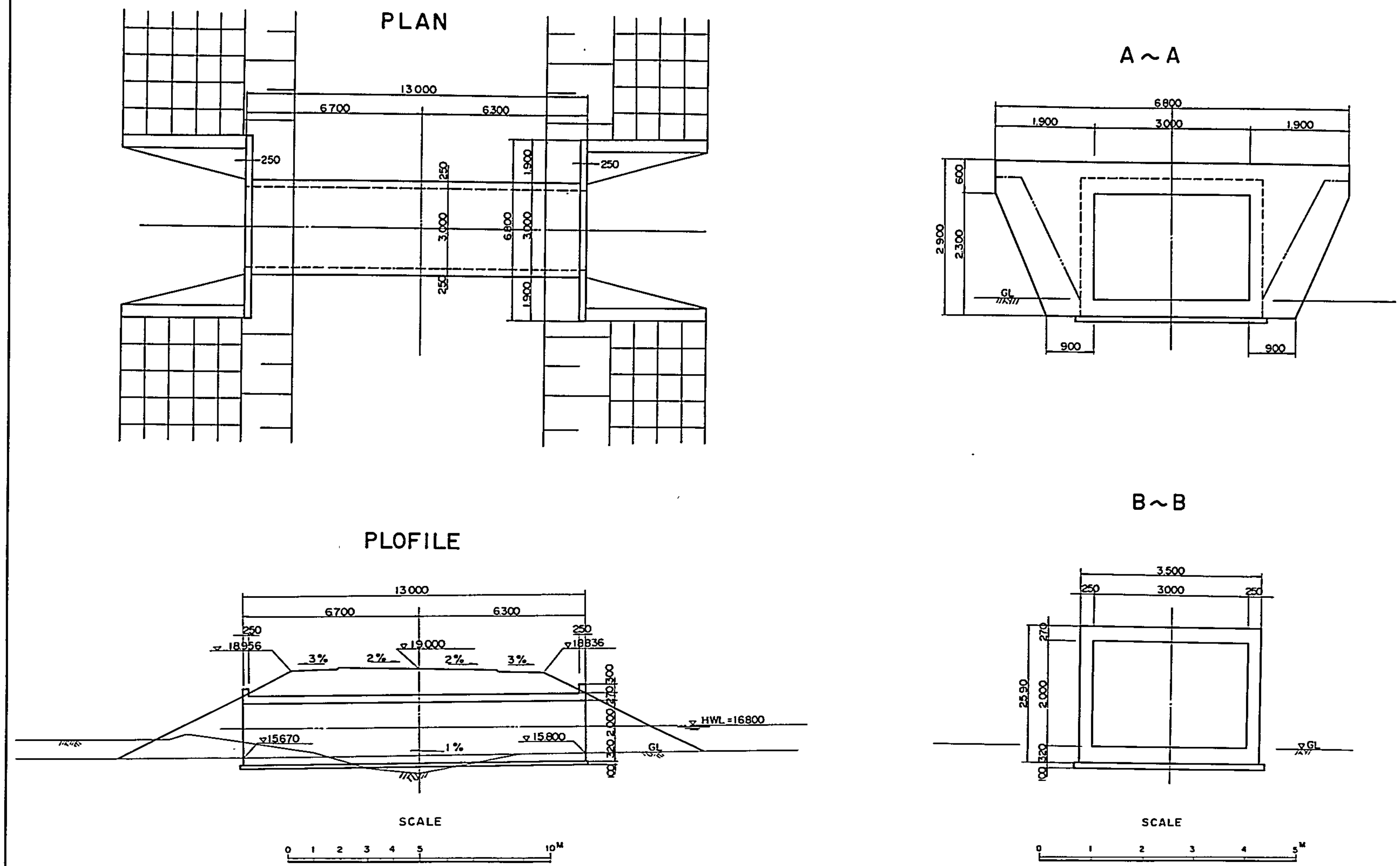


END INTER

BOX CULVERT (STA.36+150)

RUFIJI RIVER BRIDGE CONSTRUCTION PROJECT
(DAR ES SALAAM-LINDI COASTAL LINK ROAD)
APPROACH ROAD
BOX CULVERT(STA. 36+150)

DRAWN BY		CHECKED BY	
DATE	JUNE 1972	DWG NO	38

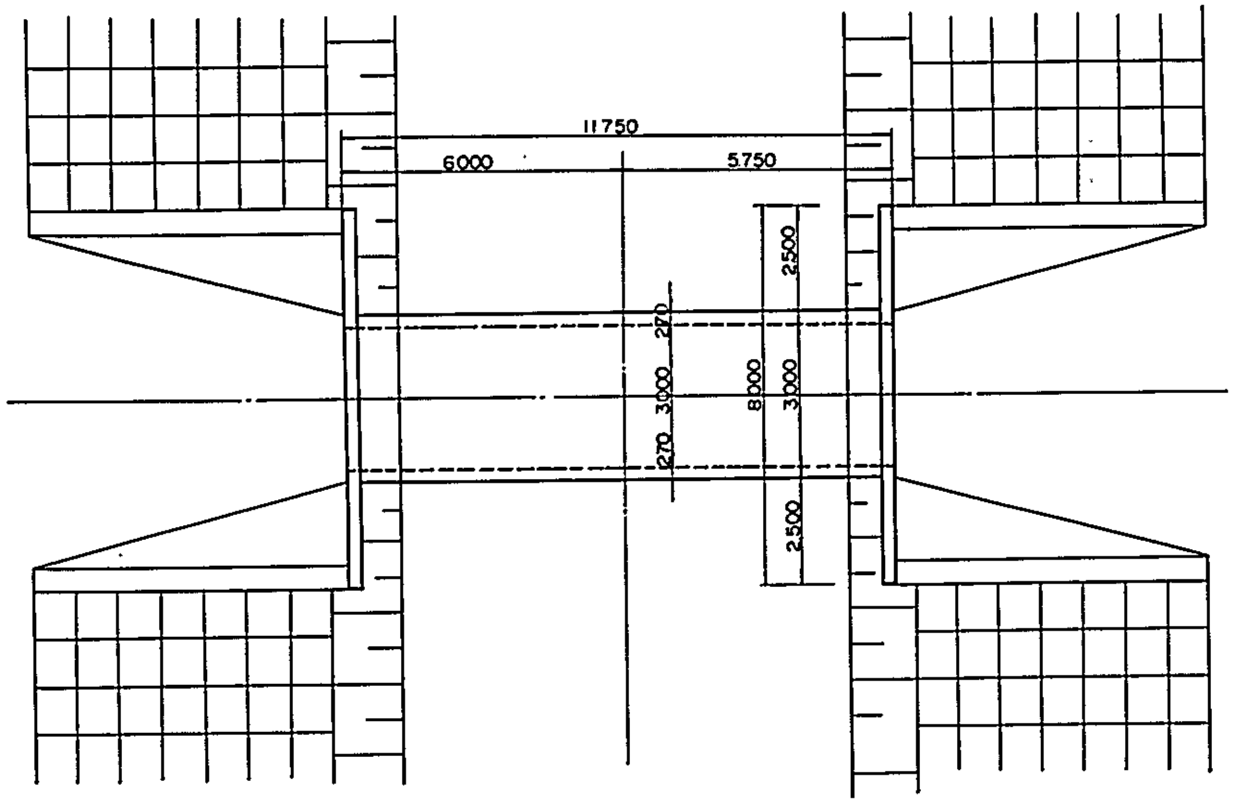


RUFIJI RIVER BRIDGE CONSTRUCTION PROJECT
(DAR ES SALAAM-LINDI COASTAL LINK ROAD)

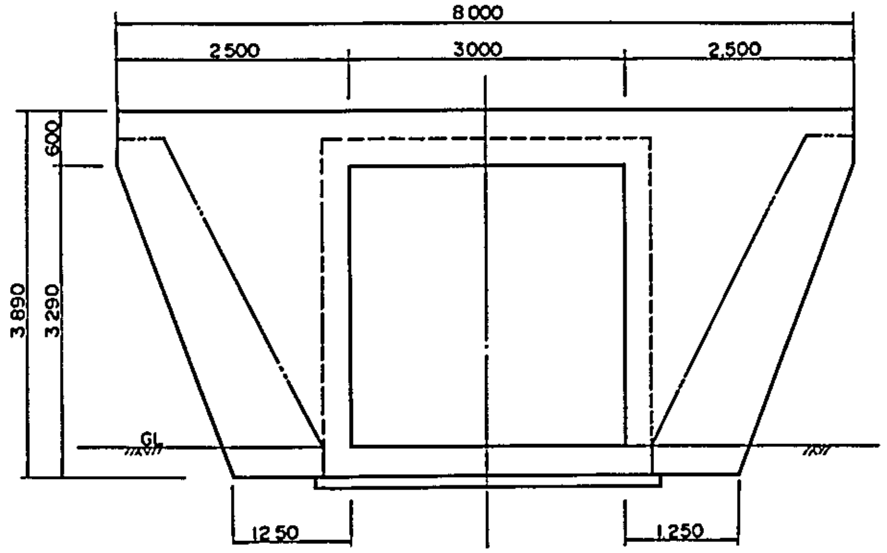
APPROACH ROAD	
BOX CULVERT (STA.38+200)	
DRAWN BY	CHECKED BY
DATE. JUNE 1972	DWG. NO 39

BOX CULVERT (STA. 38+200)

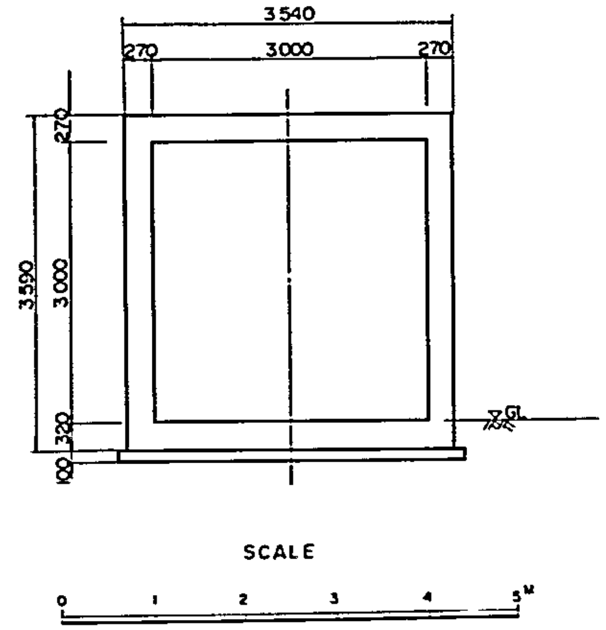
PLAN



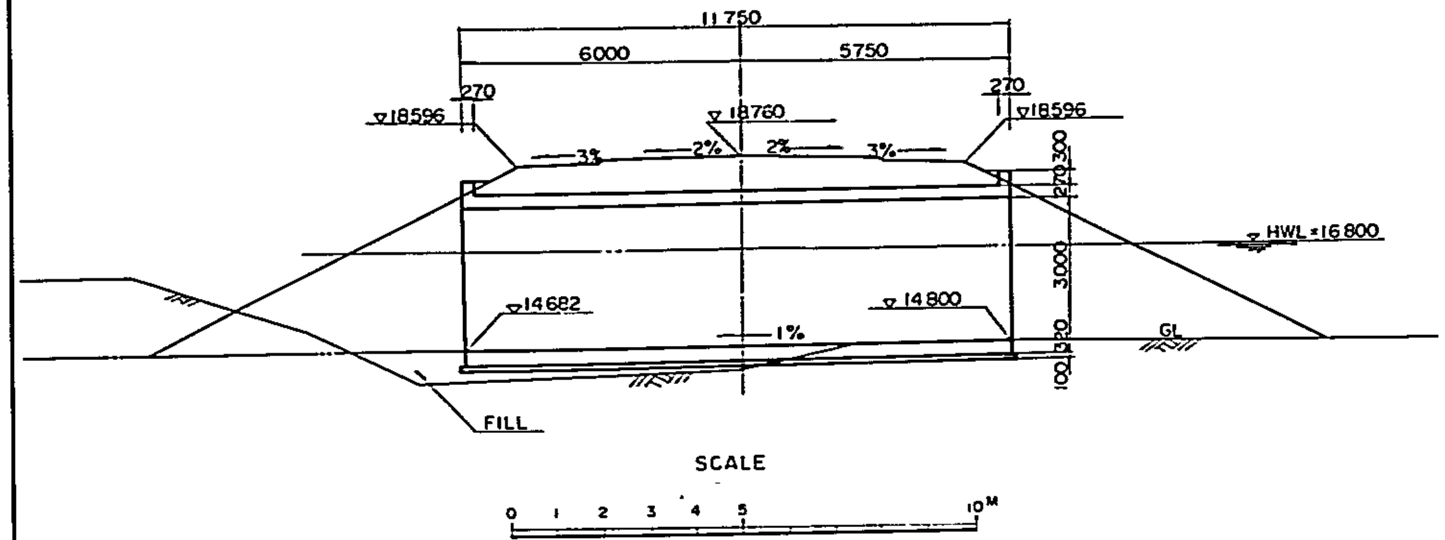
A ~ A



B ~ B



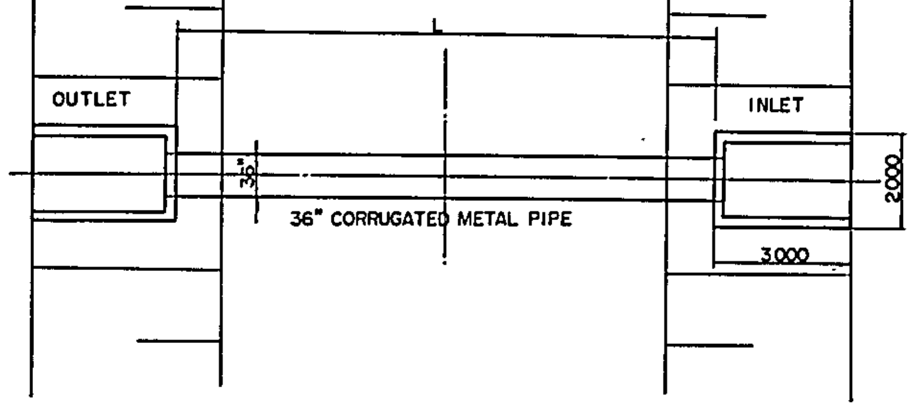
PROFILE



RUFIJI RIVER BRIDGE CONSTRUCTION PROJECT (DAR ES SALAAM-LINDI COASTAL LINK ROAD)	
APPROACH ROAD	
CORRUGATED METAL PIPE	
DRAWN BY	CHECKED BY
DATE. JUNE 1972	DWG NO 40

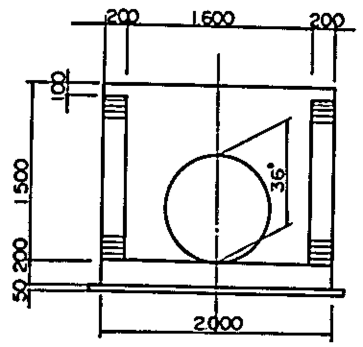
CORRUGATED METAL PIPE

PLAN

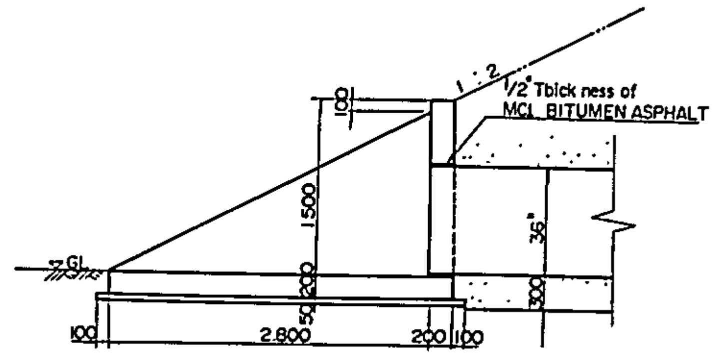


INLET AND OUTLET

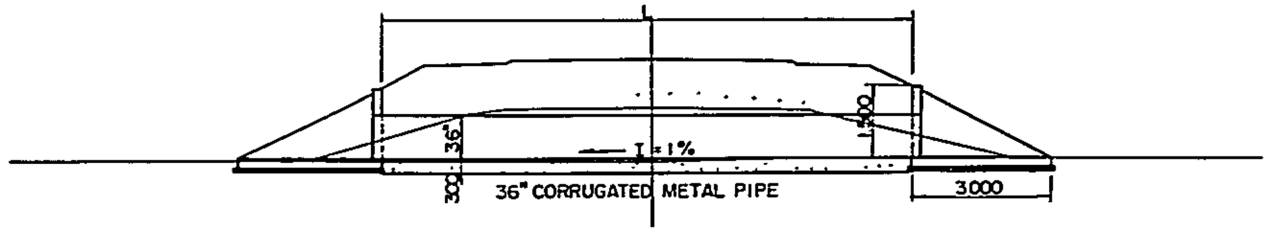
ELEVATION



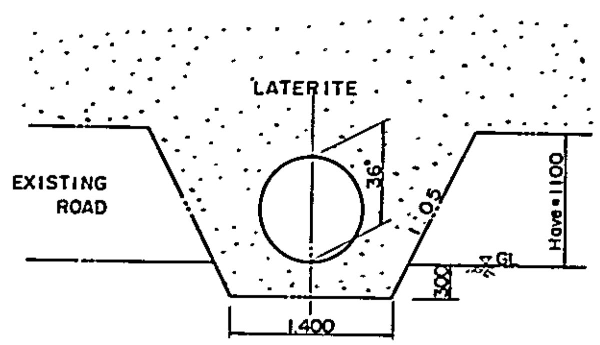
SECTION



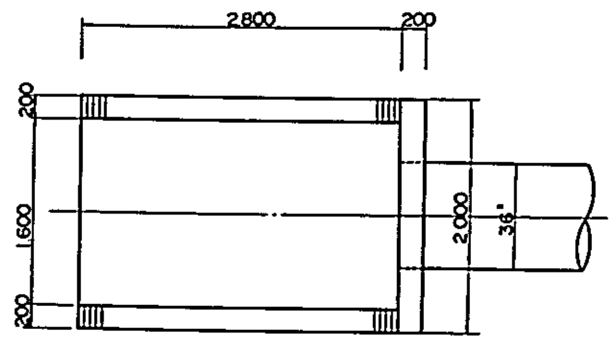
PROFILE



SECTION



PLAN



SCALE

0 1 2 3 4 5 10 M

SCALE

0 1 2 3 4 5 M

RUFIJI RIVER BRIDGE CONSTRUCTION PROJECT
(DAR ES SALAAM-LINDI COASTAL LINK ROAD)

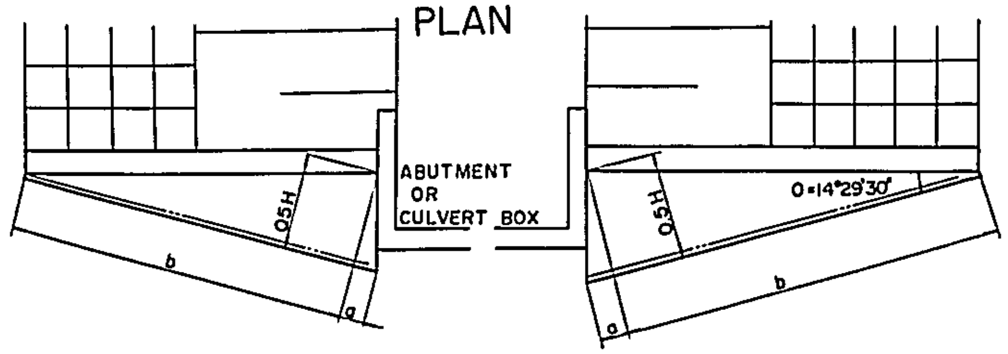
APPROACH ROAD

RETAINING WALL

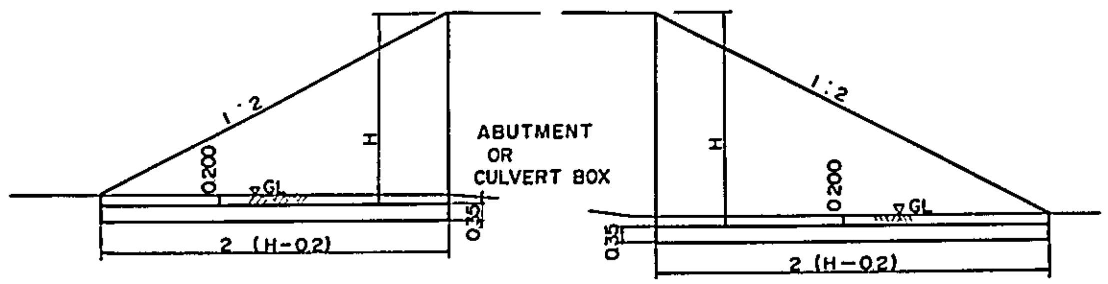
DRAWN BY	CHECKED BY
DATE: JUNE 1972	DWG NO 41

RETAINING WALL

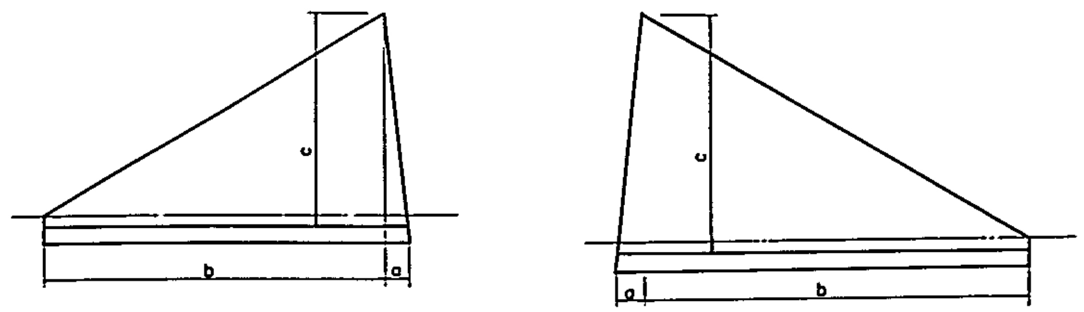
PLAN



SIDE ELEVATION

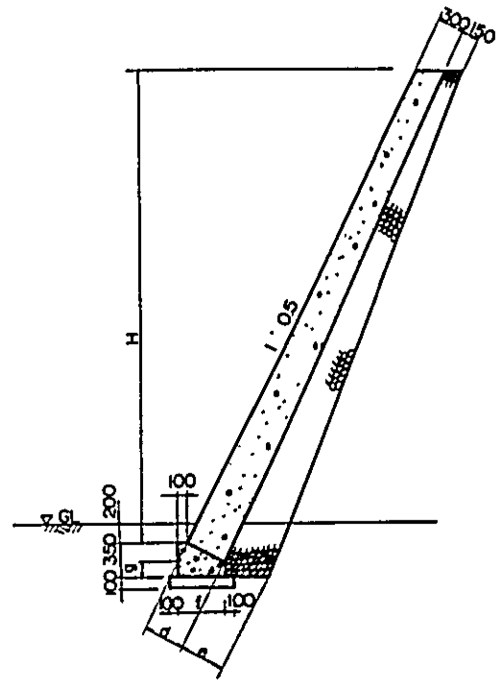


DEVELOPMENT



SCALE

SECTION



SCALE

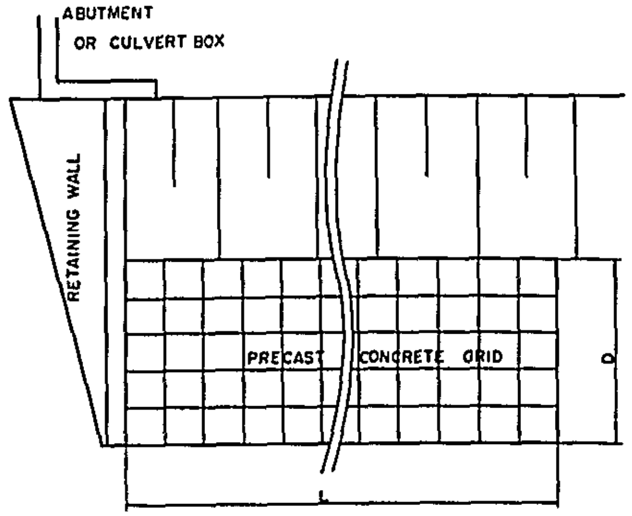
DIMENSION

UNIT - M

BRIDGE OR VIADUCT	SIDE	LEFT OR RIGHT	GL	H	a	b	c	d	e	f	g
IKWIRIRI RIVER BRIDGE	IKWIRIRI	L	15.80	4.10~0	0.530	7.550	4.580	0.420	0.430	0.480	0.160
		R	16.40	3.50~0	0.450	6.390	3.910	0.420	0.430	0.480	0.160
	NYAMWAGE	L	16.00	3.80~0	0.490	6.970	4.250	0.420	0.430	0.480	0.160
		R	16.30	3.50~0	0.450	6.390	3.910	0.420	0.430	0.480	0.160
VIADUCT L=4000M	IKWIRIRI	L	14.90	5.00~0	0.650	9.290	5.590	0.450	0.500	0.500	0.150
		R	14.70	5.20~0	0.670	9.680	5.810	0.450	0.500	0.500	0.150
	NYAMWAGA	L	14.60	5.20~0	0.670	9.680	5.810	0.450	0.500	0.500	0.150
		R	14.50	5.30~0	0.680	9.880	5.930	0.450	0.500	0.500	0.150
RUFIJI-RIVER BRIDGE	IKWIRIRI	L	16.60	3.60~0	0.460	6.580	4.030	0.420	0.430	0.480	0.160
		R	16.80	3.40~0	0.440	6.200	3.800	0.390	0.360	0.450	0.170
	NYAMWAGE	L	16.80	3.10~0	0.400	5.620	3.470	0.390	0.360	0.450	0.170
		R	16.80	3.10~0	0.400	5.620	3.470	0.390	0.360	0.450	0.170
VIADUCT L=700M	IKWIRIRI	L	15.70	4.20~0	0.540	7.740	4.700	0.420	0.430	0.480	0.160
		R	15.50	4.40~0	0.570	8.130	4.920	0.420	0.430	0.480	0.160
	NYAMWAGE	L	14.80	5.10~0	0.660	9.490	5.700	0.450	0.500	0.500	0.150
		R	14.80	5.10~0	0.660	9.490	5.700	0.450	0.500	0.500	0.150
VIADUCT L=300M	IKWIRIRI	L	14.20	5.70~0	0.740	10.650	6.370	0.480	0.570	0.530	0.140
		R	14.80	5.10~0	0.660	9.490	5.700	0.450	0.500	0.500	0.150
	NYAMWAGE	L	13.70	6.10~0	0.790	11.420	6.820	0.480	0.570	0.530	0.140
		R	14.00	5.80~0	0.750	10.840	6.480	0.480	0.570	0.530	0.140
C-Bx (STA 36+150)	IKWIRIRI	L & R	15.80	2.27~0	0.290	4.390	2.530	0.360	0.290	0.425	0.180
C-Bx (STA 38+200)	NYAMWAGE	L & R	14.80	3.27~0	0.420	6.330	3.650	0.390	0.360	0.450	0.170

PRECAST CONCRETE GRID

PLAN



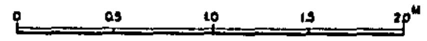
DIMENSION

UNIT – M

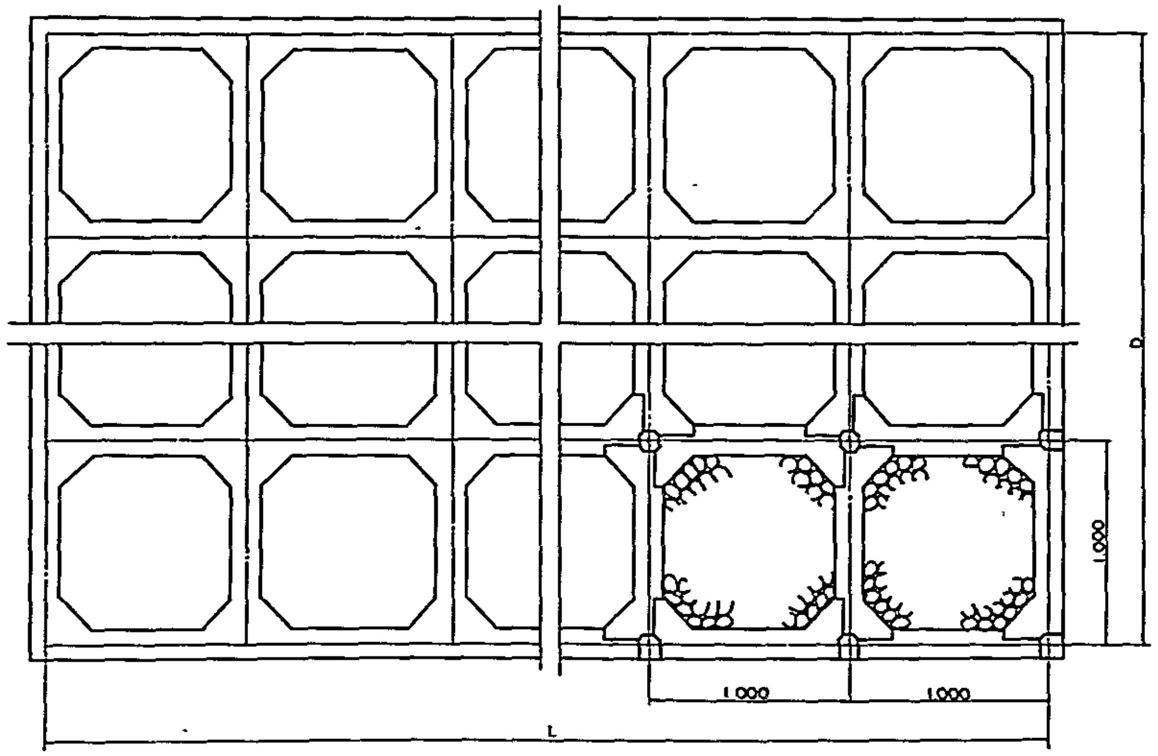
	SIDE	LEFT			RIGHT		
		GL	D	L	GL	D	L
KILAGASA –RIVER BRIDGE	IKWIRIRI	15.80	5.00	20.00	16.40	3.00	20.00
	NYAMWAGE	16.00	4.00	*	16.30	3.00	*
VIADUCT L = 4000M	IKWIRIRI	14.90	7.00	*	14.70	7.00	*
	NYAMWAGE	14.60	7.00	*	14.50	8.00	*
RUFIJI –RIVER BRIDGE	IKWIRIRI	15.80	5.00	*	16.20	4.00	*
	NYAMWAGE	16.40	3.00	*	16.40	3.00	*
VIADUCT L = 700M	IKWIRIRI	15.70	5.00	*	15.50	5.00	*
	NYAMWAGE	14.80	7.00	*	14.80	7.00	*
VIADUCT L = 300M	IKWIRIRI	14.20	9.00	*	14.80	7.00	*
	NYAMWAGE	13.70	9.00	*	14.00	8.00	*
STA.36+150 C-Bx	BOTH	15.80	5.00	10.00	15.80	5.00	10.00
STA.38+200 C-Bx	BOTH	14.80	7.00	*	14.80	7.00	*

RUFIJI RIVER BRIDGE CONSTRUCTION PROJECT (DAR ES SALAAM–LINDI COASTAL LINK ROAD)	
APPROACH ROAD	
PRECAST CONCRETE GRID	
DRAWN BY	CHECKED BY
DATE JUNE 1972	DWG NO 42

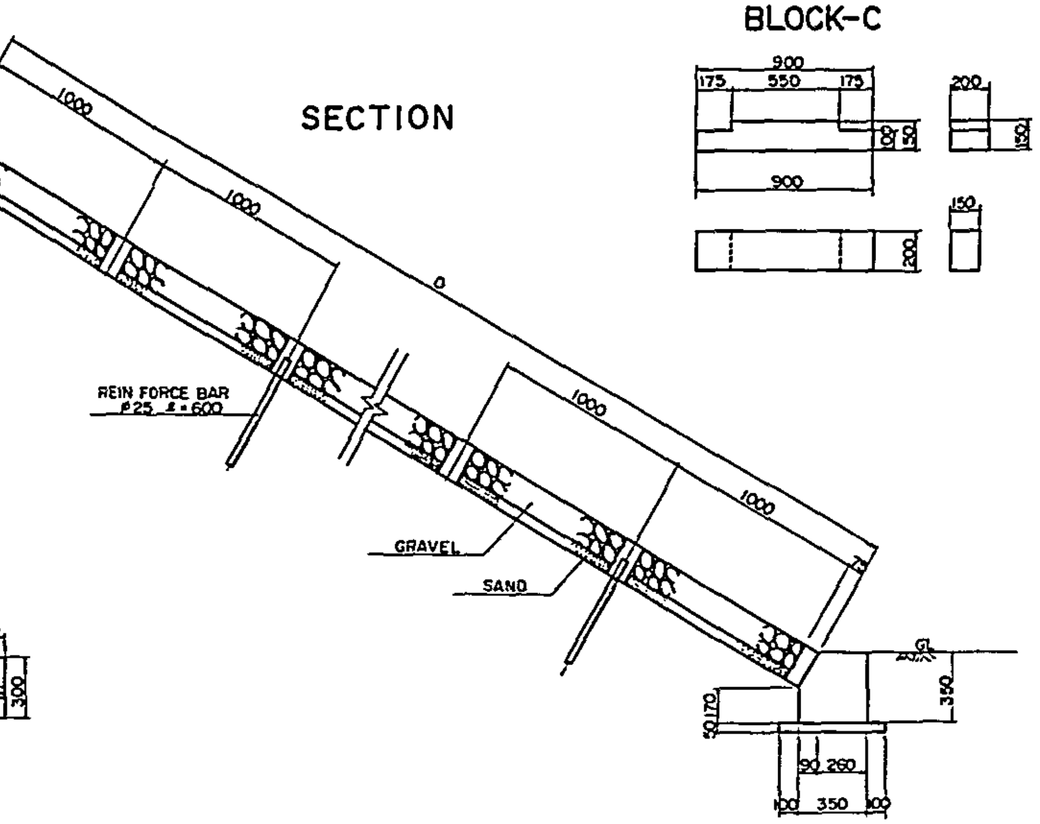
SCALE



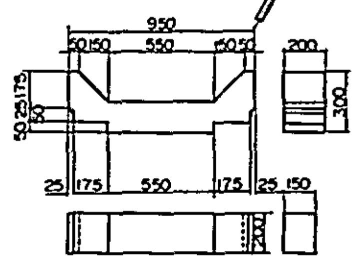
FRONT ELEVATION



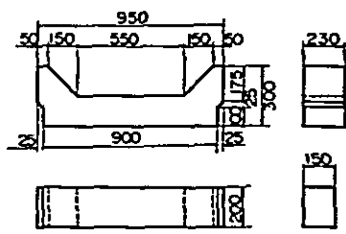
SECTION



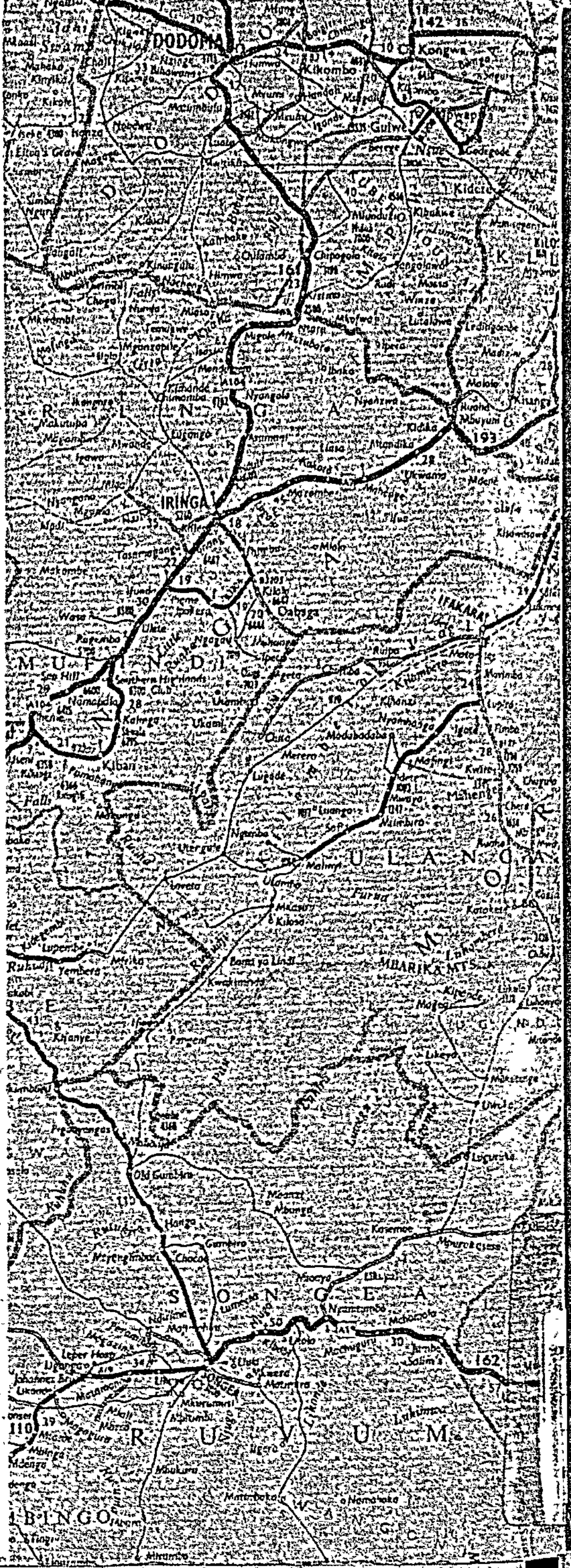
BLOCK-A



BLOC-B



BLOCK-C



DODOMA
Kongwa
Kikombo
Gulwe
Kidete
Nyangolo
Kidika
Mbuyuni
IRINGA
IFAKARA
Sao Hill
Southern Highlands Club
M U F I N D I
Kibao
Mahenge
U L A N G A
MBARIKA MTS
Lupembe
Old Gumbiro
Kitanda
S O N G E A
R U V U M A
M B I N G O