THE UNITED REPUBLIC OF TANZANIA

THE SELANDER BRIDGE EXPANSION PROJECT

CONSTRUCTION PROGRAMME AND METHOD

JUNE 1980

JAPAN INTERNATIONAL COOPERATION AGENCY

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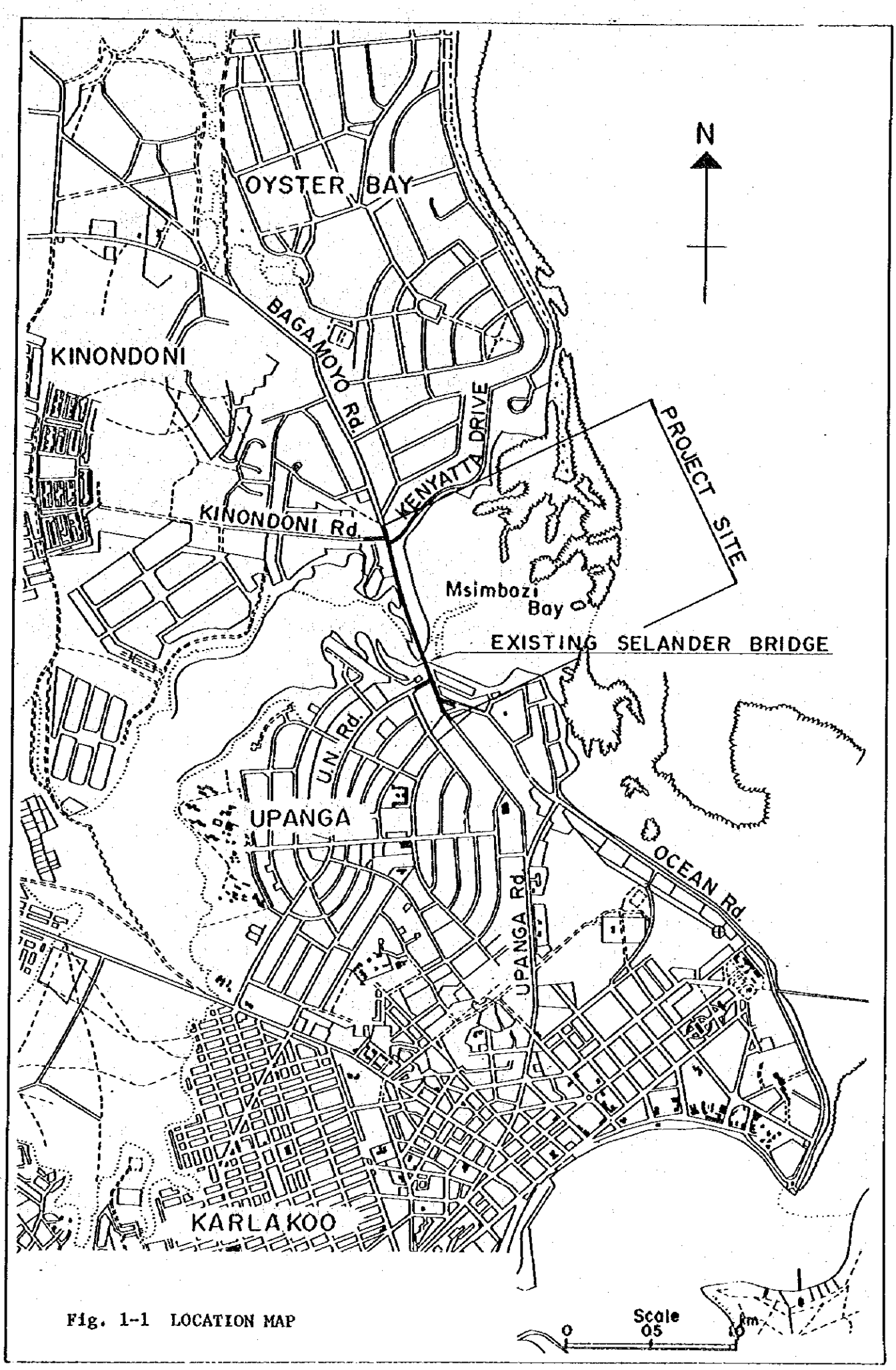

Fig. 1-1 LOCATION MAP

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CHAPTER I SCOPE OF WORKS

1-1 Location of the Project

The Selander Bridge Expansion Project (hereinafter referred to as the Project) extends on the Bagamoyo-Upanga road along the rim of the Msimbazi bay as shown in Figure 1-1.

The Bagamoyo-Upanga road which runs from north to south is one of the important arterial roads in Dar es Salaam, the United Republic of Tanzania.

The existing 86 meters long Selander Bridge is a part of the Bagamoyo-Upanga road.

Other main roads such as Kinondoni road, Kenyatta drive, United Nations road and Ocean road join the Bagamoyo-Upanga road around the Selander Bridge and constitute major junctions.

1-2 Scope of Work

The Project consists of three kinds of works: namely, the construction of a new Selander Bridge, the upgrading of the existing approach roads and the improvement of three major junctions. The details of these major work items are summarized below.

(1) Selander Bridge

Dimensions

Ocean side : 75.75m long, 7.50m wide
(2-carriageways) with 4.00m wide
pedestrian/bicycle track

Inland side : 75.75m long, 7.50m wide (2-carriageways)

Superstructure : 5-span continuous reinforced concrete hollow slab

Substructure

Foundation : Steel pipe piling (ϕ600mm)

Piers : Reinforced concrete columns (5-nos.)

Abutments : Inverse T-shaped walls (2-nos.)

(2) Approach Roads (Bagamoyo road and Upanga road)

Dimensions : Approx. 1.2km long, 25.5m wide including a 3.00m wide median strip

Pavement structure:

Surface course : Asphaltic concrete (t=5 cm)

Binder course : " " (")

Base course : Grading controlled (t=15 cm)

Subbase course : Crusher-run (t=15 cm)

(3) Junctions

The following three major junctions are included in the Project.

North Junction : The junction of the Kinondoni road and Kenyatta drive with the Bagamoyo road,

West Junction : The junction of the United Nations road with the Upanga road,

South Junction : The junction of the Ocean road with the Upanga road.

All three junctions will be signal controlled for vehicles and pedestrians.

1-3 Quantity of Work

The work items of the Project and their respective work quantities are shown in Table 1-1.

Table 1-1 WORK QUANTITIES

Work Item	Unit	Quantities	Remarks
Safety measures for traffic on existing road	L.S.	1	
Safety measures for existing public utilities	L.S.	1	Safety measures for pedestrians, traffic and public utilities
Demolition of obstructions and safety measures for pedestrians	L.S.	1	
Temporary works	L.S.	1	
Structure excavation	m^3	1,570	
Structure backfill	m^3	450	
Foundation cobble stone	m^3	70	
Concrete (Class A)	m^3	990	
Concrete (Class B)	m^3	620	
Concrete (Class D)	m^3	40	
Reinforcing bar(Class A)	kg	47,790	Bridge work
Reinforcing bar(Class B)	kg	126,970	
Piling (ϕ600 Steel pipe)	m	1,536	
Bridge pavement	m^2	1,420	
Elastic bearing	each	60	
Bridge railing	m	303	
Newel post	each	4	
Expansion joint	m	19	
Drainage	each	8	
Clearing and grubbing	m^2	27,250	Earth work
Waste excavation	m^3	230	

Table 1-1 WORK QUANTITIES

(Continued)

Work Item	Unit	Quantities	Remarks
Side-borrow embankment	m^3	3,340	Earth work
Borrow-pit embankment	m^3	7,600	
Improved subgrade	m^3	920	
Slope protection-sodding	m^2	2,360	
Slope protection rock riprap	m^2	220	
Kerb stone	m	2,270	Drainage work
Side ditch-A	m	1,210	
Side ditch-B	m	1,380	
Side ditch cover (G)	each	53	
Culvert	m	180	
Catch basin	each	39	
Rock-riprapped outlet	each	5	
Crusher-run subbase course (t = 15cm)	m^2	18,490	Pavement work
Grading controlled base course (t = 15cm)	m^2	19,380	
Asphaltic concrete binder course (t = 5 cm)	m^2	19,620	
Asphaltic concrete surface course (t = 5 cm)	m^2	20,800	
Sidewalk pavement	m^2	7,700	
Street lighting pole P-1	set	55	Traffic safety facilities
" Pole P-2	set	28	
" Pole P-3	set	11	

Table 1-1 WORK QUANTITIES

(Continued)

Work Item	Unit	Quantities	Remarks
Traffic signal S-1	set	10	Traffic safety facilities
" S-2	set	16	
" S-3	set	4	
Cable laying and wiring for lighting	m	3,000	
Cable laying and wiring for traffic signals	m	640	
Distribution panel for lighting	each	2	
Control panel for traffic signals	each	3	
Road sign-A	each	10	
" -B	each	6	
" -C	each	14	
Delineator	each	20	
Road marking	m^2	830	
Handrail	m	28	
Bus stop shelter	each	1	Miscellaneous work
Median strip	m^2	2,850	
Planting	each	550	
Office for Engineer's use	L.S.	1	
Vehicle for Engineer's use	L.S.	1	

CHAPTER II WORK SCHEDULE

2-1 Work Days

The number of work days a year was calculated for the establishment of the work schedule and the estimation of the construction period of the Project.

The number of work days was simply obtained by subtracting the total non-work days from 365.

(1) Number of Non-working Days

The non-working days include Sundays, national holidays in the Republic of Tanzania and non-working days when work cannot proceed due to rainfall.

a) Sundays

Number of Sundays a year; 53 days

b) National holidays

National holidays in the Republic of Tanzania ; 13 days

c) Non-working days due to rainfall

Based on the meteo-hydrological data, the average number of rainy days per month in and around the Project area was estimated with respect to the total daily rainfall as shown in Table 2-1.
Based on the consultants' experience, rainfall less than 10mm a day will hardly affect the workmanship or progress of the work. Therefore rainy days with less than 10mm a day were excluded from the non-working days.

From Table 2-1, the number of non-working days was estimated as 37 days in total.

Because of the unfavorable ground condition, however, high quality performance of work cannot be expected in the day following heavy rainfall. Consequently, additional non-working days were estimated by introducing a coefficient of 1.5 for daily rainfall of more than 30mm.

As a result, the number of non-working days due to rainfall was estimated as 47 days.

Table 2-1 NON-WORKING DAYS DUE TO RAINFALL

Month	Daily Rainfall (mm)				Total (Days)
	0 ∿ 1	1 ∿ 10	10 ∿ 30	30 ∿	
JAN.	28	1	0	2	31
FEB.	25	2	0	1	28
MAR.	25	3	2	1	31
APR.	15	4	4	7	30
MAY	25	1	5	0	31
JUN.	23	6	0	1	30
JUL.	27	3	1	0	31
AUG.	29	2	0	0	31
SEP.	28	1	0	1	30
OCT.	30	0	1	0	31
NOV.	13	6	2	4	30
DEC.	26	0	2	3	31
Total days	299	29	17	20	365
Non-working coefficient (C)	0	0	1	1.5	
Number of non-working days (U)x(C)	0	0	17	30	47

d) Total Annual Non-working Days

The number of total non-working days a year is as follows:

Total non-working days = 53 + 13 + 47 = 113 days/year
(Sundays + Holidays + Non-working days due to rainfall)

(2) Total Annual Work Days

The number of work days a year was calculated as follows:

Total Work Days = 365 - 113 = 252 days/year
(Days per year - Non-working days)

Therefore, the average work days per month is estimated as 21 days ($\frac{252}{12} = 21$).

This figure is used as the basis for the establishment of the Project work schedule.

2-2 Project Work Schedule

The work schedule was determined for major work items based on the work quantities, number of work days and availability of materials as shown in Figure 2-1.
As shown in Figure 2-1, the total construction period of the Project is estimated as 18 months.

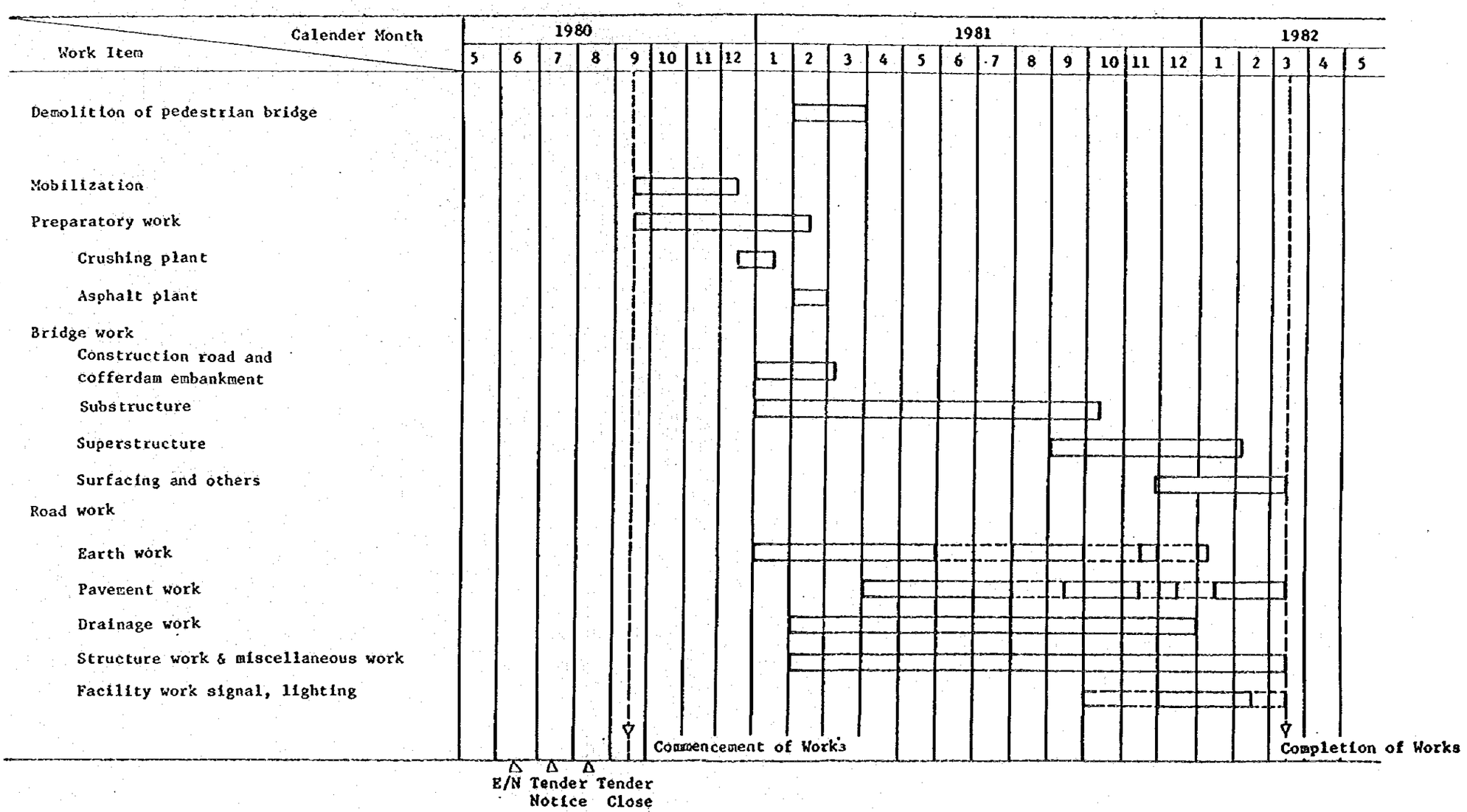


Fig. 2-1 WORK SCHEDULE OF THE SELANDER BRIDGE EXPANSION PROJECT

CHAPTER III CONSTRUCTION METHODS

3-1 General

3-1-1 Preparatory Works

All the works of the Project shall be constructed by the Contractor under the supervision of the Engineer employed by the Owner.

As the Project is comprised of the diversified work items as mentioned in section 1-3, several expert enginners will be required as supervision staff of the Project.
The Engineer shall stay at the Project site through the entire construction execution period of the Project. The site office for the Engineer shall be installed by the Contractor at the place designated by the Engineer. Tentative location of the site office is indicated in Figure 3-1.

The required floor space and other office utilities such as water supply, electricity, sewerage facilities, etc. are shown in Table 3-1.
To meet the convenience of the Engineer, a vehicle shall be provided as transport.

Within the specified period after the date of the signing of the Contract, the Contractor shall commence work at the Project site.
Preparatory works such as the construction of site office, dwelling houses, laboratory, etc. must precede all other works.
Tentative locations of the temporary facilities are indicated in Figure 3-1.

3-1-2 Pedestrian Path

The existing foot bridge shall be demolished, after completion of a temporary path for pedestrians, which will be installed at the ocean side along the construction road.
The details of pedestrians path is shown in Fig. 3-2

3-1-3 Source of Aggregates

(1) Rock Materials

Rock materials for coarse aggregate shall be quarried at two places: namely, Msorwa and Kunduchi; the hauling distances are about 130 kms and 14 kms, respectively.

The rock material at Msorwa is hard enough to meet the abrasion requirement. Therefore, the aggregates for asphalitic concrete surface course and cement concrete structures shall be a product of the rock material at Msorwa.

For other works such as subbase course, base course and asphalitic concrete binder course, rock material at Kunduchi shall be used.

These rock materials must be transported to the crushing yard to be located at about 2 kms north of the Project site as shown in Figure 3-1.

(2) Sand

Sand for fine aggregate will be available from the river deposit of the Mpiji river, about 40 kms north of the Project site.

3-1-4 Setting-out of Work

Based on the drawings and design documents, the Contractor shall establish the position of the basic stakes mentioned below. These important stakes shall be painted with colour paints to identify their locations. All positioning work shall be performed by expert surveyors.

(1) Basic Stakes

Basic stakes for the Project implementation shall be made available to the Contractor after checking and position confirming by the Engineer.

The Contractor shall provide reference stakes for basic stakes soon after receiving the basic stakes. Those reference stakes shall be installed so as not to be damaged by vehicles or other hazards.

(2) Bench Marks

Permanent bench marks shall be confirmed to the Contractor by the Engineer.

The Contractor shall provide temporary bench marks related to the permanent stakes after obtaining the approval of the Engineer. Special care shall be exercised to see that the stakes will not be damaged by vehicles or other hazards.

(3) Center Stakes or Tacks

Center stakes or tacks shall be provided at intervals of 10m and 20m for small curvature sections and straight sections, respectivly.

If center stakes are damaged, they should be repaired by referring the nail of a batter board on the shoulder.

Reference points for main stakes shall be provided and protected by wooden fences.

(4) Formation Level

The proposed formation level shall be maintained as shown on the Drawings. Embankment and cutting shall be executed in accordance with the datum of the batter board. The interval of batter boards shall be the same as that of center stakes described above.

Batter boards shall be checked from time to time and maintained in specific positions.

(5) Batter Boards

The Contractor shall provide batter boards prior to the commencement of each work and shall obtain approval of the Engineer for each one.

Special attention shall be taken to see that none of the labourers damages any datum stakes.

3-1-5 Work Flows

Works included in the Project will be clasified into two main flows: namely, the Salander Bridge work and roadway works including earthworks, drainage works, pavement works, traffic safty facilities work and miscellaneous works.

Following the preparatory works, the bridge work will start with temporary works such as construction roads and cofferdam embankments. The total bridge work will take 14 months.

The roadway work will begin with clearing and grubbing the site following the mobilization of construction equipment.
The total roadway work will take 14 months.

Table 3-1 REQUIRED PREPARATORY WORKS

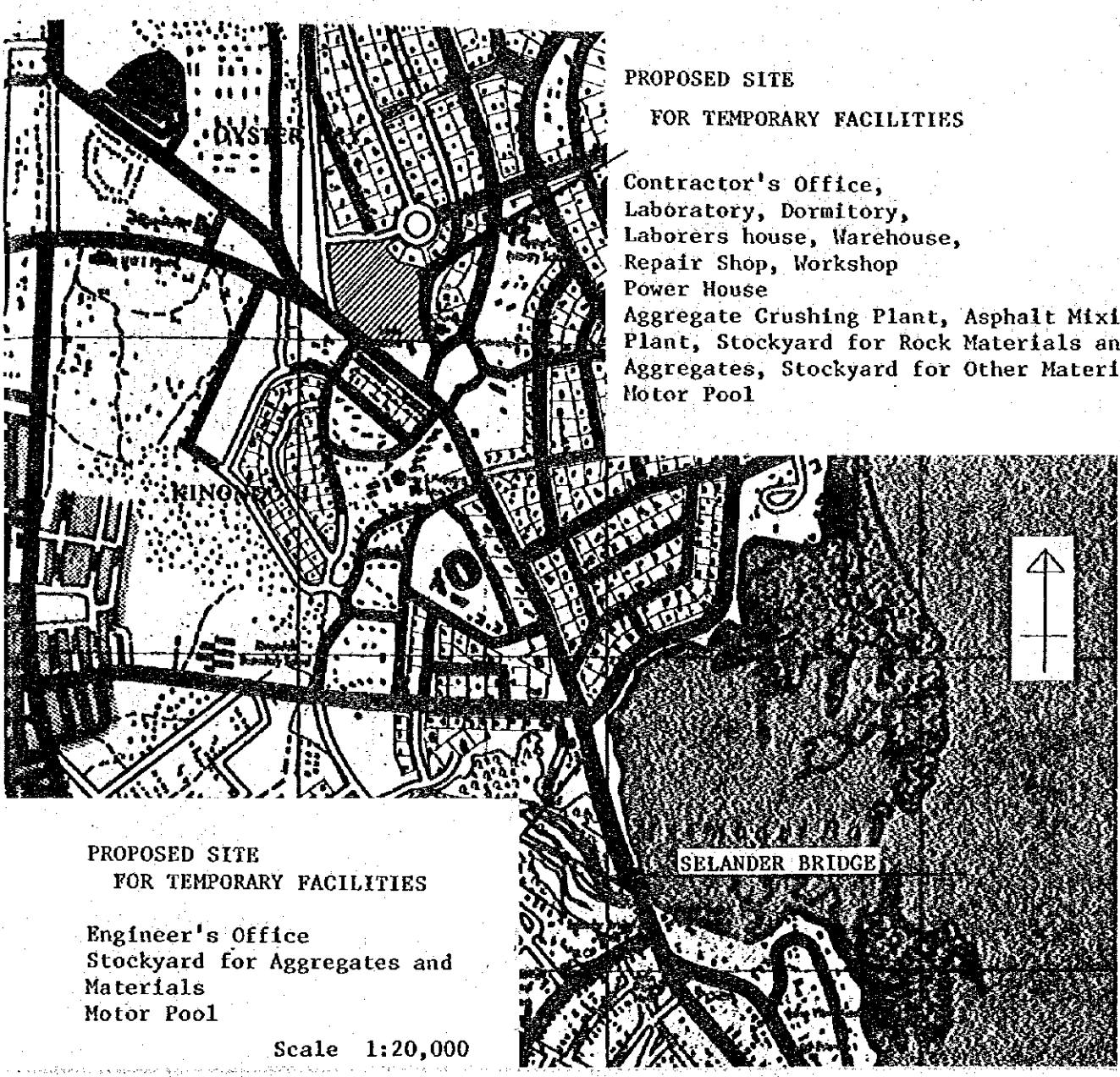
1. Buildings and Land

Description	Area (m^2) Building	Land
Office (for Engineer)	180	300
Office (for Contractor)	110	220
Dormitory	80	160
Labourers' house	140	280
Laboratory	30	60
Warehouse (Cement)	140	210
Warehouse	80	120
Repair shop, Workshop	300	450
Stockyards for materials	-	2,000
Motor pool	-	800
Aggregate crushing plant	-	7,000
Asphalt plant	-	
Stockyards for aggregates and rock materials		

Note; Land acquisition for quarry sites (at Msorwa, at Kunduchi and Mpiji river) shall be required.

2. Accommodation and Office Furniture for the Engineer

Vehicle		1 unit
Utilities	Water supply, Electric supply	
	Sewerage facilities, Drainage facilities	1 (lumpsum)
	Drainage facilities, Air conditioner	



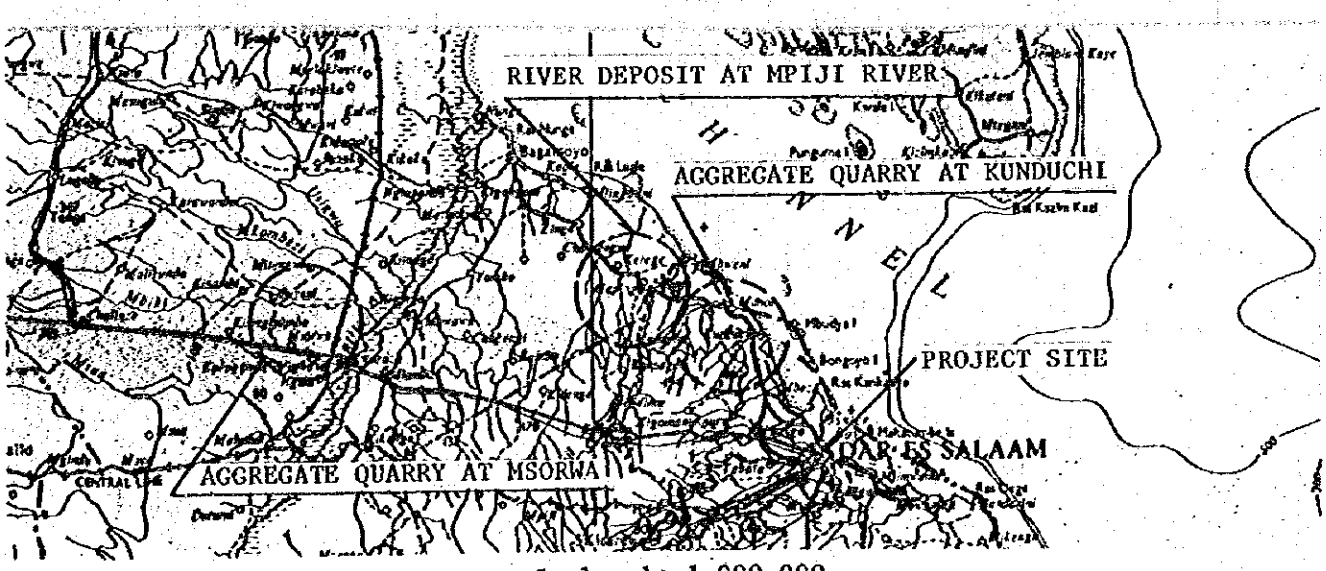


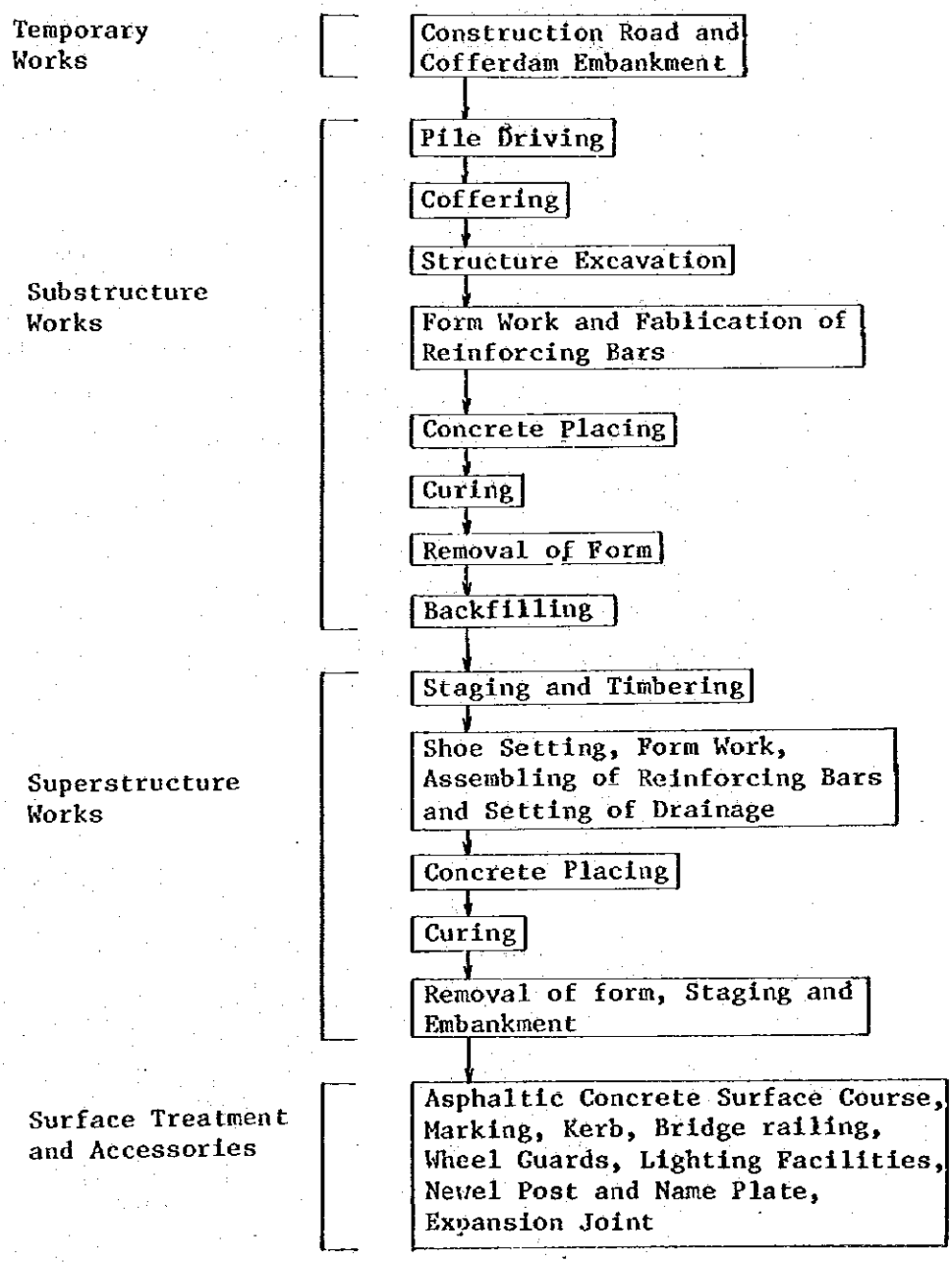
Fig. 3-1 LOCATION OF TEMPORARY FACILITIES AND QUARRY SITES

3-2 Bridge Work

3-2-1 Work Procedure

The bridge work is composed of diversified works and will be accomplished following the procedure shown below.

Bridge Work Procedure



3-2-2 Temporary Work

Prior to the construction of main works, temporary works such as construction roads and cofferdam embankments shall be executed.

Cofferdam embankment, construction roads and pedestrian path which is described in 3-1-2 shall be constructed as a unit as shown in Figure 3-2.

Road widths of pedestrian path and construction roads are 2m and 4m, respectively.
The elevation of the road was calculated taking account of the wave height and was adopted as 3.00m above mean sea level.

The existing channel under the Selander Bridge shall be kept open even during the construction of the new Selander Bridge.

It is assumed that 6 meters wide is enough for the new channel, taking the low sea current and the depth of water into consideration. The channel shall be set up between pier No.3 and pier No. 4 as shown in Figure 3-2. A temporary bridge shall be constructed across the channel.

The quantity of embankment volume is approximately 4,000 m^3, and construction period of the embankment is assumed as 2 months.

3-2-3 Substructure

(1) Work Quantity

Quantities for substructure work are as follows

Work Quantity

Descritpion	Unit	Quantity
Structure excavation	m^3	1570
Concrete Class B	m^3	630
Reinforcing bar Class A and Class B	ton	25
Steel pipe piling (ϕ600 mm)	m	1536

(2) Steel Pipe Piling (ϕ600 mm)

The steel pipe piles for foundation are 10m, 6m and 5m long with a diameter of 600 mm and thickness of 9 mm.
The pile shall be driven by a diesel hammer with a weight of 3.2 tons and a leader attached to a crawler crane.

Prior to the pile driving, test driving shall be carried out by the Contractor with attendance of the Engineers.

The length of piles will be finally determined by the Engineer based on the results of the test driving.

The required time for driving one pile is calculated by the following formula

$$H = \frac{T_1 + T_2 + T_3 + T_4 + T_5}{60}$$

Where, H: Driving time (hours)

T_1: Time of preparation and replacement of crane (10 minutes)

T_2: Time of hanging and installing of piles ($6 \times n_1$ minutes)

T_3: Time of driving defined by the following formula

$$T_3 = a\,(\bar{N} + c)\beta \cdot \ell = 0.05(\bar{N} + 3) \times 1.2 \times \ell \quad \text{minutes}$$

where ℓ: Total length per pile, and $\bar{N}$: Average of N value

T_4 : Time of welding $23 \times n_2$ minutes

T_5 : Time of installment of embanked equipment 5 minutes

n_1 : Number of members per pile

n_2 : Number of welding places per pile

Design Combinations of Piling Working Period

Place	Length and combination of piles (m)	Number of piles (Nos)	Number of members per pile (Nos)	Number of weldings per pile (Places)	Working hour per pile (hour)	Working period (days)
A_1	30 (10+10+10)	12	3	2	1.9	6
P_1	25 (5+10+10)	14	3	2	2.0	7
P_2	20 (10+10)	14	2	1	1.4	5
P_3	15 (5+10)	14	2	1	1.4	5
P_4	12 (6+6)	14	2	1	1.2	4
A_2	12 (6+6)	14	2	1	1.2	4

(3) Shuntering Out Underground Water

Underground water level is convineed higher than the bottom of abutments and piers. Shuntering out underground water shall be done by coffering, with trench sheet piles or steel sheet piles. A vibrating hammer shall be provided for driving sheet piles.

Sheet Piles

Place	Materials	Length of shuntering and number of sheet piles	Daily output (number of sheet piles)	Working period (days)
Abutment A1, A2	Trench sheet pile ℓ=6.0m(B=0.25m)	ℓ=60.5 n=242.0	20	17
Pier P1	Trench sheet pile ℓ=6.0m(B=0.25m)	ℓ=52.2 n=208.8	20	15
Pier P2	Steel sheet pile ℓ=7.0(B0.4m)	ℓ=52.2 n=130.5	14	14
Pier P3,P4	Steel sheet pile ℓ=9.0(B=0.4m)	ℓ=52.2 n=130.5	12	16

(4) Structure Excavation

Structure excavation shall be carried out by a clamshell and labourers after the coffering beforementioned.
Water from surface excvated shall be excluded out by water pumps.
Probable output per hour of the clamshell is estimated 12 cu.m on land and 9 cu.m in water. Quantity and working period is assumed and shown in the following table

Structure Excavation

Place	Quantity	By labourers	Quantity by a clamshell	Working Period (days)
A1	270	135	135	7
P1	240	105	135	5
P2	230	105	125	6
P3	170	105	65	4
P4	180	105	75	4
A2	490	135	355	13

Note : Number of labourers 20 persons : 2.0 m^3/day per labourer.

(5) Assembling of Reinforcing Bar, Form Work and Concrete Work

Setting of form work and assembling of reinforceing bar will take about 14 days for each substructure.
Three portable concrete mixers, ten dumptrucks and three vibrators shall be provided for concrete works.
Quantity of concrete and working period of substructures is shown on the following table.

Concrete Work

Place	Footing		Wall	
	Concrete volume (m^3)	Working period (day)	Concrete volume (m^3)	Working period (day)
A1	92	3	53	2
P1	52	2	16	1
P2	52	2	25	1
P3	52	2	34	1
P4	52	2	34	1
A2	92	3	72	2

3-2-4 Superstructure

(1) Work Quantity

Quantities for superstructure work are as follows:

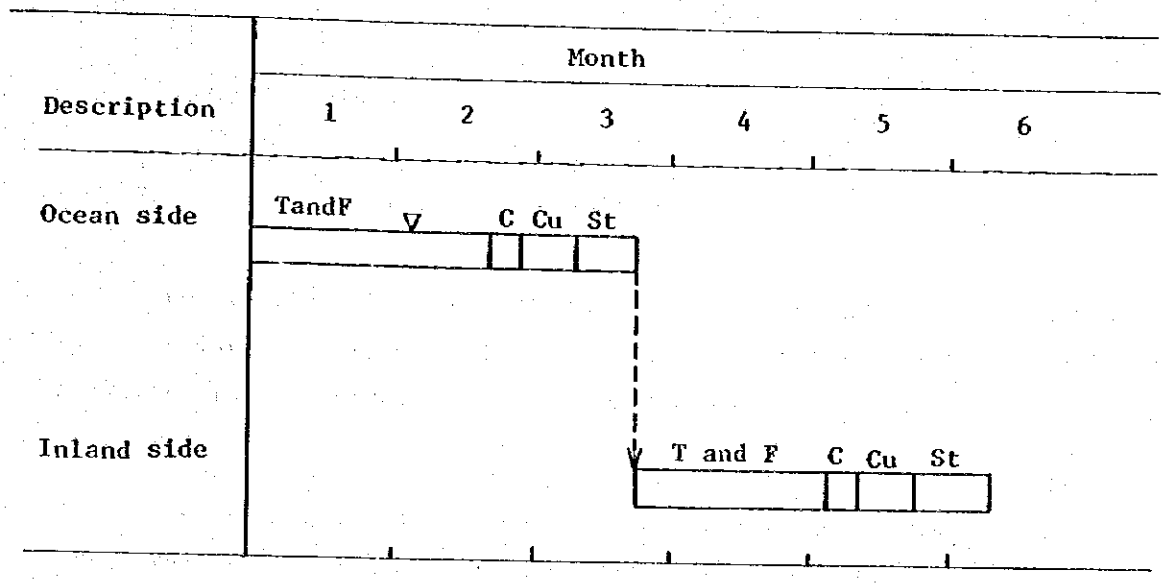
Work Quantity

Description	Unit	Quantity
Concrete Class A	m^3	990
Rainforcing bar Class A and Class B	ton	150
Form	m^3	2200
Cylindrical form for hollow (ø800mm)	m	693

(2) Work Schedule

Work schedule of superstructure is as follows:

Work Schedule



V : Completion time of substructure

T and F : Timbering, Form work and Assembling of Reinforcing Bar

C : Concrete placing

Cu : Concrete curing

St : Removal of form and timbering

(3) Timbering, Form Work and Assembling of Reinforcing Bar

Timbering members shall be wooden timber and forms shall be made of plywood. Timbering and forms shall be constructed so rigidly as to prevent deformation due to load, drying and wetting, vibration and other problems.

For consideration of deflection by the weight of concrete, cambers shall be correctly set up and cylinderical form shall be set and fastened with steel bands.

Reinforcing bar shall be cut and bent at a processing yard and transported to the work site.
It shall be assembled and fastened to each other in place correctly.

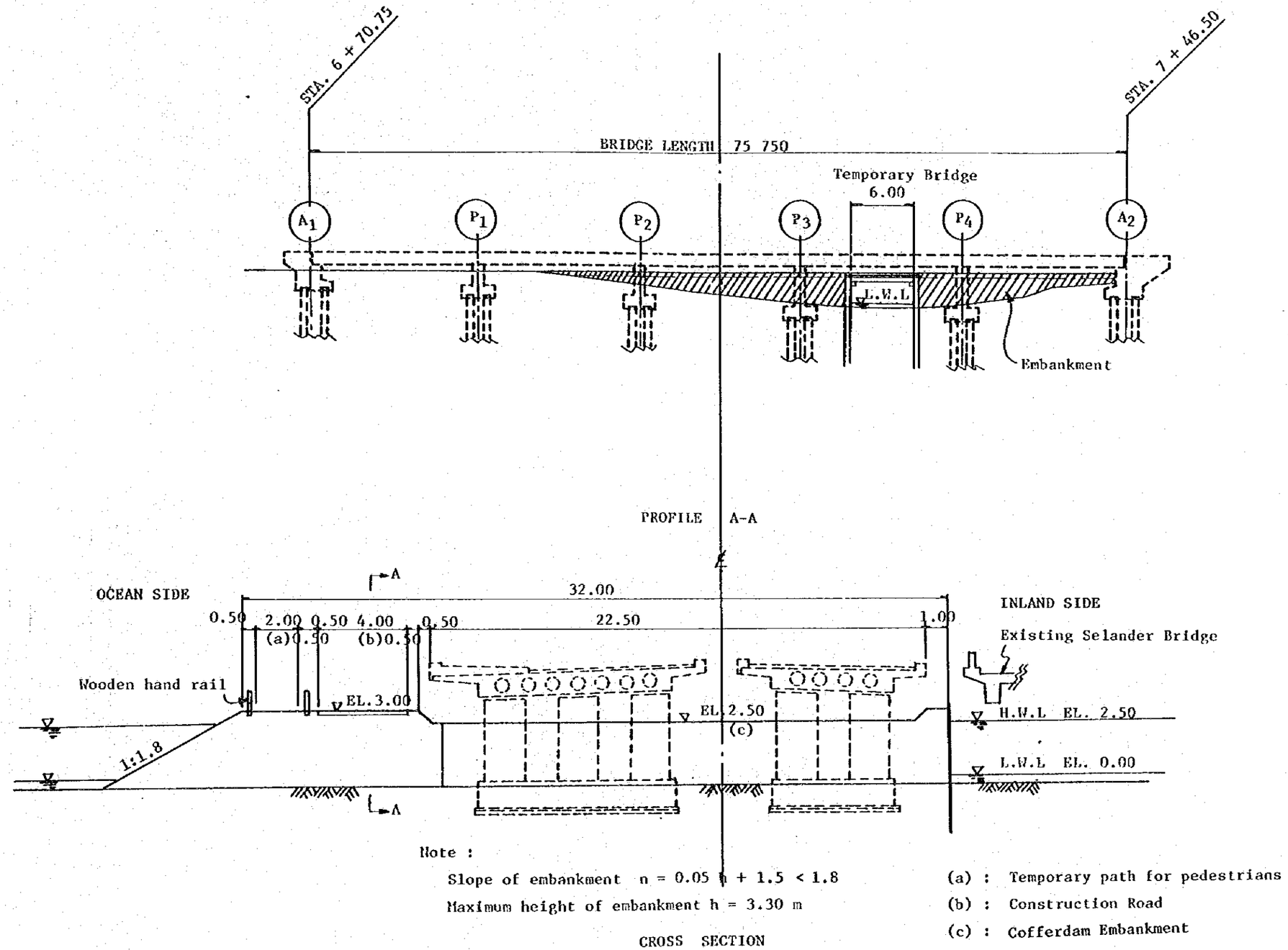
(4) Concrete Work

Concrete Volume

Ocean side	590 m^3
Inland side	400 m3

Concrete placing on each side shall be carried out continuously day and night. Therefore, three or four working teams for shifts and facilities for the night work shall be provided.

Order of placing concrete has been studied not to cause cracking of concrete or excessive deflection. During placing concrete under cylindrical forms, great care is needed to fill them up.



Note :

Slope of embankment n = 0.05 h + 1.5 < 1.8

Maximum height of embankment h = 3.30 m

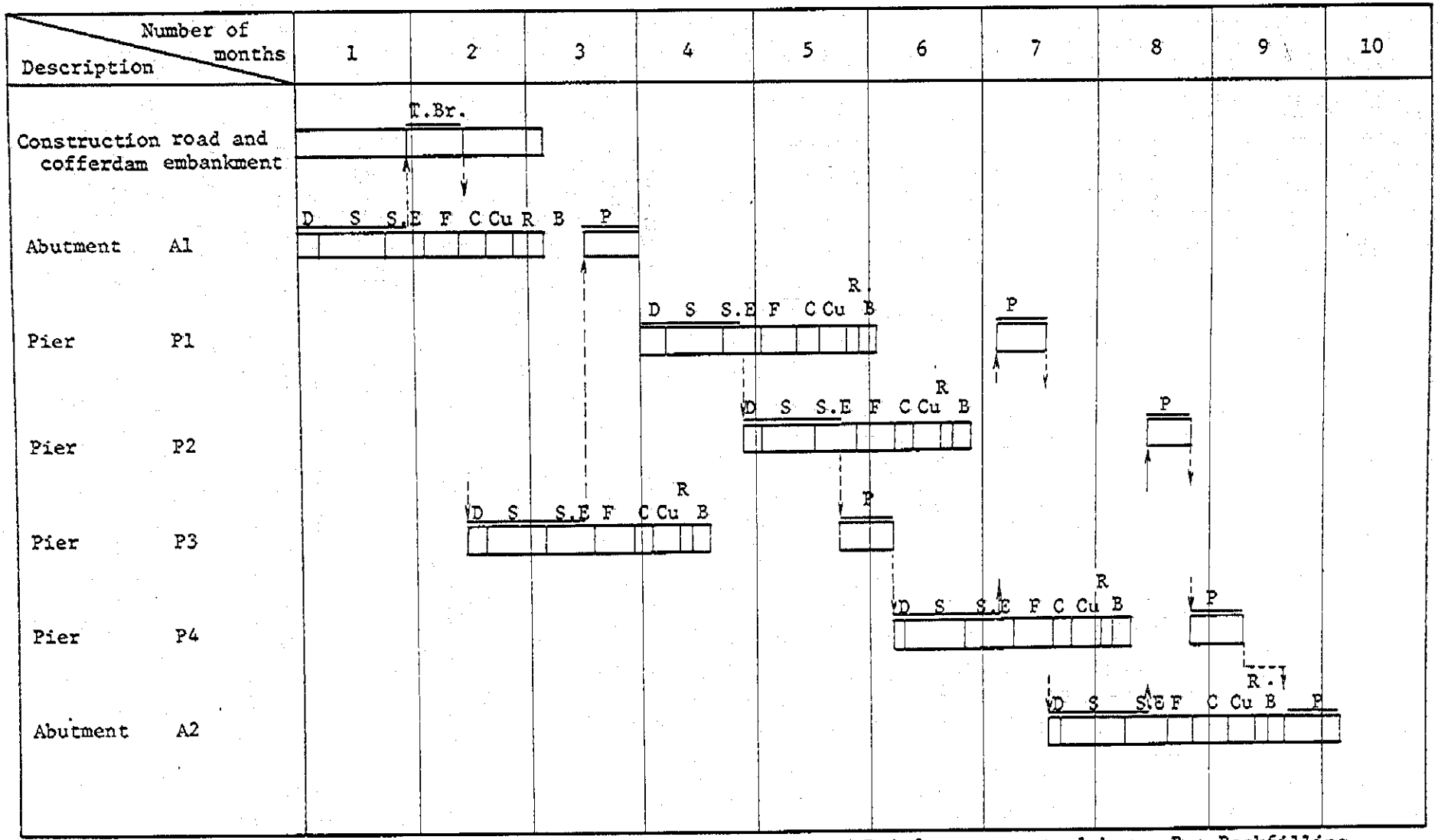
(a) : Temporary path for pedestrians

(b) : Construction Road

(c) : Cofferdam Embankment

CROSS SECTION

Fig. 3-2 CONSTRUCTION ROAD AND COFFERDAM EMBANKMENT



Note : T.Br : Temporary bridge
D : Driving pile
S : Shuttering
S.E. : Structure excavation
F : Form work and Assembling of Reinforcement steel bar
C : Placing Concrete
Cu: Curing
St: Removable of form
B : Backfilling
P : Pulling out sheet piles
→ : Work flow of crawler crane

Fig. 3-3 WORK SHEDULE FOR SUBSTRUCTURES

3-3 Roadway Work

3-3-1 Staged Construction of Road

(1) Stage Construction Method

To keep the public traffic free even during construction, road work shall be carried out by the stage construction method so that the road work is accomplished in parts within the roadway cross section.

When one carriageway is finished, public traffic is switched to the newly completed carriageway, leaving the original carriageway for a work area.

By repeating this work process, the entire roadway work is completed.

The stage construction method is illustrated in Figure 3-4.

Work quantities for each stage were calculated as shown in Table 3-2.

The construction period for each stage was calculated, based on the work quantities at each stage and work capacity mentioned in sections 3-3-2 and 3-3-3.

In the estimation of the construction period, drainage works, structure works and subsidiary works were taken into consideration.

As a result, the construction period for each stage was obtained as follows:

1st Stage and 2nd Stage	6.5 months
3rd Stage	3.5 months
4th Stage and 5th Stage	3.5 months

(2) Traffic Control

When work is carried out in or around the construction site of the roadway expansion, necessary measures shall be taken to public vehicles to pass through the construction site without much difficulty or danger.

For the safety of public vehicles during the construction period, construction notice boards, warning sign boards, direction sign boards, detour sign boards, dead end sign boards, barricades,

safety cones and security lights shall be furnished, located and arranged on the construction sites.
Sign boards shall be easily visible from a distance in order to maintain a smooth traffic flow.

Traffic controllers and watchmen will be posted around and at the construction site. Special care will be required and taken at junctions. Adequate drainage will also be provided to maintain the roadway in good condition.
As for the traffic related to the construction Project, special care must be paid to the followings:

a) The traffic regulations in force and the contractual reqirements shall be strictly complied with.

b) Prior permission shall be obtained from the authorities concerned for transport of extra heavy items and or exceptionally large cargoes.

3-3-2 Earth Work

(1) Work Quantity

Quantities of Earth Work are summarized as follows:

Work Quantity

Description	Unit	Quantity
Clearing	m^2	27,260
Waste excavation	m^3	230
Side-borrow embankment	"	3,180
Borrow-pit embankment	"	420
Improved subgrade	"	920

(2) Construction Equipment and Capacity

The Construction equipment to be used for the Earth Work and their respective capacities are as follows:

Construction Equipment

Work Item	Equipment	Model	Work	Number	Capacity
Clearing	Bulldozer	11t		1	120 m^2/hr
Embankment side-borrow	Bulldozer	11t	dozing	1	35 m^3/hr
	Tractor shovel	1.0 m^3	loading	1	45 m^3/hr
	Dump truck	8t	hauling	3	15 m^3/hr
	Bulldozer	11t	spreading, compacting	1	40 m^3/hr
Embankment borrow-pit	Tractor shovel	1.3 m^3	excavation, loading	1	20 m^3/hr
	Dump truck	8 t	hauling	3	8 m^3/hr
	motor grader	3.1m	spreading	1	360 m^2/hr
	Tyre roller	15-28t	compaction	1	480 m^2/hr

(3) Work Capacity

Probable work capacities of each Earth Work are as follows:

Probable Earth Work Capacity

Description	Unit	Per Hour	Per Month
Clearing	m^2	120	15,120
Waste excavation	m^3	35	4,410
Side-borrow embankment	"	35	4,410
Borrow-pit embankment	"	20	2,520
Improved subgrade	"	20	2,520

(4) Working Method

a) Clearing and Grubbing

Clearing shall be done by a bulldozer and labourers Excavated soil including roots and obstructions shall be transported to a spoil bank area and discarded.

b) Excavation and Embankment

The working method will vary according to the hauling distance.

At short hauling distance, excavation and dozing shall be done by a bulldozer. In case hauling distance is more than 90m, a bulldozer, a tractor shovel and dump trucks shall be used for excavation, loading and hauling, respectively.

A spoil bank area and borrow-pit shall be recommended about 2km from the site. Spreading and initial compaction shall be done by a bulldozer. A tyre roller shall be used for compaction. A motor grader shall be used for spreading, compacting and shaping.

3-3-3 Pavement Work

(1) Crusher-run Subbase Course and Grading Controlled Base Course

a) Materials

Aggregates for subbase course and base course shall respectively meet the following grading requirements.

Crusher-run Subbase Course

Sieve (mm)	50	40	20	5	2.5
Percentage by weight passing	100	95-100	50-80	15-40	5-25

Grading Controlled Base Course

Sieve (mm)	50	40	20	5	2.5	0.4	0.74
Percentage by weight passing	100	95-100	60-90	30-65	20-50	10-30	2-10

b) Construction Equipment

Construction equipment for the execution of subbase course and base course are as follows:

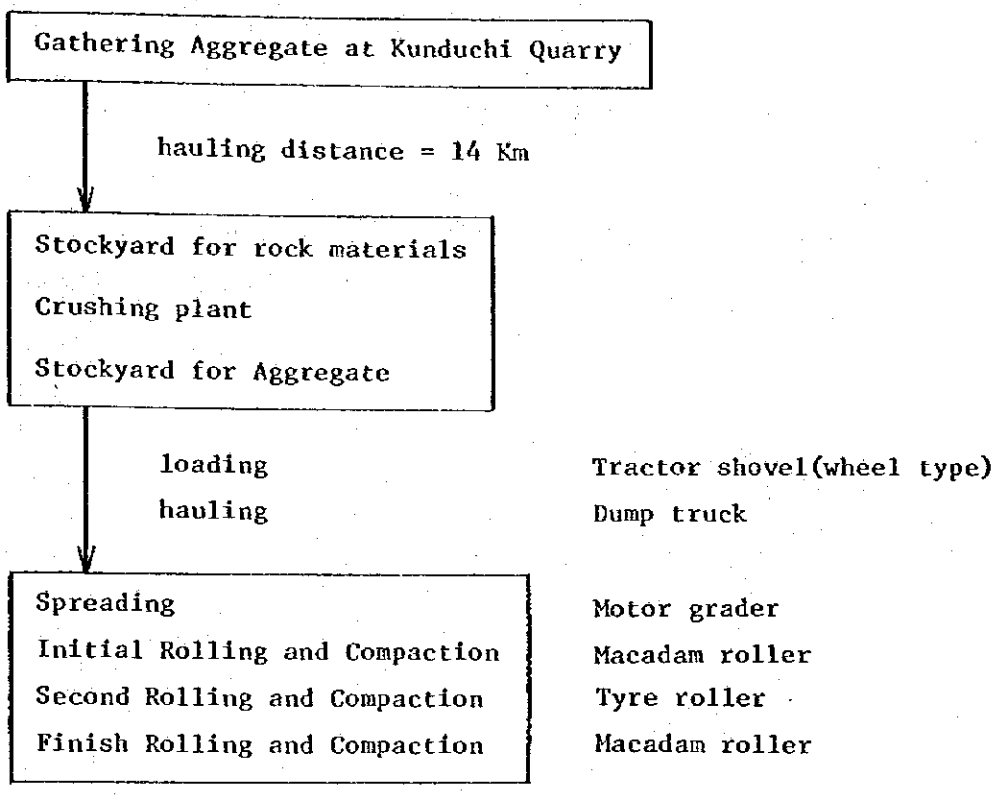
Construction Equipment

Equipment	Model	Number	Capacity
Motor grader	3.1m	1	360 m^2/hr
Macadam roller	12 - 15 tons	1	520 "
Tyre roller	12 - 28 tons	1	480 "
Vibrating roller	2.5 ton	1	210 "
Soil compactor	1.6 ton	1	-
Tractor shovel	1.3 m^3	1	240 "
Dump truck	8 tons	5	9.2 m^3/hr
Water truck	5,500 ℓ	1	7,600 ℓ/hr

c) Working Method

Material shall be transported to the working site by dump trucks from stockyards for aggregate, and spread and leveled by a motor grader. Spread material shall be uniformly compacted to the density in accordance with the provision of the Specifications. Material shall be kept and adjusted at optimum moisture content for satisfactory compaction by a water truck. Initial rolling is performed with a macadam roller. A tyre roller is used following the completion of initial rolling. Finish rolling shall be done by a macadam roller. The finished surface shall be true to the required grade and level.

The work diagram is as follows :



d) Work Capacity

Work quantity and work capacity are summarized as follows:

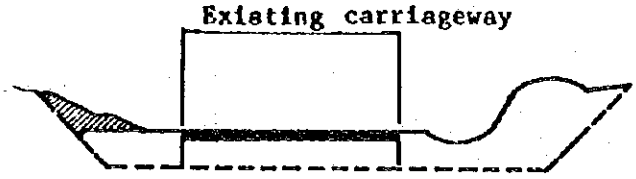
Work Quantity

Description	Work Quantity m^2	Probable output m^2/hour	Probable output m^2/month
Crusher-run subbase course (t=15cm)	18,500	240	30,240
Grading controlled base course (t=15cm)	19,400	240	30,240

ROAD WORK

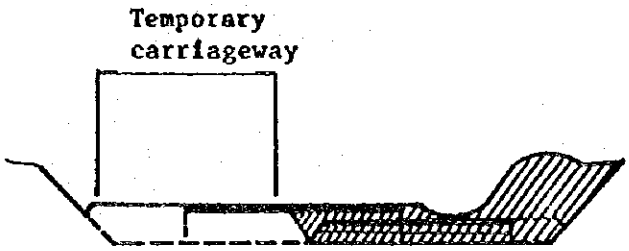
1st Stage

Expand width of existing carriageway



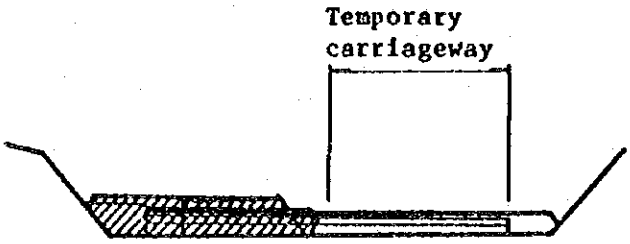
2nd Stage

Earth work is excuted to the required level. Following completion of it, subbase course and base course are carried out



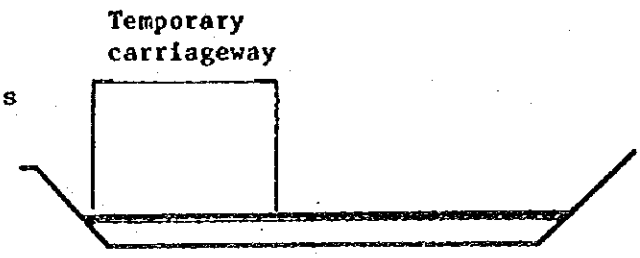
3rd Stage

Earth work and pavement work are carried out including some asphaltic concrete surface course.



4th Stage

The remaining asphaltic concrete surface course is excuted



5th Stage

The work at junctions and around traffic islands is executed.

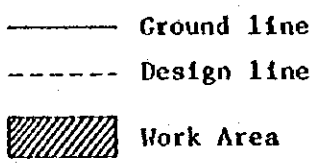


Fig. 3-4 WORK DIAGRAM OF HALF WIDTH STAGED CONSTRUCTION OF ROAD WORKS

Table 3-2 WORK QUANTITIES AT EACH STAGE

Description	Unit	Approx. Quantity per stage 1st and 2nd	3rd	4th	5th	Total
Earch work						
(Excavation)	m^3	(3,160)	(790)	-	-	(3,950)
(Embankment)	m^3	(8,600)	(870)	(2,400)	-	(11,870)
Clearing	m^2	21,810	5450	-	-	27,260
Waste excavation	m^3	230	-	-	-	230
Side-borrow embankment	m^3	2,640	530	(180)	-	3,350
Borrow-pit embankment	m^3	5,400	-	2,200	-	7,600
Improved subgrade	m^3	570	340	100	20	1,030
Pavement work						
Crusher-run subbase course (t=15cm)	m^2	10,070	6,190	1,830	410	18,500
Grading controlled Base course (t=15cm)	m^2	10,400	6,760	1,780	440	19,380
Asphaltic concrete Binder course (t=5cm)	m2	9,840	7,210	2,180	390	19,620
Asphaltic concrete Surface course (t=5cm)	m2	-	9,100	9,360	2,340	20,800

(2) Asphaltic Concrete Binder Course and Surface Course

a) Materials

Asphalt Penetration type 60 - 80

Aggregate Production of aggregate is mentioned in section 3-4.

Asphaltic Concrete Binder Course (t=5cm)

Aggregate quarry at Kunduchi

Grading

Sieve (mm)	25	20	13	5	2.5	0.6	0.3	0.15	0.074
Percentage by weight passing	100	95 ~ 100	70 ~ 90	35 ~ 55	20 ~ 35	11 ~ 23	5 ~ 16	4 ~ 12	2 ~ 7

Asphaltic Concrete Surface Course (t=5cm)

Aggregate quarry at Msorwa

Grading

Sieve (mm)	20	13	5	2.5	0.6	0.3	0.15	0.074
Percentage by weight passing	100	95 ~ 100	55 ~ 70	35 ~ 50	18 ~ 30	10 ~ 21	6 ~ 16	4 ~ 8

b) Construction Equipment

Construction equipment for the execution of binder course and surface course are as follows:

Equipment	Model	Number	Capacity
Asphalt plant	45 tons/hour	1	45 tons/hour
Asphalt finisher	2.4 m	1	400 m^2/hour
Macadam roller	12-18 tons	1	520 m^2/hour
Tyre roller	22-28 tons	1	600 m^2/hour
Soil compactor	1.6 t	1	
Dump truck	8 tons	4	14.1 tons/hour
Engine sprayer	200 ℓ	1	

c) Working Method

Asphaltic mixtures shall be produced at the asphalt plant. The mix proportion shall be determined by trial mixing and the results in prior runs used to carry out production.

Asphaltic mixtures shall be transported by dump trucks. The inner faces of loading beds should be lubricated with a small quantity of light oil. An asphalt finisher shall be used for paving. Flatness is the most important factor for this work and thickness and level are all controlled using an automatic screen.
A macadam roller shall be used as initial rolling compaction, a tyre roller shall be used as second, and the macadam roller shall be used also as final compaction instead of a tamdem roller. In narrow places where above mentioned equipment could not be used, a soil compactor shall be used.

The construction joint of pavement shall be tacked with cutback-asphalt to increase adhesion.

To keep the flatness of the joint, an asphalt finisher shall be used.

After placing, rakers shall be used for correcting the flatness. Moreover, a macadam roller shall be used as a final rolling compaction.

Before spreading a new mixture, previously rolled materials shall be cut and trimmed to make the vertical edge of the joint.

d) Asphalt Plant

Amount of asphaltic mixtures

Asphaltic concrete binder course t=5cm	2,310 tons
Asphaltic concrete surface course t=5cm	2,580 tons
Asphaltic concrete surface course t=3cm	5 tons
Total	4,895 tons

Capacity of Asphalt plant to be required is calculated follows.

$$C = \frac{Q \times f}{T \times P \times t} = \frac{4895 \times 1.2}{60 \times 0.7 \times 6} = 23.3/hr$$

f : Allowance P : Factor

Q : Asphalt mixture (ton) t : Working hours per day

T : Number of Work days

Paving work of asphaltic mixtures should be carried out as continuously as possible and the asphalt plant should have a surplus capacity of production. Therefore a 45-tons/hour asphalt plant shall be used for this project.

Asphalt plant	45-tons/hour
Plant area	about 4,000 m^2
Total driving power	about 90 KWH

e) Work Capacity

Work quantities and work capacity are summarized as follows :

Description	Quantity m^2	Probable output m^2/hour	m^2/month
Asphaltic concrete binder course	19,620	400	50,400
Asphaltic concrete surface course	20,800	400	50,400

Working diagram

Dump truck——Asphalt finisher——Macadam roller——Tyre roller——— Macadam roller

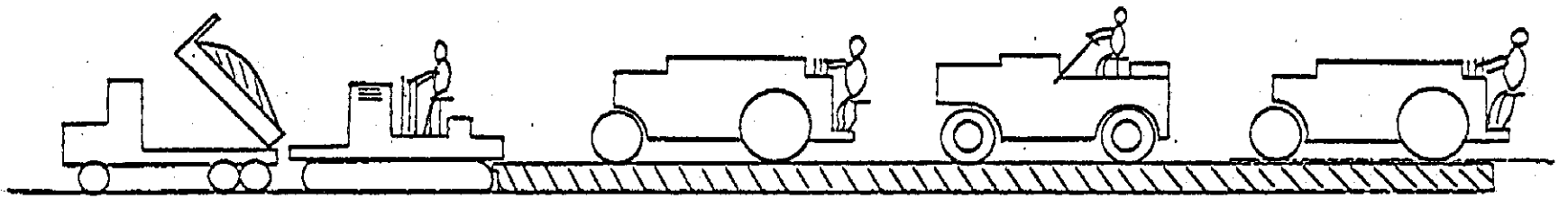


Fig. 3-5 DIAGRAM OF ASPHALTIC CONCRETE WORK

3-3-4 Concrete Work

(1) Quantity of Concrete

Concrete volumes used for the total works of the Project are summarized as follows:

Description	Classification	Quantity (m^3)
Concrete Class A for superstructure of bridge	A	1,000
Concrete Class B for substructure of bridge	B_1	620
Concrete Class D for leveling concrete	D	40
Kerb	A	70
Culvert	B_2	60
Catch basin and head wall	C	20
Ditch (kerb, cover, channel)	A, B_2, C	440
Foundation of traffic facilities	C	90
Slope protection (Rock riprap)	D	70
Total		2,410

(2) Equipment for Concrete Work

The equipment used for concrete works are as follows:

Equipment	Model	Number	Remarks
Concrete mixer	0.3 m^3	3	Probable output 3m^3/hr
Portable vibrator		3	
Hand cart		12	
Truck	2 tons	2	
Water tank	1 m^3	3	

(3) Materials

Rock materials for coarse aggregate shall be procured at Msorwa quarry about 130 km from the Project site. The road materials shall be transported from the quarry site to the crushing plant yard near the Project site by trucks.

Fine aggregate shall be gathered at the river deposit of the Mpiji river. All aggregates shall be stored in stockyards for aggregates and must be kept clean. Cement packed in paper bags shall be used and stored at warehouses for cement having storing capacity half a month at least. The amount of cement required is about 1,140 tons. Special attention shall be exercised to drain the storage site.

(4) Classification of Concrete

Concrete is classified as follows:

Class	Compressive Strength at 28 days (kg/cm^2)	Maximum size of Aggregates	Remarks
A	240	25	Ordinary Portland Cement
B_1	210	40	"
B_2	210	25	"
C	160	40	"
D	135	40	"

(5) Working Method

Mixing concrete shall be performed with three portable mixers. Concrete shall be transported and placed by hand carts and compacted by portable vibrators. Concrete products which can be standardized, (kerb, ditches, cover of ditches) shall be produced at places near the stockyards for aggregate.

Special attention shall be exercised for concrete not to have it affected directly by sunshine or weather. Concrete shall also be placed within 1 hour after mixing.

Segregation of the concrete is undesirable. Inclined chutes shall be used to avoid undersirable segregation of concrete due to dropping of the mass from a great height. During curing time, vinyl sheets shall be used for covering the surface of concrete to prevent exposure by sunshine directly upon it. Water tanks or a water truck shall be provided to sprinkle water for curing.

Plywood or wooden forms which can easily assembled or removed shall be used for placing the concrete of the bridge work, catch basin and other structures where concrete shall be cast in place.

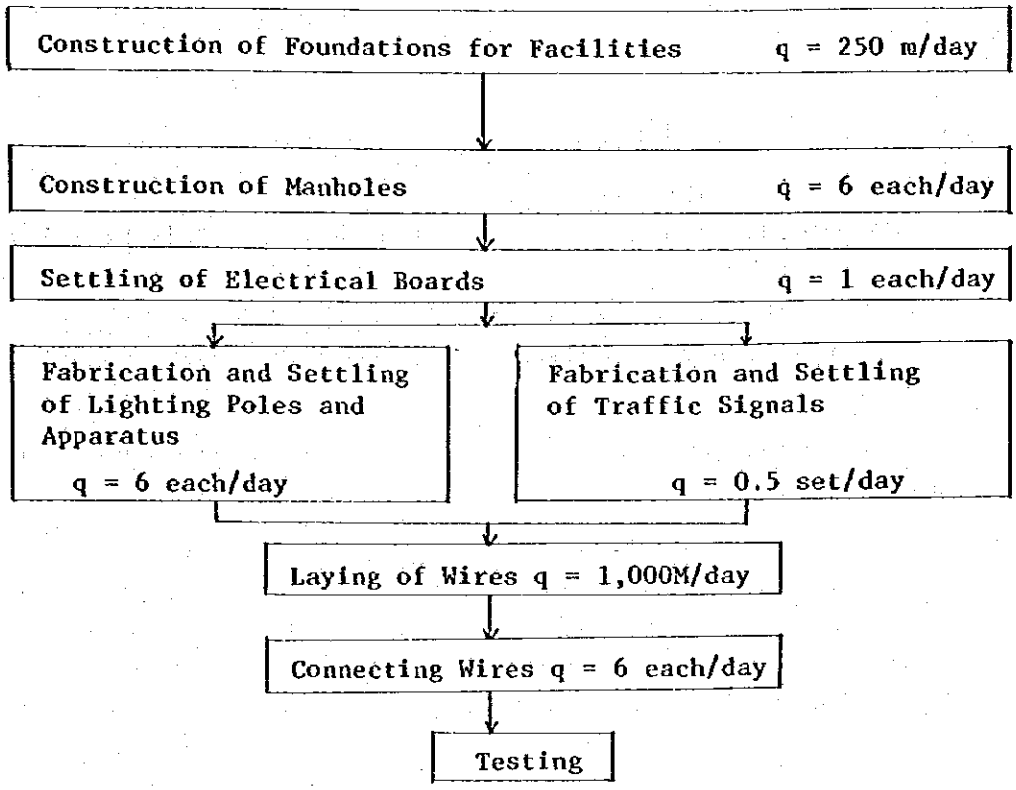
Forms for concrete products not to be cast in place or to be produced at the place before-mentioned, shall be recommended to use metal forms.

Lublicant shall be applied to the inside of the form to make concrete finish neatly and allow removal of the form easily. Care shall be exercised not to impact the finished concrete.

3-3-5 Traffic Safety Facilities

Traffic signals and lighting facilities shall conform to the requirements specified in Technical Specifications.

A working diagram and probable daily work performance is shown as follows.



Note: q : probable output per day

However, wires which should be located under the carriageway or across the road shall be laid before the pavement works.

3-4 Aggregates for the Project

3-4-1 Coarse Aggregates

Coarse aggregates for cement concrete structures and pavement works shall be produced by crushing plants which are planned to be installed at designated yards, about north of the Project area.

Two kinds of rock materials shall be used for the above mentioned works. Rock material quarried at Msorwa shall be used for asphaltic concrete surface course and cement concrete structures only. The other material quarried at Kunduchi shall be used for subbase course, base course, asphaltic concrete binder course and other purposes.

(1) Required Quantities

Asphaltic concrete surface course Cement concrete structures	Approx. 4,600 tons
Crusher-run subbase course Grading controlled base course Asphaltic concrete binder course etc.	Approx. 11,150 tons
Total	15,750 tons

(2) Production/Consumption Schedule

Aggregate production shall commence following the completion of installing the aggregate crushing plant and test operation. Based on the working schedule, consumption schedule and production schedule of crushed stone for coarse aggregates are assumed as shown in Table 3-3.

(3) Capacity of Aggregate Plant

Monthly maximum production of crushed stone to be required is assumed from figure as follows:

Aggregate of Msorwa Quarry	:	Approx. 450 tons/month
" of Kunduchi "	:	Approx. 1,000 tons/month

As the maximum productions mentioned above fall roughly at the same time, the required maximum production per month is a summation of both productions and is adopted as 1,450 tons/month.

The hourly production capacity of the plant is obtained by the following formula.

$$Q = \frac{P\ (1+\ell)}{H \cdot D}$$

where, Q : Hourly production capacity (tons/hr)
P : Required monthly maximum production (tons/month)
ℓ : Handling loss coefficient (ℓ= 10%)
H : Operation hours per day (H = 6 hrs)
D : Working days a month (D = 21 days)

Substituting the values in the above formula, hourly production capacity was calculated as 12.7 tons/hr

$$Q = \frac{1450 \times (1 + 0.10)}{6 \times 21} = 12.7 \text{ tons/hr}$$

(4) Aggregate Crushing Plant

An aggregate crushing plant with production capacity of 30 tons/hr shall be provided for this Project. Grading distribution shall be done in accordance with each work specified in the Specifications. The required sieves are 40mm, 25.7mm, 12.7mm, 4.8mm and 2.5mm. Operation period of aggregate crushing plant is assumed as 13 months, based on the production schedule in Table 3-3.

(5) Rock Material

Explosives shall be used to get rock materials. Jack hammers shall be used for drilling and cutting. Blasting method and planning shall be done so that fragments after blasting will be small in order to crush easily. For gathering and loading, a bulldozer with ripper and a tractor shovel (crawler type) shall be used. Rock materials shall be transported to storage at the place of crushing plant nearby.

For blasting work, the contractor shall submit planning of blasting work to the Engineer prior to commencement of works. When blasting work shall be carried out, special care shall be exercised to avoid any Flying fragments.

The quantity of rock materials to be quarried is estimated below after considering handling losses and effectiveness of production for aggregates. The production coefficient is assumed at 1.65.

a) Rock material at Msorwa

Amount of rock material required Approx. 7,600 tons
Maximum quantity to be transported per month 750 tons

$$750 \text{ tons} \div 1.6 \text{ tons/m}^3 = 470 \text{ m}^3$$

b) Rock material at Kunduchi

Quantity required Approx. 18,400 tons
Maximum quantity to be transported per month 1,650 tons

$$1,670 \text{ tons} \div 1.6 \text{ tons/m}^3 = 1,050 \text{ m}^3.$$

3-4-2 Fine Aggregate

(1) Material

Fine aggregate for the Project shall be taken from the river deposit in the Mpiji river, about 40 kms north of the Project site.

(2) Required Quantity

Required quantities of fine aggregate are as follows:

Pavement works	:	Approx. 5,190 tons
Concrete structure works	:	Approx. 1,830 tons
Total		7,020 tons

(3) Consumption/Supply Schedule

The consumption and supply schedule of fine aggregate is shown in Table 3-4. In table 3-4, the required monthly maximum quantity of fine aggregate is obtained as 610 tons.

(4) Amount of Material

Amount of river deposit to be quarried were calculated taking the loss ratio of 20% at quarry site and stockyard.

Amount of river deposit to be quarried	Approx. 8,700 tons
Maximum quantity to be transported per month	740 tons
	470 m^3

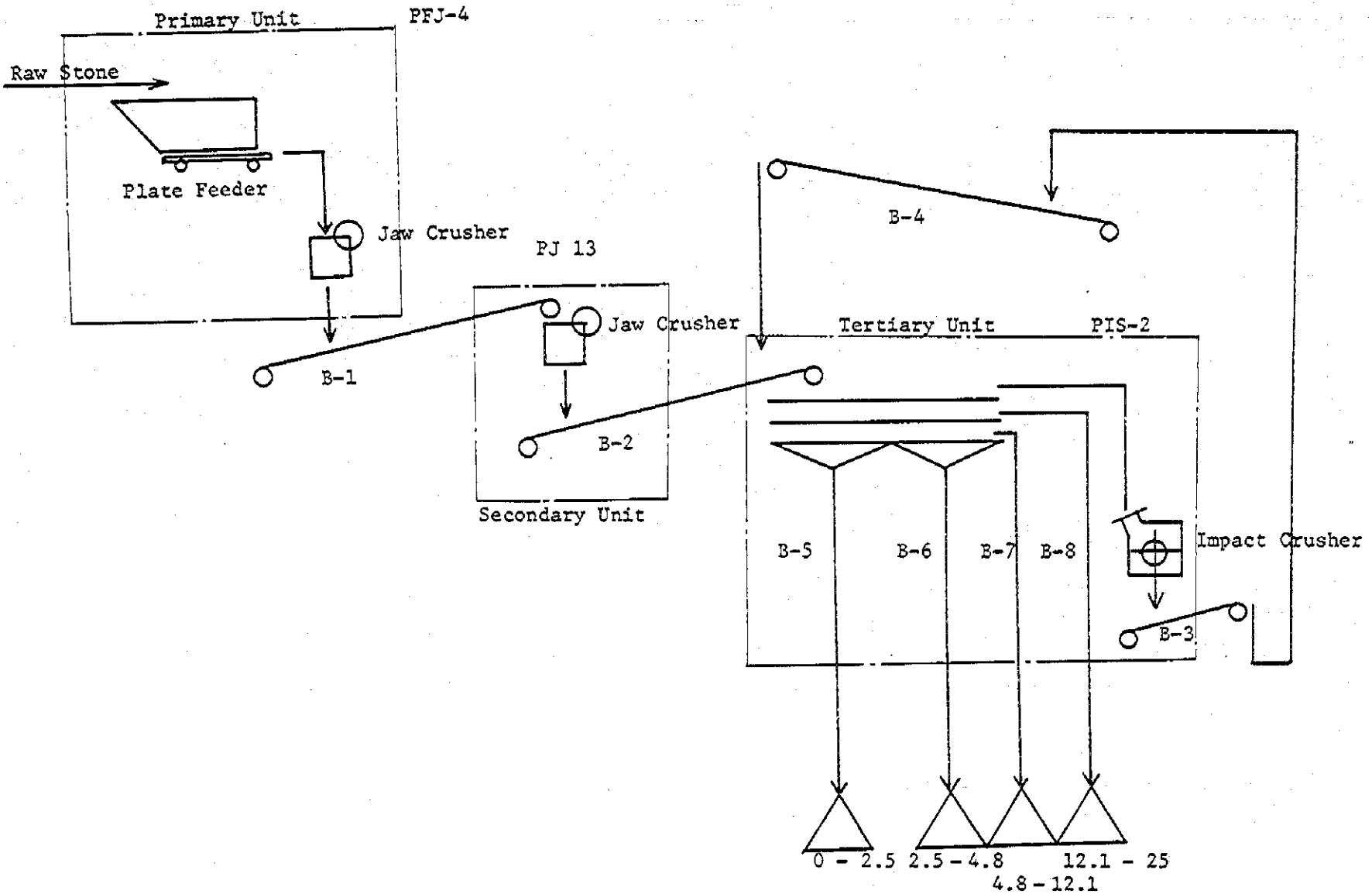


Fig. 3-6 AGGREGATE CRUSHING PLANT

Table 3-3 CONSUMPTION SCHEDULE AND PRODUCTION SCHEDULE OF COARSE AGGREGATES

Work and Quantity	Crushed stone (Unit=ton)	1980				1981												1982		
		9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
Material from Msorwa Quarry																				
Concrete work																				
Bridge Superstructure 1,000.0 m3	1,140														680			460		
Substructure 660.0 m3	850						200	120		90	110	120		210						
Drainage work 590.0 m3	730					40	70	70	70	70	70	70	70	70	70	60				
Slope protection and miscellaneous 160.0 m3	210							50		50	30	30		50						
(Sub-total)	(2,930)																			
Pavement work																				
Asphaltic concrete surface course (t=5cm) 20,800.0 m2	1,670															740	680		250	
Asphaltic concrete surface course (t=3cm) 75.7 m2	(3.4) 1,650																			
Total	4,600					40	270	240	70	210	210	220	70	330	750	800	680	460	250	
						40	290	550	620	830	1040	1260	1330	1660	2410	3210	3890	4350	4600	
Material form Kundochi Quarry																				
.Pavement work																				
Crusher-run subbase course 18,500.0 m2	4,350								1580	790				1460				520		
Grading controlled base course 19,390.0 m2	4,560										1630				1590			520		
Asphaltic concrete binder course 19,620.0 m2	1,010											510			370			130		
Sidewalk pavement & others	1,230												620			610				
Total	11,150								1580	1610	1630	510	620	1460	1960	610		1170		
									1580	3190	4820	5330	5950	7410	9370	9980		11150		
Consumption schedule	15,750					40	270	240	1650	1820	1840	730	690	1790	2710	1410	680	1630	250	
						40	310	550	2200	4020	5860	6590	7280	9070	11780	13190	13870	15500	15750	
Production schedule		1300	1300	1300	1300	1300	1300	1300	1450	1450	1450	1050	1000	250						
		1300	2600	3900	5200	6500	7800	9100	10550	12000	13450	14500	15500	15750						

Table 3-4 CONSUMPTION AND SUPPLY SCHEDULE OF FINE AGGREGATE

		1980				1981													1982		
		9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	
Concrete works																					
Bridge Superstructure 1,000 m3	770														460			310			
Substructure 660.0 m3	510						120	70		60	60	60		140							
Drainage work 590 m3	430					30	40	40	40	40	40	40	40	40	40	40					
Slope protection and miscellaneous 160 m3	120							30		20	20	20		30							
Pavement work																					
Asphaltic concrete surface course (t=5cm) 21,940 m2	510															230	200		80		
Asphaltic concrete surface course (t=3cm) 75.7 m2	(1.4)																				
Sub-total	2,340					30	160	140	40	120	120	120	40	210	500	270	200	310	80		
Pavement work																					
Crusher-run subbase course (t=15cm) 18,500 m2	1,810								640	320				610				240			
Grading controlled base course (t=15cm) 19,390 m2	1,900									340	680				660			220			
Asphaltic concrete binder course (t=5cm) 19,620 m2	460											230			170			60			
Sidewalk pavement & others	510												260			250					
Sub-total	4,680								640	660	680	230	260	610	830	250		520			
Total	7,020																				
Consumption schedule	7,020					30	160	140	680	780	800	350	300	820	1330	520	200	830	80		
							190	330	1010	1790	2590	2940	3240	4060	5390	5910	6110	6940	7020		
Production schedule	7,020					600	600	600	600	600	600	600	600	600	600	500	500	20			
						600	1700	1800	2400	3000	3600	4200	4800	5400	6000	6500	7000	7020			

3-5 Construction Equipment

The major construction equipment employed in the Project are as follows:

Equipment	Model	Number	Remarks
Bulldozer	11 tons	1	
"	21 tons	1	Ripper
Tractor shovel	1.3 m^3	1	Wheel type
"	1.0 m^3	1	"
"	1.4 m^3	2	Crawler type
Crane	35 HP	1	Crawler type
Clamshell	0.3 m^3	1	Attachment only
Diesel pile hammer	ram= 3.5 tons	1	
Vibrating hammer	22 KW	1	
Leader	ℓ= 20m	1	Piling
Welding machine	13 KW	1	
Motor grader	3.1 m	1	
Macadam roller	10∿15 tons	1	
Tyre roller	25∿28 tons	1	
Vibrating roller	2.5 ton	1	
Asphalt finisher	2.5 m	1	
Engine sprayer	200 ℓ	1	
Soil compactor	1.6 t	1	
Concrete mixer	0.3 m^3	3	Portalbe type
Ashpalt plant	45 t/hr	1	
Aggregate crushing plant	30 t/hr	1	
Jack hammer	3 m^3/min	10	
Hand breaker	15 kg	2	
Diesel generator	25 KVA	2	
	100KVA	1	
Air compressor	37 KW	2	
	100KW	1	
Vibrator	ϕ 60mm	3	Engine
Water pump	13 KW	6	
Water tank	1 m^3	6	

(continued)

Equipment	Model	Number	Remarks
Water truck	1,600	1	
Dump truck	8 t	4	
	11 t	7	
Truck	2 t	2