APPENDIX TO GENERAL SPECIFICATIONS

APPENDIX I : SPECIFICATIONS OF BATCHER PLANT

I. Main Specifications

(1)	Type	:	Unit type fully automatic batcher plant
(2)	Mixer capacity	:	not less than 750 lit.
(3)	Production capacity of homogeneous fresh concrete	:	not less than 40 m^3/hour
(4)	Maximum size of crushed aggregates usable	:	ø 80 mm
(5)	Scraper output	:	60 m^3/hour (by hand operation)
(6)	Batching control method	:	Ten key presetting, electronic automatic weighing
(7)	Power source	:	200 V, 50 Hz
(8)	Weighing instrument/device		

Material	Dial scale	Accuracy
Sand	100 kg/5 kg	Within ±3%
Cement	350 kg/1 kg	Within ±1%
Water	250 kg/1 kg	Within ±1%
Additive agent	60 kg/20 kg	Within ±3%

II. Specifications of parts

1. Mixing unit

1-1	Mixer		:	One (1) set
	(1)	Type	:	Stationary horizontal shaft mixer of counterflow forced agitating system
	(2)	Agitating speed	:	19.5 rpm
	(3)	Electric motor	:	22 kW x 4p, totally enclosed fan and cooled type geared motor
	(4)	Lining and paddle	:	JIS FCMW 38, lining 12 mm, paddle 25 mm
	(5)	Discharge	:	Mixer bottom part will be opened or closed by air cylinder. Discharge will be completed in 8 seconds.
	(6)	Lubrication	:	Automatic feeding of main bearing part
1-2	Concrete hopper (1.5 m^3)		:	One (1) set
	(1)	Type	:	Square shaped with a round outlet and rubber gate bottom part opened or closed by air cylinder.
	(2)	Steel plate	:	6 mm lining
	(3)	Vibrator	:	250 W-1

1-3 Automatic batching control board : One (1) set

(1)	Type	:	Stationary type with operating desk
(2)	Control device	:	Punch card system full automatic electronic control
(3)	Measuring elements	:	1 kind of gravel, 2 kinds of gravel cumulative, 1 kind of sand, cement and additive agent each 2 kinds selectable, water 1 kind
(4)	Moisture compensation	:	Sand-water 15%
(5)	Change of volume	:	0.75 m^3, and 0.5 m^3
(6)	Circuit	:	Timer preset of charge and mixing. Mis-action will be avoided by an interlocking circuit.
(7)	Manual control circuit	:	An individual operation of weighing or discharging will be done by a change - over switch.

1-4 Motor circuit board : One (1) set

(1)	Type	:	Stationary type
(2)	Power source to be used	:	3-phase, 200 V, 50Hz
(3)	Switching apparatus	:	Cubicle type provided with main switch, electro-magnetic switches and relays, etc., which are required for the automatic operation of mixer and skip, and with included leak breaker.

1-5 Unit frame and batching control cabin : One (1) set

(1)	Type	:	Shaped steel construction of box type
(2)	Dimensions	:	Width 2.32 m x height 2.5 m. x length 8.75 m
(3)	Control cabin	:	The inside of the frame its partitioned for the cabin. It is equipped with wide view windows, one (1) steel door and one (1) ventilating fan.
(4)	Main unit	:	Sturdy box frame of welded section steel construction, wherein mixer and control cabin equipped with each control board are arranged. On the central part at an incline of 70°, the guide rails for the skip is mounted. By placing another unit upon the main unit and joining them together, the plant body is formed. (A rain cover or a roof is not attached except to the control cabin. Heat insulator at the back of the steel plate is as per special specification)

1-6 Charging chute : One (1) set
with cement dust preventing damper

2. Batching unit

2-1 Cement weigher : One (1) set

(1) Dial scale : 350kg x 1kg, having an accuracy of 1/350

(2) Type : Single pendulum type, 300° dial indication

(3) Gate closing : Cone gate actuated by air cylinder

(4) device : COVP-N-09CB- Z75 x 100st

(5) Weighing accuracy : ± 1%

2-2 Water weigher : One (1) set

(1) Dial scale : 250kg x 1kg, accuracy 1/250

(2) Type : Single pendulum type, 300° dial indication

(3) Water supply : Solenoid valve 2", PVS–50A–210
Fine feed valve 3/4" AD11–20A 1 pc. respectively

(4) Water discharge : Cell cylinder COV–03CB–50x50st
Flat Valve Z175

(5) Weighing accuracy : ± 1%

2-3 Weigher for additive agent : One (1) set

(1) Dial scale : 6kg x 20g, accuracy 1/300
With protecting device against overweighing

(2) Type : Single pendulum type, 300° dial indication

(3) Feel in : Solenoid valve 1" cylinder valve
CVS –25A –25SWK -2sets

(4) Discharge : Cell cylinder
CKV-FA-32-50

(5) Weighing accuracy : ± 3%

2-4 Winch unit for hoisting an aggregate skip : One (1) set

(1) Skip capacity : 1,500 lit.

(2) Hoisting force : 2,100 kg

(3) Electric motor : 15 kW x 4P, totally –enclosed fan –cooled type geared motor with brake

(4) Wire rope : ø16, 6xFi (29) – 38 m long

(5) Hoisting speed : 0.52 m/sec, taking 22 secs. between above and below

2-5 Unit frame

Type	:	Shaped steel construction of box type
Dimensions	:	Width 2.32m x height 2.45m x length 8.0m
Roof	:	2.3 mm thick Steel plate
Main unit	:	Batching unit is sturdy box frame of welded section

2-6 Factory assembly

3. Stand, legs, guide rails

Stand & legs	:	Welded H-shaped steel construction
Guide rails	:	Mounted at an incline of 70° in parallel with the stand brace
Lower guide	:	Guide rails outside the stand are to be detached separately rails

4. Gangway & stairs

Gangway	:	Brackets are bolted around each unit and handrail is attached to the 600 mm wide gangway. A gangway to inspect the surroundings of scraper is provided also.			
Stairs	:	To mixing unit	:	Two sets of 600 mm wide stairs with an intermediate landing	
		To batching unit	:	600 mm stairs	1
		To rooftop	:	Gangway ladder	1

5. Aggregate weighing device : One (1) set

Type	:	Single pendulum type, 300° dial indication			
Weigh bin	:	1 set for gravel 1, 1 set for sand Capacity; Gravel 1,100 lit., Sand 1,100 lit.			
Gravel weigher	:	Dial scale 1200kg x 5kg ;			1 set
Sand weigher	:	Dial scale 1000kg x 5kg ;			1 set
Fed gate	:	For gravel	;	300mm x 325mm ;	2
		For sand	;	400mm x 325mm ;	1
		(Actuated by air cylinder, with jogging device)			
Discharge	:	Air cylinder, sector gate			
Vibrator	:	For sand 25W–2			

6. Radial scraper stand

Height	:	4.9 m
Division	:	Five division with 6 partition walls.

The body of this stand is of welded section steel construction with 6 mm thick plate, serving as a prop for mounting the radialscraper as well as a grooved post for mounting partition walls which classify aggregates, wooden boards are inserted in the grooves of the above-mentioned post and of the stock yard supports (Wooden boards are 60mm thick which are excluded from our supply) .

7. Radialscraper

Output	:	60 m^3/h
Bucket capacity	:	500 lit.
Boom length	:	13.3 m
Electric motor	:	11 kw x 4P, totally -enclosed fan-cooled type geared motor
Pulling rope	:	Z 146 x Fi (25) – 26 m long
Return rope	:	Z10 6 x Fi (25) – 37 m long
Anchor rope	:	Z106 x Fi (25) – 111 m long
Slewing angle	:	Within 230°
Total weight	:	3800 kg
(Boom suspension type	:	special order)

8. Cement screw conveyor

Output	:	40 t/h in a horizontal position
Drive motor	:	3.7 kw x 4P
Dribble feeding device	:	0.4 kw x 4P with brake, feeding 2 kg/sec

9. Other equipments and installations

9-1 Pneumatic gate closing device : One (1) set

Including 4-way solenoid valves, oilers, regulator, filter, gauge etc. Actuated through a signal transmitted from the automatic preset board a solenoid valve operates an air cylinder.

9-2 Air compressor

Type	:	Reciprocating
Pressure in normal	:	7 kg/cm
Drive motor	:	5.5 kw x 4P
Air tank capacity	:	200 lit.
Protecting cover	:	Sheet iron

9-3 Feed pump

Type	:	High pressure centrifugal pump, caliberΔ 50
Drive motor	:	2.2 kw x 4P, totally –enclosed outer fan type

9-4 Pressure tank

Volume	:	1000 lit.
Max. pressure in normal service	:	4kg/cm
Caliber	:	Inlet ; 2", outlet ; 2"

9-5 Painting : One (1) set

Undercoating with anticorrosive paint once. Finishing paint in standard colour once.

9-6 Agitating tank for additive agent : One (1) set

Capacity 500 lit., geared pump

0.4 kw x 2, including wiring and piping.

9-7 Mounting and test rum : One (1) set

(Dispatch of guide master to outside the country is to be counted in a special outlay, and outside the country transportaition or dispatch of worker is to be counted in exclusion specifications.)

10. Aggregate weigher stand : One (1) set

Aggregate weigher stand is in a body with the skirt of section steel panel, in this case there is no need of a crate when transporting the aggregate weigher, and it can be done together with the stand.

APPENDIX II : SPECIFICATIONS OF AGGREGATE PLANT

1 FEED HOPPER : One (1) set

Heavy-duty, steel feed hopper with min. capacity of $10m^3$.

2 GRIZZLY VIBRATING FEEDER : One (1) set

Heavy-duty grizzly vibrating feeder, 1.0 m x 3.0 m driven by variable-speed 15 kW motor.

3 PRIMARY JAW CRUSHER : One (1) set

Heavy-duty, single toggle jaw type crusher with 36"x24" feed opening, driven by 75 kW, 6P motor.

4 SURGE BIN NO.1 AND FEEDER : One (1) set

Steel surge bin with vibrating pan feeder of 700 mm x 1,500 mm, driven by 0.4 kW x 2 units vibro motors.

5 SECONDARY CRUSHER : One (1) set

Mechanical, spring-loaded type cone crusher having mantle diameter of 40" (1,000 mm), driven by 90 kW, 6P Motor, complete with lubrication unit and water-cooled oil cooler. Construction shall be simple for easy maintenance, therefore hydro cone type shall not be acceptable.

6 TERTIARY CRUSHER : One (1) set

Impact crusher, horizontal shaft type, with rotor size of ø 1,250 mm x 1,050 mm, driven by 110 kW motor. The hammer shall be made of chrominium casting and all the hammer edges shall be serviceable for maximum service life against abrasive rocks. The crushing chamber shall consist of 3-stage repulsion plates (breaker plates) for maximum crushing effect.

7 VIBRATING SCREEN : One (1) set

Inclined vibrating screen 5'x14' for separation of 80 mm and 40 mm sizes, driven by 15 kW motor, equipped with spray bar.

8 VIBRATING SCREEN : One (1) set

Inclined Vibrating screen 5'x10' for separation of 20 mm and 5 mm sizes, driven by 11 kW motor, equipped with spray bar.

9 SURGE BIN NO.2 (SAND) AND FEEDER (OPTION) : One (1) set

Steel surge bin with vibrating pan feeder of 400 mm x 1,200 mm, driven by 0.13 kW x 2 units vibro motors.

10 ROD MILL : One (1) set

Rod mill of 6'x12' driven by 150 kW slip-ring motor, for increased sand production can be offered together with other related equipment as optional equipment.

11 VIBRATING SCREEN : One (1) set

Horizontal vibrating screen, 0.5x1.8 m for separation of 3-5 mm oversize of rod mill product, driven by 2.2 kW.

12 CLASSIFIER : One (1) set

Rotary classifier of ø 3.0 x 6 m drum size.

13 BELT CONVEYORS

Approximate conveyor size shall be as follows :

B1	Jaw crusher to surge bin	600 mm x 20 m	5.5 kW
B2	Surge bin to cone crusher	600 mm x 20 m	5.5 kW
B3	Cone crusher to impact crusher	600 mm x 20 m	5.5 kW
B4	Impact crusher to screens	600 mm x 40 m	11.0 kW
B5	Return from screens	500 mm x 40 m	7.5 kW
B6	Screen to sand surge bin	450 mm x 20 m	1.5 kW
B7	Surge bin to rod mill	350 mm x 18 m	1.0 kW
B8	Surge bin to rod mill	350 mm x 18 m	1.0 kW
B9	Return to surge bin	350 mm x 16 m	1.0 kW
B10	Reject conveyor	500 mm x 10 m	2.2 kW
B11	Product conveyors	450 mm x 15 m	2.2 kW
B12	Product conveyors	450 mm x 15 m	2.2 kW
B13	Product conveyors	450 mm x 15 m	2.2 kW
B14	Product conveyors	450 mm x 15 m	2.2 kW

APPENDIX III : SPECIFICATIONS OF CEMENT SILO

1.	Cement silo	:	One (1) set	
	(1) Type	:	Steel plate division type	
	(2) Storage capacity	:	100 ton	
	(3) Side plate	:	t=4.5mm/t=3.2mm	
	(4) Cone part	:	t=6mm	
	(5) Foot part	:	SGP 250A	
	(6) Main measure	:	Diameter	4000 mm
			Cone part ;	3095 mm
			Cylinder part ;	5800 mm
			Length of foot ;	5200 mm
	(7) Accessories	:	Handrail of roof, Ladder, Manhole, Air vent	
2.	Bucket elevator	:	One (1) set	
	(1) Type	:	Centrifugal discharge type	
	(2) Output	:	40 ton / hour	
	(3) Motor	:	5.5 kw x 4p x 1 /20	
	(4) Bearing box	:	Upper part ;	UCP 316 (ø80)
			Under part ;	UCT 211 (ø50)
	(5) Chain	:	RS 100	
	(6) Wheel	:	RS 100 ;	NT 16 NT 30
	(7) Case measure	:	1,140 mm x 580 mm	
	(8) Bucket capacity	:	0.0047 m^3 (350 long x 150 wide x 160 height)	
	(9) Total length	:	15.5 m	
	(10) Belt speed	:	80 m / min.	
3.	Under screw conveyer	:	Each one (1) set	
	(1) Type	:	Pipe type	
	(2) Output	:	40 ton / hour	
	(3) Motor	:	3.7 kw x 4p x 1 / 10	
	(4) Bearing box	:	UKP 215 + H 2315 (ø 65)	

(5)	Chain	:	RS 100
(6)	Wheel	:	RS 100
(7)	Case measure	:	SGP 10"
(8)	Total length	:	3.0 m
(9)	Transports	:	Cement
(10)	Blade	:	ø 240 x 200P x t 3.2

4. Feed screw conveyer with cement hopper : One (1) set

(1)	Type	:	Pipe Type
(2)	Output	:	40 ton/hour
(3)	Motor	:	3.7 kW x 4P x 1 / 10
(4)	Bearing box	:	UKP 215 + H 2315 (ø 65)
(5)	Chain	:	RS 100
(6)	Wheel	:	RS 100 NT 15 NT 18
(7)	Case measure	:	SGP 10"
(8)	Total length	:	4.0 m
(9)	Transports	:	Cement
(10)	Blade	:	ø 240 x 200p x t 3.2
(11)	Hopper capacity	:	1000 lit. with gangway

5 Rotary feeder : One (1) set

(1)	Type	:	Rotary valve type (6 blade)
(2)	Output	:	40 ton / hour
(3)	Motor	:	0.75 kw x 4p x 1 /30
(4)	Bearing box	:	UKP 207 (ø 65)
(5)	Chain	:	RS 60
(6)	Wheel	:	RS 60 ; NT 15 ; NT 28
(7)	Measure	:	300 x 300 x 420h
(8)	Blade	:	ø 320 x 300 x t = 6
(9)	Transports	:	Cement

6	Emergency gate	:	One (1) set
	(1) Type	:	Hand operation
	(2) Measure	:	300 x 300 x 125h
7	Airration	:	One (1) set
	(1) Power	:	Nozzle and element
	(2) Accessory equipment	:	Solenoid, regulator, air filter and valve
8	Level switch	:	Two (2) sets
	Type	:	C5 - L, long shaft type, L - 500 or the equivalent

APPENDIX IV : LIST OF LABORATORY TESTING EQUIPMENT

Item	Unit	Quantity
CONCRETE TESTING EQUIPMENT		
- Slump Test Set	set	5
- Portable Concrete Mixer,85 liters capacity	set	1
- Cylinder Mould (150 mm d x 300 mm h)	No.	100
- Capping Set with cylinder carrier and sulfur melting pot	set	1
- Washington Type Air Meter Set, 7 liters capacity	set	5
- Proctor Penetrometer Test Set	set	1
- Portable Compression Testing Machine (100 tons capacity)	No.	1
- Standard Test Sieve for Fineness of Cement	No.	2
- Le-Chatelier Flask	No.	2
- Vicat Apparatus	set	2
- Mortar Flow Table for cement test	set	1
- Mechaelis Cement Flexure Tester	No.	1
- Mortar Compression Testing Machine (20 tons capacity)	No.	1
- Three Gang Mortar Beam Mould	No.	6
- Aggregate Test Sieve Set (18 meshes per set)	set	2
- Wooden Frame Sieve Set (17 meshes per set)	set	2
- Specific Gravity and Absorption Test Set	set	2
- Unit Determination Test Set consisting of 2, 10 and 30 liter containers	set	1
- Los Angeles Testing Machine	set	1
- Coarse Aggregate Gravity Test Set	set	1
- Platform Scale (100 kg capacity, 50 g sensibility)	No.	1
- Platform Scale (20 kg capacity, 10 g sensibility)	No.	1
- Precision Balance (2 kg capacity, 0.1 g sensibility)	No.	1
- Aggregate Soundness Test Set	set	1
- Proving Ring for 100 tons compression testing machine	No.	1

Item	Unit	Quantity
- Dial Gauge, 30 mm	No.	4
- Magnet Stand (Dial gauge holder)	No.	4
- Stop Watch	No.	1
- Tool Set	No.	1
- Burette	No.	2
- Pepette	No.	5
- Sieve Brush	No.	10
- Mixing Plate	No.	1

APPENDIX V : METEOROLOGICAL DATA

(1) Mean Monthly Rainfall at Reduit (El. 311m) between 1887 and 1980

(Unit :mm)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
255	259	257	134	87	70	68	64	44	44	66	170	1519

(2) Mean Monthly Rainy Days at Reduit between 1961 and 1980

Rainfall (mm)	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
0.1	18.9	19.0	21.3	17.0	16.9	16.3	21.5	21.0	15.5	14.0	12.3	15.5	209.2
1.0	15.3	14.9	16.9	12.6	10.7	12.6	15.7	15.0	9.9	8.6	7.9	12.2	152.3
5.0	7.9	7.8	8.9	5.5	4.5	4.5	4.7	3.7	2.0	1.9	3.0	5.7	59.9
10.0	5.0	5.5	5.0	3.5	1.7	1.7	1.1	1.4	0.9	0.9	2.1	3.8	32.6

Note : Monthly values above show average number of days per each month on which daily rainfall reached or exceeded the rainfall depths in the first column.

(3) Mean Monthly relative humidity at Vacous (El. 424m between 1971 and 1980

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
83	84	84	85	83	82	82	81	80	79	80	81	82

(4) Mean Monthly and Monthly Maximum/Minimum Air Temperature at Vacous between 1961 and 1980

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Mean	23.9	24.0	23.9	22.7	20.8	19.1	18.3	17.9	18.7	19.9	21.6	23.1	21.2
Max.	30.8	31.0	30.8	30.0	28.3	26.9	25.7	25.5	27.3	28.3	29.9	29.7	–
Min.	20.2	20.5	20.4	19.5	17.5	15.9	15.3	14.9	15.2	16.3	17.7	19.3	–

(5) Extreme Wind (Gust) Speed Records in Mauritius in Cyclones between 1960 and 1983

(Unit: km/Hour)

Name of Cyclone	Name of Metrological Station (Election,m)							
	Medine (91)	St. Antoine (30)	F.U.E.L. (146)	Plaisance (58)	Vacoas (424)	M.D. Alma (368)	Fort William (6)	Pamps. (55)
Carol (Feb. 1960)	156	–	238	209	190	–	258	238
Jenny (Feb. 1962)	208	–	168	151	185	–	276	196
Danielle	146	–	156	219	164	–	190	159
Garuaise (Feb. 1975)	204	185	169	204	190	280	258	186
Cbudetta (Dec. 1979)	173	211	200	221	175	193	258	201
Bakaly	170	117	104	134	171	197	–	131

APPENDIX VI : STREAMFLOW DATA OF TRIBUTARIES OF GRNW

(1) Mean Monthly Discharge of the Plains Wilhems River

Station No. : W03

Catchment Area : 29.7 km^2

(Unit : m^3/s)

Hydrological Year	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Annual Average
1972			0.28	0.34	0.36	0.34	0.37	0.37	0.33	0.29	0.29	0.37	
1973	0.79	0.40	0.44	0.37	1.48	0.38	0.37	0.37	0.38	0.39	0.41	0.34	0.51
1974	0.15	0.17	0.19	0.35	0.38	0.37	0.34	0.37	0.35	0.31	0.37	0.23	0.30
1975	0.16	0.21	0.23	0.27	0.48	0.35	0.57	0.32	0.23	0.34	0.34	0.27	0.31
1976	0.21	0.19	0.15	1.52	0.29	0.36	0.24	0.90	0.28	0.29	0.29	0.28	0.33
1977	0.19	0.19	0.22	0.28	0.30	0.32	0.28	0.28	0.26	0.14	0.14	0.14	0.23
1978	0.10	0.24	1.32	0.14	0.09	0.43	0.17	0.18	0.16	0.16	0.16	0.14	0.27
1979	0.08	0.12	0.31	0.20	0.68	0.22	0.19	0.21	0.21	0.26	0.12	0.14	0.23
1980	0.11	0.97	12.10	1.31	3.01	1.90	0.43	0.19	0.31	0.27	0.23	0.23	1.75
1981	0.18	0.12	0.14	0.18	0.21	0.47	0.23	0.24	0.25	0.22	0.25	0.21	0.23
1982	0.20	0.24	0.26	6.03	0.33	0.26	0.85	0.30	0.54	0.40	0.26	0.27	0.83
1983	0.28	0.62	0.41	0.23	0.21	0.21	0.20	0.18	0.22	0.14	0.09	0.07	0.24
1984	0.13	3.05	0.30	0.29	0.24	0.14	0.13	0.14	0.15	0.17	0.18	0.16	0.42
1985	0.12	0.22	0.72	5.97	0.25	0.47	0.24	0.25	0.25	0.23	0.22	0.25	0.76
1986	0.19	1.14	0.30	0.31	0.32	0.30	0.25	0.23	0.16	0.21	0.15	0.18	0.31
Average	0.21	0.56	1.22	1.17	0.59	0.44	0.32	0.30	0.27	0.25	0.23	0.21	0.48
Maximum	0.79	3.05	12.10	6.03	3.10	1.90	0.85	0.90	0.54	0.40	0.41	0.34	1.75
Minimum	0.08	0.12	0.14	0.14	0.09	0.14	0.13	0.14	0.15	0.14	0.09	0.07	0.23
Var.	0.17	0.76	3.03	1.99	0.75	0.41	0.18	0.18	0.10	0.08	0.09	0.07	0.40

Var. : Standard Deviation

(2) Mean Monthly Discharge of the Cascade River

Station No. : W05

Catchment Area : 20.7 (km^2)

(Unit : m^3/s)

Hydrological Year	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Annual Average
1966			0.67	0.47	0.45	0.19	0.12	0.57	0.21	0.37	0.15	0.12	
1967	0.09	0.46	1.02	0.26	1.27	1.15	0.35	0.46	1.08	1.01	0.48	0.44	0.67
1968	0.92	1.09	0.31	3.47	2.65	0.38	0.26	0.29	0.59	0.46	0.22	0.20	0.90
1969	0.19	0.17	0.14	0.48	0.47	1.30	0.47	0.51	0.95	0.52	0.25	0.15	0.47
1970	0.15	0.65	3.24	1.78	4.22	0.63	0.35	0.97	0.30	0.14	0.16	0.16	1.09
1971	0.15	0.15	0.16	0.68	0.23	1.23	0.67	0.48	0.48	0.21	0.16	0.15	0.40
1972	0.21	0.15	0.18	1.31	0.45	1.01	0.42	0.83	0.77	1.52	0.35	0.31	0.63
1973	0.53	0.47	0.76	0.52	1.18	0.51	0.32	0.89	0.71	1.06	0.84	0.42	0.45
1974	0.32	0.21	0.24	0.52	0.55	0.35	0.26	0.49	0.61	1.19	0.43	0.28	0.45
1975	0.26	0.30	0.20	1.05	0.83	0.51	1.33	0.73	0.52	0.44	0.45	0.31	0.58
1976	0.20	0.16	0.13	0.98	0.47	1.24	1.18	1.27	0.52	0.58	0.35	0.33	0.64
1977	0.29	0.39	1.21	0.92	0.44	0.84	0.60	0.39	0.48	0.40	0.28	0.19	0.54
1978	0.17	0.35	1.61	0.36	0.71	2.33	0.74	0.57	0.70	0.52	0.39	0.24	0.72
1979	0.22	0.17	0.56	1.27	1.61	0.71	0.42	0.39	0.33	0.68	0.24	0.20	0.57
1980	0.17	3.08	8.15	1.56	3.38	2.14	0.93	0.64	0.49	0.31	0.29	0.29	1.79
1981	0.28	0.24	0.19	0.17	0.27	2.24	0.64	0.45	0.32	0.32	0.29	0.18	0.47
1982	0.21	0.30	0.52	6.14	0.93	0.54	2.02	0.96	1.12	1.33	0.80	0.84	1.31
1983	0.82	1.19	1.56	0.7	0.41	0.38	0.24	0.25	0.30	0.22	0.15	0.17	0.54
1984	0.17	2.13	2.09	0.72	0.36	0.53	0.45	0.32	0.32	0.37	0.28	0.21	0.66
1985	0.19	0.37	2.48	6.67	1.18	1.25	0.51	0.55	0.99	0.50	0.43	0.25	1.28
1986	0.31	2.06	0.57	0.97	1.06	0.97	0.52	0.36	0.22	0.43	0.21	0.20	0.66
Average	0.29	0.70	1.24	1.48	1.10	0.97	0.62	0.59	0.57	0.62	0.34	0.27	0.73
Maximum	0.92	3.08	8.15	6.67	4.22	2.33	2.02	1.27	1.12	1.52	0.84	0.84	1.79
Minimum	0.09	0.15	0.13	0.17	0.23	0.19	0.12	0.25	0.21	0.21	0.15	0.12	0.40
Var.	0.21	0.79	1.76	1.74	1.04	0.61	0.45	0.26	0.27	0.37	0.18	0.15	0.35

Var. : Standard Deviation

APPENDIX VII : WATER QUALITY DATA

(1) In dry season

(Unit : mg/l)

Sampling place	Consumption Potassium Permanganate	T-N	T-P	NH4-N	NO2,No3-N	PH	Turbidity	Hardness
Moka River (Baptiste)	1.4	2.4	0.024	0.10	2.31	7.20	0.4	39.0
" (Vocage)	1.2	2.3	0.012	0.04	2.25	7.76	0.1	46.4
Profonde River	1.4	3.4	0.022	0.10	1.57	7.80	0.2	56.5
Cascade "	1.1	2.1	0.022	0.10	1.91	7.83	0.5	47.3
Terre Rouge "	3.0	1.7	0.024	0.06	1.57	7.23	1.6	25.0
Champagne Dam Reservoir	2.8	0.4	0.022	0.08	0.34	7.03	1.6	25.0
Valetta Reservoir	9.2	0.3	0.017	0.04	0.10	7.10	3.9	22.5

Samples	Chlorine Ion	Alkalinity	Ferrum	Managanese	Evaporation Residue	BOD	Color
Moka River (Baptiste)	16.3	30.1	0.02	0.00	118	0.1	<5
" (Vocage)	16.3	35.5	0.06	0.01	113	0.2	<5
Profonde River	19.1	39.0	0.06	0.01	155	0.3	<5
Cascade "	13.5	37.3	0.08	0.01	122	0.5	<5
Terre Rouge "	12.5	53.3	0.15	0.02	133	1.0	<5
Champagne Dam	9.1	22.0	0.35	0.05	71	0.2	8
Valetta Reservoir	9.1	18.1	0.27	0.03	71	0.5	13

(2) In wet season

(Unit : mg/lit.)

Consumption of Potassium Permanganate	T-N	T-P	NH2-N	NO3-N	pH	Turbidity
Moka wo3	10.1	0.9	0.034	0.05	0.52	6.7	0.8
Moka wo4	9.4	1.1	0.013	0.01	0.99	6.6	1.2
Moka wo5	11.1	1.9	0.020	0.00	1.56	6.6	2.4
Moka wo8	11.2	2.0	0.008	0.01	1.64	6.8	0.4
Moka wo12	11.9	2.2	0.013	0.00	1.98	6.9	0.8
Champagne Dam Reservoir	12.3	0.1	0.028	0.00	0.00	6.8	0.8
Valetta Reservoir	12.9	0.6	0.020	0.00	0.15	6.6	4.8
Pailbs	13.3	2.1	0.015	0.00	1.33	6.7	2.8

	Hardness	Chlorine Ion	Alkalinity	Ferrum	Manganese	Evaporation Residue	BOD	Color
Moka wo3	71.5	18.3	59.1	0.01	0.001	119	1.5	5
Moka wo4	20.5	15.8	20.3	0.28	0.000	56	0.9	7
Moka wo5	36.5	15.6	25.7	0.33	0.003	98	0.3	7
Moka wo8	46.2	19.4	33.2	0.08	0.003	110	0.5	5
Moka wo12	41.5	16.0	26.9	0.22	0.001	107	0.2	7
Champagne Dam Reservoir	14.4	9.0	11.4	0.05	0.003	36	1.1	5
Valetta Reservoir	18.3	11.7	12.6	0.1	0.011	48	1.0	5
Pailbs	30.5	18.5	26.5	0.37	0.011	99	0.8	8

TECHNICAL SPECIFICATIONS

TECHNICAL SPECIFICATIONS

Table of Contents

TECHNICAL SPECIFICATIONS

CHAPTER T1 DEWATERING DURING CONSTRUCTION

T1.1 General

The work specified in this Chapter consists of:

- The dewatering of all open-air construction sites,
- The dewatering of all underground construction sites.

The work shall include the design and construction of pits, trenches, dykes, pipes, plants of dewatering equipment including furnishing, operation, maintenance and relocation required for the performance of the Works.

All excavation areas open-air and underground shall be drained off. The required dewatering system will consist of pumps, pump sumps, pits, trenches, pipes, dykes and all auxiliary facilities for a safe and continuous operation of the dewatering.

The Contractor shall be responsible for maintenance of these facilities until completion of the respective Works or section of the Works and subsequent removal.

T1.2 Execution of Work

The Contractor shall design the complete dewatering system required for all construction sites in such a way that water coming from any source can be drained. These dewatering systems includes pumps, pump sumps, pits, trenches, pipes, dykes, etc. and mechanical, electrical and structural appurtenance.

General design drawings and working procedures with explanatory reports shall be submitted to the PMO/Engineer for his approval prior to commencement of any work under this Chapter. These shall show quantity, type, capacity, arrangement, location, etc. of the required system and shall be subject to the approval of the PMO/Engineer.

The Contractor shall supply all the labour, materials, equipment and installations for the dewatering system required for the performance of the Works.

The Contractor shall maintain ready-for-service and cleaning of all the dewatering systems during construction period of the pertinent structures. After the dewatering systems have served their purpose, they shall be removed upon the approval of the PMO/Engineer in such a manner that will have a sightly appearance and will not interfere with the operation or usefulness of the Works. If any damage to the Works arises from improper removal of the dewatering system, removal or disposal of the structures including incidental repairs and adjustments shall be made by the Contractor at his own expense.

In order to be able to continue water drainage in the event of power failure, diesel driven emergency units shall be made available.

The Contractor shall be responsible for and shall repair at his own expense any damage to the Works caused by water, flood or failure of the dewatering.

T1.3 Measurement and Payment

No separate payment will be made for the work under this Chapter. The cost of the dewatering system shall be included in the unit prices stated in the Bill of Quantities to which the work is incidental.

CHAPTER T2 EARTHWORK

T2.1 Clearing and Stripping

T2.1.1 General

This work shall consist of clearing and stripping the area within the limits of the Site as defined in the Drawings or directed by the PMO/Engineer. All trees, stumps, bushes, roots, down-timber, wood, rubbish, and any other vegetation or objectionable matter in the area shall be cleared of.

It shall include the removal of buildings, foundations, fences, retaining walls and other obstructions interfering with the project work, and burning or otherwise disposing of to the satisfaction of the PMO/Engineer.

T2.1.2 Execution of work

The Contractor shall perform the work of clearing and stripping in accordance with statutory regulations. Such material from clearing and grubbing operation shall be removed from the Site or burned or otherwise disposed of as specified or directed by the PMO/Engineer. Care shall be exercised to see that the burning of such material does not destroy or damage public or private property, and the Contractor shall be fully responsible for any destruction, damage, or nuisance. Burning shall be done at such times as approved by the PMO/Engineer.

T2.1.3 Measurement and payment

Measurement for payment of clearing and stripping will be made based on the area to the lines as shown on the drawings or directed by the PMO/Engineer.

Payment for clearing and stripping will be made at the unit price per square meter stated in the Bill of Quantities, which unit price shall include the cost of all labour, materials and equipment to remove the materials to the disposal area and all other items necessary to complete the work.

T2.2 Explosives and Blasting

T2.2.1 Explosives

The transportation, hauling, storage, and use of explosives shall be subject to the Law and Regulations of the Government as well as the instruction of the PMO/Engineer. The Contractor shall

maintain an inventory record of storage and withdrawal of all explosives and shall make it available to the PMO/Engineer at any time. Any loss or theft of explosives shall be promptly notified to the PMO/Engineer. The Contractor shall provide such reasonable and adequate protective facilities as are necessary to prevent loss or theft of explosives. Overnight storage of explosives and detonators outside of the magazines shall not be permitted.

Caps or other exploders or fuses shall be in no cases stored, transported or kept in the same places in which dynamite or other explosives are stored, transported or kept.

T2.2.2 Blasting

All blasting operations, the depth and sizes of holes, and the sizes and characteristics of the charges shall be well planned. The explosives for each blast shall be of such quantity and power and shall be used at such locations as will neither open seams nor crack the rock outside of the limit of excavation. As an excavation approaches its final line, the depth of holes for blasting and the amount of explosives used for per hole shall be reduced progressively. Whenever, in the opinion of the PMO/Engineer, further blasting may injure the rock on or against which concrete is to be placed, the use of explosives shall be discontinued and the excavation shall be completed by wedging, barring, channeling, line drilling as directed by the PMO/Engineer. Blasting will be permitted only after adequate provision has been made for the protection of persons, the Works, and public and private properties. Approval by the PMO/Engineer of any of the Contractor's blasting operations shall not relieve the Contractor of his responsibility for safety of persons and properties. Damages to the Works or to the public or private properties by blasting shall be repaired by and at the expense of the Contractor. Excavation by blasting shall be carried out only under personal supervision of competent persons and trained workmen. All supervisors and workmen working with blasting materials and operations shall be adequately insured by the Contractor.

T2.3 Open-Cut Excavation

T2.3.1 General

All open-cut excavation for structures shall be executed as specified in this Section and to the lines, slopes and dimensions as shown on the Drawings or as directed by the PMO/Engineer. Such excavation shall include but not be limited to, portals of tunnel, and the Construction Facilities Yard and access/haul roads. During the progress of the work, it may be found necessary or desirable to alter the depth, the slopes or the dimensions from those shown on the Drawings. Any increase or decrease of quantities excavated as a result of such alteration or causes beyond the control of the contractor will be included in the measurement for payment, provided that the unit prices stated in the

Bill of Quantities for excavation shall not be adjusted. Any other excavation performed at the option of the Contractor to secure access to the required work, for disposal of excavated material or for any other purpose shall be within the limits approved by the PMO/Engineer and shall be at the Contractor expense.

T2.3.2 Classification of excavation material

Except as otherwise specified in these Specifications, open-cut excavation will be classified for measurement and payment as follows:

(1) Rock

Rock is sound and intact rock in place that cannot be excavated without drilling and blasting as determined by the PMO/Engineer.

(2) Weathered rock

Weathered rock is disintegrated rock by weathering that can be excavated efficiently after loosening by ripping or the use of power tools without drilling and blasting as determined by the PMO/Engineer.

(3) Common

Common is all material other than rock and weathered rock including, but not limited to, clay, silt, sand, solid rock not exceeding 1.0 m^3 in volume, and mixtures thereof with gravel and boulders as determined by the PMO/Engineer. Solid rock exceeding 1.0 m^3 in volume is classified as rock. The Contractor shall prepare survey maps of the stripped area, and submit them to the PMO/Engineer for his approval, before comencing excavation.

When the Contractor observes the boundary lines between weathered rock and common, and rock and weathered rock, as defined above during the excavation work, the Contractor shall prepare and submit the survey maps to the PMO/Engineer for his approval in advance of weathered rock excavation and rock excavation, respectively. The Contractor shall also prepare and submit to the PMO/Engineer for his approval the survey maps for the final excavation lines actually excavated. These surveys shall be performed in the presence of the PMO/Engineer, and be the basis of quantities for claim for payment. The Contractor shall notify the PMO/Engineer of his intention to undertake such surveys.

T2.3.3 Execution of work

(1) General

Working schedule with explanatory reports for open-cut excavation shall be submitted prior to the commencement of the work for the approval of the PMO/Engineer. The schedule shall include the quantity, type and capacity of the equipment, working method envisaged, transportation and distribution of excavated material, location of temporarily stockpile or disposal area as well as labour deployment, etc. The schedule and any amendment thereto shall be subject to the PMO/Engineer's approval.

(2) Safety measures

The Contractor shall be responsible for all necessary safety measures and follow the safety regulations.

Proper strutting, sheeting and bracing including rearrangement of the installations, protection of slopes and appropriate measures to ensure the safety during the work shall be provided by the Contractor. The cost thereof shall be included in the unit prices stated in the Bill of Quantities to which the work is incidental.

(3) Over-excavation

All necessary precaution shall be taken to preserve the material below and beyond the establish lines of all excavation in the soundest possible condition. Unless otherwise ordered in writing by the PMO/Engineer, any and all over-excavation performed by the Contractor for any purpose or reason is unauthorized excavation and shall be at the expense of the Contractor.

Where required to complete the work, all unauthorized excavation shall be backfilled, as directed by the PMO/Engineer, at the expense of the Contractor. Slopes shattered or loosened by blasting shall be removed at the expense of the Contractor.

(4) Protection of excavated surfaces

The excavated surfaces on or against which concrete is to be placed shall be protected by leaving a temporary cover of 30 cm of unexcavated material, if it is deemed necessary in the opinion of the PMO/Engineer. The final 30 cm excavation shall be made by continuous operation within a specified time to be determined by the PMO/Engineer. Such excavation shall be followed without delay by backfilling of fill material, by application of protective

coatings, or by placement of structural or backfill concrete as shown on the Drawings or as directed. No additional allowance above the unit prices stated in the Bill of Quantities for excavation shall be made on account of leaving the temporary cover of unexcavated material.

Where and when directed by the PMO/Engineer, the Contractor shall place protective coatings of shotcrete on excavated surfaces on which concrete is to be placed. The Contractor shall not perform excavation, when directed by the PMO/Engineer, within the final 30 cm of finished surfaces in areas which will require protective coatings until all equipment and facilities required for immediate application of protective coatings are available and in working condition. Coatings shall be as provided in Section 4.2.

Planking and strutting necessary to retain the sides of the excavations shall be provided, erected and maintained in a safe condition by the Contractor. No separate payment will be made for planking and strutting.

(5) Excavation for structure foundation

The bottom and side slopes of excavation upon or against which concrete is to be placed shall be excavated to the required dimensions as shown on the Drawings or directed by the PMO/Engineer. No material will be permitted to extend within the neatlines of the structure. The PMO/Engineer will have the right to decide whether the foundation excavation indicated in the drawing is sufficient, or whether deeper foundations are necessary. This decision will be final and binding on the Contractor. If, at any point in excavation, upon written orders of the PMO/Engineer, material is excavated beyond the limits required to receive the structure, the additional excavation shall be filled solidly with concrete, or as directed by the PMO/Engineer. Payment for concrete placed in such additional excavation will be made at the appropriate unit price stated in the Bill of Quantities for concrete. Excess excavation and over-excavation performed by the Contractor for any purpose or reason without written orders of the PMO/Engineer shall be refilled with concrete by the Contractor at his own expense.

T2.3.4 Stockpiling and disposal

Suitable material from excavation, as decided by the Engineer, shall be used for the Works. These material shall be directly transported and placed at the designated final location if practicable, or shall be placed in temporary stockpiles upon the Engineer's approval. Location of stock pile will be as approved by the Engineer. Such material actually placed in the completed construction will be included for payment under appropriate items in the Bill of Quantities covering such construction.

The Contractor shall protect all temporary stockpiles against erosion or slide of slope by the construction of drains, drop structures, revetments or any other structure. The Contractor shall not be entitled to additional allowance above the unit prices stated in the Bill of Quantities on account of the requirement to control erosion or slide of the slope.

Excavated material which are unsuitable or not required for permanent construction shall be disposed in the disposal area as shown on the Drawings or elsewhere as approved by the PMO/Engineer. Such material shall be disposed in a horizontal layer not exceeding 0.5 m in thickness to receive appropriate compaction. Unless otherwise approved by the PMO/Engineer, the finished outer slopes of the disposed material shall not be steeper than 1 vertical to 3 horizontal and shall be covered with strip sodding or other approved means.

The Contractor shall grade the top surface of all material placed within the disposal area and shall construct permanent drains and other protective works sufficient to ensure that surface run-off will not erode the slopes of all material placed therein.

The cost of disposing excavated material and the cost to form disposal areas to the satisfaction of the PMO/Engineer shall be included in the unit prices stated in the Bill of Quantities for the various items of work for excavation.

Location changes or additions of disposal areas for the Contractor's own convenience shall be subject to the approval of the PMO/Engineer and relevant authorities, and made at the expense of the Contractor.

T2.3.5 Measurement and payment

Measurement for payment of open-cut excavation of each class of material will be made to the lines shown on the Drawings or otherwise established by the PMO/Engineer. Quantities shall be calculated from the survey maps mentioned in Clause T 2.3.2 (3) by following standard procedures approved by the PMO/Engineer.

Payment for open-cut excavation will be made at the unit prices per cubic meter stated in the Bill of Quantities, which unit prices shall include the cost of all labour, equipment, and materials for excavation, slide prevention, erosion control and other works necessary to maintain the excavation in good order during construction. For payment, no distinction will be made as to whether the material excavated is dry, moist, or wet. These unit prices shall also include the entire cost of transporting the materials from the excavation to the point of final use, and where stockpiles are used, the unit prices shall include the entire cost of transporting the materials to the stockpiles, re-handling and transporting such material to the point of final use; and the entire cost of cleaning up excavated

surfaces and the areas where excavated material had been stored before re-use by the Contractor. The unit prices shall also include the cost of disposal of unsuitable excavated material, as per Clause 2.3.4, up to a distance of 1 km from the place of excavation. If the final disposal area is more than 1 km away, additional charges for transportation will be payable for the extra distance, in accordance with the rate quoted in Schedule 7 of the Schedule of Particulars..

T2.4 Underground Excavation

T2.4.1 General

Relevant Sections from Clause T 2.3 shall apply to underground excavation also, except as otherwise specified hereunder.

The term "underground excavation" means all required excavation performed by methods for diversion tunnel, and other underground structures other than open-cut excavation.

Prior to underground excavation, the Contractor shall outline the arrangement of machines, equipment and facilities, the system of excavation and hauling, and the progress schedule, in due consideration of the condition of geology, climate and prescribed construction period, and the plan so laid down shall be subject to the approval of the PMO/Engineer.

T2.4.2 Design section

Underground excavation shall be made to the lines shown on the Drawings or established by the PMO/Engineer.

The A-lines shown on the sections on the Drawings are lines within which no material of any kind and no support other than permanent steel support will be permitted to remain. In the use of permanent steel support, the inside face of the support will be allowed to project from the A-line equal to or less than 7.5 cm.

The B-lines are the outside limits to which measurement for payment of excavation and concrete will be made, and measurement for payment will in all cases be made to the B-lines regardless of whether the limits of the actual excavation fall inside or outside of the B-lines.

The application of each type of section shown on the Drawings for underground excavation is only indicative, and will be determined by the PMO/Engineer according to the geological condition at the site during the progress of the work.

The PMO/Engineer will determine to increase or decrease the distance between the A-line and the interior finish surface of concrete lining for certain stretches of underground structure, if he thinks necessary to do so. In such event the position of the B-line shall be moved in such a manner that at every point the distance between the A and B-lines will remain unchanged. Such change of quantities resulting from increasing or decreasing of the distance between the A-line and the interior finish surface of concrete lining will be included in the measurement for payment, provided that the unit prices stated in the Bill of Quantities for excavation and concrete shall not be adjusted.

T2.4.3 Excavation procedure

Proper excavation procedures shall be adopted to suit the design section to be accommodated, the material to be excavated and the conditions to be encountered.

During the excavation work, the Contractor shall, at his full responsibility, maintain the lines shown on the Drawings by accurate surveying as approved by the PMO/Engineer.

All drilling and blasting shall be carefully performed so that the finished excavated surface will not be loosened or shattered. Unless otherwise determined by the PMO/Engineer, all excavation beyond the B-lines shall be completely filled with concrete entirely at the Contractor's expense.

The drill holes shall be exactly located by scaling the design section on the heading face by surveying, showing accurately the direction and figure of excavation.

With proper drainage, ventilation and lighting system, the Contractor shall perform the work efficiently and safely, taking into consideration the method and sequence of supports and concrete lining.

Complete sections of excavation shall be subject to the inspection of the PMO/Engineer before lining concrete is placed.

Stockpiling and disposal of excavated material shall conform to the requirements of Clause of 2.3.4.

T2.4.4 Steel support

(1) General

Permanent steel support shall be used to support the roof and sides of the underground excavation as required or determined by the PMO/Engineer.

Permanent steel supports completed with all bolts, tie rods, foot plates and other accessories required for assembling the supports and supporting them in place until the lining concrete is placed shall be furnished by the Contractor.

Temporary steel supports that are not required to be in place as the permanent work shall be removed unless such removal is judged impracticable by the PMO/Engineer.

Type and size of steel support for permanent or temporary shall be as shown on the Drawings. However, the Contractor may propose alternation for them. In that case, type and size of the steel supports, of alternation, its miscellaneous details, location and spacing shall be submitted to the PMO/Engineer for approval. The clear distance between the flanges of the installed supports shall not be less than 30 cm unless otherwise approved by the PMO/Engineer.

(2) Installation

The steel supports shall be installed to the proper lines and grades and shall be maintained by the Contractor in the proper condition and alignment until the lining concrete is placed about them. The Contractor shall securely brace the supports with tie rods and collar braces and the minimum practicable amount of blocking and wedges. Any steel support installed improperly or damaged by the Contractor's operation shall be adjusted or repaired or replaced to the satisfaction of the PMO/Engineer within 24 hours after notification of the PMO/Engineer.

The Contractor may, to facilitate his operation, place permanent steel support at a greater distance from the inside finishing surface of concrete lining than shown on the Drawings or prescribed by the PMO/Engineer, provided that any increase in quantity of steel supports and any excavation and concrete lining outside the B-lines required thereby shall be at the expense of the Contractor.

Permanent steel supports required for the sections not shown on the Drawings shall be in accordance with designs submitted by the Contractor and approved by the PMO/Engineer

Temporary timber collar braces shall be furnished and installed by the Contractor where required and shall be removed before placement of lining concrete unless such removal is judged impracticable by the PMO/Engineer.

T2.4.5 Measurement and payment

(1) Underground excavation

Measurement for payment of underground excavation will be made of the volume determined by the specified sectional dimensions within the B-lines as prescribed in Clause 2.4.2.

Payment for underground excavation will be made at the unit prices per cubic meter stated in the Bill of Quantities, which unit prices shall include the cost of all labour, equipment and materials for excavation, including the cost of drainage, ventilation, lighting, transportation and disposal of excavated material, and maintaining the excavation in satisfactory condition until the lining concrete is placed. Relevant portion of Clauses T 2.3.5 shall apply for transportation of unsuitable excavated material.

(2) Permanent steel support

Measurement for payment of permanent steel support will be made of the weight of main steel supports actually installed excluding all accessories.

Payment for permanent steel support will be made at the unit prices per ton stated in the Bill of Quantities, which prices shall include the cost of all labour and materials for cutting, bending assembly and installation of the supports and supporting them in place until the concrete is placed, and all other items including accessories necessary to complete the work.

T2.5 Embankment, and Backfill and Miscellaneous Fill

T2.5.1 General

The Contractor shall perform embankment, backfill and miscellaneous fill as shown on the Drawings or directed by the PMO/Engineer. This work shall include selecting, stockpiling, spreading, wetting or drying, compacting, shaping and finishing materials, and all incidental items of the work. Unless otherwise approved, materials to be used for backfill and miscellaneous fill shall be those obtained from open-cut excavation or underground excavation.

Materials for fill or embankment shall be obtained from excavation for permanent structures or from stockpiles of excavated material as far as they meet the requirements of these Specifications. Borrow areas necessary for the embankment works shall be proposed by the Contractor and approved by the PMO/Engineer prior to execution of embankment work.

Distribution within embankments of construction materials from excavation shall be done in the way approved by the PMO/Engineer. Embankment fills shall be preferably constructed during periods of relatively low precipitation.

The surface to be covered with filling material shall be treated by the Contractor as follows:

- Clearing and stripping shall be done in accordance with the requirements as specified in Section 2.1. Stump holes or other small excavations in the limits of backfill and miscellaneous fill shall be backfilled with suitable material and thoroughly tamped by approved methods before commencement of the work.

- Springs and seepage along the foundation of the work shall be treated by the method as approved by the PMO/Engineer.

- Where backfill and miscellaneous fill are to be placed on sloped foundation, care shall be taken to prevent slipping and shall be treated by means of step cutting or other method as approved by the PMO/Engineer.

- Bearing test will be carried out, if it is deemed necessary in the opinion of the PMO/Engineer, at the locations as directed by the PMO/Engineer.

Unless otherwise specified or directed by the PMO/Engineer, the height of extra embankment shall be 3% of the designated height and shall be in the tolerance of less than around 5 cm. The volume of the extra embankment shall not be taken into account for measurement for payment.

T2.5.2 Free draining backfill

Free draining backfill shall be placed to the lines and dimensions as shown on the Drawings or as directed by the PMO/Engineer.

The materials to be used for free draining backfill shall be selected previous mixtures well graded with the maximum grain size of 20 cm. Fragments larger than 20 cm may be used if approved by the PMO/Engineer, provided that such fragments shall be evenly distributed in the backfill. The free draining backfill shall not contain, more than 5% by weight, material passing a 0.074 mm mesh sieve provided in JIS.

The material shall be handled and placed in such a manner as to prevent segregation. The method of placing free draining backfill shall be subject to the approval of the PMO/Engineer. Free draining

backfill on either side of each structure shall be kept approximately at the same elevation as the placing of backfill progresses. Free draining backfill shall be placed and roughly levelled off in layers not more than 50 cm in thickness after being compacted. Free draining backfill shall be thoroughly compacted to the satisfaction of the PMO/Engineer by approved means.

T2.5.3 Random Fill and Backfill

Random fill and backfill shall be placed to the lines and dimensions as shown on the Drawings or directed by the PMO/Engineer.

The materials to be used for Random fill and backfill shall be selected mixtures well graded with the maximum grain size of 30 cm. Random backfill shall be placed and roughly levelled off in layers not more than 50 cm in thickness after being compacted. Prior to and during compaction operations, the material shall have the optimum moisture content required for the purpose of compaction, as determined by the PMO/Engineer, and the moisture content shall be uniform throughout each layer. Each layer shall be thoroughly compacted to the satisfaction of the PMO/Engineer by approved means.

T2.5.4 Embankment

The materials to be used for embankment shall be selected mixtures well graded with the maximum grain size of 20 cm. Of the embankment materials, rock fragments shall be tough and durable to withstand both the procedures involved in procuring and placing them and the normal weathering process as it prevails in the areas of the works. Furthermore, the rockfill material shall be free from cracks, seams and other defects and from any deleterious matter such as clay, silt, friable rock, etc.

Maximum size of the embankment material shall be less than 20 cm unless otherwise approved by the PMO/Engineer, except the rockfill material. When approved by the PMO/Engineer, materials more than 20 cm in size may be used at locations designated by the PMO/Engineer, provided that the voids in these coarse materials shall completely be filled with finer materials as approved by the PMO/Engineer. The materials shall be placed and spread so that no single layer exceeds 30 cm in thickness after compaction. The compaction equipment shall be suitable to the materials which will be embanked to the place.

Placement of materials shall not be permitted to commence in any portion of the foundation of the embankment until the section is completely drained and suitably prepared and has been approved by the PMO/Engineer.

Before placing embankment material on the foundation and on the surface of the already placed fill, each portion in the entire area shall be properly moistened, graded and the surface scarified before the following lift is placed. The fill of each lift shall be moistened, if required, and compacted in specified lift heights and passing by suitable equipment, approved by the PMO/Engineer to reach the density specified by PMO/Engineer.

Each lift or layer shall be continuously placed and compacted without any delay. The thickness of lifts and the passes of the compaction equipment for the different kinds of material will be subject to the approval of the PMO/Engineer.

When any layer fails to comply with the degree of compaction specified above, the Contractor shall recompact, wet or dry, improve or replace the materials immediately. Any soft or yielding areas which may develop in the embankment during construction shall be corrected by recompaction, or removing the unsuitable materials and replacing it, immediately after the direction ordered by the PMO/Engineer. No direct payment shall be made for such works unless otherwise approved by the PMO/Engineer and the cost hereof shall be compensated by the Contractor at his own expense.

Provision shall be made on the construction site for well functioning drainage system by means of sufficient inclination in lifts to the outside of the embankment and for additional trenches and drainage ditches of suitable size and area to provide a continuous run-off in case of rain, etc. The entire site shall be kept in such condition that water puddles do not occur on completed layers. Compacted layers with water puddles on the surface may be subject to rejection upon the decision of the PMO/Engineer. Muddy surface due to adverse weather conditions shall be removed or dried out before the next layer is applied.

The rockfill material shall be dumped and distributed within the embankment as shown on the Drawings or as approved by the PMO/Engineer. However, the gradation in any layer shall be such that the material is suited for satisfactory compaction to ensure a good mechanical lock, high relative density and stability of the rockfill body.

T2.5.5 Gravel bedding and gravel metalling

Gravel bedding and gravel metalling shall be placed at the location, shown on the Drawings or as directed by the PMO/Engineer.

The Materials shall be selected from previous mixtures well graded with the maximum size of 80 mm for gravel bedding and 40 mm for gravel surfacing. The materials shall not contain more than 5%, by weight,of material passing a 0.074 mm mesh sieve provided in JIS.

The Contractor shall handle and place the material in such a manner as to prevent segregation. The method of placing gravel bedding and gravel surfacing shall be subject to the approval of the PMO/Engineer.

T2.5.6 Measurement and payment

Measurement for payment of backfill, miscellaneous fill and embankment will be made of the volume of material in place to the prescribed lines, grades and dimensions.

Payment for backfill, miscellaneous fill and embankment will be made at the unit prices per cubic meter stated in the Bill of Quantities, which unit prices shall include the cost of all labour, materials and equipment, and for all incidental work connected therewith, but excluding the cost of obtaining and transporting materials for which payment is provided in the Bill of Quantities for various items of excavation for permanent work.

T2.6 Gabion Mat

T2.6.1 General

This Clause shall specify gabions mat in all areas of the Site as shown on the Drawings or as directed by the PMO/Engineer.

T2.6.2 Material

The Contractor shall provide the gabions at the position as shown on the Drawings or as directed by the PMO/Engineer.

Prior to setting gabions, the foundation for gabions shall be prepared as clean and plane to the lines by excavation or fills to the satisfaction of the PMO/Engineer. The materials for the foundation fills shall be same gravel or rocks as that of the gabion or approved equivalent and shall placed uniformly and compacted firmly.

If not otherwise clearly specified in the Drawings, the Contractor shall submit a proposal of the type and dimension of gabions, the stonefill (type, strength, grain size, etc.), the method of placing and the time schedule for delivery and construction. The Contractor shall not commence the construction of gabions before approval of the PMO/Engineer.

The size of mesh will be 15 cm in hexagonal. The frames will be woven with the specified iron wire at other place near by the setting position separating the lower part of the frame from the top surface net.

The lower part of the gabion frame shall be arranged on the foundation prepared already as shown on the Drawings or as approved by the PMO/Engineer. The cobbles or rocks in gabions shall be filled densely enough alternating between large and small sizes.

The Contractor shall be subject to the inspection of degree of cobble or rock packing by the PMO/Engineer before closing of the top surface net.

T2.6.3 Measurement and Payment

Measurement for payment of gabions will be made on the basis of placed volume of gabions in cubic meters determined by the lines and positions as shown on the Drawings or as approved by the PMO/Engineer.

Payment of gabion will be made for the number of cubic meters measured as provided above at the unit price stated in the Bill of Quantities. The unit prices shall include all labour, tools, Constructional Plant, materials and all other costs for preparation of foundation, weaving and setting of gabion frame, packing of cobbles or rocks, finishing and other items necessary to complete the Works.

T2.7 Drainage

T2.7.1 General

The work under the Clause shall cover the construction of drainage structure including the general items pertaining to materials, excavation, foundation, construction or installation and backfill in connection with the drainage structure.

T2.7.2 Materials

(1) Reinforced concrete drain pipes

The Contractor shall furnish and install reinforced concrete drain pipes as shown on the Drawings or as directed by the PMO/Engineer. Reinforced concrete drain pipe shall conform to the requirements of JIS A5302-84, Reinforced Concrete Pipes, or approved equivalent, and provisions stipulated in CHAPTER IV, CONCRETE WORK.

(2) Drain ditch

The Contractor shall furnish and install drain ditch made of reinforced concrete or non-reinforced concrete as shown on the Drawings or as directed by the PMO/Engineer. Concrete to be used for the drain ditches shall be of Class B and shall conform to the applicable provisions of CHAPTER IV, CONCRETE WORK.

Excavation for trenches shall be performed in accordance with the applicable requirements of Clause 2.3, Open Cut Excavation, in these Specifications. Bedding surface shall provide a firm foundation of uniform density. Each section of pipe shall rest upon the pipe bed for its full length, with recess excavated to accommodate bells and joints.

Each pipe shall be carefully inspected before it is laid. Any defective or damaged pipe shall be rejected. The laying of pipe shall proceed upgrade beginning at the lower end of the pipeline. Under no circumstances pipe shall be laid in water and no pipe shall be laid when the trench conditions or weather is unsuitable for such work. Full responsibility for the diversion of drainage and dewatering of trenches during construction shall be borne by the Contractor.

When pipe laying is interrupted, the Contractor shall seal the ends of the pipe line to prevent the entry of water or foreign matter. No backfill or concrete shall be placed over or around the piping until the installation has been approved by the PMO/Engineer.

Unless otherwise specified PMO/Engineer or shown on the Drawings, bedding material below pipe shall be clean sand or other approved granular material and remaining backfill in the pipe trenches shall be approved material free from stones lager than 80 mm and other objectionable materials.

Concrete used for drainage structures shall conform to the applicable requirements of CHAPTER IV, CONCRETE WORK in these Specifications. Mortar shall be stiff and composed of 1 part Portland cement and 2 parts sand by weight.

After cutting, and before threading, all steel pipes shall be reamed and have burs removed. All screw joints shall be made with graphite or other approved compound applied to make threads only. Thread shall be full cut and not more than 3 threads on the pipe shall remain exposed.

Flanged joints shall be faced true, packed and made up perfectly square and tight. Gaskets shall be ring type 1.5 mm thick sheet asbestos, or as approved by PMO/Engineer.

Joints in P.V.C. pipes and fittings shall be socket or threaded joints made up as recommended by the manufacturer.

After the bedding has been prepared and the pipe installed, backfill material at a moisture content which will facilitate compaction, shall be placed alongside the pipe in layers not exceeding 15 cm in depth unless otherwise specified or shown on the Drawings.

Care shall be taken to ensure thorough compaction of the fill under the Pipe. Each layer shall be thoroughly compacted by rolling, tamping with mechanical rammers, or by hand tamping with heavy iron tampers of which the tamping face area shall not exceed 150 sq.cm. This method of filling and compacting shall be continued until the fill has reached an elevation 30 cm above the top of the pipe. The remainder of the trench shall be backfilled and thoroughly compacted in layers not exceeding 15 cm. The density of compaction shall be as specified by the PMO/Engineer.

The test shall be made as directed by the PMO/Engineer where considered necessary by the PMO/Engineer.

T2.7.3 Measurement and Payment

(1) Reinforced concrete drain pipes

Measurement for payment for reinforced concrete drain pipes will be made of the length of pipes actually installed in accordance with the Drawings or the direction of the PMO/Engineer.

Payment will be made at the unit prices per meter stated in the Bill of Quantities, which unit prices shall constitute full compensation for the cost of concrete work and earth work, all labour, tools, equipments and materials therefor including furnishing and loading, hauling, unloading, installing and jointing the pipes and fittings, and other items necessary to complete the works.

(2) Drain ditch

Measurement for payment for drain ditch will be made of the length of drain ditch actually installed in accordance with the Drawings or the direction of the PMO/Engineer.

Payment will be made at the unit prices per meter stated in the Bill of Quantities, which unit prices shall constitute full compensation for the cost of concrete work and earth work, all labour, tools, equipments and materials therefore including furnishing and loading, hauling, unloading, installing and jointing the pipes and fittings, and other items necessary to complete the works.

CHAPTER T3 DRILLING AND GROUTING

T3.1 General

The work covered by this Chapter comprises the following operations and work incidental thereto;

(1) Backfill grouting for filling up the gaps between the lining concrete of a diversion tunnel and the surrounding rock, or the initial lining concrete and the backfill concrete in the tunnel by means of injecting cement-sand grout into the gap,

(2) Consolidation grouting for filling up fissures, joints and cracks in foundation rock or rock surrounding the tunnel by means of injecting cement grout into them,

(3) Curtain grouting for forming a low permeability zone around the tunnel to cut off water leakage through it by means of injecting cement grout into the surrounding rock.

In relation to the above-listed grouting operation, the Contractor shall drill holes for consolidation and curtain grouting, furnish and place steel pipe and fittings for backfill grouting.

The amount of drilling and grouting that will be required is uncertain and the Contractor shall not be entitled to additional compensation above the unit prices stated in the Bill of Quantities by reason of increase or decrease of such quantities.

The location, direction, and depth of each grout hole shall be as shown on the Drawings or directed by the PMO/Engineer. The order in which the holes are drilled and the manner in which each hole is drilled and grouted, the proportions of all grout mix, the time of grouting, the pressure used in grouting, and all other details of the grouting operation shall be as specified in this Chapter or as directed by the PMO/Engineer.

The Contractor shall submit to the PMO/Engineer the operation plan and time schedule for grouting work for his approval prior to the commencement of the work.

During the grouting operation, reliable foremen shall be stationed at the mixing plant and in the vicinity of injection holes to ensure quality. All grouting operation shall be performed in the presence of the PMO/Engineer.

Unless otherwise approved, no grouting operation shall be performed until all concrete within a distance of 15 m has been in place for at least 4 weeks and drilling and water pressure test shall not be performed within a distance of 15 m from the hole being grouted.

If, during the grouting of any hole, grout is found to flow from adjacent grout holes or grout connections in sufficient quantity to interfere seriously with the grouting operation or to cause appreciable loss of grout, such holes or connections may be capped temporarily. Where such capping is not essential, ungrouted holes shall be left open to facilitate the escape of air and water.

Unless otherwise directed by the PMO/Engineer, the grouting operation shall not be discontinued before completion of the work.

The Contractor shall submit to the PMO/Engineer the detail record in the form approved by the PMO/Engineer of all of drilling, grouting and incidental operations. Such record shall cover, but not limited to;

a. Daily progress record,
b. Actual injection record in detail (concentration, pressure, injection time, injection quantities) presented in tables and figures,
c. Lugeon value of each stage at the time of water pressure test,
d. Miscellaneous record and data as directed by the PMO/Engineer.

After the grouting work has been completed, the Contractor shall clean the work site to the satisfaction of the PMO/Engineer.

T3.2 Grout Material

Grout will consist of cement and water, or sand. Admixtures (if necessary) shall be subject to the approval of the PMO/Engineer.

Cement for grout shall be in conformity with the requirement of JIS R 5210-79 ordinary Portland cement or approved equivalent.

Mixing water for grout shall be reasonably clean and free from objectionable quantities of oil, silt, organic matter, alkali, salt, acid and other impurities.

Sand shall be clean, hard, durable and of proper grading, and it shall be free from objectionable quantities of dirt, silt, organic matter and other deleterious materials. Sand shall pass a 2.5 mm standard screen in 100% and pass a 0.6 mm screen in not less than 50%.

T3.3 Equipment

T3.3.1 Drilling Equipment

Grout holes shall be drilled with either rotary type drills or percussion type drills, provided that where holes for subsequent grouting cannot be drilled satisfactorily with percussion type drills, the rotary type drills will be directed by the PMO/Engineer. The minimum diameter of each grout hole shall be not less than 38 mm.

T3.3.2 Water Pressure Testing Equipment

Water pressure testing equipment shall include single packer type or double packer type water pressure test assemblies, water storage facilities, flowmeters, pressure gauge including gauge savers valves, hoses, fittings and pumps capable of delivering at least 60 litres/min. at 60 kg/cm^2 of the maximum pressure and maintaining constant pressures. Packers shall be the mechanically expanding rubber ring type.

T3.3.3 Grout plant

The grout plant shall be of a type approved by the PMO/Engineer and shall be capable of supplying, mixing, agitating and pumping grout to fulfill the following requirements;

(1) Grout pumps of a reciprocating piston type having a capacity to force thick grout (water-cement ratio; 0.7) into the grout holes or grout connections in a continuous, uninterrupted flow at any pressure up to a maximum of 15 kg/cm2 , and at the maximum discharge of not less than 100 litre/minute.

(2) Mixers of a mechanical operated, double drum, high speed (more than 800 r.p.m.) colloidal type with each drum capacity of not less than 200 litres. Apparatus shall be provided at the mixer for an accurate measurement of the grout materials so that the mix proportions can be carefully controlled and recorded.

(3) Pressure gauges having the maximum capacity of 20 to 25 kg/cm^2 and the reading intervals of not more than 0.5 kg/cm^2. The pressure gauge shall be provided at the pump and at the hole collar.

(4) Packers will be of a mechanically expanded type or pneumatically expanded rubber ring type. The type of packer shall be determined to suit rock conditions. The packer shall be designed so that they can be expanded to seal the drill hole at the specified position.

(5) The grout plant shall be maintained in a manner approved by the PMO/Engineer and so as to insure continuous and efficient performance during any grouting operation.

T3.4 Backfill Grouting

T3.4.1 General

The Contractor shall backfill with cement-sand mortar, under low pressure, gaps between the lining concrete and the surrounding rock, or the initial lining concrete and the backfill concrete at the locations as shown on the Drawings or directed by the PMO/Engineer. The mortar shall be injected through steel pipes set in the concrete or drilled holes as shown on the Drawings.

The grout shall be composed of cement, sand and water. The proportions of mortar and sand shall be 1:1 by weight unless otherwise approved by the PMO/Engineer. The flow value of mortar shall be in the range of 18 to 20 seconds.

No grouting operation shall be made until all concrete within a distance 15 m has been in place at least 4 weeks.

T3.4.2 Steel pipe for backfill grouting

Steel pipes, 50 mm diameter carbon steel pipe, shall be furnished and embedded by the Contractor for backfill grout connection and air vent. The pipes shall be held firmly in position and protected from damage while concrete is placed. A gap shall be left between the rock and the upper ends of pipes and the lower ends shall be made flush with the interior surface of the lining concrete.

Care shall be taken to avoid clogging or obstructing the embedded pipes and any pipe that becomes clogged or obstructed from any cause shall be thoroughly cleaned by the Contractor.

T3.4.3 Grouting operation

The grout shall be injected through grout pipes. Prior to starting and finishing the mortar injection, the cement grout with concentration of 1:4, 1:2 and 1:1 shall be injected. Mix proportion of mortar

shall be 1:2 of ratio of cement/sand by weight in principle unless otherwise directed by the PMO/Engineer.

Maximum allowable pressure shall be 2 kg/cm^2 measured at near the hole collar or as directed by the PMO/Engineer. Grouting shall be continued until the injection rate decreases to zero under the maximum allowable pressure, unless otherwise directed by the PMO/Engineer.

In case that injected mortar flows out from other holes, those holes shall be plugged and, if required, re-drilled afterwards by the use of drift for further grouting. The backfill grouting shall be completed by cement grouting injected after the pressure of backfill grouting reached at the maximum pressure of 2 kg/cm^2.

T3.5 Consolidation Grouting

T3.5.1 General

The Contractor shall perform the grouting under pressure to rock surrounding the tunnel and elsewhere as shown on the Drawings or directed by the PMO/Engineer for the consolidation of the rock. The grouting for the surrounding rock of the tunnel shall not be done within 15 days after the backfill grouting is completed at the location.

T3.5.2 Drilling grout holes

Grout holes shall be drilled by the Contractor into the formation, and the location, direction, order of drilling and depth of each hole shall be as shown on the Drawings or directed by the PMO/Engineer. The use of bentonite, rod dope, rod grease or other lubricants on the drilling rods or in the grout holes will not be permitted.

When the drilling of each hole has been completed, clean water shall be circulated through the hole until it is flushed free of all drill cuttings. Then the hole shall be protected from becoming clogged or obstructed by being capped temporarily until grouting operations requires it to be opened. Any hole that becomes obstructed before it is grouted shall be opened completely by the Contractor at his own expense.

T3.5.3 Grouting operation

Grouting shall be performed at one stage by attaching a packer to the end of a grout supply pipe while inserting it in the hole. Provided that it is deemed necessary in the opinion of the

PMO/Engineer, the grouting shall be carried out in stages. The grouting shall be started after conducting water pressure test prescribed in Section 3.8.

The maximum allowable grouting pressure shall be 2 kg/cm2 unless otherwise specified or directed by the PMO/Engineer.

Grouting shall be started with grout of a concentration of 1:10 in cement-water ratio by weight. Then, the concentration shall be successively charged thicker in accordance with the grout take as directed by the PMO/Engineer. The maximum concentration of grout shall be 1:1 unless otherwise specified or directed by the PMO/Engineer.

When the maximum allowable grouting pressure has been attained, the grouting shall be continued under the same pressure with the same concentration of grout until 30 minutes after the grout take decreases below 0.2 litres per minute per liner meter of the hole. After the grouting is completed, the final or residual pressure shall be maintained on the grout until the grout has set sufficiently to be retained in the hole.

T3.5.4 Concentration of Grout

Unless otherwise specified or directed by the PMO/Engineer, grouting shall be started with grout of a concentration of 10:1 in water/cement ratio by weight. In accordance with changes in injection volume and pressure, the concentration of grout shall be successively changed to 6:1, 4:1, 2:1, 1:1, mortar of 4:1, 2:1 or 1:1.

Unless otherwise directed by the PMO/Engineer, standard injection rates for changing of grout concentration for consolidation grouting shall be as follows:

No.	Concentration of grout before changing (c/W)	Standard injection rates for changing (lit/10 min/m)	Concentration of grout after changing (c/w)
1	1:10	more than 100	1:6
2	1:6	" 50	1:4
3	1:4	" 30	1:2
4	1:2	" 20	1:1

Note : The maximum concentration shall be 1:1 unless otherwise specified or directed by the PMO/Engineer.

T3.5.5 Time of Completion

When the maximum allowable pressure has been attained, injection of grout shall be continued keeping the same pressure by regulating the return line valve, and keeping the same concentration,

until the injection rate decreases below 0.2 litres per minute per metre. Then the injection shall be continued under the maximum allowable pressure for 30 minutes.

T3.5.6 Treatment of Grout Leakage

When injected grout leaks from cracks, fissures, etc. in the course of grouting, these sources of leakage shall be effectively sealed or caulked. During the grouting of a hole, adjacent holes shall be left uncapped to facilitate the passage of air and water. If sufficient grout leaks from these holes to interfere with grouting, these holes shall be treated by the PMO/Engineer's instruction.

T3.6 Curtain Grouting

The Contractor shall perform the curtain grouting in stages in order to form a low permeability zone around the tunnel at the location as shown on the Drawing or directed by the PMO/Engineer. Unless otherwise specified herein, the curtain grouting operation shall be performed in conformity with the stipulations prescribed in Clause T3.5.

The length of one stage shall be 5 m and the maximum allowable pressure shall be 0.4 times grout hole depth in meter (kg/cm^2), unless otherwise directed by the PMO/Engineer.

Stage grouting shall be made outward from the tunnel. Redrilling for a subsequent stage shall not be performed within 12 hours after completion of the preceding grouting operation.

T3.7 Water Pressure Test

Prior commencement of consolidation grouting or curtain grouting, water pressure test for each hole shall be performed by the Contractor in order to assess the rock condition. Water injection shall be continued at least 10 minutes, after water take has become stable, under the pressure specified by the PMO/Engineer.

The Contractor shall record hole number, pressure attained, water take, Lugeon value and submit them to the PMO/Engineer.

T3.8 Check Hole

After completion of grouting, the result of grouting will be checked by drilling holes and water pressure test at the locations as directed by the PMO/Engineer. A rotary type drill shall be used, when directed by the PMO/Engineer, to recover cores. The Contractor shall keep the cores in a manner to the satisfaction of the PMO/Engineer, and furnish them to and at the time requested by the PMO/Engineer.

The water pressure test shall be conducted through the check hole in the manner as prescribed in Clause T3.7.

Unless otherwise directed by the PMO/Engineer, the test holes shall be tightly packed to the full length by ramming with dry mortar and then patched.

T3.9 Permeability Test

The Contractor shall execute permeability tests in test holes by stages of less than 5 metres.

Prior to commencement of grouting in each stage, permeability test shall be done for the purpose of assessing the rock condition. Packer shall be set tightly at the top of the stage to be tested and clean water shall be pumped into the hole under constant pressure that is so controlled by handling the return line valve. Injection of water shall be continued at least 10 minutes for each pressure of 5.0 kg/cm^2, 10 kg/cm^2, 15 kg/cm^2, 20 kg/cm^2, 10 kg/cm^2, 5 kg/cm^2, after the injection rate become stable.

The Contractor shall record all necessary data of the test such as the hole number, the stage, the ground water level, the pressures, the injection rates and the height of pressure gauge from the net of the hole.

The pressure to be applied shall be directed by the PMO/Engineer in the site shall not exceed 80% of maximum allowable pressure for the stage in grouting, unless otherwise directed by the PMO/Engineer.

T3.10 Measurement and Payment

T3.10.1 Drilling grout holes and check holes

Measurement for payment of drilling grout holes and check holes will be made only to the depth of holes actually drilled as directed by the PMO/Engineer in formation rock or concrete. Redrilling hardened grout holes will not be included for measurement.

Payment for drilling grout holes and check holes will be made at the unit prices per meter stated in the Bill of Quantities, which unit prices shall include the cost of all labour, materials and equipment for drilling, washing and maintaining the holes free from obstructions until grouted, redrilling hardened grout and recovering cores if required, and for all incidental work connected thereto.

T3.10.2 Backfill grouting

Measurement for payment of backfill grouting will be made of the volume of cement-sand mortar actually injected as directed by the PMO/Engineer.

Payment for backfill grouting will be made at the unit prices per cubic meter stated in the Bill of Quantities, which unit prices shall include the cost of all the labour, materials and equipment, including furnishing and installing steel pipes and for all incidental work connected thereto.

T3.10.3 Consolidation grouting and curtain grouting

Measurement for payment of consolidation grouting and curtain grouting will be made of the weight of cement actually forced into the holes as directed by the PMO/Engineer.

Payment for consolidation grouting and curtain grouting will be made at the unit prices per ton stated in the Bill of Quantities, which unit prices shall include the cost of all the labour, material and equipment, including packer setting-up and for all incidental work connected thereto.

T3.10.4 Water pressure test

No separate payment for the water pressure tests will be made and the cost thereof shall be deemed to be included in the unit prices stated in the Bill of Quantities for various items.

T3.10.5 Permeability test

Measurement for payment of permeability test shall be made on the basis of actual number of test to be determined by the detailed data as approved by the PMO/Engineer.

Payment shall be made for the number of test as provided above at the respective Contract unit prices per test stated in the Bill of Quantities, which unit prices for permeability test shall constitute full compensation for the cost of all labour, tools, equipment, and materials including furnishing, loading, haling, unloading, stocking and other items necessary to complete the works.

CHAPTER T4 CONCRETE WORK

T4.1 Mass and Reinforced Concrete

T4.1.1 General

These Specifications shall apply to all works and materials in connection with the mass and reinforced concrete in the structure.

Unless specifically provided in these Specifications, concrete shall be manufactured, transported, placed, cured, finished, and tested by the Contractor in accordance with the provisions of JIS or other equivalent standards approved by the PMO/Engineer.

Prior to starting concrete works, the Contractor shall submit for the approval of the PMO/Engineer the construction program including construction facilities, method and quality control plan of the concrete work in detail with the drawings.

T4.1.2 Materials

(1) Cement

Cement for concrete and mortar shall be furnished by the Contractor. Cement to be furnished shall conform to the requirements of JIS R 5210-79, ordinary portland cement, or approved equivalent. The use of any other type of cement shall be subject to the approval of the PMO/Engineer.

Cement shall be delivered in the manufacturer's bags or in bulk. Each consignment shall be sampled at the mill and shall be accompanied by a test certificate issued by the manufacturer. The PMO/Engineer will have the right to attend the sampling and testing at the mill at any time. If delivery is not directed from the factory, the intermediate storage and delivery arrangements shall be subject to the approval of the PMO/Engineer.

Cement shall be stored in a damp-proofed storehouse having a floor more than 30 cm above the ground. Cement shall be stored in such a manner that the "first-in" can be "first-out" and inspection of stock quality can be easily performed. Proper spacing shall be provided between piles of cement. Not more than 13 bags shall be permitted to be piled up, and this number shall be limited to 7 bags when the storage period is expected to be longer than 60 days.

No cement which has been stored at the site for more than 90 days shall be used in the work unless re-test proves it to be satisfactory.

The Contractor shall make a weekly report showing on a daily basis what quantity has been received and issued during the week, and in what portions of the works the cement has been used.

(2) Aggregate

(i) General

Fine and coarse aggregate for concrete will be procured by the Contractor in Mauritius. The Contractor shall confirm the following requirements for the raw material.

The stone shall be fine or medium grained, hard, bright and uniform in colour, breaking with a clean fracture, and making a ringing sound when struck with a hammer. It shall be free from dust, decay, vesicles, holes, veins, flows, cracks, and other defects. If, after 24 hours of immersion in water, the percentage water absorption exceeds 1.5% of its dry weight, the stone shall be rejected.

(ii) Fine aggregate

Fine aggregate shall be clean, hard, solid, durable and of proper grading, and it shall be free from dirt, mud, silt, organic matter or other deleterious materials. Fine aggregate, as batched, shall be well graded to conform to the following limits:

Sieve designation mean opening (mm)	Individual percent by weight retained on screen	
	Minimum	Maximum
10	0	0
5	0	8
2.5	5	20
1.2	10	25
0.6	10	30
0.3	15	30
0.15	12	20
Pan	2	15

The grading of sand shall be controlled so that the fineness modulus of at least 9 out of 10 consecutive test samples of finished sand, when samples are taken hourly, will

not vary more than 0.2 from the average of fineness modulus of the 10 test samples. The fineness modulus of sand shall range between 2.4 and 3.2.

The amount of deleterious substance in fine aggregate shall not exceed the limits prescribed below:

Item	Percentage by weight
- Clay lumps	1.0
- Material passing 0.074mm sieve	3.0 *
- Material floating on a liquid having a specfic gravity of 1.95	0.5

* In the case of crushed sand, if the material finer than 0.074 mm sieve consists of rock dust free from clay or silt, this percentage may be increased to 5.0.

Fine aggregate producing a colour darker than the standard in the colorimetric test for organic impurities may be rejected. Loss of fine aggregate subjected to five cycles of the sodium sulphate soundness test shall not exceed 10 percent.

(iii) Coarse aggregate

Coarse aggregate shall consist of solid, uncoated rock fragments, clean, hard, durable and free from objectionable quantities of flat or elongated particles, organic matter or other deleterious material.

Unless otherwise approved or directed by the PMO/Engineer, the coarse aggregate shall be separated into nominal sizes and graded as follows:

Designation of Max.Size (mm)	Nominal Size (mm)			
	80 - 40	40 - 20	20 - 10	10 - 5
	Percent by Weight (%)			
80	40 - 20	40 - 20	25 -15	15 - 10
40	-	55 - 40	35 - 30	25 - 15
20	-	-	70 - 30	45 - 20

The amount of deleterious substance in coarse aggregate shall not exceed the limits prescribed in the following table:

Item	Percent by weight
Clay lump	0.25
Soft particles	5.0
Material passing 0.074 mm sieve	1.0 *
Material floating on a liquid having a specific gravity of 1.95	1.0

* In the case of crushed aggregate, if the material finer than 0.074 sieve consists of rock dust free from clay or shale, this percentage may be increased to 1.5

Loss of aggregate subjected to Los Angeles test (500 revolutions) shall not exceed 40 %. Loss of aggregate subjected to five cycles of the sodium sulphate soundness test shall not exceed 12%.

(iv) Storage

Aggregate shall be delivered, stored and handled so as to avoid mixing of different sizes, segregation in a particular size, breakage, contamination with deleterious matter and retention of water. The aggregate shall be stored with free draining facility for at least 48 hours before use and fine aggregate shall not be drawn from the bottom 50 cm of the stockpile. All storage facilities shall be subject to the approval of the PMO/Engineer and shall be such as to permit easy access for identification and inspection.

Sufficient aggregate shall be maintained at the site at all times to assure continuous placement of concrete at a rate consistent with the requirements of the approved concreting schedule.

If the aggregate is stockpiled on the ground, the sites of stockpiles shall be cleared, graded evenly for drainage, and sprinkled if required.

(v) Moisture control

The free moisture content of the fine aggregate and of the smallest size group of coarse aggregate, as delivered to the mixers, shall be controlled so as not to exceed 4.0 % and 1.0 %, respectively, by weight of the saturated surface dry aggregates

unless higher limits are allowed by the PMO/Engineer. The moisture content of the other sizes of the coarse aggregate shall be controlled so that the aggregates are delivered to the mixers with the least amount of free moisture and the least variation in free moisture as practicable under job conditions. The Contractor may accomplish the required moisture control by use of free draining storage, covered transportation and storage mechanical dewatering devices, or any other means acceptable to the PMO/Engineer.

(3) Water

The water for washing aggregate and mixing concrete, grout and mortar shall be reasonably clean and free from objectionable quantities of silt, organic matter, alkali, salts, acids and other impurities.

(4) Admixtures

(i) General

The Contractor shall furnish and use, upon approval of the PMO/Engineer, concrete admixtures so as to improve workability and finishability of concrete or mortar. Admixtures other than those for improving workability and finishability may be used upon approval of the PMO/Engineer.

Admixtures shall be accompanied with the manufacturer's certification in compliance with specifications provided herein. The PMO/Engineer will reject admixtures proposed by the Contractor when he deems such admixtures are unsatisfactory to produce a high degree of uniformity throughout the course of the work. The Contractor shall, if the PMO/Engineer deems it necessary, submit samples and perform tests on samples of the admixtures prior to shipment, and sample and test the admixtures after delivery at the Site.

The Contractor shall be responsible for any difficulties arising or damages occurring as a result of the selection and use of admixtures such as delay or difficulty in concrete placing or damage to the concrete during form removal.

All costs incidental to the use of admixtures shall be included in the unit prices stated in the Bill of Quantities for applicable items for concrete in which the admixtures are used.

(ii) Air entraining agent

An approved air entraining agent shall be used to produce the specified amount of stable entrained air in the the concrete mixture, and shall conform to the requirement of ASTM standard C260, "Air-entraining Admixtures for Concrete". The required air content of the concrete is as follows:

Maximum Aggregate Size of Concrete (mm)	Total Air % by Volume
20	6.0 ± 1.0
40	4.5 ± 1.0
80	3.5 ± 1.0

(iii) Water reducing admixture

A water reducing admixture that does not retard the initial set of the concrete shall be added to the concrete during mixing in the amount approved by the PMO/Engineer. This admixture shall conform to the requirements of ASTM C 494, Type A.

(iv) Initial set retarding admixture

An initial set retarding admixture shall be added to the concrete during mixing where and in the amounts as approved by the PMO/Engineer in order to obtain the retardation of the initial set of the concrete. This admixture shall conform to the requirements of ASTM C 494-82, type B and D.

(v) Compatibility

The compatibility of admixtures, where two or more kinds of admixture are used in one batch, shall be tested in a manner as directed by the PMO/Engineer.

(vi) Storage

Liquid or powdered admixture for concrete shall be kept in waterproof stores with adequate provision for the prevention of water absorption. Storage shall be so arranged that the materials will be used in the order in which they arrive at the Site.

Sufficient quantities of admixture shall be kept in storage to ensure uninterrupted concrete placing.

T4.1.3 Mix proportions

(1) Mix proportions

The mix proportion of all concrete shall be as approved by the PMO/Engineer. The Contractor shall propose the mix proportion of concrete for the approval of the PMO/Engineer together with sufficient data for the judgement by the PMO/Engineer, sufficiently in advance to the intended placing of concrete for the examination by the PMO/Engineer and,if directed, the adjustment of mix proportion by the Contractor. The PMO/Engineer may direct the Contractor to change the mix proportion from time to time at his discretion. In such case the Contractor shall no longer be entitled to use the previous mix proportion and he shall propose a new mix proportion for the approval of the PMO/Engineer. The table below gives particulars of classes of concrete to be placed in the various types of structures.

Class	Max. size of aggregate (mm)	Design strength at 28 days (kg/cm^2)	Slump (cm)	Tentative cement content (kg/m^3)
A	20	210	16 ± 2	345
B	20	180	13 ± 1	308
C	40	180	13 ± 1	322
D	40	140	9 ± 1	262
E	80	120	9 ± 1	220
F	40	100	9 ± 1	227

Compressive strength of concrete at the age of 28 days measured by the testing method as stipulated in Clause 4.1.4 shall be more than 80% of the design strength stated above in a probability not less than 95% and more than the design compressive strength in a probability not less than 75%.

Unless otherwise specified, water-cement ratio by weight of each class of concrete shall not be more than 60 %.

Cement contents stated above are only tentative and the PMO/Engineer may order the Contractor to vary the cement contents of any class or classes of concrete during the course of the Works, and for such change in cement contents within 10% the Contractor shall not claim any compensation above the unit prices stated in the Bill of Quantities.

If the change in cement contents will occur beyond 10%, adjustment of unit prices for concrete will duly be made on the basis of its breakdowns to be submitted by the Contractor.

For various structures specified herein, the classes of concrete to be used are designated in principle in the following list and on the Drawings. They are subject to revision as directed by the PMO/Engineer.

Concrete	Location in work
A	2nd concrete for blockout,Building work
B	Drain ditch,drain pipe
C	Tunnel lining,inlet & outlet
D	Backfill concrete, foundation of building
E	Submergible bridge
F	Lean concrete

(2) Trial mixes

At least 60 days prior to the start of permanent concrete work, the Contractor shall produce trial mixes for each of the classes of concrete specified under the supervision of the PMO/Engineer, using the entire aggregate producing, batching and concrete mixing plant provided for the execution of the Work. Such trial mixes shall be produced until concrete complying with these Specifications is produced.

No separate payment for trial mixes will be made and all cost incidental to trial mixes except furnishing and installing testing equipment shall be included in the unit prices stated in the Bill of Quantities for the applicable items of concrete.

T4.1.4 Tests of concrete and concrete material

Except where otherwise specified, sampling and testing of concrete material, fresh concrete and hardened concrete shall be conducted by the Contractor under the direction of the PMO/Engineer in accordance with JIS or approved equivalent. Such tests of concrete aggregates, fresh concrete and hardened concrete will include, but will not be necessarily restricted to, those listed below:

Test	Designation No
- CONCRETE -	
Sampling of concrete	JIS A 1115 - 75
Compressive strength	JIS A 1108 - 76, JIS A 1132 - 76
Slump	JIS A 1101 - 75
Air content	JIS A 1118 - 75
Unit weight	JIS A 1116 - 75
- AGGREGATE -	
Material passing 0.074 mm sieve	JIS A 1103 - 76
Surface moisture	JIS A 1111 - 76
Organic impurities	JIS A 1105 - 76
Sodium sulphate soundness	JIS A 1122 - 76
Grading of aggregate	JIS A 1102 - 76
Los-Angeles Abrasion	JIS A 1121 - 76
Units weight	JIS A 1104 - 76
Specific gravity and absorption	JIS A 1109 - 76, JIS A 1110 - 76

The Contractor shall execute the routine test of concrete to determine the compressive strength, slump and air content. The number and frequency of the tests of fresh concrete shall be as directed from time to time by the PMO/Engineer, provided that such tests shall be made at least once for each class of concrete which is produced during a shift. The compressive strength of the concrete shall be determined by tests of 15 cm diameter and 30 cm high cylinders, three of which shall be tested at 7 days and three at 28 days for each class of concrete which are produced during the shift. The tests of concrete aggregates shall be made as directed from time to time by the PMO/Engineer. Results of the routine test shall be submitted to the PMO/Engineer in the approved forms and in such intervals that the PMO/Engineer may direct.

The PMO/Engineer will make the check test of concrete material, fresh concrete and hardened concrete when he deems necessary. The Contractor shall fully assist the PMO/Engineer in the check test.

If at any time, the 7-day test indicates the strength at 28 days may not be achieved as specified, the PMO/Engineer will suspend concreting operations till the reasons are investigated and corrected, and/or the mix has been redesigned. This decision will be binding on the Contractor, and such suspension shall not be made a reason for any claims.

The Contractor shall provide such facilities, material and labour as may be necessary for producing, handling and waste disposal of representative test samples for tests specified in this Clause. Samples will be required of all concrete ingredients and fresh concrete at aggregate plants, batching and mixing plants and at the forms where concrete is being placed. All batching and mixing plants shall be equipped with sampling devices and facilities approved by the PMO/Engineer for obtaining samples of water, cement, aggregates, admixtures and fresh concrete. Such sampling devices will

be used frequently and should be designed to ensure that representative samples of appropriate size of the required material are obtained with the minimum disruption of the Contractor's production of aggregate and concrete.

No separate payment for the provisions specified in this Clause will be made and all cost incidental to samplings, testings and providing sampling devices and facilities except furnishing and installing testing equipment shall be included in the prices stated in the Bill of Quantities for the applicable items for concrete. The Contractor shall not be entitled to any additional compensation for any delays or cost incurred in the provisions of samples.

T4.1.5 Batching

(1) General

Batching of cement, admixtures, fine and coarse aggregates entering each batch of concrete shall be made by weighing measurement. Unavoidable use of volumetric measurement of ingredients because of special circumstances of the jobsite shall be strictly subject to the approval of the PMO/Engineer.

All measuring devices shall be capable of ready adjustment to compensate for the varying moisture content of the aggregate and to change the weights of the materials being batched.

The combined accuracy of batching equipment in feeding and measuring the material shall be within the following limits :

Cement and water	1 %
Aggregate and admixtures	3 %

(2) Calibration of measuring devices

Unless otherwise directed by the PMO/Engineer, check tests of equipment used for measuring water, cement, and the admixtures shall be made in the presence of the PMO/Engineer, at least once in every two weeks, and of equipment used for measuring fine and coarse aggregates at least once every month. After completion of check test, the Contractor shall make such adjustment, repair or replacements as the PMO/Engineer may deem necessary to secure satisfactory performance before further use of the measuring or recording devices will be allowed.

The Contractor shall provide standard test weight and any other auxiliary equipment required for checking the operating performance of each scale or other measuring device. Periodical tests according to the manufacture's instruction shall be made in the presence of the PMO/Engineer in such a manner and at such intervals as may be directed by the PMO/Engineer.

(3) Batching and weighing equipments

Each weighing unit shall include a visible springless dial which will register the scale load at any stage of the weighing operation or shall include an over-and-under indicator which will show the scale in balance at no load and when loaded to the beam setting. The weights of the components of each batch shall be automatically recorded and the records shall be submitted to the PMO/Engineer, in such intervals that the PMO/Engineer may direct.

Each weighing indicator and water measuring device shall be in full view of the operator and the weighing equipment shall be so arranged that the operator may conveniently observe the operation of the bingates and also the materials discharging into the mixer. The arrangement for controlling the measuring and mixing operations shall be such that the mixer cannot be charged with a fresh batch until it has been emptied of the previous one.

The batching equipment shall be so constructed and arranged that the sequence and timing of the batcher discharge gates can be controlled to produce an intermixing of the aggregate, water and cement as the materials pass through the changing hopper into the mixer. The batching control shall be so interlocked that a new batching cycle cannot be started until all the weighing hoppers are completely empty.

The weighing hoppers shall be constructed in a manner which will permit convenient removal of overweight material in excess of the prescribed tolerances, and acceptable facilities shall be provided for readily obtaining from the batches representative samples of the materials for testing.

The operating mechanism in the water measuring device shall be such that no leakage will occur when the valves are closed and that the discharge valve cannot be opened until the filling valve is closed.

The device for adding admixtures shall be interlocked with the batching and discharging operation of the water so that the batching and discharging of the admixture will be automatic. The measuring device for cement shall be automatic.

The batching equipment shall include an accurate recorder for marking a continuous visible combined record on a single chart of the separate measurement of each concrete ingredient, including all mixing water and admixture and of consistency of the concrete during the mixing process.

T4.1.6 Mixing

The batched ingredients of concrete shall be so mixed in power-driven batch mixer as to produce a homogeneous mass of uniform consistency. Hand-mixing shall not be used for permanent structures and, when used for temporary structures, it shall be strictly subject to the approval of the PMO/Engineer.

The quantity of material in each batch shall not exceed the normal continuous rated capacity of the mixer and the speed of rotation shall be controlled within the deviation of 1 rpm from the manufacture's recommended speed. Components shall be fed into the mixing drum so as to ensure the most efficient use of the mixing period and to avoid any loss of material.

Unless otherwise directed or approved by the PMO/Engineer, the mixing of each batch shall continue for not less than the following numbers of minutes, after ingredients including the full amount of water and admixtures are in the mixer.

Capacity of mixer (cubic meter)	Time of mixing (minutes)
3 to 2	2.5
2 to 1.5	2
1.5 or less	1.5

The minimum mixing period specified above is predicated on proper control of the speed of rotation of the mixer and of the introduction of the materials including water into the mixer. The mixing time shall be increased when, in the opinion of the PMO/Engineer, the charging and mixing operations fail to result in the required uniformity of composition and consistency.

The efficiency of mixing operation shall be determined by means of measuring the difference in unit weight of mortar mixed in the batch mixer in conformity with JIS A 1119 - 76. The unit weight of two samples of air-free mortar taken from the first and last portion of the batch as discharged from the mixer shall not vary more than 1 percent from the average weight of the two mortar samples. Furthermore, the weight of coarse aggregate per cubic meter in samples taken from the first and last portion of the batch as discharged from the mixer, each of which is 50 litres in volume, shall not vary more than 8 percent from the average weight of the two coarse aggregate samples. These measurements shall be made by the Contractor in the presence of the PMO/Engineer at the time as

directed by the PMO/Engineer. No separate payment will be made for these measurement and the cost thereof shall be included in the unit prices of the applicable items for concrete stated in the Bill of Quantities.

The remixing of partially hardened concrete with or without additional cement, aggregate, or water will not be permitted.

Mixers shall be periodically cleaned as directed by the PMO/Engineer.

T4.1.7 Transportation

The method and equipment used for transporting concrete shall be such that concrete having the required composition and consistency will be delivered to the point of placement without objectionable segregation or, unless otherwise approved by the PMO/Engineer, loss of slump in excess of 2.5 cm.

Addition of water to concrete after it has been discharged from the mixer or "retempering" will not be permitted.

In case that concrete is transported by the following types of equipment, the equipment shall be installed and handled according to the following specifications.

(1) Agitator truck

The agitating speed of the drum shall be between 2 and 4 rpm. The volume of mixed concrete in the drum shall not exceed the manufacturer's rating nor exceed 70 percent of the gross volume of the drum. The interval between feeding of water into the mixer drum and final discharging of the concrete from the agitator shall not exceed 1.0 hour. During this interval, the mixture shall be agitated continuously at the speed above mentioned. Upon approval of the PMO/Engineer, truck mixer may be used instead of agitator trucks for transportation of central-plant-mixed concrete.

(2) Chute

In general, transportation of concrete by the use of chutes will not be permitted unless approved by the PMO/Engineer. The chute shall have a section with round corner and shall have a proper fixed slope so as to allow the concrete to flow satisfactory and without segregation. The lower end of chute shall be provided with a drop chute not less than 0.6 m

in height to avoid segregation of falling concrete. Chutes shall be protected from the direct rays of the sun.

(3) Concrete pump or placer

Delivery pipes shall be so installed as to permit easy removal. Before starting pump or placer operation, about one cubic meter of mortar with the same proportions of water, admixture, cement and sand as designated for the regular concrete mix shall be passed through the pipe. The pipe shall be set as straight as possible. Air boosters shall not used except in conditions that the outlet of pipes is completely embedded at least 2 meters in fresh concrete.

The use of concrete pump or placer shall in general be limited to tunnel work and locations where other transportation and placement methods are deemed impracticable by the PMO/Engineer.

(4) Belt conveyer

Transporting concrete by belt conveyers will not be permitted unless approved by the PMO/Engineer. Belt conveyers shall be such that belts are protected from rain, wind and sunlight, and that a proper hopper or vertical chute at least 0.6 m in depth is used at the end of each conveyer.

(5) Bucket

Buckets shall be such that concrete will be delivered to the point of placement without segregation. The bucket shall be equipped with a flexible drop chute not less than 0.6 m in height.

T4.1.8 Placing of concrete

(1) General

At least 30 days before placing concrete for the permanent works, the Contractor shall submit construction procedures showing the methods of concrete placement he proposes to use, to the PMO/Engineer for his approval.

No concrete shall be placed until all formwork, installation of parts to be embedded and preparation of surfaces involved in the placing have been completed by the Contractor and the completion has been inspected and approved by the PMO/Engineer.

Unless otherwise permitted by the PMO/Engineer, no concrete shall be placed in rain and standing water, and no concrete shall be placed in running water.

Communication facilities between the mixing plant and placing site shall be furnished by the Contractor where necessary or desirable as determined by the PMO/Engineer.

(2) Preparation for placing

Immediately before concrete is placed, all surfaces of rock foundations to which concrete is to be bonded shall be cleaned of oil, mud, organic matter, wooden pieces, objectionable coating, debris, loose rock fragments, or other perishable materials by the use of high-velocity air-water jets or other effective means approved by the PMO/Engineer.

Sharp projections of rock shall be knocked off. Faults, veins, crushed zones or any other weakness shall be treated as directed by the PMO/Engineer. This treatment may include consolidation grouting if necessary. Anchorages shall be provided if found necessary, and as directed the PMO/Engineer.

The surfaces of rock foundation shall be moistened thoroughly at least 18 hours before placing concrete and standing water shall be removed.

The surfaces of soil or sand and gravel foundations to which concrete is to be placed shall be free from standing or running water, wooden pieces or other objectionable materials above-mentioned. For soil or sand and gravel foundation, the foundation shall be in damp condition before placing concrete.

The surfaces of construction joints of old concrete including the surface of blockouts, on which new concrete to be placed shall be roughened and cleaned by chipping, high-velocity air-water jet, wire brushing or other approved method, and kept moist for at least 18 hours prior to placing the new concrete after the above mentioned treatment of the joints. Cleaning shall consist of the removal of all laitance, loose or defective concrete, coating, and foreign materials.

The surfaces of all contraction joints shall be cleaned thoroughly of accretions of concrete or other foreign materials by scrapping, chipping or other means satisfactory to the PMO/Engineer. Contraction joints shall be given a coat of compound approved by the PMO/Engineer to prevent bond.

(3) Placing

After the surface have been prepared satisfactorily, all approximately horizontal surface of rock and construction joints of mass concrete shall be covered with a layer of over-sanded mix. The mix shall have a proportion of cement and sand as directed by the PMO/Engineer. The over-sanded mix shall be spread uniformly in a layer of 1.5 - 2 cm in thickness and concrete shall be placed immediately upon it.

Any concrete which has become so stiff that proper placing cannot be assured unless retempered shall be wasted at the Contractor's expense.

Concrete shall be deposited in vertical dropping to minimize segregation and be placed so carefully as not to exert unfavourably impact on the reinforcing bars or forms assembled. The vertical free drop of falling concrete shall not exceed 1.5 m. Care shall be taken in placing concrete through reinforcing bars to minimize segregation.

All formed concrete, except lining concrete for underground structures, shall be placed in horizontal layers, the thickness thereof shall not exceed 0.5 meter or any lower limit specified by the PMO/Engineer. The height of one lift of concrete placing shall not be more than 1.5 m unless approved by the PMO/Engineer. The time between successive lifts shall be at least 24 hours for all structures. This time may have to be extended to 96 hours in case of massive structures during critical periods of high internal heat generation in the concrete. Time limits shall be subject to the approval of the PMO/Engineer.

Unless otherwise approved by the PMO/Engineer, all concrete shall be placed in its final position within 1 hour after feeding of water into the mixer drum.

Cold joints shall be avoided where practicable. In the event of equipment breakdown, or if for any other reason continuous placing will be interrupted, the Contractor shall thoroughly consolidate the concrete at such joints to a reasonably uniform and stable slope while the concrete is plastic. The concrete at the surface of such cold joints shall be cleaned and wetted as required for construction joints before being covered with fresh concrete.

(4) Temperature of concrete

Temperature of concrete when it is being placed shall be not more than 32 °C. If the PMO/Engineer deems it necessary to do so, the Contractor Shall employ effective means, such as precooling of mixing water and placing at night, to maintain the temperature of the concrete, as it is placed, below 32 °C.

(5) Consolidation

Each layer of concrete shall be immediately consolidated with suitable appliances so that the concrete is compacted to the maximum practicable density and closes snugly against all surfaces of forms and embedded materials. Subsequent layers of concrete shall not be placed until the layers previously placed have been worked thoroughly as specified.

In general, concrete shall be consolidated with electric or pneumatic power-driven internal-type vibrators, operating at a speed of at least 7,000 rpm when immersed in concrete. The vibrating head shall be inserted in concrete vertically and at least 5 cm into the underlying layer. Where it is difficult to use internal vibrators, concrete may be consolidated with the external-type vibrator or compacted with the hand-plunger as directed by the PMO/Engineer. The external-type vibrator shall be operated at a speed of 8,000 rpm and be large enough to effect consolidation.

Care shall be exercised to avoid contact of the vibrating head with surfaces of the forms or embedded objects to avoid excessive local vibration. Application of the vibrators shall be made systematically and at such intervals that the zones of influence overlap and the concrete is properly compacted. Over-vibration, causing segregation and surface laitance, or tending to bring an excessive of water to the surface, shall be avoided.

Any such excess water that rises to the surface shall be removed by mopping or sponging. In no case shall it be covered by concrete or dry concrete to soak up the excess water.

T4.1.9 Curing and protection of concrete

The Contractor shall protect all concrete against injury or harmful effect due to sudden drying, loading, shock or vibration until it has hardened sufficiently to prevent damage. Exposed finished surfaces of concrete shall be protected from the direct rays of the sun for at least the first 3 days after placement. All concrete and mortar surfaces shall be kept continuously moist for at least 14 days after placement.

The method of keeping concrete moist shall be by continuous sprinkling or spraying with water, as may be necessary to keep the concrete from drying, or by other methods approved by the PMO/Engineer. Water curing shall be handled so as to prevent the formation of unsightly stains on concrete surfaces which will be permanently exposed. The water shall be free from oil and salts which may stain the concrete.

All concrete shall be adequately protected from damage. No fire or excessive heat, including the heat resulting from the welding of steel or reinforcing bars, shall be permitted near or in direct contact with concrete at any time. All conduits and other openings in the concrete, if any, shall be closed during the entire curing period.

In case the curing actions are inadequate or unsatisfactory, the PMO/Engineer shall be entitled to take such steps as he deems necessary to make up the deficiencies or defects at the Contractors risk and cost.

Should the concrete perish, i.e., become dry or powdery through negligence in curing, or get damaged through negligence in protection, such work shall be demolished and rebuilt as directed by the PMO/Engineer, at the Contractor's risk and cost.

T4.1.10 Construction joints

The location of construction joints shall be as shown on the Drawings or approved by the PMO/Engineer.

The surfaces of the construction joint shall be prepared for receiving the succeeding lift concrete by cleaning and roughening with chipping, high-velocity air-water jet, wire brushing or other approved means.

High pressure air-water jet shall be used as directed by the PMO/Engineer. The surface shall be cut with a high-pressure air-water jet by removing all laitance and by exposing clean,sound aggregate, but not so as to undercut the edges of larger particles of aggregate. The air pressure used in the jet shall be 7 kg/cm^2 and the water pressure shall be just sufficient to bring the water into effective influence of the air pressure. After cutting, the surface shall be washed and rinsed as long as there is any trace of cloudiness of the wash water. The surface shall again be washed with an air-water jet just prior to placing the succeeding lift.

The method used in disposing of waste water employed in cutting, washing and rinsing of concrete surfaces shall be such that the waste water does not stain, discolour, or affect exposed surfaces of the structures.

T4.1.11 Contraction joint and waterstop

Contraction joint as indicated on the Drawings or elsewhere as directed by the PMO/Engineer shall be provided by the Contractor. The joint material will consist of a layer of bituminous coating on the face of the first concrete.

Waterstops shall be furnished by the Contractor and shall be placed at such positions as shown on the Drawings or as directed by the PMO/Engineer. Waterstops shall be of flexible polyvinyl chloride meeting JIS K 6773-74 or approved equivalent. Waterstops prescribed in this Clause shall include groutstop.

All waterstops shall be stored in a place as cool as practicable and in no case shall waterstops be stored in the open or exposed to direct rays of the sun. All waterstops shall be stored so as to permit free circulation of air about them.

All field splices and intersections of waterstops shall be made so as to provide watertight connections by such means as specified by the manufacturer or as indicated on the Drawings.

The Contractor shall provide suitable support and protection during the progress of work to protect the Waterstops from damage, deterioration, or warping.

Waterstops shall be installed with equal widths of the material embedded in the concrete on each side of the joint. The concrete shall be carefully placed and vibrated around the waterstop for a complete bond between the concrete and all embedded areas of the waterstop. After installation and before, it is embedded in concrete, the waterstop shall be protected from direct rays of the sun.

The Contractor shall replace or repair, at his expense, any waterstops torn, punctured or otherwise damaged before final acceptance of the work.

The watertightness of joints for which waterstops are provided shall be the Contractor's responsibility. The Contractor shall supply all materials and labour and perform all the work necessary to rectify leaking joints to the PMO/Engineer's satisfaction.

T4.1.12 Formwork

(1) General

Forms shall be used, wherever necessary or particularly directed by the PMO/Engineer, to confine concrete and shape it to the required lines.

The forms shall have sufficient strength and rigidity to hold the concrete and to withstand the pressure resulting from placement and vibration without deflection from the prescribed lines. The surfaces of all forms to be in contact with the concrete shall be clean, rigid, smooth, and sufficiently tight to prevent loss of mortar or cement slurry.

All exposed joints, edges, and external corners shall be chamfered not less than 2 cm at 45° except as otherwise directed. Internal corners shall be filleted where indicated or required by the PMO/Engineer.

Immediately before concrete is placed, precaution shall be taken to see that all forms are in proper alignment, and that all form supports are thoroughly secure and tight.

In case of sliding formwork used for tunnel lining, and also in case of any other formwork as directed by the PMO/Engineer, the Contractor shall submit the design drawings of the formwork for approval of PMO/Engineer, before manufacturing the forms. Such approval shall not relieve the Contractor of his responsibility for adequacy and strength of the formwork.

(2) Material

All materials used in the forms shall be subject to the approval of the PMO/Engineer. Lumber shall be sound, straight, free from warp, decay and loose knots and shall be dressed smooth and uniform in width and thickness prior to fabrication of formwork.

Form to be used in water passages and for concrete which will ultimately be exposed to view shall be faced either with plywood or steel and shall be free of all defects which will be reproduced as blemishes on the concrete surfaces.

Particular care shall be taken for curved formwork, which shall be such that it will not warp or spring up during concreting.

Where plywood is used, it shall be non-warping, non-wrinkling and manufactured with special waterproof glues. In so far as is practicable, plywood sheets shall be of uniform width and length.

(3) Construction tolerances

Variation in alignment, grade and dimensions of the structures from the established alignment, grade and dimensions shown on the Drawings shall be within the tolerances specified in this Paragraph. Concrete work that exceeds the tolerance limits specified herein shall be remedied or removed and replaced by the Contractor at his own expense.

(i) Construction tolerances for reinforced concrete structure

		Tolerance	
a. Variation from vertical			
- In the lines and surfaces of columns, piers, walls and towers		In 3 m	5 mm
		In 6 m maximum	8 mm
		In 12 m or more	16 mm
- For exposed columns, control joints, grooves and other conspicuous lines		In 6 m maximum	5 mm
		In 12 m or more.....	10 mm
b. Variation from the level or from the grades indicated on the Drawings:			
- In floors, inverts, ceilings, and beam soffits		In 3 m	5 mm
		In any bay of 6 m maximum - Minus	8 mm
		In 12 m or more - Minus	16 mm
c. Variation of linear structure lines from established position in plan and related position of walls and columns		In any bay or 6 m maximum	12 mm
		In 12 m or more.....	25 mm
d. Variation in locations of sleeves and sizes and locations of floor openings and wall openings		.....	5 mm
e. Variation in cross-sectional dimensions of columns, beams and in the thickness of slabs and walls		Minus.....	5 mm
		Plus.....	10 mm
f. Variation in steps:			
- In a flight of stairs		Rise.....	3 mm
		Tread	5 mm
- In consecutive steps		Rise	2 mm
		Tread	3 mm

(ii) Construction tolerances for mass concrete structure

a. Variation of the constructed linear outline from established position in plan		In 6 m	12 mm
		In 12 m.....	18 mm
b. Variation from the level or from the grades indicated on the Drawings		In 3 m	6 mm
		In 9 m	12 mm
c. Variation in cross-sectional dimensions		Minus	6 mm
		Plus	12 mm
d. Variation in the thickness		Minus	6 mm
		Plus	12 mm

(iii) Construction tolerances for tunnel

a.	Departure from established alignment or from established grade but parallel to it:	.....	12 mm
b.	Variation from inside dimensions	In 5 m	3 mm
c.	Variation in thickness, at any point	Minus.....	0 mm

(iv) Construction tolerance for placing reinforcing steel

a.	Variation of protective covering	With 50 m cover or less	5 mm
		With more than 50 mm cover.....	10 mm
b.	Variation from indicated spacing (any one bar)	.....	25 mm

(4) Installation and preparation

Forms shall be installed so that the joint marks on concrete surfaces are in alignment both horizontally and vertically, and the joints between surfaces shall be smooth. All edges or corners of the concrete exposed permanently shall be chamfered as prescribed.

Before placing concrete, all forms be rigid and tight and shall be thoroughly cleaned, and all wooden chips, saw dust, dry mortar lumps, foreign matter and excess water shall be removed from between the forms. The surfaces of the forms shall be oiled with a non-staining commercial mineral oil of a type approved by the PMO/Engineer. The form oil shall be applied before the reinforcement is placed. Forms, which have been left in place for such a period that they have dried out, shall receive further surface treatment as directed by the PMO/Engineer.

Care shall be taken to prevent the oil from coming in contact with construction joints or reinforcement.

Where forms for continuous surfaces are placed in successive lifts, care shall be taken to fit the forms tightly over the entire surface so as to prevent leakage of mortar or cement slurry from the concrete and to maintain accurate alignment of the surface. Forms to be used more than once shall be maintained in serviceable condition and shall be thoroughly cleaned before being reused. Forms on exterior faces on walls shall be kept clean by means of splash boards.

(5) Internal ties

Internal ties consisting of bolts and rods shall be so arranged that embedded metal shall terminate not less than 3 cm from the formed surface of the concrete after forms are removed where the maximum size of aggregate is 40 mm, and not less than 5 cm where the maximum size of aggregate is 80 mm or larger. Wire ties through forms shall not be used unless authorized by the PMO/Engineer. Holes left after the removal of ties shall be filled with dry pack mortar.

(6) Removal

Forms shall not be removed until the concrete has hardened and is of sufficient strength to carry its own weight safely, together with any construction loads likely to be imposed upon it. Forms shall be removed only with the approval of the PMO/Engineer and, in general, the forms shall be left for the periods not less than the following number of hour after the concrete is placed:

Arches, conduit roofs, beams and deck-type slabs	168 hrs
Columns and walls	72 hrs
Mass concrete	48 hrs
Tunnels and shafts	
Invert	16 hrs
Arch	24 hrs
Wall poured separately from arch	48 hrs
Conduit in open cut	72 hrs

Care shall be taken in removing forms to prevent damage to the concrete.

T4.1.13 Finishes and finishing

(1) General

The classes of finishes and the requirements for finishing concrete surfaces shall be as specified in this Clause. Surface irregularities in finishes, as described herein, shall be distinguished from construction tolerances which are allowable deviations from established lines, grades and dimensions and are described in Paragraph T4.1.12 (3).

Surface irregularities are designated "abrupt" and "gradual" for the purposes of classifying finishes. Off-sets resulting from displaced, misplaced, or mismatched forms or loose knots in forms, or other similar form defects shall be considered "abrupt" irregularities and will be

checked by direct measurement. All other surface irregularities shall be considered "gradual" irregularities and will be measured as a departure from the testing edge of a 1.5 m template for formed surfaces and of a 3 m template for unformed surfaces.

Finishing of concrete surfaces shall be performed only by skilled workmen.

(2) Formed surfaces

The classes of finish for formed surfaces are designated by use of symbols F1, F2, F3 and F4.

F1 - Finish F1 is a finish applied to formed surfaces which will be covered by fill material or by concrete. Correction of surface irregularities, measured as previously described, shall be required only for depression which exceed 25 mm, when measured as previously described.

F2 - Finish F2 is a finish applied to formed surfaces which will be permanently exposed and where a reasonably attractive appearance is required. Surface irregularities, measured as previously described, shall not exceed 6 mm for abrupt irregularities and 15 mm for gradual irregularities.

F3 - Finish F3 is a finish applied to formed surfaces which will be permanently exposed to public view and where an attractive appearance is paramount. Surface irregularities, measured as previously described, shall not exceed 3 mm for abrupt irregularities and 6 mm for gradual irregularities

F4 - Finish F4 is a finish applied to formed surfaces for which alignment and evenness of surface are of paramount importance from the standpoint of eliminating destructive effects of water action. Surface irregularities, measured as previously described, shall not exceed 3 mm for abrupt irregularities not parallel to the direction of flow, 6 mm for abrupt irregularities parallel to the direction of flow, and 10 mm for all gradual irregularities. Gradual irregularities that have a slope steeper than 1 vertical to 20 horizontal and all abrupt irregularities in excess of the allowed limits shall be ground to a slope of 1 vertical to 20 horizontal, except that abrupt irregularities such as pitting shall be remedied in accordance with the provisions in sub-clause T4.1.14.

(3) Unformed surface

The classes of finish for unformed surface are designated by use of symbols U1 and U2.

Finish U1 is a screeded finish applied to unformed surfaces which will be covered by fill material or by concrete. Finish U1 is also the first stage of finish U2. Finishing shall consist of sufficient levelling and screeding to produce uniform surfaces. Surface irregularities measured as previously described shall not exceed 10 mm.

Finish U2 is a floated finish applied to unformed surfaces of waterway or surfaces which will be generally exposed to view. Floating shall be started as soon as the screeded surface has stiffened sufficiently, and shall be the minimum necessary to produce a surface that is free from screed marks and is uniform in texture. Surface irregularities for waterways shall be measured in accordance with the requirements of finish F4. Surface irregularities of areas other than waterways measured as previously described shall not exceed 3 mm.

No separate payment shall be made for the work under this Clause. The cost thereof shall be included in the appropriate unit prices of concrete work stated in the Bill of Quantities.

T4.1.14 Damaged or defective concrete surface

Defective concrete and concrete damaged from any cause shall be removed and replaced with acceptable concrete by the Contractor at his own expense. Irregularities of alignment due to inaccurate finishing of surfaces, bulging of forms, or other defects shall be rectified by and at the expense of the Contractor.

Patching and finishing work shall be done only by skilled workmen and shall be subject to the PMO/Engineer's inspection. Before final acceptance of the work, the Contractor shall clean all exposed concrete surfaces of all encrustations of cement, mortar, or grout, and shall remove all unsightly stains to the satisfaction of the PMO/Engineer.

All porous and fractured concrete and surface concrete, to which additions are required to bring it to prescribed lines, shall be removed by chipping openings into the concrete to bare the reinforcement. The extent and dimensions of the chipped openings shall be as directed by the PMO/Engineer. The chipped openings shall be sharpedged and keyed and shall be filled to the required lines with fresh concrete or dry patching mortar, as directed by the PMO/Engineer. Where concrete is used for filling, the chipped openings shall not be less than 8 cm in depth and the fresh concrete shall be reinforced and dowelled to the surface of the openings, as directed by the PMO/Engineer.

Mortar for patching shall consist by volume of one part of cement, two parts of regular concrete sand, and just enough water so that after thorough mixing of the ingredients the mortar will barely hold together when compacted by squeezing with the hand. The mortar shall be fresh when placed and any mortar that is not used within two hours after preparation shall be wasted. Immediately prior to mortar application, the surface to which the mortar is to be bonded shall be dampened, then scrubbed with a small quantity of mortar using a wire brush.

Where repairs are more than 3 cm deep, the mortar shall be applied in layers not more than 2 cm thick to avoid sagging. After each layer, except the last, is placed, it shall be thoroughly roughened by scratching with a trowel to provide an effective bond with the succeeding layers. The last of finishing layer shall be smoothed with a trowel to form a continuous surface with the surrounding concrete. The addition of a small quantity of water to the finished surface of the patch to aid in securing a smooth finish will be permitted, but other than this no additional water shall be used.

All patches on exposed surfaces shall be neat and smooth and as near as possible of the same colour as the adjoining concrete as possible. All patches shall be thoroughly bonded to the surfaces of the chipped opening and shall be sound and free from shrinkage, cracks and drummy areas.

In repairing damaged or defective concrete at important locations, the Contractor shall use epoxy resin bonding if directed by the PMO/Engineer.

All patches and repairs shall be kept continuously damp for a period of not less than 7 days and kept out of the direct rays of the sun for at least 7 days immediately following completion of the patch or repair.

T4.1.15 Reinforcing bars

(1) General

Reinforcing bars required for all permanent construction shall be furnished, fabricated and placed by the Contractor.

Reinforcing bars shall be deformed steel bars and shall comply with JIS G 3112-85, SD 30 or approved equivalent.

During the course of the Works, the PMO/Engineer will issue to the Contractor reinforcing bar drawings showing the position and size of all required reinforcing bars. The Contractor shall submit to the PMO/Engineer for his approval reinforcing bar bending and cutting

drawings, and bar list for each reinforcing bar bending and cutting drawing. Bends, hooks, splicing and anchorage shall conform to the standard details shown on the Drawings.

(2) Fabrication and placing

Bending bars with the aid of heat shall not be permitted unless otherwise approved by the PMO/Engineer.

The position of joints or splices of reinforcing bars shall be approved by the PMO/Engineer and those in adjacent bars shall be staggered if directed by the PMO/Engineer. The number of joints or splices shall be kept to a minimum.

Before the reinforcement is placed, the surfaces of the bars and the surfaces of any bar supports shall be cleaned of heavy flaky rust, loose mill scale, dirt, grease, or other foreign substances, which, in the opinion of the PMO/Engineer, are objectionable. If necessary as determined by the PMO/Engineer, exposed, previously placed bars shall be cleaned of rust and debris before being covered by concrete.

Reinforcing bars shall be accurately placed and fixed in position so that they will not be displaced during the placing of concrete.

Bars shall be tied at all intersections, and splicing tied at several points, by using annealed iron wire more than 0.9 mm in diameter or suitable clips.

Distances from the surfaces or forms of foundations shall be maintained correctly by means of metal hangers, mortar blocks, metal supports, or other supports approved by the PMO/Engineer.

T4.1.16 Concrete in tunnel

(1) Form

Forms used for tunnel concreting which are generally either sliding forms or collapsible forms shall have structures adequate for construction conditions and have sufficient strength.

Sliding forms shall meet the following requirements.

(a) Sliding forms for the arch and sidewall lining shall be provided with ample openings through which concrete may be deposited and inspected as it moves into space, or concrete may be compacted, or sliding forms may be cleaned.

(b) The length of a sliding form shall be such that:

- Total concrete volume per sliding form does not exceed the volume of concrete which is continuously placed, or the capacity of concreting equipment.

- Sliding forms can be shifted smoothly in a curve of tunnels without any contact or collision with excavated surface or lined concrete.

- No shrinkage crack takes place on the concrete surface due to temperature change and drying.

- Construction tolerances for tunnel specified in Clause T4.1.12 (3) shall be met.

Collapsible forms shall have structure easy to assemble and dismantle.

Shifting and setting of forms shall be made, paying full attention to the following points.

(a) Prior survey is prerequisite to place forms at the exact locations.

(b) Rails for shifting forms shall be firmly placed, being free from vertical and horizontal movement.

(c) Forms shall be shifted in a manner that forms are kept off the surface of concrete.

(d) To prevent sticking of concrete, the surface of forms shall be treated with a suitable oil or other coating material in a manner described in Clause T4.1.12 (4) of the Technical Specifications.

(e) Forms shall be fixed firmly by tightly fastening bolts and nuts. Because there is a large possibility that sliding forms loosen due to vibration, the bolts and nuts of sliding forms shall be examined as often as possible and tightened if required.

Removal of forms shall be made as stipulated in Clause T4.1.12 (6) or as approved by the PMO/Engineer.

Necessary finish shall be as shown on the drawings, unless otherwise directed by the PMO/Engineer.

(2) Concrete placement

Concrete in tunnels may be placed by pumping or any other methods approved by the PMO/Engineer. Equipment and methods used in placing shall be such as will introduce the concrete into forms without high velocity discharge and segregation.

In the event of equipment breakdown, or if for any other reason continuous placing is interrupted in one block, the Contractor shall thoroughly consolidate the concrete at such joints to a reasonably uniform and stable slope while the concrete is plastic. If cold joints occur, the concrete at the surface of such joints shall be cleaned as required for construction joints as stipulated in Clause T4.1.10, and wetted before being covered with fresh mortar and concrete. Concrete required to be placed incidental to the installations of tunnel supports or to other temporary work shall be removed before any permanent concrete is placed, unless it is at least equal in all respects to the permanent concrete specified.

The transportation of concrete for tunnel shall be made by using agitators unless otherwise approved by the PMO/Engineer in order to prevent the segregation of concrete and the intrusion of harmful foreign materials.

The concrete shall be placed and sufficiently compacted with vibrators in such manners that it is free of segregation, that it is deposited as level as possible in both sides, that entrapment of air is avoided within partially enclosed spaces to be filled, and that any openings do not remain behind the steel supports.

The arch crown shall be filled with the blow-up method by connecting the discharge pipe end to a feeding hole provided in the form plate. When this method is impracticable in the opinion of the PMO/Engineer, the discharge pipe end shall be kept continuously embedded at least 2 m in fresh concrete and the air booster shall be installed to the discharge pipe near the arch crown and used intermittently for filling the arch crown. During filling of the arch, the operation shall be managed by maintaining constant observation through openings in the form.

Curing shall be made in manners as stipulated in Clause T4.1.9. When concrete with large slump is used, special care shall be taken to prevent shrinkage crack.