CHAPTER 6

CONSTRUCTION METHOD AND PLANNING

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6.1 Construction Condition of Project Site

6.1.1 General

Rapid infrastructure development has been achieved in the Sultanate of Oman within the last twenty years beginning from the first five-year plan in 1976 to the 4th five-year plan in 1995. The road infrastructure has, in particular, undergone a significant development, following the completion of various road construction projects. Around Muscat, numerous flyover crossings for grade separation can generally be found.

The Directorate General of Road (DGR), Ministry of Communication, is concerned with the road construction projects and the contractors of the Sultanate of Oman are well experienced in road construction works, usually undertaken not only in the Sultanate of Oman, but also in the neighboring countries.
Moreover, at several sites around Muscat, several road construction works are now in progress, and the construction planning will be carried out taking into consideration the conditions at these construction sites. Refer to Fig. 6.1.

6.1.2 Construction Conditions

(1) Hot Weather Concreting

In case of concreting in summer, according to the General Specification 503, the concrete temperature shall be lower than 33°C, and it is specified that the concrete shall be placed during the time when the air temperature is lower than 35°C; and provided that the night-time air temperature is lower than 35°C and the construction environment is favourable with the installation of lighting facilities, the night-time concrete placement shall be authorized.

The maximum air temperature of the city around Batinah Highway is about 50° C during the month of June. During the time of the year, from March to October, the air temperature is higher than 35°C. However, the minimum air temperature during this period (night time) is less than 35°C and it is considered that the night-time concreting is possible in accord with the above mentioned specification. Refer to Table 6.1 and Table 6.2.

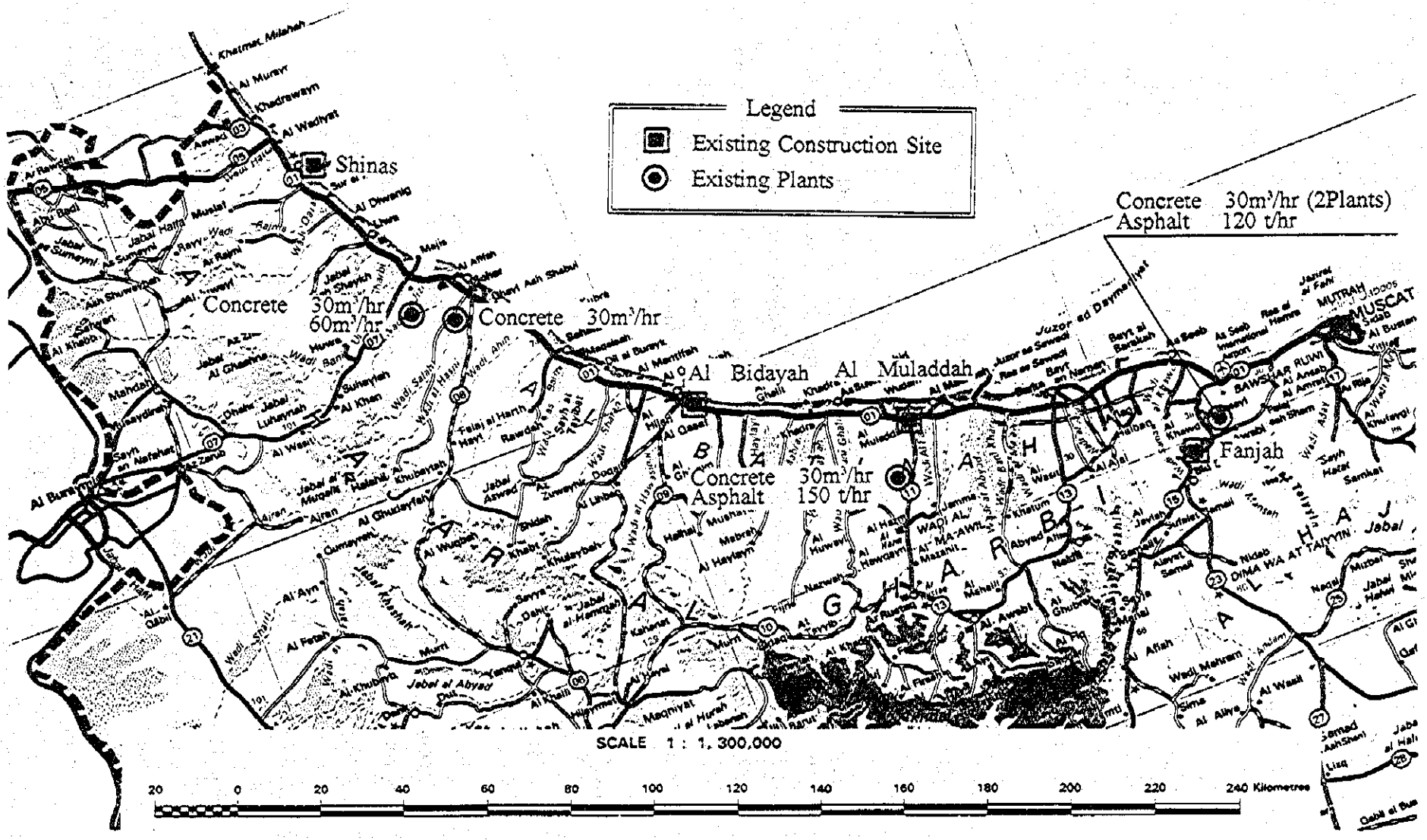


Fig 6-1 Location Map of Existing Construction Site and Plants

Accordingly, the summer-time concreting shall be conducted during night time when the air temperature is less than 35°C, installing the lighting facilities. Furthermore, in addition to the night-time concreting, the following countermeasures shall also be conducted in the case of the concreting in summer.

Table 6.1 Maximum and Minimum Annual Air Temperatures

(unit : centigrade)

Location	Year	1987	1988	1989	1990	1991	1992	1993	1994
Muscat	Max.	47	47	47	49	47	48	47	49
	Min.	12	15	13	15	10	13	13	14
Sohar	Max.	50	48	46	48	47	46	47	45
	Min.	9	8	8	11	7	8	6	9

Table 6.2 Maximum and Minimum Monthly Air Temperatures during 1994

(unit : centigrade)

Location	Month	1	2	3	4	5	6	7	8	9	10	11	12
Muscat	Max.	33	29	35	42	44	49	43	43	43	40	33	33
	Min.	14	14	17	20	24	25	26	26	23	20	19	14
Sohar	Max.	29	32	33	39	44	45	39	38	37	34	33	31
	Min.	12	9	13	18	21	24	28	27	19	18	17	12

The values in the Tables are obtained from STATISTICAL YEAR BOOK.

1) The stocked aggregate shall be protected from temperature rise by spraying it with water and covering its surface with wet linen, keeping it away from direct sun light.
2) Keep the girder manufacturing yard away from sun-light, protecting it with roof, and protect formworks and reinforcements from temperature rise. Keep the initial curing temperature of concrete as low as possible.
3) Cover the pondage tank with roof and prevent its water from temperature rise through direct exposure to sunlight.
4) Let agitators and other vehicles park under the shade of a roofed parking area. Cover concrete and pump with sheets to protect them from direct sunlight.
5) Keeping the curing temperature of concrete at normal condition is quite essential. Hence keep the concrete cured with sufficient amount of water spraying after its placement and keep it off direct sunlight by means of sheet covers, etc.

(2) Specifications for Construction Works

The following Construction Specifications of the Sultanate of Oman shall be adopted for the present project.

1) General Specifications for Roads, April 1994
2) Highway Design Manual, Volume-1, February 1994
3) Highway Design Manual, Volume-2, January 1994

6.1.3 Construction Equipment

(1) Construction Base Camp

As the project for the F/O construction requires to set up the girder manufacturing yard, girder stock yard and temporary plants, a base camp shall have to be planned.

The base camp for the past construction works was located, due to some environmental reasons, about 20 km toward the mountain when viewed from Batinah Highway (Fig. 6.1). For the present project too, the construction camp shall be located around that area for the construction works.
Furthermore, the contractors that gets contracted to the project is required to conduct the site study and the construction base camp planning, and obtain approval from the Ministry of Regional Municipalities and Environment, Ministry of Housing, Ministry of Mineral and Petroleum and Ministry of Water Resources before the beginning of construction works. An existing base camp for construction works is shown in Fig. 6.2.

(2) Girder Manufacturing Yard

Taking into account the required number of girders and the time limit for completion of construction works, for each F/O two girder manufacturing yards shall be established with ten girder manufacturing platforms for each yard.

(3) Concrete Plant

As to the concrete plant, the temporary plant owned by the Contractor shall be relocated at the construction base camp. Due to the following reasons, two

concrete plants, each having a capacity of 30 m^3/hr, shall be established for each F/O construction site. And a similar plant shall also be required for P/U.

1) 2 girder manufacturing yards are required.
2) A specific quantity of concrete is required to place, such as footings, etc.
3) Concrete structures are numerous.
4) Different types of specified concrete are required for the project.

(4) Asphalt Plant

Similarly, just like the case of concrete plant, the asphalt plant owned by the Contractor shall be relocated at the construction site for temporary use. Here one asphalt plant shall be sufficient with a capacity of 70 - 150 t/hr. And a similar plant shall also be required for P/U.

(5) Crusher Plant

Similarly, just like the case of concrete plant, the crusher plant owned by the Contractor shall be relocated at the site adjacent to the quarry. The capacity is to be determined based on the Contractor's plant capacity (100 to 200 t/hr with screen). And a similar plant shall also be required for P/U.

(6) Erection Equipment

The present girder erection site is in the vicinity of Batinah Highway and it is accessible by cranes. And several crane erection works have been carried out in the Sultanate of Oman. Hence the crane erection method shall be employed in the present project.

The maximum crane capacity ever used in the Sultanate of Oman is 100 ton suspension type. The 100-ton suspension cranes shall be used for the present project too.

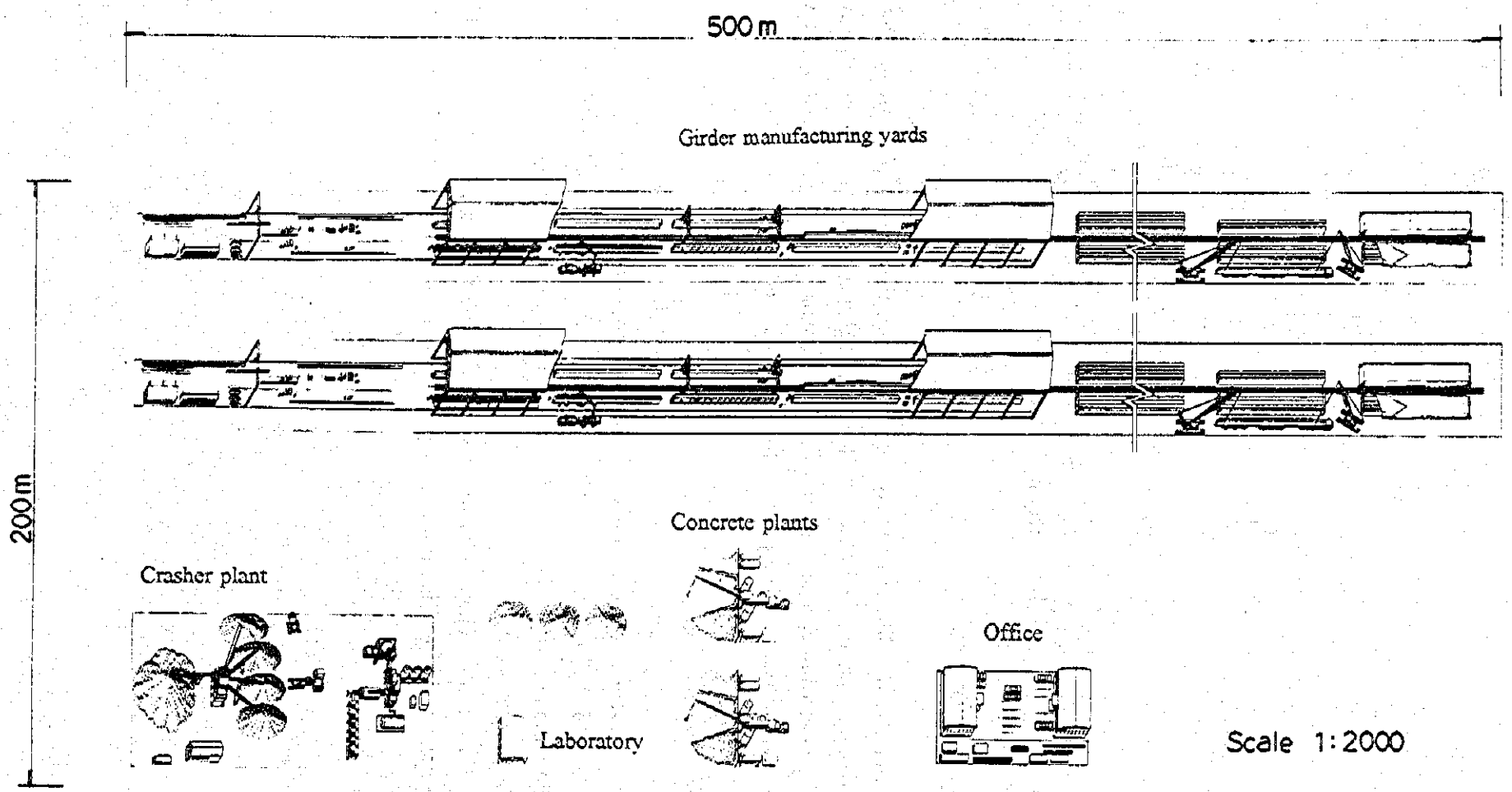


Figure 6.2 Illustration of construction Base Camp

(7) Pile Driving Equipment

Piles with diameters from Ø 500 to Ø1000 mm are usually employed depending upon the scale of construction in the Sultanate of Oman. And the construction method described in Fig. 6.3 is applicable to the present project.
The non-displacement method which is noiseless and vibration-free is recently adopted in the Sultanate of Oman.

The non-displacement method, usually employed in the Sultanate of Oman, has three versions.

I. Rotary Pile Drilling Rig (Ø 450 - 1200 mm):10 piles/day (Ø600 mm, L=10 m)

In this method, the drilled hole is protected and the drilled earth is discharged by circulation of the bentonite muddy solution, and the concreting is performed after the insertion of reinforcements.

II. Flight Auger (Ø450 mm - 800 mm) 25 piles/day (Ø600 mm, L=10 m)

In this method, after the drilling is completed by Earth Auger, the concreting is performed by inserting concrete at high pressure, while pulling out the auger. And the reinforcing bars are inserted just after the concreting is performed.

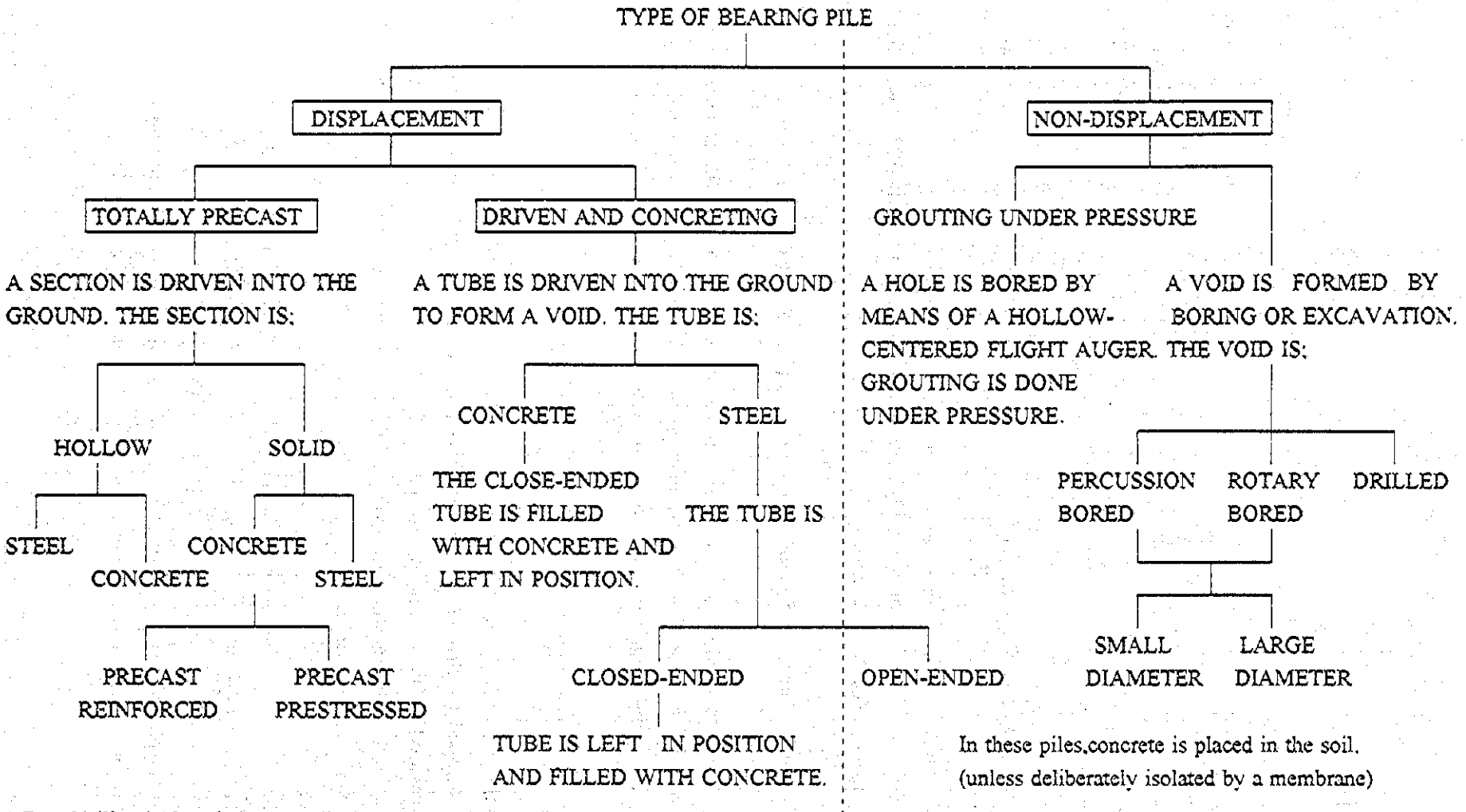
III. Percussion Piling Rig (Ø450 - 900 mm): 6 m/day

In this method, a scaffolding is erected and a percussion head attached to a winch is dropped for drilling, protecting the earth around the drill and displacing the excavated earth by means of bentonite muddy solution. This method is efficiently used in a narrow space or in case of existence of some obstructions such as boulders and rocks.

Due to the following reasons, the method I. is adopted for the present project.

1) The viability of using the pile diameters Ø600 - Ø1000 mm
2) The ease of construction for the sand gravel foundation
3) The possibility of employing the method III in case of obstruction of boulders.

The sequence of pile installation by this method is illustrated in Fig. 6.4.



* Bored piling is therefore a non-displacement technique (it removes material and replaces the material with another material), where drive piling system is a displacement technique (it creates a space with removal of material).

Fig 6.3 Classification of Bearing Pile Types

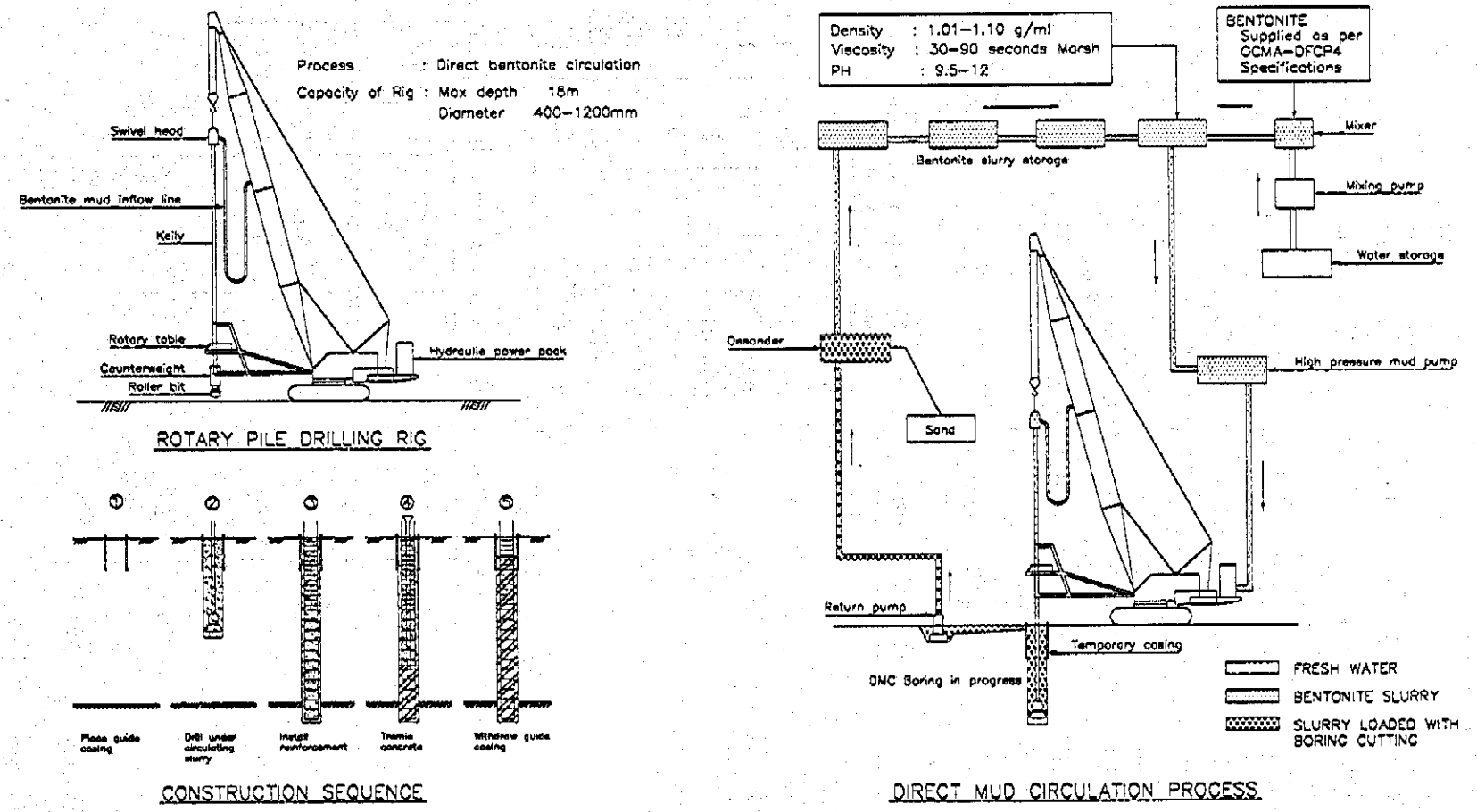


Fig 6.4 Execution Scheme of Pile Works

(8) Prestressing

Considering from the type of superstructure and the fact that several projects have been carried out using the method of work in the Sultanate of Oman, the Freyssinet Method shall be employed for the prestressing works. In the structural planning the strength of concrete during prestressing is taken around 320 kg/cm^2 and the number of days required for the attainment of this strength while prestressing is estimated using D.A. Abrams' concrete strength estimation formula.

$$\sigma = A \log t + B$$

where σ: compressive strength of concrete,

t: age in days,

A, B: Constants.

Table 6.3 Compressive Strength Prediction Equation

Name of Institution	σ28Prediction Equation		Constant	
	Suggested Equation	σ7	A	B
Ministry of Construction	1.170 σ7 + 56.1	294	177	144
Ministry of Transport	0.883 σ7 + 112	326	123	223
Hokkaido Development Agency	0.883 σ7 + 112	265	224	76
Japan Highway Public Corporation	1.150 σ7 + 95	292	180	140
Japan Railway Corporation,	0.970 σ7 + 117	288	186	131
,,,	1.190 σ7 + 83.3	266	222	78
,,	1.220 σ7 + 96	285	191	124

Table 6.4 Predicted Values by D.A. Abrams Prediction Equation

	7-day	8-day	9-day	10-day	11-day	12-day
Ministry of Construction	294	304	313	321	328	335
Ministry of Transport	326	333	340	345	350	355
Hokkaido Development	265	278	290	300	309	318
Japan Highway Public Corp.	292	302	311	320	327	334
Japan Railway Corporation,	288	299	308	317	324	332
,,	266	279	290	301	310	318
,,	285	296	306	315	323	330
Average	274	299	308	317	324	332

Reference is made to "Concrete Engineering, Vol. 1 Construction, by T. Higuchi, Z. Murata, H. Kobayashi, Shoukokusha, 1975

The constants used in the above equation are derived from the values of $\sigma 7$ and $\sigma 28$ proposed by various institutes in Japan. Take $\sigma 28 = 400$ kg/cm^2 and determine the value of $\sigma 7$. This value is substituted and the constants A and B are computed and tabulated as in Table 6.3 and Table 6.4. From the estimated results of Table 6.3 and Table 6.4, the development of strength 320 kg/cm^2 requires 11 days after concrete placement. In the present project, the prestressing will be carried out 11 days after the placement of concrete.

(9) Traffic Guidance System for Temporary Road

The speed limit of the Batinah Highway is 120 km/h. When the issue of safety is taken into account during the traffic detour on the highway, the traffic guidance is an essential requirement. And it shall be conducted in accord with the Sultanate of Oman Highway Design Manual and using the construction experiences on Al Bidayah P/U. The procedure is as shown in Fig. 6.5 and Fig. 6.6 conforming to the following design standards.

1) Speed Limit: 50 km/hr

2) Decelerator Lane and Two-lane to One-Lane Reduction Section

The traffic lane control markers are to be marked at 4 locations at 200 m interval and beyond that point the lane will be tapered within a distance of L=75 m.

3) Traffic Guidance to Temporary Road

Beyond the above tapering length L=75 m, a straight lane of L=25 m will be secured. (this is the minimum of the standard lengths for establishment of control markers, and with the tapering length of L=40 m the traffic will be guided to temporary road.)

4) Width of Temporary Road

Straight-line section 0.5 + 2@3.0 + 0.5 = 7.0 m

Curve Section 0.5 + 2@4.0 + 0.5 = 9.0 m

(As to the traffic at Aqr, it is light and the P/U has a comparatively short restricted time to construct. Hence the left-side single lane traffic will be all right.)

5) Cone: Tapering Section L=75 m 10 Nos. (Min.)

" L=40 m 6 Nos. (Min.)

Others @ 9m (Max.)

6) Night-time Guidance Lamp

Tapering Section L = 75 m 9 Nos. (Min.)

" L = 40 m 5 Nos. (Min.)

7) Rotary Lamp, Barrier and Road Marker Location

Refer to Fig.6.5 to Fig.6.6.

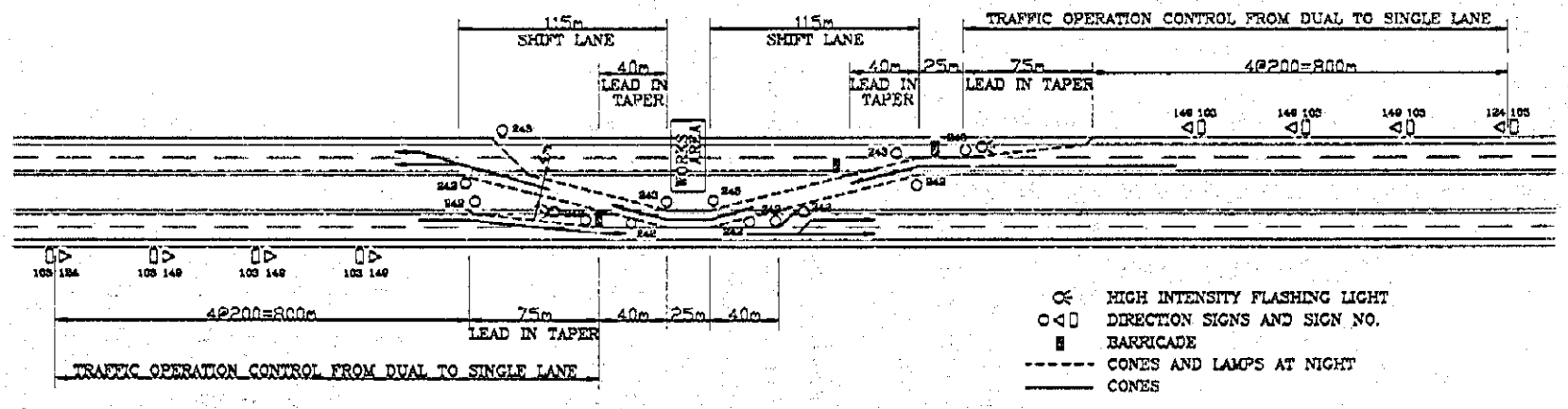


Fig 6.5 Genera Layout Plan of P/U Works

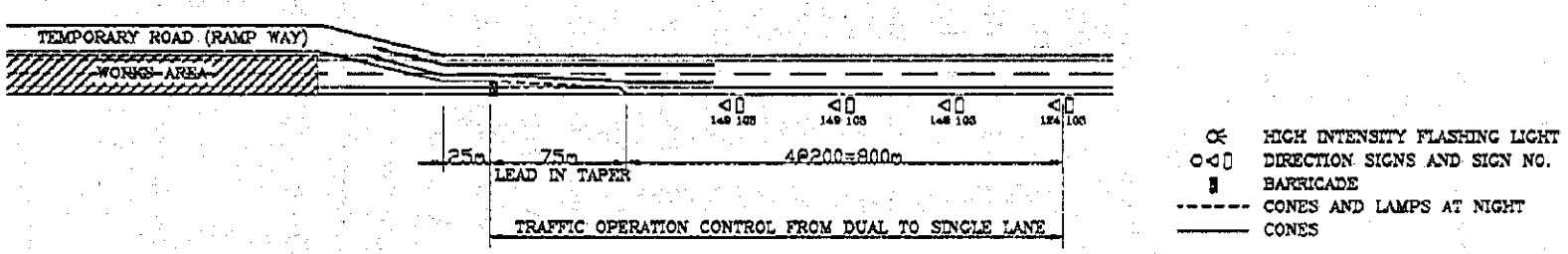


Fig 6.6 General Layout Plan of F/O Works

6.2 Construction Method for Flyovers

6.2.1 Construction Sequence

The F/O construction is carried out at the roundabout (R/A) of Batinah Highway which is the trunk-road in the Sultanate of Oman. Here the safety of ordinary vehicles is a prerequisite and also an important consideration. When the traffic of both the highway and the crossing is taken into account, the F/O construction sequence shall have to place priority on the improvement works for the R/A.

(1) F/O that overpasses R/A (excluding the Aqr section)

Taking into due consideration the traffic detour plan of R/A as stated in para. 6.2.5, the construction sequence is planned as follows.

1)Construction of substructure within the scope of not giving any effect on the existing R/A (inner section of R/A)

2)Detour the existing traffic to the temporary road, and construct the substructure and the retaining wall within the scope of not giving any effect on the temporary R/A.

3)Detour the existing traffic to the improved R/A and construct the remaining substructure.

The model illustration of the construction sequence of the project structures is shown in Fig. 6.7.

(2) The F/O at Aqr

The construction sequence is envisaged as follows, taking into consideration the planning for the traffic detour in para. 6.2.5.

1) Construction of substructure and superstructure

2) After the traffic detour is conducted, using the existing road, construct the approach section of the ramp (retaining wall, embankment for retaining wall section, pavement works for the ramp).

3) Conduct the detour of traffic to the ramp and then conduct the earth filling works of the highway together with the pavement works.

The model illustration of the construction sequence of the F/O at Aqr is shown in Fig.6.8.

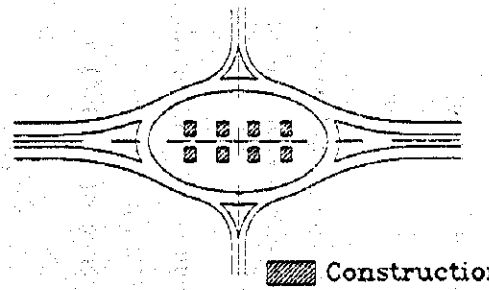
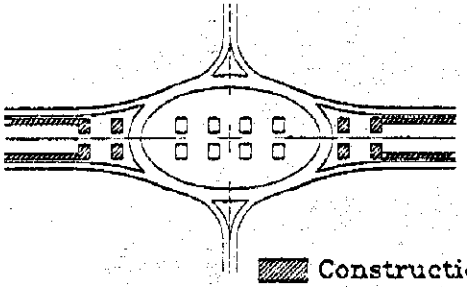
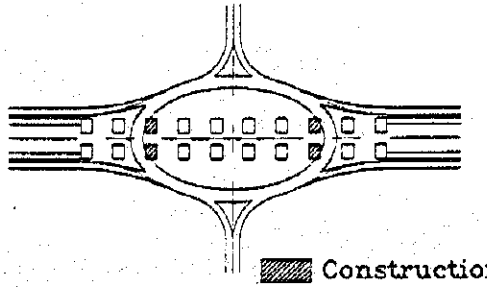
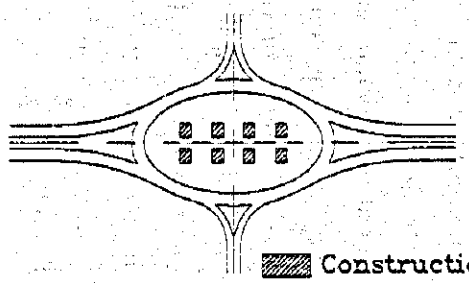
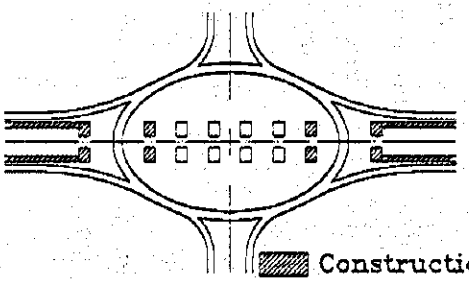
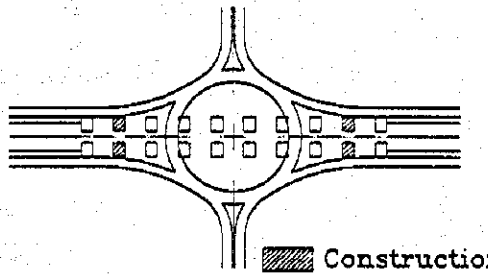
	FIRST STAGE	SECOND STAGE	THIRD STAGE
WITHOUT R/A IMPROVEMENT			
	* Construction of substructure. (inner section of existing R/A)	* Construction of structure. (external section of existing R/A)	* Detour the R/A traffic to temporary R/A. * Construction of substructure.
WITH R/A IMPROVEMENT			
	* Construction of substructure. (inner section of existing R/A)	* Construction of substructure. (inner section of temporary R/A) * Construction of substructure and retaining wall.	* Construction of substructure. (external section of improved R/A)

Fig 6.7 Construction Sequence of F/O Structures

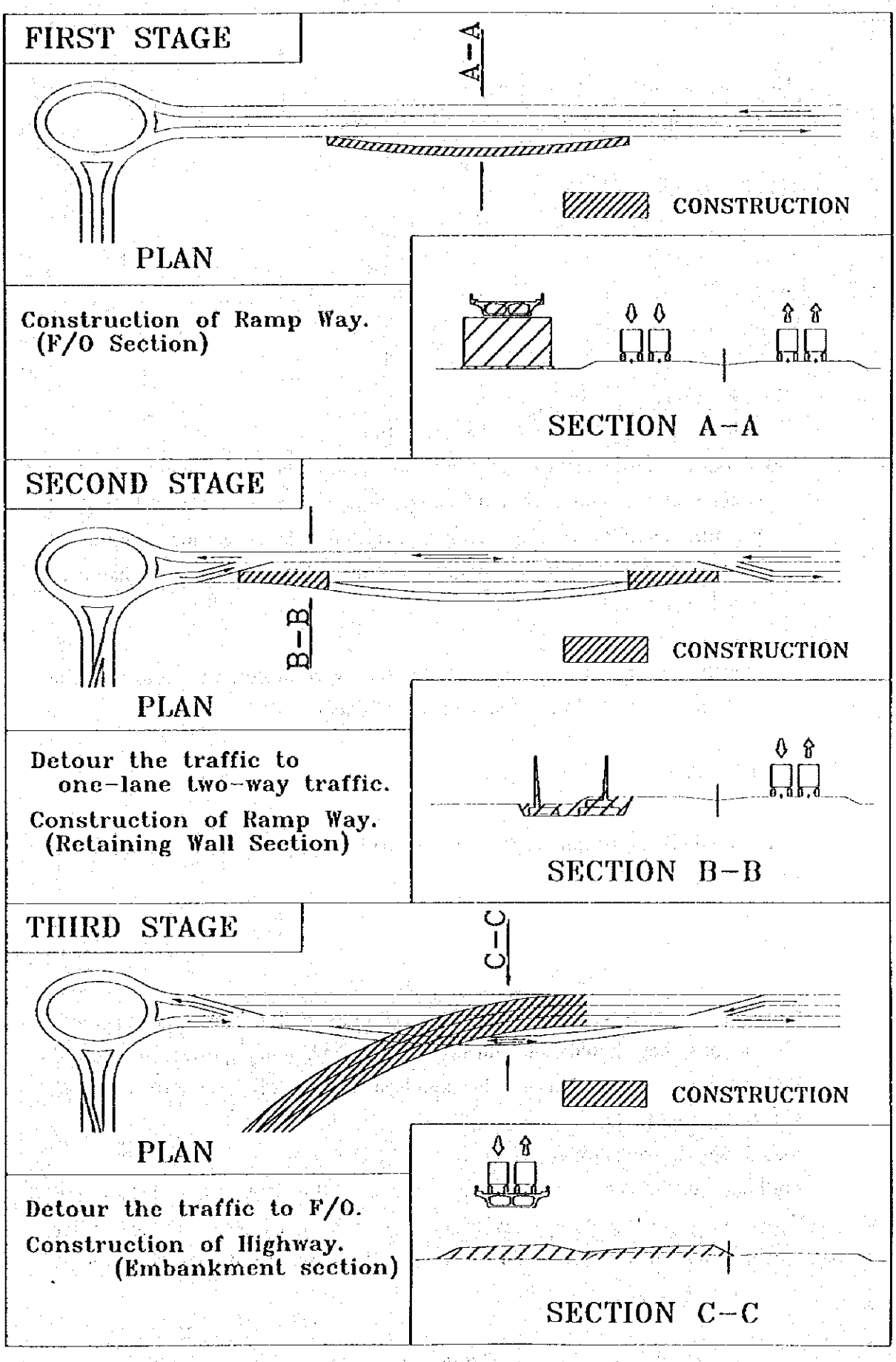


Fig 6.8 Construction Sequence and Detour Plan for Aqr F/O Works

6.2.2 Foundation

The foundation is important as it is a basic requirement for the structures. Hence the foundation structure shall be set up precisely on the foundation layer.

(1) Pile Foundation

In this method, the drilled hole is protected and the excavated earth is discharged by circulating the bentonite muddy solution, and the following precautions should be taken in the execution of the works.

1) The precise performance of drilled hole protection and bottom slime treatment are necessary after the completion of drilling.
2) Secure a sufficient concrete cover for reinforcements using spacers. In concreting, precautions should be taken to pour concrete from the bottom of the drilled surface using tremie. Moreover, confirm by eye the condition of the drilled hole and it is necessary to confirm the complete discharge of muddy solution.

The construction management of the pile shall be conducted in accord with the General Specification 1001 of the Sultanate of Oman.

(2) Direct Foundation

In this method, the bearing capacity of the load-bearing layer shall be confirmed by the plate bearing test.

(3) Obstructions

Cross drainage culverts exist at the F/O construction site. As to these obstructions, they should be lengthened prior to the beginning of construction of F/O main structure. And for locations, sizes, etc. of these cross-drainage structures, refer to the
road design drawings for each F/O.
Furthermore, the detour of a drainage channel within R/A at both Saham and Sohar is planned, and the new channel shall be constructed in the similar sequence with that of F/O main structure. The sequence of construction is as

follows. First construct external portion of existing highway and then internal portion after the detour of traffic to the temporary road is carried out.

6.2.3 Substructure and Retaining Wall

Concrete works shall be in principle performed in accord with General Specification 500. Considering aesthetic aspects, the structures are planned as follows.

1) Steel Reinforcement

Due to uneven nature of slit, the effective cover of concrete over reinforcement shall be an important factor and separators and reinforcement erection bars shall be sufficiently installed in concreting.

2) Formwork

For numerous places with similar forms, steel formworks shall be used and for other places, timber formworks shall be employed.
The formworks shall be painted with concrete separation paints. At places which are above the surface, the form-works surface shall be treated with synthetic resin for a good finishing of concrete.

Moreover, the cross-beam, a prestressed member of pier of the F/O at Aqr shall be constructed in conformity with the construction planning of the superstructure.

6.2.4 Superstructure

(1) Box-slab Section Post-tension PS Girders

1) Formwork
As shown in Fig. 6.9, 10 girder manufacturing platforms shall be required. Two girder manufacturing yards shall be established to manufacture 10 girders per 30 days. 10 to 12 repeated uses of formworks shall be required. Hence the formworks shall be made of steel.

Moreover the hollow-type formworks, as they are to remain perpetually set into concrete, shall be made of timber, and to protect them from sliding during placing of concrete, they shall be fixed precisely to the outer formwork.

Platfor	5 |	10 |	15 |	20 |	25 |	30 Day |
1	A B C D F G					
2	A B C D F G					
3	A B C D F G					
4	A B C D F G					
5	A B C D F G					
6	A B C D F G					
7	A B C D F G					
8	A B C D F G					
9	A B C D F G					
10	A B C D F G					

A: Reinforcement, PC Steel, Internal Formwork, External Formwork

B: Concrete Placing C: Curing D: Prestressing

E: Transfer to Stockyard F: Grouting

Fig. 6.9 The Cycle of Girder Manufacturing Works

2) Prestressing

The order of prestressing of cables is reflected in the design calculation and prestressing is to be done in accordance with the numbers given to the cables, such as C_1,C_2,C_3, etc. in the drawing.

3) Grouting

The grouting work shall be conducted in accord with the General Specification 506.

4) Transverse Movement of Manufactured Girder

After prestressing, the girders are to be moved to Girder Stockyard by using temporary rail. The maximum girder weight is 115 t and the girder's transverse movement in the yard shall be accomplished by suspension of the girders using a portal crane. Refer to Fig. 6.10.

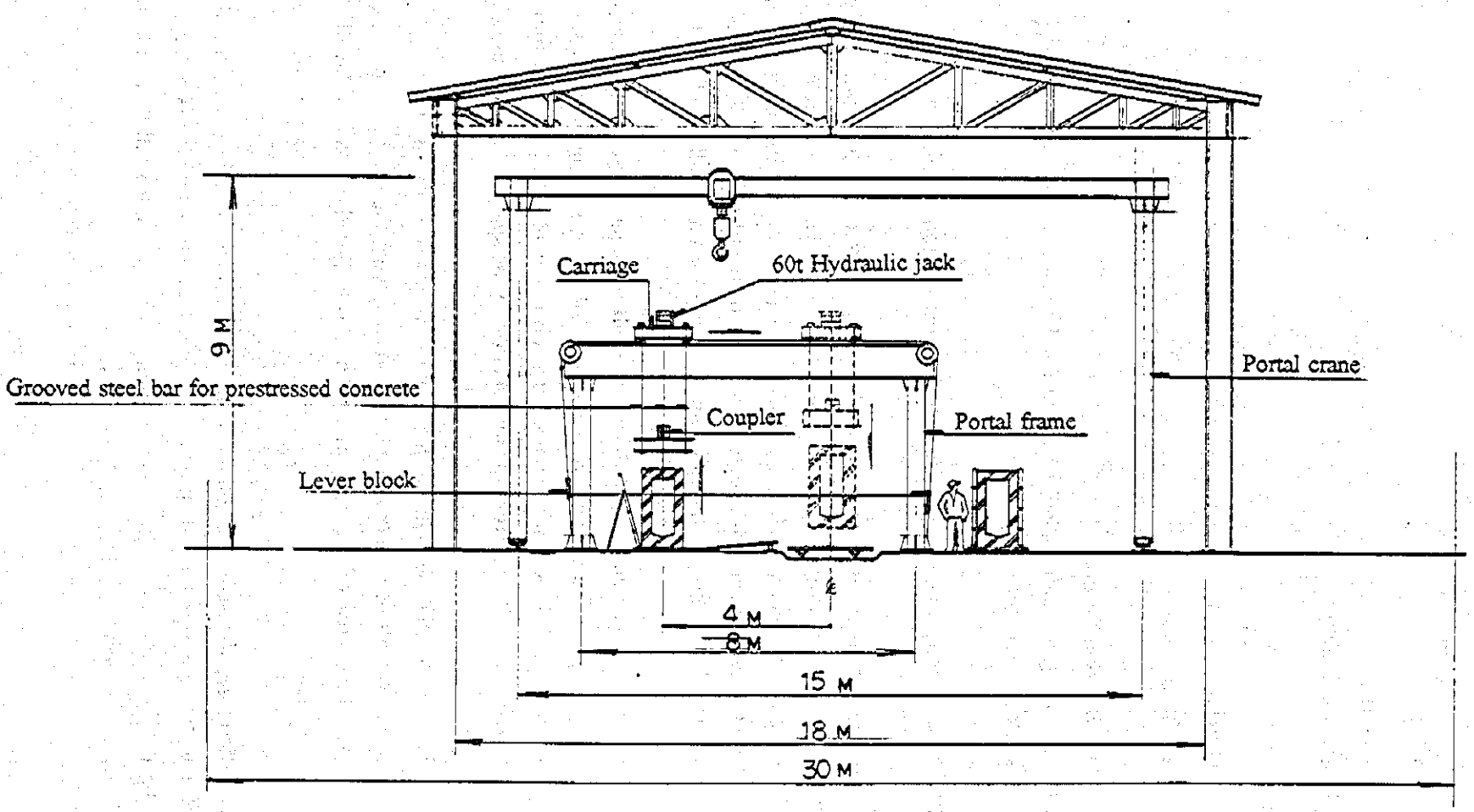


Fig 6.10 Details of Heavy Duty Lifting Crane

5) Erection of Girders

The weight of girder is 62.4 t to 114.2 t and the girder erection shall be made by suspension using a 100 t crawler crane. In case the girder cannot be installed at the predetermined position due to the insufficient span of the crane, the girder shall be temporarily dropped on the substructure and then it shall be moved in the transverse direction. Refer to Fig. 6.11.

The transport of girders from the stockyard to the erection site shall be made using B1-type trailers. Lighting facilities shall be installed at the site to conduct the night-time transport and erection.

6) Overhanging Section

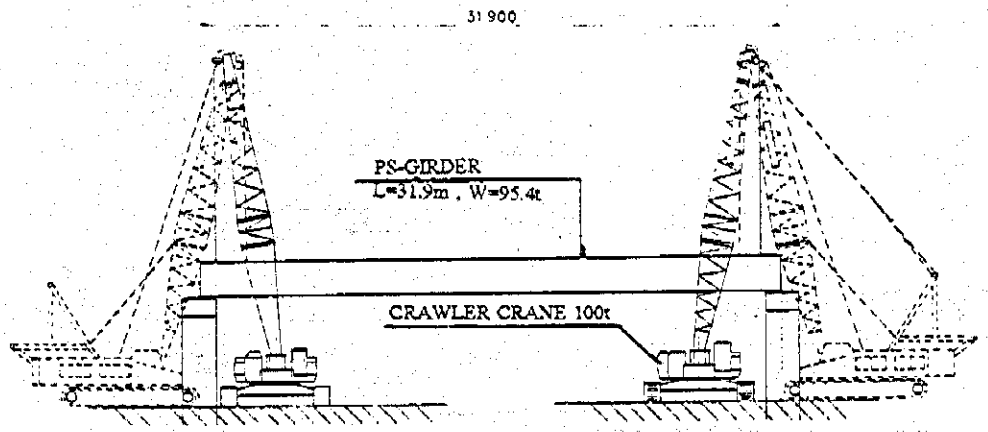
The overhanging section shall be constructed by setting up suspended supports as illustrated in Fig. 6.12.

(2) Three Manufactured-on-site Continuous Post-tension PS Girders

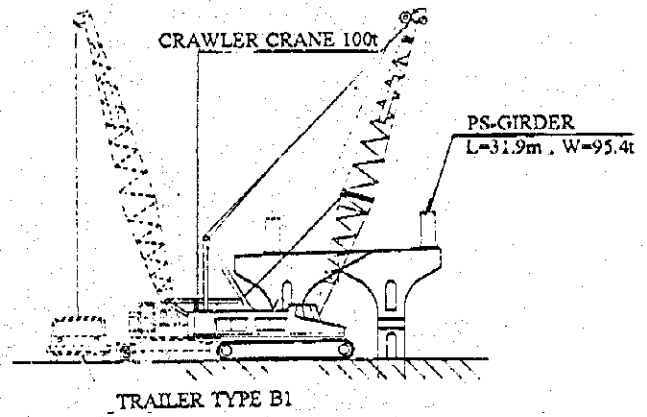
The precautionary measures that should be taken in this kind of girder manufacturing are: (a) elastic subsidence of the supporting structure accompanied by concrete placement (b) an influence on the concrete finishing due to the differential settlement that occurs as a result of insufficient bearing capacity of foundation. In this project the following countermeasures shall be adopted.

1. Concrete placement for the floor slab shall be done following the concreting of the lower flange and web section. As a countermeasure against the supports' elastic subsidence resulting from the placement of concrete, the concreting shall start from the mid section of the span and ends at the support section.
2. The differential settlement that occurs as a result of insufficient bearing capacity shall be counteracted by means of laying the levelling concrete over the whole area of the support's foundation after the latter is levelled and compacted.

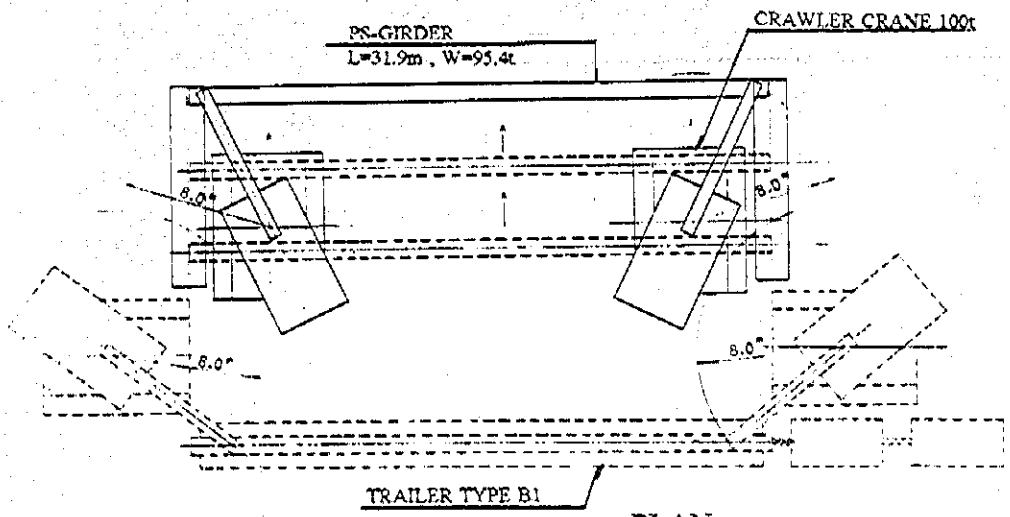
Furthermore, the sequence of tensioning PC cables is reflected in the design calculation and reference shall be made to the steel cable number (C_1, C_2, ...) of the PC steel reinforcement assembly plan. The grouting shall be conducted in accord with the General Specification 506.



SIDE VIEW



CROSS SECTION



PLAN

Fig 6.11 Procedure for Girder Installation

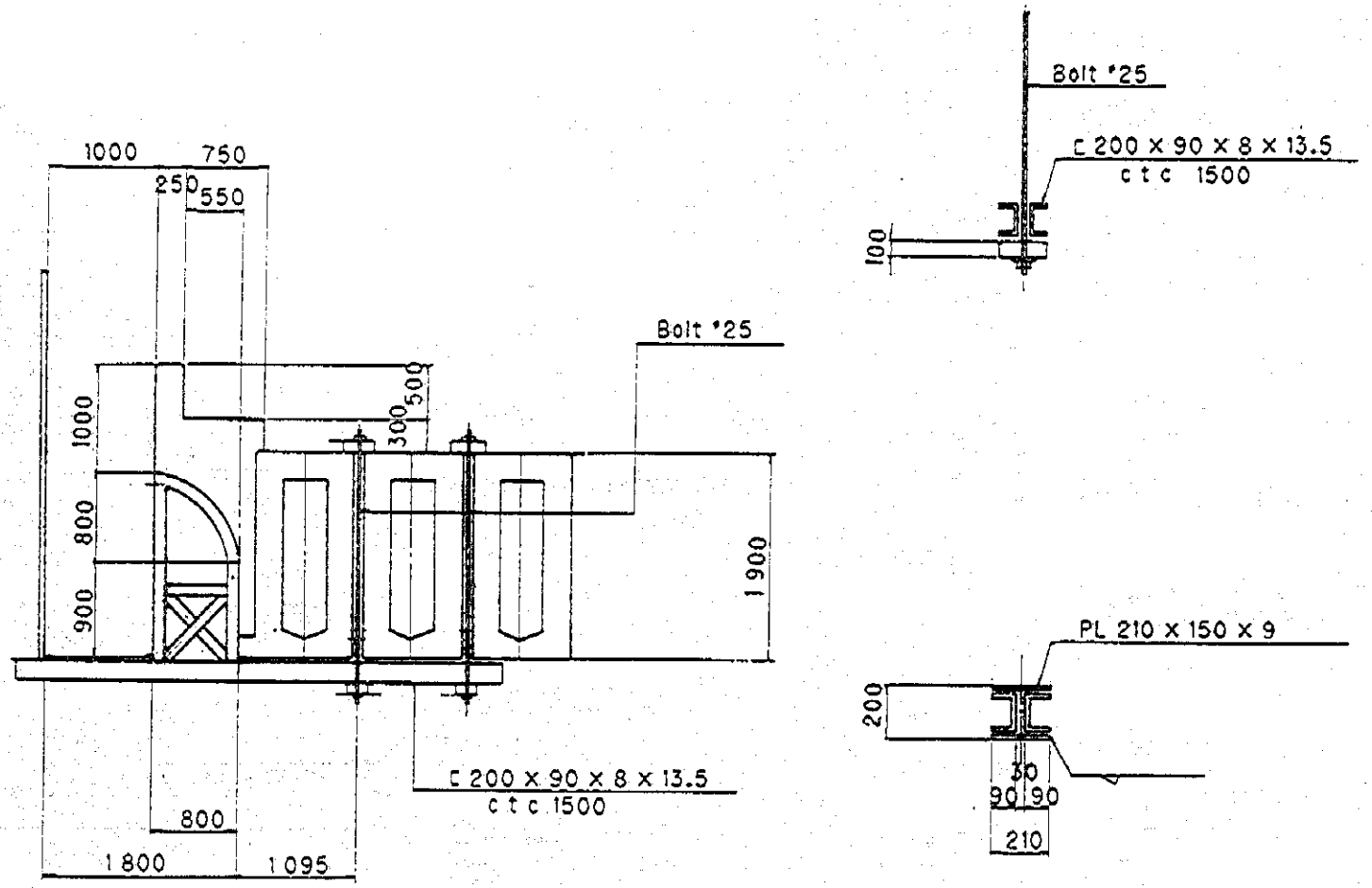


Fig 6.12 Details of Suspended Support

6.2.5 Temporary Diversion

(1) F/O other than that at Aqr

The detour of traffic on R/A shall be planned on the basis of using a part of ramp (under planning) as a temporary road, securing the efficiency of R/A and maintaining the smooth traffic flow on the highway and the cross-over structure.

1) In case of the place where R/A improvement is required

a) The planned ramp shall be constructed to make use of it as a temporary road and a temporary R/A shall be constructed around the outer perimeter of the existing one.

b) After the traffic is detoured to the temporary ramp section and the temporary R/A, the improvement works on R/A shall be conducted.

c) After the traffic is detoured to the improved R/A, the temporary R/A shall be removed.

2) In case of the place where R/A improvement is not required

a) The planned ramp shall be constructed to make use of it as a temporary road.

b) In case the construction of substructure has an influence on the existing R/A, a section of R/A shall be temporarily paved and the traffic shall be shifted to that section.

c) The ramp shall be constructed to its completion.

The model illustration of the traffic detour plan is shown in Fig. 6.13 and Fig. 6.14.

(2) F/O at Aqr

Since the ramp section is a crossing for grade separation, the following traffic detour plan is envisaged based on the idea of giving priority to F/O construction.

a) The F/O construction works shall be carried out with the existing traffic going on as usual.

b) Using the half portion of the existing highway, a two-way traffic shall be imposed on the existing one.

c) After the completion of the ramp way (F/O), the traffic shall be detoured to the ramp.

As to the model illustration of the traffic detour, refer to the above mentioned Fig. 6.8.

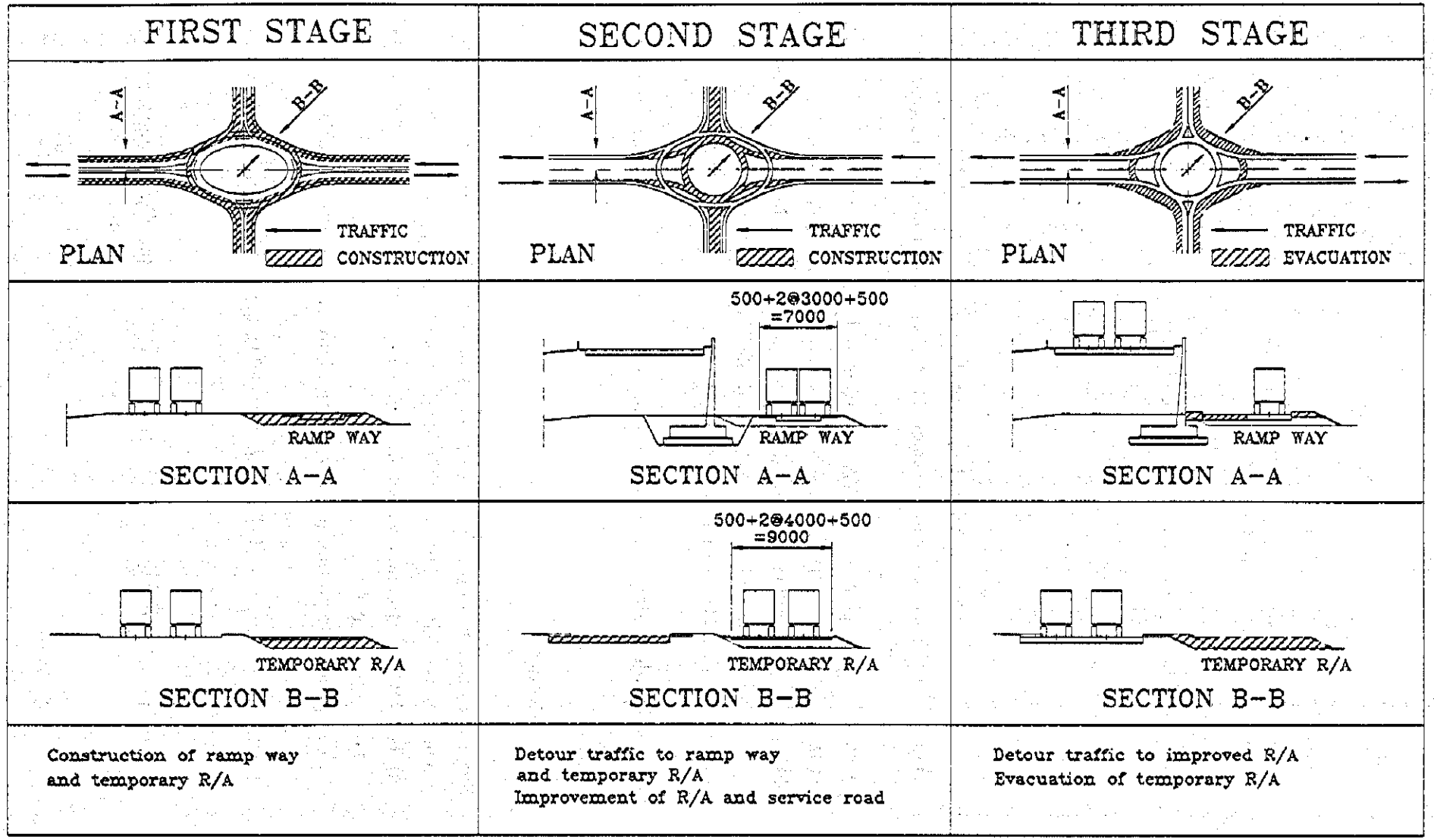


Fig 6.13 Detour Plan for F/O Construction (with R/A improvement)

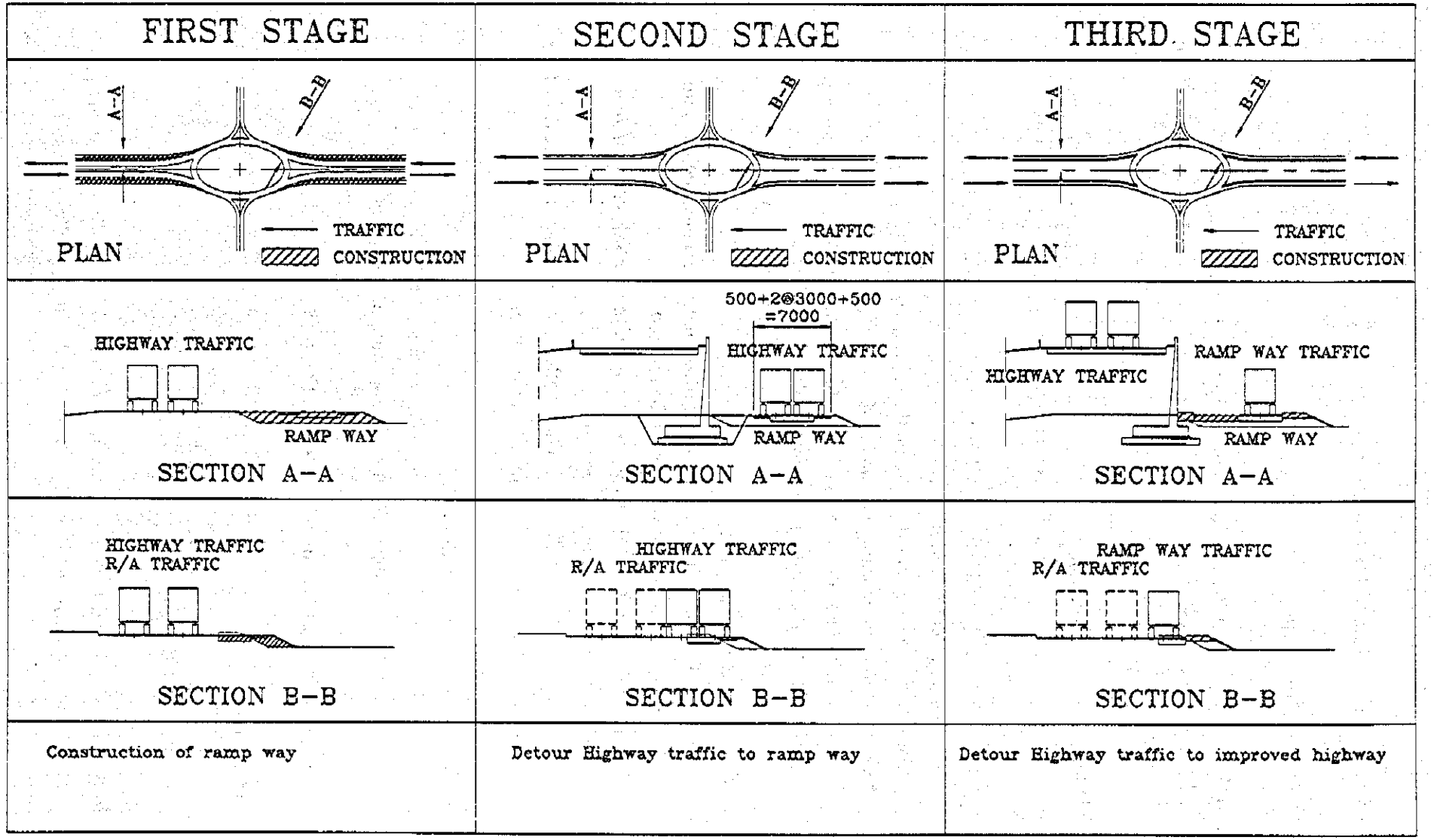


Fig 6.14 Detour Plan for F/O Construction (with R/A improvement)

6.3 Construction Method for Pedestrian Underpasses

6.3.1 Construction Sequence

Taking into account the traffic detour plan in 6.3.3 and making reference to the Al Bidayah P/U construction experiences, the sequence of P/U construction shall be as follows.

1) First-stage Construction
* Temporary pavement of the central separator zone and preparatory works such as removal of existing guard rails, etc.
* Detour of the Batinah Highway traffic and securing the construction yard for the first-stage construction works
* Construction of box and staircase on the central separator zone
* Construction of remaining box and roof
* After conducting the road-surface rehabilitation works, such as asphalt pavement, etc. the traffic restrictions shall be removed.

2) Second-stage Construction
* After the Batinah Highway traffic is detoured, the construction yard for second stage construction works shall be secured.
* Construction of box and staircase on the side of the central separator zone
* Construction of remaining box and roof
* The removal of traffic restriction after conducting the road-surface rehabilitation works, such as asphalt pavement, etc.

3) Completion of construction woks
* Removal of temporary pavements and renovation of guard rails
* After completion of appurtenant works, opening of P/U to traffic

The sequence of construction is as shown in Fig. 6.15.

6.3.2 Structures

(1) Foundation Structure

In the present project, the bearing layer is confirmed by eye-check, and any part of foundation layer with bad soil shall be replaced with a good-quality soil.

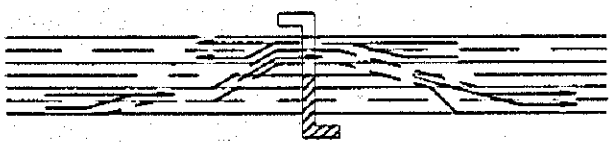
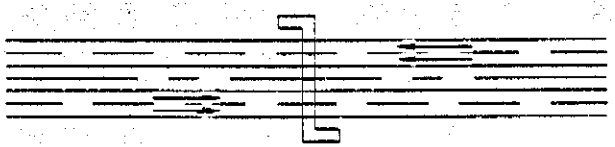
FIRST STAGE	 TRAFFIC TEMPORARY ROAD CONSTRUCTION	* Prepare detour and demarcate construction site. * Construct the P/U. * Restore the road pavement and remove traffic control.
SECOND STAGE	 TRAFFIC TEMPORARY ROAD CONSTRUCTION	* Prepare detour and demarcate construction site. * Construct the P/U. * Restore the road pavement and remove traffic control.
THIRD STAGE	 TRAFFIC	* Install all accessories to P/U and open to traffic. * Construction complete.

Fig 6.15 Construction Sequence and Detour Plan for P/U Works

(2) Box Construction Work

The box is an RC structure with the side wall of thickness 40 cm, and as to the construction management, the following precautionary measures shall be enforced.

1) Steel Reinforcement and Form-work

A sufficient number of separators shall be installed to insure a constant concrete cover above the reinforcements.

2) Concrete Works

Concreting by bucket shall be practised due to the small quantity of concrete requirement; and compaction works shall be carried out precisely.

3) Supports

Supports shall be set up precisely and their removal shall be conducted just before the back-filling.

4) Back-filling

The back-filling shall precisely be conducted in accord with the General Specification 206.

Furthermore, as to the block-division of the box, the maximum length shall be taken L = 15 m and the box shall be divided into six divisions including 2 divisions at the staircase section and 4 at the box section.

6.3.3 Temporary Traffic Diversion

Using the Al Bidayah P/U construction experience as a reference, the temporary diversion shall be planned as follows.

1) First Stage Traffic Detour

The traffic detour shall be conducted using the half portion of the highway and making it a two-way traffic.

2) Second Stage Traffic Detour

* After the completion of the first stage construction works, the completed section shall be open to the traffic.
* The traffic detour shall be conducted using the completed half portion of the highway and making it a two-way traffic.

3) Third Stage Traffic Detour

* After the completion of the second stage construction works, the whole road shall be open to the traffic.

The model illustration of the traffic detour plan is shown in Fig. 6.15.

6.4 Construction Method of Road Facilities and Utilities

6.4.1 Road Facilities

The road facilities of this project consist of safety barriers, reflectors, traffic signs, roadmarkings, road studs and street lighting. These facilities will be installed by using materials and construction methods mentioned in the General Specification for Roads and/or the tender drawings. The installation process of each facility is briefly mentioned below:

(1) Corrugated Steel Beam Safety Barrier

a) Safety barriers shall be installed at the locations shown on the drawings. Posts shall be set plumb and to the indicated lines and levels.
b) The contractor may use driven posts or posts set in concrete foundations.
c) Beams shall be spliced by lapping with the edge facing away from the near side direction of traffic.

(2) Reflectorized Markers for Safety Barriers

a) Reflectors shall be fixed to safety barriers at a regular interval.

(3) Traffic Signs

-Sign Faces

a) The type,colour,layout and size of sign faces will, except where otherwise shown on the drawings, conform to the Sultanate of Oman "Highway Design Manual".
b) Signs shall be located as instructed by the engineer and, unless otherwise shown on the Drawings, erected so that the face is vertical and at an angle of 92° to the road centerline.

-Sign Supports

a) Sign supports shall be vertical. Signs shall be centrally placed on single post supports unless otherwise shown on the drawings.

b)After excavation, concrete shall be placed against the excavated faces. Where footings are to be exposed, exposed surfaces and excavated surface 150 mm below it be nade level. The concrete shall be thoroughly compacted Backfill shall be compacted by mechanical tampers up to the finished ground level.

(4) Road Markings

a) Lines, chevron striping, arrows and lettering shall be provided to the size and at the location shown on the drawings and in accordance with the "Oman Highway Design Standards".
b) Obsolete or existing marking to be replaced shall be removed by a line removal machine capable of operating at between 600 and 2500m/h.
c) The surface to be painted will be clean and dry.
d) Spraying equipment shall consist of a motor-powered self-propelled machine with compressor. The bead gun shall be synchronized to spray glass spheres immediately onto the hot thermoplastic. An automatic skip mechanism shall be fitted to produce broken and dotted lines as shown on the drawings, without pre-measurement.
e) Where indicated on the dawings, curbs shall be painted alternately black and yellow to cover the entire exposed surface.

(5) Road Studa (Reflective Stud and Rumble Strip)

a) Road studs shall be installed after completion of the wearing course.
b) Studs shall be applied on clean, sound and dry asphalt surface.

(6) Street Lighting

Note: The expenses of the removal and relocation of existing lighting, and the new installation will be carried out by this project, but the design of layout and details, excepting service ducts, will be carried out by other project.

-Foundation

a) The sides of excavations for foundations that will be subject to uplift or lateral forces shall be compacted and approved before any concrete is poured.
b) The position of anchor bolts in the concrete bases shall be set by means of templates.

-Road Lighting Masts and Columns

a) Masts and columns shall be erected to the height and with the luminaries as shown on the drawings.
b) Luminaries on columns shall be aligned parallel with the longitudinal profile of the road and set at 90° to the center line.
c) Masts and columns shall be bolted to concrete bases. Anchor bolts, nuts, lockouts and washers will not be subject to load until the concrete base has reached its design strength.
d) Each mast and column shall be bonded to the earthling cable.
e) Final setting and adjustment of the luminaries shall be carried out after the masts are erected.

6.4.2 Utilities

The utilities affected by this project are shown follows:

Kind of Utilities		R/A-2 A'Naseem Garden	R/A-3 Barka	R/A-5 Al Muladdah	R/A-8 Al Khaburah
Electricity	Overhead Line	Exists	Exists	Exists	Exists
	Buried Cable	Exists	Exists	Exists	Exists
	Substation	Exists	Nil	Nil	Nil
Telephone	Overhead Line	Nil	Exists	Nil	Nil
	Buried Cable	Nil	Exists	Exists	Exists
Water	Irrigation pipe	Exists	Exists	Exists	Exists
	Main pipe	Nil	Nil	Nil	Nil

Kind of Utilities		R/A-10 Saham	R/A-12 Sohar	R/A-14 Falaj Al Qabail	R/A-18 Aqr
Electricity	Overhead Line	Exists	Exists	Exists	Exists
	Buried Cable	Exists	Exists	Exists	Exists
	Substation	Nil	Exists	Nil	Nil
Telephone	Overhead Line	Nli	Nil	Nil	Exists
	Buried Cable	Exists	Exists	Exists	Nil
Water	Irrigation pipe	Exists	Exists	Exists	Nil
	Main pipe	Nil	Exists	Exists	Nil

Note: The present irrigation pipes are installed in the landscaping area.

This project includes the expenses for the removal, relocation and protection of existing utilities, and the installation of new utilities. However, the detailed cost-estimate, tender and supervision of these utilities will be carried out by the relevant authorities mentioned in Clause 2.3.5.

6.5 Earth Work and Paving Work

6.5.1 Earth Work

(1) Earth-filling

The earth-filling works shall be executed on the existing highway; hence the removal of existing structures (pavement, etc.), the levelling of uneven surface, etc. are necessary prior to the beginning of works. The earth-filling works are, mostly, done in the area surrounded by structures. Accordingly, care should be exercised in executing earth-filling in the narrow backward areas.
The filling works are to be carried out in accord with the General Specification 204. The thickness of earth-spread layer is generally 250 mm. At the back-filling area of a structure, it shall be 200 mm, and required to be compacted with care by rammers.

(2) Back-filling within Structures

In case the back-filling work is defective or of inferior quality, the running performance of cars shall be affected as a result of differential settlement of the foundation. And it is also possible that an abnormal external pressure shall exert on the underground structure due to the changes in earth pressure. Accordingly, the backfilling shall be performed with care and in accord with the General Specification 206.

6.5.2 Paving Work

(1) Subgrade Construction

The subgrade construction begins after the end of earth-filling work and it shall be performed in accord with the General Specification 204. The construction thickness of material spreading for the subgrade shall be of 150 mm for each layer of the 300 mm construction thickness.

(2) Sub-base Course Construction

The subbase course in this project shall be made of crushed stones and it shall be executed in accord with the General Specification 300. The spreading material

layer shall have a thickness of less than 150 mm, and in case the thickness of subbase course is more than 150 mm, 2-layer construction shall be adopted using the Class A materials.

(3) Asphalt Base Layer Construction

The asphalt base layer shall be constructed in accord with the General Specification 402. Class A aggregates shall be used for pavement thickness 100 mm and Class B for pavement thickness 70 mm and/or 50 mm respectively.

(4) Asphalt Surface Layer Construction

The asphalt surface layer shall be constructed in accord with the General Specification 405. The Class A materials shall be used for pavement thickness 50 mm.

6.6 Construction Planning

6.6.1 Construction Materials, Machinery and Labour

(1) Construction Materials

The construction materials required for the F/O and P/U construction works can be procured in the Sultanate of Oman, but some have to be necessarily imported from neighbouring countries or Europe. In fact, the engineers of the Sultanate of Oman have already had the experience of prestressed concrete bridge, road and pavement construction and it is presumed that the procurement of construction materials shall not pose any problem in the project.
For the list of suppliers of the construction materials, required for the F/O and P/U construction works of the project, refer to Chapter 2 of the present report.

As to the soil and rock materials, they shall be picked up from the borrow pit that is authorized by the Government of the Sultanate of Oman. All kinds of borrow pits are required to be officially approved by the Ministry of Regional Municipalities and Environment, Ministry of Housing, Ministry of Mineral and Petroleum and Ministry of Water Resources. All the approvals are valid till the end of construction works.

The quarries around Batinah Highway are mostly located in the inland area 20 km away from Batinah Highway. (Refer to Chapter 2) In this project too, the quarry shall be established at a site about 20 km from Batinah Highway. In this case, the contractor of the construction works shall have to plan the establishment of quarry properly based on a thorough investigation and obtain, in principle, the authorization from each Ministry and start construction works.

In the case of the past projects, the water required for construction works has been secured by means of pumping up of the ground water from a tube well in the inland area or buying the water from the existing plant. In case of establishing a tube well in the inland area, the contractor shall have to plan the establishment properly based on a thorough investigation, and obtain, in principle, the authorization from each Ministry before starting construction works.

Moreover, various material testings are conducted under the geological investigation for this project, and these test results are analyzed as follows.

1) Backfilling Material

When referred to the results from soil testing, the specific gravity of the sand gravel soil is round about 2.6 g/cm^3 and pH is a neutral or a slightly alkaline value. The soil taken at the site does not consist of impurities such as organic matters, etc. and hence it is judged suitable for earthworks of the project. However, from the sieve analysis, the proportion of sand to sand-gravel under the grain size of 0.075 mm is less than 15% and the sand gravel soil has a 30% content of gravel with the size bigger than 75 mm. Accordingly the soil cannot be used for back-filling works at its natural condition as obtained from the borrow pit, hence the soil grading shall have to be made.

2) Alkali Aggregate Reaction

The alkali aggregate reaction takes place by the simultaneous interaction of the three components: reactive aggregate (SiO_2), water (H_2O) and alkali (Na^+, K^+). Various methods are used to judge the occurrence of alkali aggregate reaction. The testing methods for the latent characteristics of aggregate reaction are as stated in ASTM C289, 81, and the testings in accord with the General Specification 501, 19 yield the following results and it is judged that the aggregate has no problem of alkali aggregate reaction.

a) The latent characteristics of aggregate reaction is in an harmless range.
b) As to the specified total alkali content in concrete, both the soil and water used for mixing has a chlorine component of approximately 0 %. Hence the total alkali content of concrete means the amount that comes mostly from the cement. When the cement that conforms to the standards specified in the General Specification 501 is used, it is considered that the specified value of total alkali content in concrete is satisfied.

3) Water for Concrete Mixing

According to the results of testing on the water used for concrete mixing, a pH value of 8 is recorded, which is approximately neutral. According to the Japanese Standard specified on concrete, the water is suitable for concrete mixing if it has a pH value of 5.8 - 8.6. Thus the ground water of that region is to be judged satisfactory and usable for concrete mixing.

4) Cement

The Sultanate of Oman is an oil producing country and the use of Sulphate Resistant Concrete (SRC) is considered appropriate for underground concrete structures. However, in this project, the concrete structures in contact with soil are specified, on account of the following reasons, to be constructed with the ordinary Portland Cement and to have the surface painted with bituminous material for waterproof.

a) According to the soil test results, the sulphate concentration is recorded at a low value of 55 to 276 mg/l.
b) The planned underground structures are fairly above the ground water table.
c) At the on-going construction site, the concrete is specified to be mixed with the ordinary Portland Cement and to be painted with bituminous material for water proof.

5) Neutralization of Concrete Structure

According to the material test results, the aggregate and the water used for concrete mixing are of neutral to slightly alkaline characteristics, and it is considered that the neutralization of concrete structure due to concrete is impossible.

(2) Construction Machinery

As to the construction machinery required for F/O and P/U, the type and number are to be determined in agreement with the construction method and the construction scale. The machinery required for construction works can generally be procured in the Sultanate of Oman or from the neighbouring countries. The construction companies that are operating in the Sultanate of Oman and neighbouring countries are in possession of a large number of construction machinery and they can, in time of necessity, procure any type of construction machine after adjusting with other construction works. Their construction machinery are maintained in tip-top condition and they are of sufficient efficiency and sufficient number for the F/O and P/U construction works. As to the list of construction machinery required for construction works, refer to Chapter 2.

(3) Labor

The construction works in the Sultanate of Oman are generally carried out by European Construction Companies. Their organization is set up in such a way that the overall management of construction works can be undertaken by the company staff themselves. For each construction project, the emigrant workers from the rank of laborers to foremen mostly come from Pakistan or India. A large number of the emigrant workers are available and they are well experienced in skilled-labor works such as operation of construction machinery or construction plants. Problems hardly arise as to the labor for construction works.

The management and supervision of road construction works in the Sultanate of Oman are mostly undertaken by European Consultants.

6.6.2 Time Schedule

The construction works on 8 F/O structures and 12 P/U structures of the present project are planned to be carried out with the account of the national (Sultanate of Oman) budget during the period from the 5th five-year plan that begins in 1996 to the 6th five-year plan that ends in 2005. These works shall have to be completed in the order of priority as proposed in the present report.

(1) Working Hours

The working hours of the general business workers in the Sultanate of Oman are 7 hours a day, 5 days a week; Thursday and Friday are holidays. The working hour of the construction site is from 7:00 to 12:00 noon and from 13:00 to 18:00, i.e. 10 hours a day, and six days a week with a holiday on Friday. Thus the present time schedule for construction works shall have the rate or capacity of work-operation at 6/7 = 86 %.

(2) Rate of Work-output

The rate of work-output required for the compilation of the construction schedule shall be established based on the on-site experiences as follows.

1) Earth Work:	Embankment	500 m^3/day
	Small scale excavation(P/U)	50 m^3/day
	Small scale backfilling (P/U)	30 m^3/day
2) Concreting Work:	Substructure	20 m3/day
	Retaining Wall	30 m3/day
	Box	15 m3/day
3) Pile Foundation Work:	ϕ 1.0m (Substructure)	5 piles/day
	ϕ 0.6 m (Retaining Wall)	15 piles/day
4) Pavement Work :	F/O Construction	500 m2/day
	P/U Construction	150 m2/day
5) Superstructure		
a) Box-slab Section Post-tension PS Girders		
	Girder manufacturing	20 Nos./30days
	Erection	3 Nos./day
	Surface works	5 days/span
b) Three Continuous Manufactured-on-site Post-tension PS Girders		
	On-site manufacturing	15 days/span
	Surface works	5 days/span
6) Drainage Work:		30 m/day
7) Detour Work:	Ramp way	30 m/day
	Temporary R/A	25 m/day
	P/U Construction	30 m/day

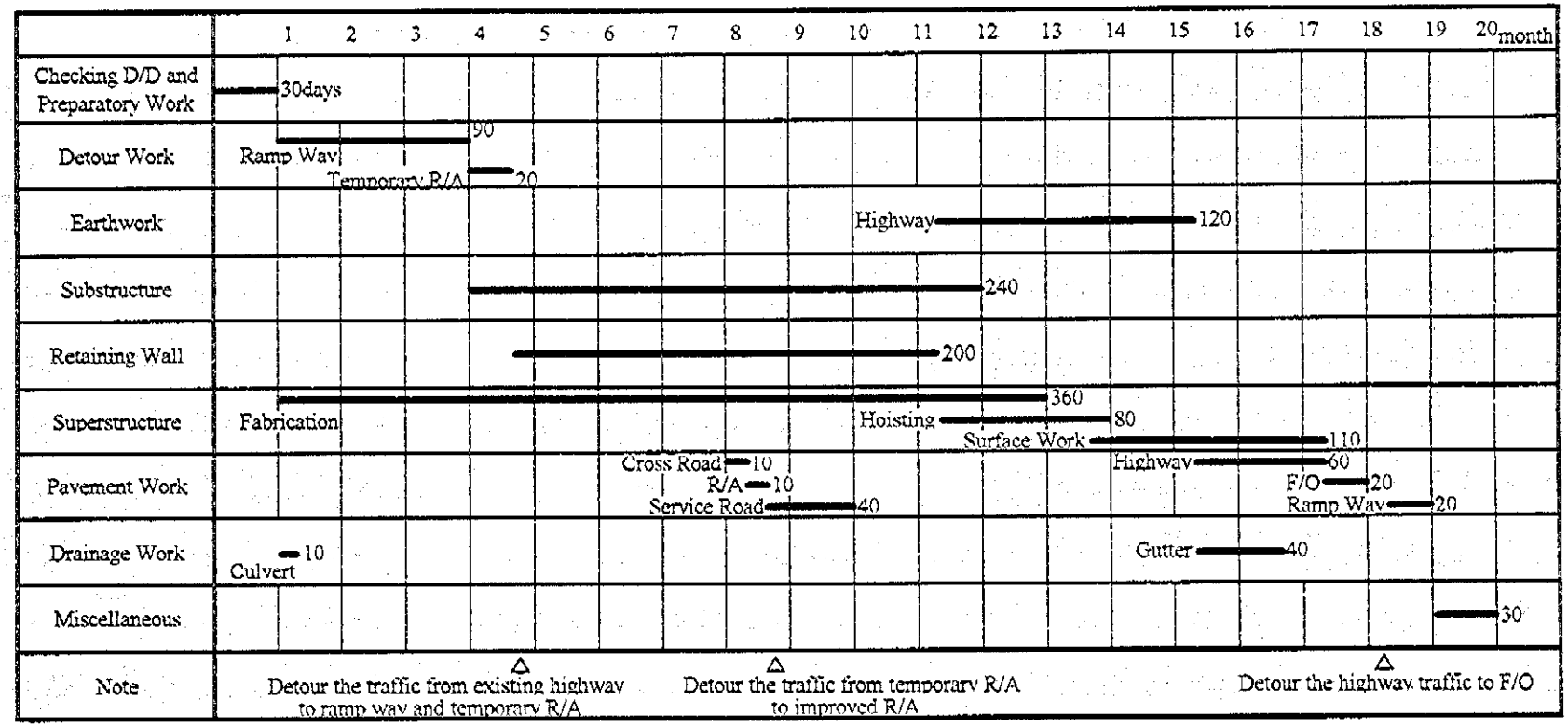
(3) F/O Construction Schedule

The construction schedule for F/O is compiled for the representative F/O sites such as Barka for the spread foundation, Sohar for the pile foundation and Aqr for a different form. The F/O construction schedule is illustrated in Table 6.5 ~ Table 6.7.

(4) P/U Construction Schedule

The P/U construction schedule is compiled for Barka taking the latter as a representative site and classifying the construction works.
The construction schedule is shown in Table 6.8.

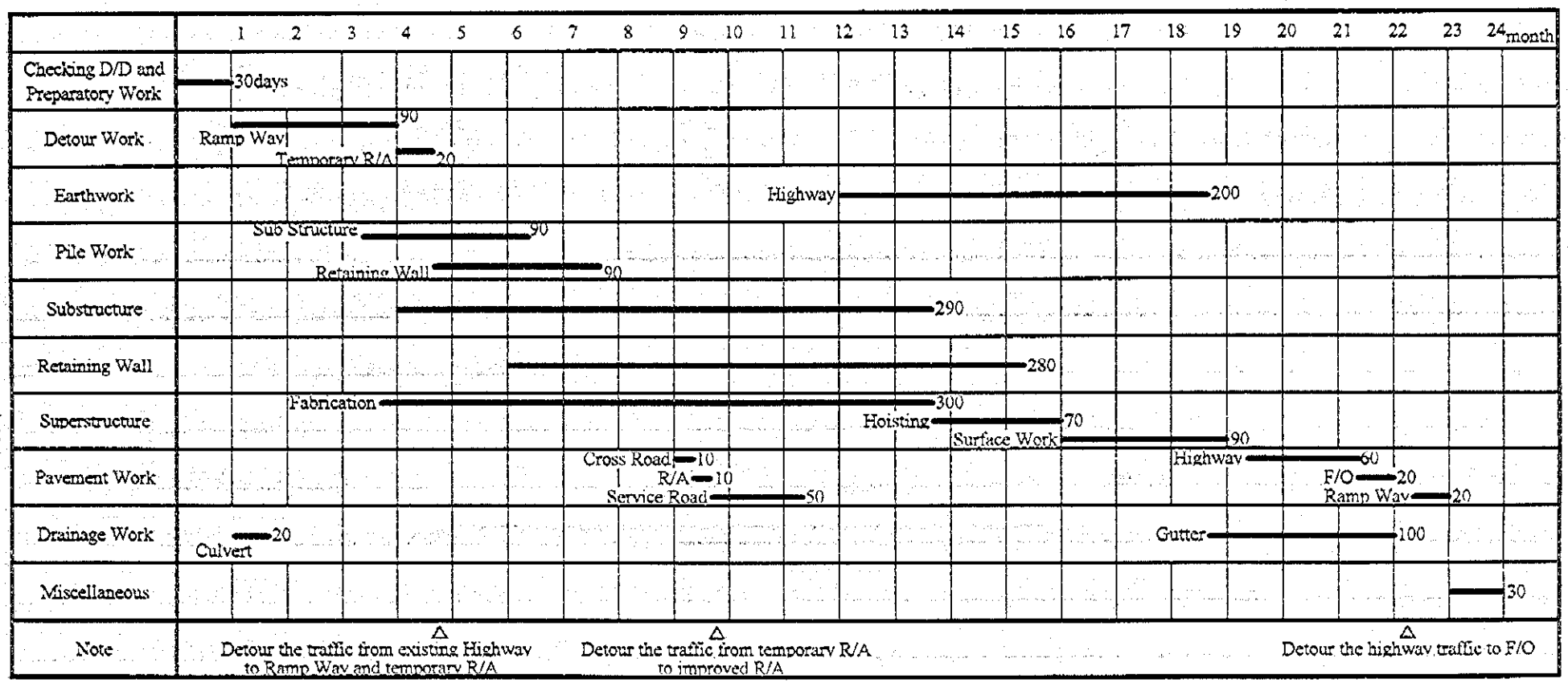
Table 6.5 Construction Program of a Typical Flyover with Spread Foundation (Barka F/O)



The following units of measurement used

* Detour Work	Ramp Way	m	* Superstructure	Beam	nos.
	Temporary Roundabout	m	* Pavement Work	Highway	m2
* Earthwork	Embankment of Highway	m3		Ramp Way	m2
* Substructure	Concrete Volume	m3		Roundabout	m2
* Retaining Wall	Concrete Volume	m3		Cross Road	m2
* Drainage Work	Culvert	m		Service Road	m2
	Gutter	m	* Miscellaneous		Lump Sum

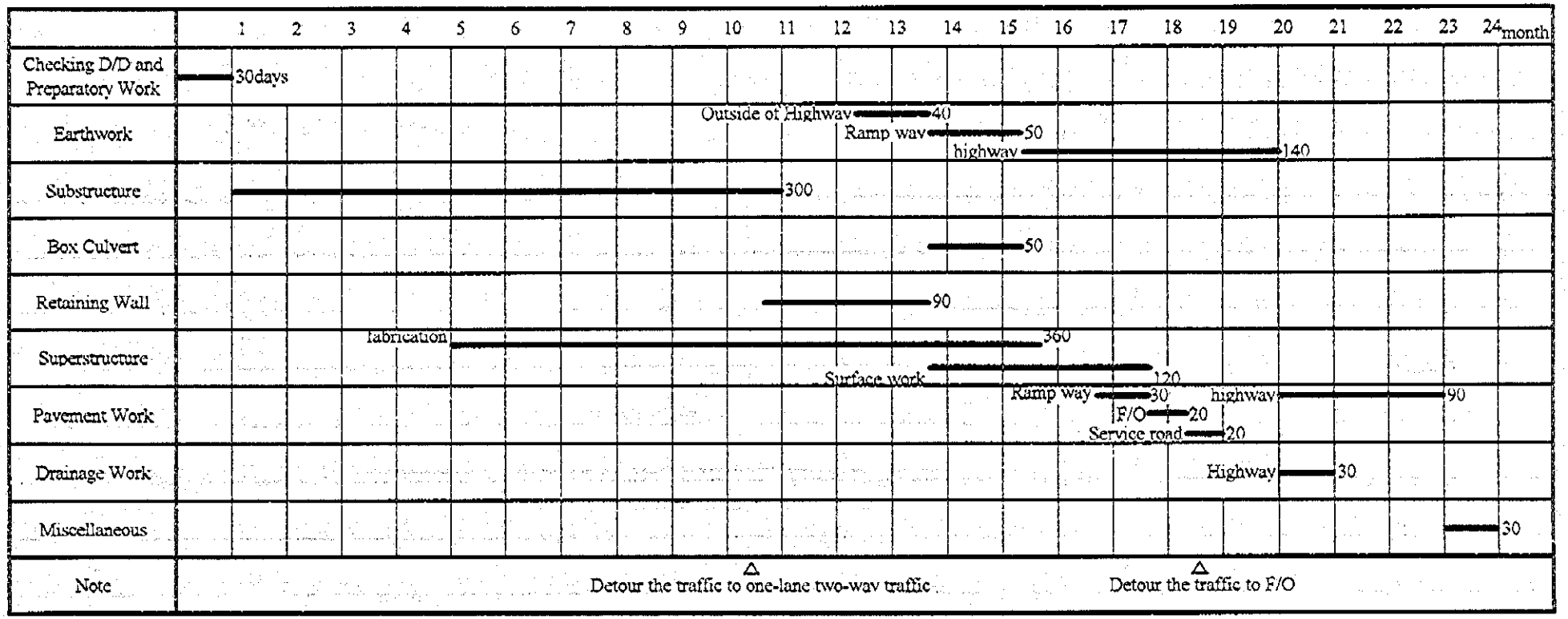
Table 6.6 Construction Program of a Typical Flyover with Pile Foundation (Sohar F/O)



The following units of measurement used

* Detour Work	Ramp Way	m	* Pavement Work	Highway	m2
	Temporary Roundabout	m		Ramp Way	m2
* Earthwork	Embankment of Highway	m3		Roundabout	m2
* Pile Work	Substructure	nos.		Cross Road	m2
	Retaining Wall	nos.		Service road	m2
* Substructure	Concrete Volume	m3	* Drainage Work	Culvert	m
* Retaining Wall	Concrete Volume	m3		Gutter	m
* Superstructure	Beam	nos.	* Miscellaneous		Lump Sum

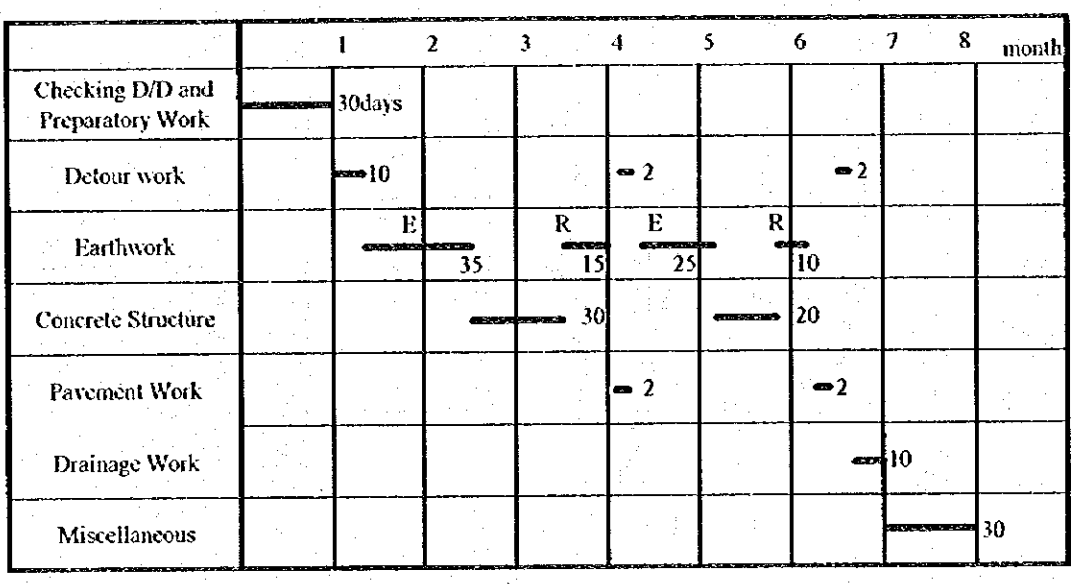
Table 6.7 Construction Program of the Aqr Flyover



The following units of measurement used

* Earthwork	Outside of Highway	m3	* Pavement Work	Highway	m2
	Ramp Way	m3		Ramp Way	m2
	Highway	m3		Service road	m2
* Substructure	Concrete Volume	m3	* Box Culvert	Cross Road (Concrete Volume)	m3
* Retaining Wall	Concrete Volume	m3		Drainage	m
* Superstructure		span	* Drainage Work	Highway	m
			* Miscellaneous		Lump Sum

Table 6.8 Construction Program of a Typical Pedestrian Underpass (Barka P/U)



Note: E=Excavation,R=Replacement

The following units of measurement used

* Detour Work	temporary pavement	m
* Earthwork	Excavation	m3
	Replacement	m3
* Concrete Structure		m3
* Pavement Work		m2
* Drainage Work		m

CHAPTER 7

SUMMARY OF QUANTITIES

CHAPTER 7. SUMMARY OF QUANTITIES

7.1 Quantities for Flyovers

Quantities of main items for flyovers were calculated as shown in the following table.

Table7.1 :Quantities of Flyovers

Items	Description	Unit	Quantities			
			R/A 2 A'Naseem	R/A 3 Barka	R/A 5 Al Muladdah	R/A 12 Sohar
Main Girder	Concrete class 40 for Internal	m3	5898	4693	4693	7073
	Concrete class 40 for External	m3	1363	91	91	1631
	PC Wire	ton	331	273	273	363
	Sheath	m	25057	24805	24805	27443
	Anchorage	n r	1584	1936	1936	1584
	Reinforcement Bar for Internal	ton	493	430	430	545
	Reinforcement Bar for External	ton	138	124	124	151
	Form for Internal Girder	m2	37479	28987	28987	45579
	Form for External Girder	m2	8613	6311	6311	10436
Cast in Place	Cross Beam Concrete class 32	m3	225	203	203	254
	Form	m2	848	799	799	945
	Anchorage	set	2304	3124	3124	2304
	Joint Concrete class 32	m3	158	150	150	176
	Form for Joint Concrete	m2	441	420	420	490
	Cantilever Concrete class 24	m3	1080	1605	1605	1210
	Form for Cantilever	m2	4055	3749	3749	4872
	Reinforcement Bar	ton	75	71	71	82
Hand Rail	Aluminum Hand Rail	m	1232	1165	1165	1286
Shoe	Fixed Shoe	set	198	242	242	198
	Movable Shoe	set	198	242	242	198
Expansion Joint	W=50 mm	m	44	44	44	44
	W=100 mm	m	176	222	222	176
Substructure	Base Aggregate	m3	364	338	343	452
	Blind Concrete	m3	182	169	171	226
	Form for Blind Concrete	m2	78	84	84	88
	Concrete for Abutment and Pier	m3	4713	4739	4770	5848
	Form for Abutment and Pier	m2	5069	5420	5583	4592
	Reinforcement Bar	ton	476	535	535	609
Piling	Pile	m				2388
Earth Work	Excavation to Waste	m3	17654	18692	19143	5516
	Excavation to Back fill	m3	4268	3951	3959	5268
Pavement	Asphalt T=10	m3	610	610	610	610

Items	Description	Unit	Quantities			
			R/A 8 Khaburah	R/A 10 Saham	R/A 14 Al Falaj Qabail	R/A 18 Aqr
Main Girder	Concrete class 40 for Internal	m3	4693	4693	4693	
	Concrete class 40 for External	m3	1091	1091	1091	5739
	PC Wire	ton	273	273	273	141
	Sheath	m	26141	26717	26723	10898
	Anchorage	n r	1936	1936	1936	240
	Reinforcement Bar for Internal	ton	430	430	428	
	Reinforcement Bar for External	ton	124	124	124	644
	Form for Internal Girder	m2	28987	28997	28987	16334
	Form for External Girder	m2	6728	6730	6743	
Cast in Place	Cross Beam Concrete class 32	m3	203	203	203	
	Form	m2	799	799	799	
	Anchorage	set	3124	3124	3124	
	Joint Concrete class 32	m3	150	150	149	
	Form for Joint Concrete	m2	420	420	419	
	Cantilever Concrete class 24	m3	1005	1003	1003	
	Form for Cantilever	m2	3749	3744	3749	
	Reinforcement Bar	ton	71	71	72	
Hand Rail	Aluminum Hand Rail	m				
Shoe	Fixed Shoe	set	242	242	242	48
	Movable Shoe	set	242	242	242	48
Expansion Joint	W=50 mm	m	44	44	44	
	W=100 mm	m	222	222	222	
Substructure	Base Aggregate	m3	348	338	339	307
	Blind Concrete	m3	174	169	169	154
	Form for Blind Concrete	m2	86	84	85	87
	Concrete for Abutment and Pier	m3	4958	4957	4541	4305
	Form for Abutment and Pier	m2	4589	4515	5477	5081
	Reinforcement Bar	ton	555	537	503	465
Piling	Pile	m	175	272		
Earth Work	Excavation to Waste	m3	2943	1781	1798	2739
	Excavation to Back fill	m3	9280	3587	7163	4905
Pavement	Asphalt T=10	m3	609	610	610	576

7.2 Quantities for Pedestrian Underpass

Quantities of main items for pedestrian underpasses were calculated as shown in the following table.

Table 7.2: Barka Pedestrian Underpass

Item	Description	Unit	Quantities
Earth Work	Structural Excavation	m3	2751
	Granular Back Fill	m3	735
	Borrow Material	m3	716
Bituminous Pavement	Bituminous Wearing Course	m3	15
	Asphalt Base Course	m3	29
	Granular Base Course	m3	55
	Subbase	m3	73
Concrete Structure	Concrete for Blinding Class 16	m3	50
	Concrete for Structure Class 24	m3	552
Structure Steel	High Yield Steel Bar	ton	49
	Galvanized Steel Bar D=50 mm	m	59
	Mild Steel for Hand Rail	m	46
Water Stop		m	74
Polyester Sheet		m2	577
Removal of Structure and Obstruction	Removal of Pavement	m3	68
	Removal of Existing Guardrail	m	22
	Removal of Curb Stone	m	11

Table7.3: Al Billah Pedestrian Underpass

Item	Description	Unit	Quantities
Earth Work	Structural Excavation	m3	2666
	Granular Back Fill	m3	661
	Borrow Material	m3	621
Bituminous Pavement	Bituminous Wearing Course	m3	13
	Asphalt Base Course	m3	26
	Granular Base Course	m3	49
	Subbase	m3	65
Concrete Structure	Concrete for Blinding Class 16	m3	46
	Concrete for Structure Class 24	m3	521
Structure Steel	High Yield Steel Bar	ton	47
	Galvanized Steel Bar D=50 mm	m	59
	Mild Steel for Hand Rail	m	45
Water Stop		m	74
Polyester Sheet		m2	519
Removal of Structure and Obstruction	Removal of Pavement	m3	100
	Removal of Existing Guardrail	m	23
	Removal of Curb Ston	m	

Table7.4: Tareef Pedestrian Underpass

Item	Description	Unit	Quantities
Earth Work	Structural Excavation	m3	3079
	Granular Back Fill	m3	692
	Borrow Material	m3	853
Bituminous Pavement	Bituminous Wearing Course	m3	13
	Asphalt Base Course	m3	26
	Granular Base Course	m3	49
	Subbase	m3	66
Concrete Structure	Concrete for Blinding Class 16	m3	55
	Concrete for Structure Class 24	m3	639
Structure Steel	High Yield Steel Bar	ton	52
	Galvanized Steel Bar D=50 mm	m	59
	Mild Steel for Hand Rail	m	67
Water Stop		m	74
Polyester Sheet		m2	543
Removal of Structure and Obstruction	Removal of Pavement	m3	109
	Removal of Existing Guardrail	m	23
	Removal of Curb Stone	m	

Table7.5: A'Tharmad Pedestrian Underpass

Item	Description	Unit	Quantities
Earth Work	Structural Excavation	m3	3175
	Granular Back Fill	m3	735
	Borrow Material	m3	869
Bituminous Pavement	Bituminous Wearing Course	m3	13
	Asphalt Base Course	m3	26
	Granular Base Course	m3	50
	Subbase	m3	66
Concrete Structure	Concrete for Blinding Class 16	m3	55
	Concrete for Structure Class 24	m3	657
Structure Steel	High Yield Steel Bar	ton	53
	Galvanized Steel Bar D=50 mm	m	59
	Mild Steel for Hand Rail	m	66
Water Stop		m	74
Polyester Sheet		m2	577
Removal of Structure and Obstruction	Removal of Pavement	m3	105
	Removal of Existing Guardrail	m	23
	Removal of Curb Stone	m	

Table7.6: A'Suwaiq Pedestrian Underpass

Item	Description	Unit	Quantities
Earth Work	Structural Excavation	m3	3016
	Granular Back Fill	m3	732
	Borrow Material	m3	705
Bituminous Pavement	Bituminous Wearing Course	m3	13
	Asphalt Base Course	m3	26
	Granular Base Course	m3	48
	Subbase	m3	64
Concrete Structure	Concrete for Blinding Class 16	m3	57
	Concrete for Structure Class 24	m3	656
Structure Steel	High Yield Steel Bar	ton	53
	Galvanized Steel Bar D=50 mm	m	59
	Mild Steel for Hand Rail	m	66
Water Stop		m	74
Polyester Sheet		m2	575
Removal of Structure and Obstruction	Removal of Pavement	m3	103
	Removal of Existing Guardrail	m	22
	Removal of Curb Stone	m	

Table7.7: Al Khadra Pedestrian Underpass

Item	Description	Unit	Quantities
Earth Work	Structural Excavation	m3	2557
	Granular Back Fill	m3	661
	Borrow Material	m3	603
Bituminous Pavement	Bituminous Wearing Course	m3	13
	Asphalt Base Course	m3	25
	Granular Base Course	m3	48
	Subbase	m3	64
Concrete Structure	Concrete for Blinding Class 16	m3	46
	Concrete for Structure Class 24	m3	526
Structure Steel	High Yield Steel Bar	ton	47
	Galvanized Steel Bar D=50 mm	m	59
	Mild Steel for Hand Rail	m	46
Water Stop		m	74
Polyester Sheet		m2	519
Removal of Structure and Obstruction	Removal of Pavement	m3	99
	Removal of Existing Guardrail	m	22
	Removal of Curb Stone	m	

Table7.8: Al Qarat Pedestrian Underpass

Item	Description	Unit	Quantities
Earth Work	Structural Excavation	m3	2437
	Granular Back Fill	m3	682
	Borrow Material	m3	661
Bituminous Pavement	Bituminous Wearing Course	m3	13
	Asphalt Base Course	m3	26
	Granular Base Course	m3	49
	Subbase	m3	65
Concrete Structure	Concrete for Blinding Class 16	m3	46
	Concrete for Structure Class 24	m3	513
Structure Steel	High Yield Steel Bar	ton	47
	Galvanized Steel Bar D=50 mm	m	59
	Mild Steel for Hand Rail	m	45
Water Stop		m	74
Polyester Sheet		m2	519
Removal of Structure and Obstruction	Removal of Pavement	m3	88
	Removal of Existing Guardrail	m	23
	Removal of Curb Stone	m	

Table7.9: Qarih Pedestrian Underpass

Item	Description	Unit	Quantities
Earth Work	Structural Excavation	m3	2349
	Granular Back Fill	m3	594
	Borrow Material	m3	661
Bituminous Pavement	Bituminous Wearing Course	m3	13
	Asphalt Base Course	m3	26
	Granular Base Course	m3	48
	Subbase	m3	64
Concrete Structure	Concrete for Blinding Class 16	m3	46
	Concrete for Structure Class 24	m3	513
Structure Steel	High Yield Steel Bar	ton	47
	Galvanized Steel Bar D=50 mm	m	59
	Mild Steel for Hand Rail	m	45
Water Stop		m	74
Polyester Sheet		m2	519
Removal of Structure and Obstruction	Removal of Pavement	m3	100
	Removal of Existing Guardrail	m	22
	Removal of Curb Stone	m	

Table7.10: Majaz A'Sughra Pedestrian Underpass

Item	Description	Unit	Quantities
Earth Work	Structural Excavation	m3	2477
	Granular Back Fill	m3	709
	Borrow Material	m3	661
Bituminous Pavement	Bituminous Wearing Course	m3	13
	Asphalt Base Course	m3	26
	Granular Base Course	m3	49
	Subbase	m3	65
Concrete Structure	Concrete for Blinding Class 16	m3	46
	Concrete for Structure Class 24	m3	518
Structure Steel	High Yield Steel Bar	ton	47
	Galvanized Steel Bar D=50 mm	m	59
	Mild Steel for Hand Rail	m	46
Water Stop		m	74
Polyester Sheet		m2	519
Removal of Structure and Obstruction	Removal of Pavement	m3	88
	Removal of Existing Guardrail	m	23
	Removal of Curb Stone	m	

Table7.11: Khor A'Siyabi Pedestrian Underpass

Item	Description	Unit	Quantities
Earth Work	Structural Excavation	m3	2426
	Granular Back Fill	m3	739
	Borrow Material	m3	630
Bituminous Pavement	Bituminous Wearing Course	m3	13
	Asphalt Base Course	m3	26
	Granular Base Course	m3	49
	Subbase	m3	66
Concrete Structure	Concrete for Blinding Class 16	m3	45
	Concrete for Structure Class 24	m3	500
Structure Steel	High Yield Steel Bar	ton	46
	Galvanized Steel Bar D=50 mm	m	59
	Mild Steel for Hand Rail	m	45
Water Stop		m	74
Polyester Sheet		m2	519
Removal of Structure and Obstruction	Removal of Pavement	m3	119
	Removal of Existing Guardrail	m	23
	Removal of Curb Stone	m	

Table7.12: Liwa Pedestrian Underpass

Item	Description	Unit	Quantities
Earth Work	Structural Excavation	m3	2555
	Granular Back Fill	m3	697
	Borrow Material	m3	692
Bituminous Pavement	Bituminous Wearing Course	m3	13
	Asphalt Base Course	m3	26
	Granular Base Course	m3	49
	Subbase	m3	65
Concrete Structure	Concrete for Blinding Class 16	m3	49
	Concrete for Structure Class 24	m3	531
Structure Steel	High Yield Steel Bar	ton	49
	Galvanized Steel Bar D=50 mm	m	59
	Mild Steel for Hand Rail	m	46
Water Stop		m	74
Polyester Sheet		m2	519
Removal of Structure and Obstruction	Removal of Pavement	m3	85
	Removal of Existing Guardrail	m	22
	Removal of Curb Stone	m	

Table7.13: Asrar Bani Sa'd Pedestrian Underpass

Item	Description	Unit	Quantities
Earth Work	Structural Excavation	m3	2253
	Granular Back Fill	m3	531
	Borrow Material	m3	660
Bituminous Pavement	Bituminous Wearing Course	m3	13
	Asphalt Base Course	m3	25
	Granular Base Course	m3	47
	Subbase	m3	63
Concrete Structure	Concrete for Blinding Class 16	m3	46
	Concrete for Structure Class 24	m3	513
Structure Steel	High Yield Steel Bar	ton	47
	Galvanized Steel Bar D=50 mm	m	59
	Mild Steel for Hand Rail	m	45
Water Stop		m	74
Polyester Sheet		m2	519
Removal of Structure and Obstruction	Removal of Pavement	m3	79
	Removal of Existing Guardrail	m	22
	Removal of Curb Stone	m	

7.3 Quantities for Road Works

Quantities of main items for road works were calculated as shown next table.

Table7.14:Quantities for Road Works

Items	Description	Unit	Quantities			
			R/A 2 A'Naseem	R/A 3 Barka	R/A 5 Al Muladdah	R/A 12 Sohar
Removal of Structure	Removal and Delivery of Trees	n r	69	78	111	257
	Removal of Existing Buildings	n r	1	6	3	5
	Removal of Reinforcement Concrete	m3	34	59	51	83
	Removal of Concrete	m3	81	282		362
	Removal of Pipe Culvert	m	248	91	33	37
	Removal of Box Culvert	m	43		54	252
	Removal of Pavement	m3	5771	6684	4831	6079
	Removal of Interlocking	m2	1040	2806	375	2893
	Removal of Curb Stone	m	1057	2747	600	6689
	Removal of Signboards	n r	42	62	23	72
	Removal of Fence	m			571	192
	Removal of Gird Rail	m	2806	3860	1279	2434
Earth Works	Suitable Excavation to Embankment	m3	18430	26128	21553	21190
	Suitable Excavation to Backfill	m3		232		
	Unsuitable Excavation to Waste	m3				
	Borrow Excavation to Embankment	m3	62000	37772	42727	91430
Structure Excavation	Structure Excavation h<2.0 m	m3	370	283	913	4890
	Structure Excavation h>2.0 m	m3				
	Structure Excavation to Waste	m3				
Granular Basecourse	Granular Basecourse T=15	m2	2347	5438	4412	10030
Aggregate Basecourse	Aggregate Basecourse T=30	m3				2396
	Aggregate Basecourse T=25	m3				6474
	Aggregate Basecourse T=20	m3	10239	11856	9879	226
	Aggregate Basecourse T=15	m3	1879	3126	3392	3389
Bituminous Pavement	Bituminous Basecourse T=5	m3	1103			13302
	Bituminous Basecourse T=7	m3		216	701	
	Bituminous Basecourse T=10	m3	2912	5619	3937	3501
	Bituminous Wearing Course	m3	3442	4262	3856	3136
	Prime Coat	kg	50982	61102	57608	46086
	Tack Coat	kg	10239	11856	9879	7003
	Interlocking Block Pavement	m2	2347	5438	4412	10030

Items	Description	Unit	Quantities			
			R/A 2 A'Naseem	R/A 3 Barka	R/A 5 Al Muladdah	R/A 12 Sohar
Curb	Curbs100 x 200 (mountable)	m	4392	4372	3936	8528
	Curbs 150 x 350(mountable)	m	1864	2499	1663	5588
	Curbs 150 x 350	m	80	80	80	80
Retaining Wall	Gravity Wall	m	110	190	193	378
	Leaning type Retaining Wall	m	40	8	8	77
Drainage and Service Ducts	Pipe Culvert d=0.6 m	m	100	97	135	154
	Pipe Culvert d=0.75 m	m	55	62		
	Box Culvert 2 m x 1 m 12 cell	m		11		
	Box Culvert 2 m x 1 m 1 cell	m	47		31	86
	Box Culvert 2 m x 1 m 2 cell	m	77		42	241
	Catch Pit 1 x 1 x 2 m	m	4	4	4	6
	Side Ditch	m	728	297	677	1149
	Open Ditch	m	499	992		1738
Slope Protection	Gabions	m3	100	113		
	Riprap	m3		708	695	1099
Road Facilities	Gird Rail Type A	m	2507	2193	2483	
	Gird Rail Type C	m	1351	1178	1338	1340
	Delineators	n r	253	222	251	88
Road Marking	L1	m2	140	190	169	146
	L2	m2	9	18	9	18
	L3	m2				
	L4	m2	1858	2113	1989	2246
	L5	m2	113	79	92	91
	L6	m2				
	L7	m2		24	8	11
	L8	m2	9	19	9	21
	L2A	m2	12	36	18	30
	Zebra	m2	891	785	825	973
	Straight Arrows (straight)	m2	18	21	18	21
	Lane Selection Arrows	m2	10	7	7	7
	Combined Arrows	m2	10	11	7	11
	Curbstone Painting	m2	1537	1530	1377	2985
	Road Studs	n r	1055	1220	1257	1091
Road Signs	Triangular Signs	n r	9	15	11	17
	Rectangle Signs	n r	18	8	10	12
	Circular Signs	n r	11	14	10	17
	Square Signs	n r	4	13	5	17
Service Ducts	A.C 150 mm 2 ways	m	77	284	75	388

Items	Description	Unit	Quantities			
			R/A 8 Khaburah	R/A 10 Saham	R/A 14 Al Falaj Qabail	R/A 18 Aqr
Removal of Structure	Removal and Delivery of Trees	n r	87	58	112	61
	Removal of Existing Buildings	n r	4	3	2	1
	Removal of Reinforcement Concrete	m3	28	28	37	35
	Removal of Concrete	m3	173	640	88	6
	Removal of Pipe Culvert	m	119	191		
	Removal of Box Culvert	m				96
	Removal of Pavement	m3	5159	4562	3978	4680
	Removal of Interlocking	m2	1515	1822	2910	
	Removal of Curb Stone	m	2894	4221	5025	
	Removal of Signboards	n r	63	74	67	45
	Removal of Fence	m	370			
	Removal of Gird Rail	m	3845	3278	4339	1058
Earth Works	Suitable Excavation to Embankment	m3	19123	22900	13130	9261
	Suitable Excavation to Waste	m3				
	Unsuitable Excavation to Waste	m3				
	Borrow Excavation to Embankment	m3	62112	62207	93628	171159
Structure Excavation	Structure Excavation h<2.0 m	m3	738	424	505	2517
	Structure Excavation h>2.0 m	m3				
Granular Basecourse	Granular Basecourse T=15	m2	5276	5318	6076	
Aggregate Basecourse	Aggregate Basecourse T=30	m3				
	Aggregate Basecourse T=25	m3		5194		
	Aggregate Basecourse T=20	m3	8070	5775	10688	8611
	Aggregate Basecourse T=15	m3	2253	1317	720	1427
Bituminous Pavement	Bituminous Basecourse T=5	m3		2630		479
	Bituminous Basecourse T=7	m3	701			2958
	Bituminous Basecourse T=10	m3	4035	4965	5344	614
	Bituminous Wearing Course	m3	3483	3260	3411	4017
	Prime Coat	kg	52318	46746	42755	54010
	Tack Coat	kg	10075	9930	10688	11599
	Interlocking Block Pavement	m2	5276	5318	6076	972

Items	Description	Unit	Quantities			
			R/A 8 Khaburah	R/A 10 Saham	R/A 14 Al Falaj Qabail	R/A 18 Aqr
Curb	Curbs100 x 200 (mountable)	m	2206	2232	2509	445
	Curbs 150 x 350(mountable)	m	80	80	80	80
	Curbs 150 x 350	m	4677	4812	5501	1722
Retaining Wall	Gravity Wall	m	345	247	210	510
	Leaning type Retaining Wall	m	16	16	21	593
Drainage and Service Ducts	Pipe Culvert d=0.6 m	m	198	254	135	100
	Pipe Culvert d=0.75 m	m			25	9
	Box Culvert 2 m x 1 m 1 cell	m				15
	Box Culvert 2 m x 1 m 2 cell	m			9	94
	Box Culvert 2 m x 1 m 3 cell	m	17		12	5
	Catch Pit 1 x 1 x 2 m	m	4	6	4	4
	Side Ditch	m	23	23	23	
	Open Ditch 300 x 300 mm	m	977	1183	926	613
	Open Ditch	m				469
Slope Protection	Gabions	m3	836			
	Riprap	m3	202	263	304	
Road Facilities	Gird Rail Type A	m	1822	2387	3140	3562
	Gird Rail Type C	m	1340	1340	1340	4572
	Delineators	n r	210	245	294	535
Road Marking	L1	m2	156	129	147	169
	12	m2	16	15	14	9
	L4	m2	2123	1960	2040	2189
	L5	m2	107	107	99	65
	L6	m2				
	L7	m2		3		
	L8	m2	11	10	9	9
	L2A	m2	20	21	18	12
	Zebra	m2	526	558	517	433
	Straight Arrows (straight)	m2	21	21	21	16
	Lane Selection Arrows	m2	7	7	7	7
	Combined Arrows	m2	8	8	8	4
	Curbstone Painting	m2	1637	1684	1925	552
	Road Studs	n r	1123	1007	1024	1060
	Triangular Signs	n r	17	14	14	10
Road Signs	Rectangle Signs	n r	14	12	12	15
	Circular Signs	n r	23	23	24	10
	Square Signs	n r	17	14	10	4
Service Ducts	A.C 150 mm 2 way	m	276	276	324	172

7.4 Quantities for Retaining Wall

Quantities of retaining wall were calculated as shown in the following table.

Table 7.15: Quantities for Retaining Wall

Items	Description	Unit	Quantities			
			R/A 2 A'Naseem	R/A 3 Barka	R/A 5 Al Muladdah	R/A 12 Sohar
Earth Works	Structural Excavation to Waste	m3	8506	7704	14763	5923
	Structural Excavation to Back Fill	m3	5145	4857	5221	7374
	Replacement by Borrow Material	m3	5834	4543	11687	390
Concrete work for Retaining Wall	Concrete for Blinding Class 16	m3	409	389	398	405
	Concrete for Gravity Wall Class 16	m3	925	1047	948	1823
	Concrete for Reversed T Class 24	m3	4861	4544	4470	6048
Structure Steel	High Yield Steel Bar	ton	343	321	372	323
	Handrail	m	1088	1030	1029	1027
Joint	Joint Filler	m2	380	367	344	516
Drainage	Pipe D=100 mm for Wall	m	431	427	407	426
Pile	D=600 mm	m				9363

Items	Description	Unit	Quantities			
			R/A 8 Khaburah	R/A 10 Saham	R/A 14 Al Falaj Qabail	R/A 18 Aqr
Earth Works	Structural Excavation to Waste	m3	5769	6105	10762	2983
	Structural Excavation to Back Fill	m3	6927	7013	4534	4606
	Replacement by Borrow Material	m3	581	591	7499	
Concrete work for Retaining Wall	Concrete for Blinding Class 16	m3	349	374	372	354
	Concrete for Gravity Wall Class 16	m3	2017	2139	1672	1558
	Concrete for Reversed T Class 24	m3	5244	5613	3724	4048
Structure Steel	High Yield Steel Bar	ton	264	299	261	276
	Handrail	m	999	998	1120	1102
Joint	Joint Filler	m2	475	509	319	359
Drainage	Pipe D=100 mm for Wall	m	614	650	386	478
Pile	D=600 mm	m	7632	7986		

7.5 Quantities for Land Acquisition

Quantities of land acquisition necessary for the project were calculated as shown in the next table.

Table 7.16: Quantities for Land Acquisition

Items	Description	Unit	Quantities			
			R/A 2 A'Naseem	R/A 3 Barka	R/A 5 Al Muladdah	R/A 12 Sohar
Land Acquisition	Commercial Area	m2		260	780	1070
	Residence Area	m2				
	Agricultural Area	m2	7430		7170	9620

Items	Description	Unit	Quantities			
			R/A 8 Khaburah	R/A 10 Saham	R/A 14 Al Falaj Qabail	R/A 18 Aqr
Land Acquisition	Commercial Area	m2	859	983	1605	
	Residence Area	m2				448
	Agricultural Area	m2	1002	710		50281