9.5.3 Selection of Structural Type

(1) Superstructure

Fig. 9.9 is a general relationship for selection of super structure for a bridge, and gives the relationship between bridge (types) and the span (RC and PC bridges).

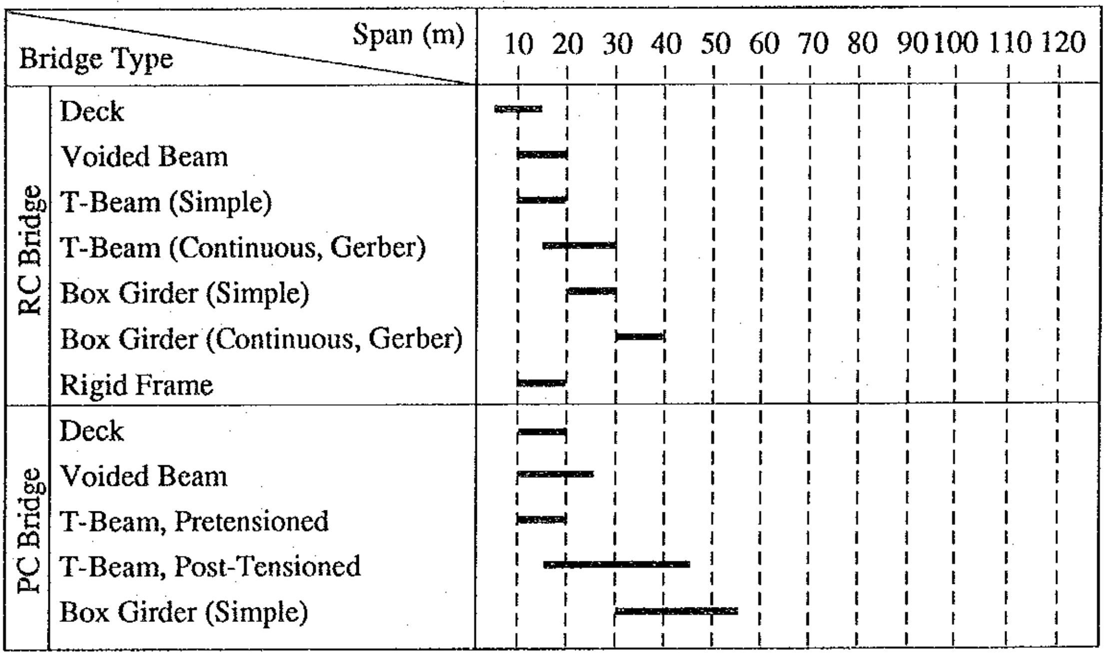
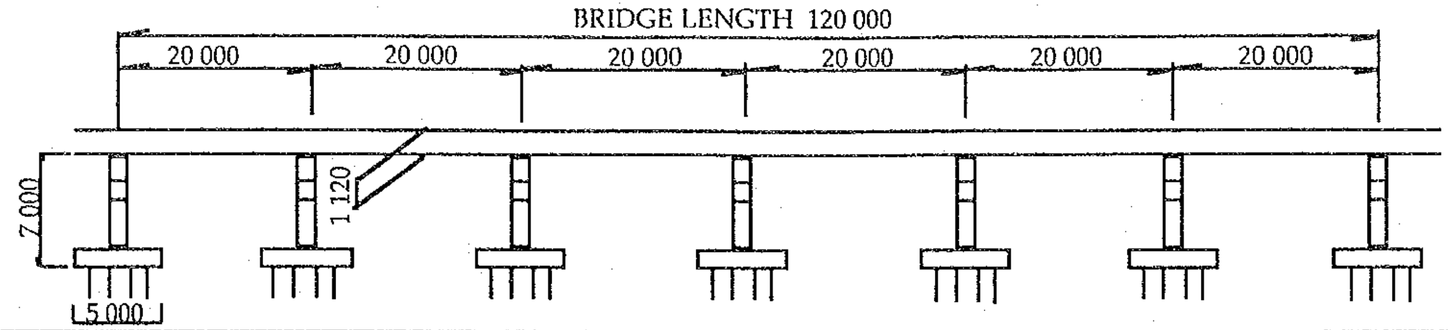
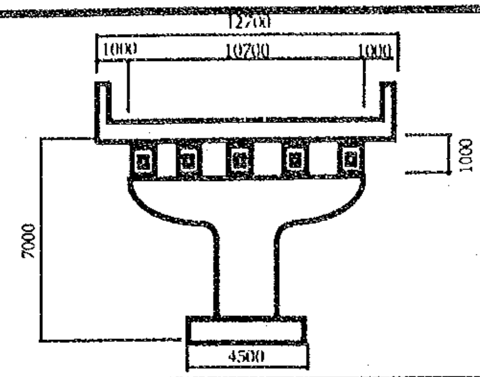
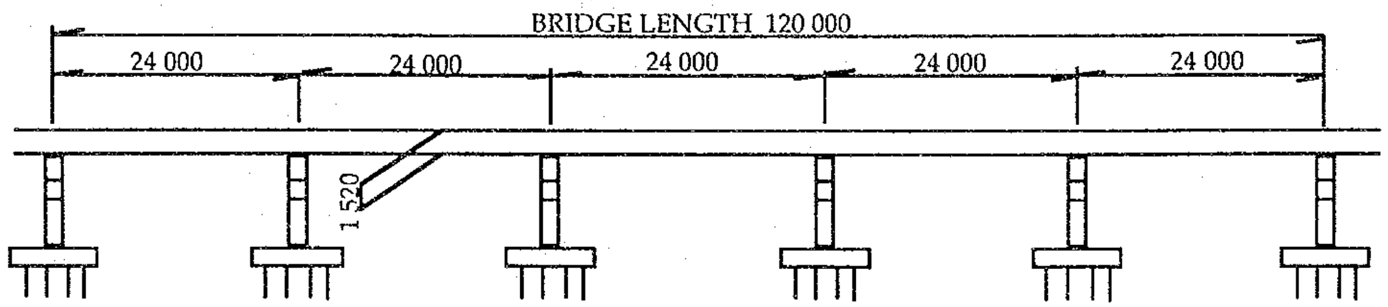
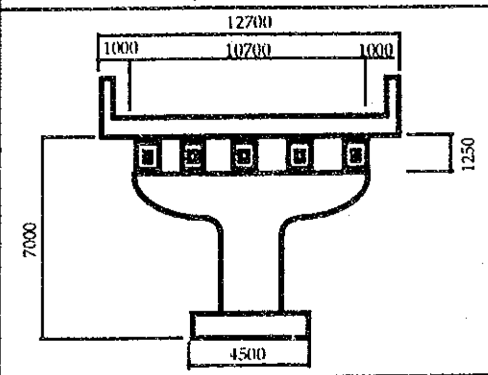
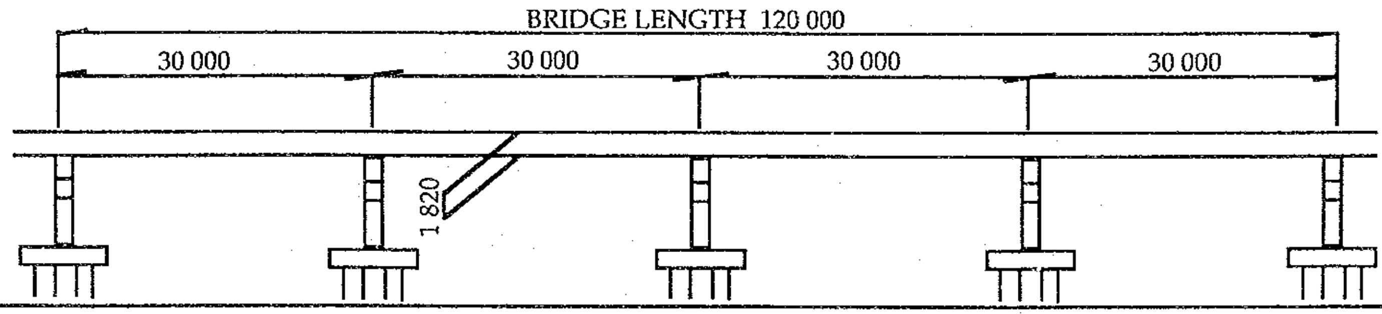
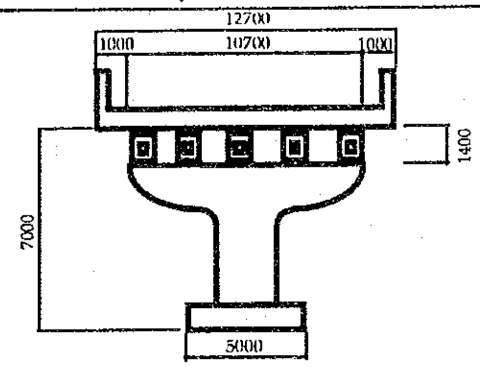
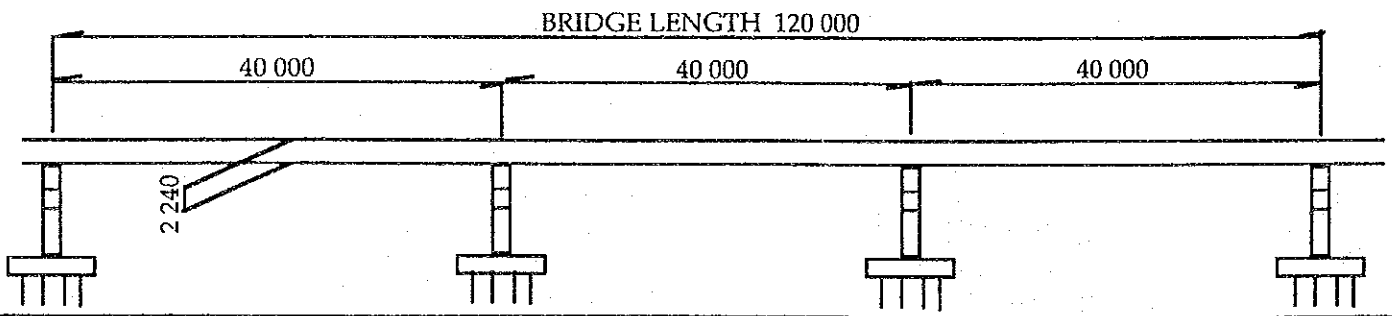
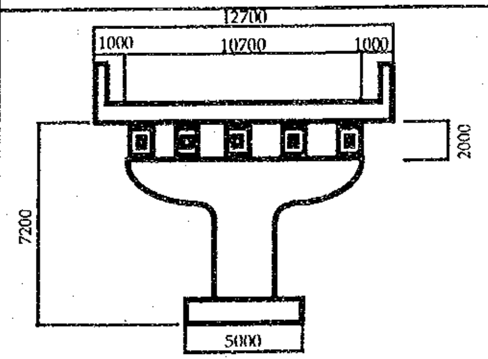


Figure 9.9 Relationship between Bridge Type and Span

For the superstructure the PC structure will be most suitable as shown in Fig. 9.9. For the superstructure, and the substructure and foundation which will be described in later chapters, the structural studies and economical comparisons were conducted.

The results of the analysis are described in Fig. 9.10. The 20 m span is the most economical. With the exception of the 40 m span, there is very little difference in the 20 m, 25 m, and 30 m spans. The spans are based on the 20 m span, and the span was decided for their aesthetic merits as stated in Chapter 11, and the sight distance characteristics of the roundabouts (refer to Fig. 9.3).

	PROFILE	SECTION	RANKING (COST RATIO)
CASE-I SPAN 20.0M			1 (1.00)
CASE-II SPAN 24.0M			2 (1.05)
CASE-III SPAN 30.0M			3 (1.15)
CASE-IV SPAN 40.0M			4 (1.40)

THE STUDY ON THE ROAD DEVELOPMENT PROJECT	JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure 9.10 Economic Comparison of Superstructure Span**

(2) Substructure

a. Abutment

Table 9.11 gives the relationship between height of the abutment and the various types. From this table, the abutments for this project were the Reverse T-Type.

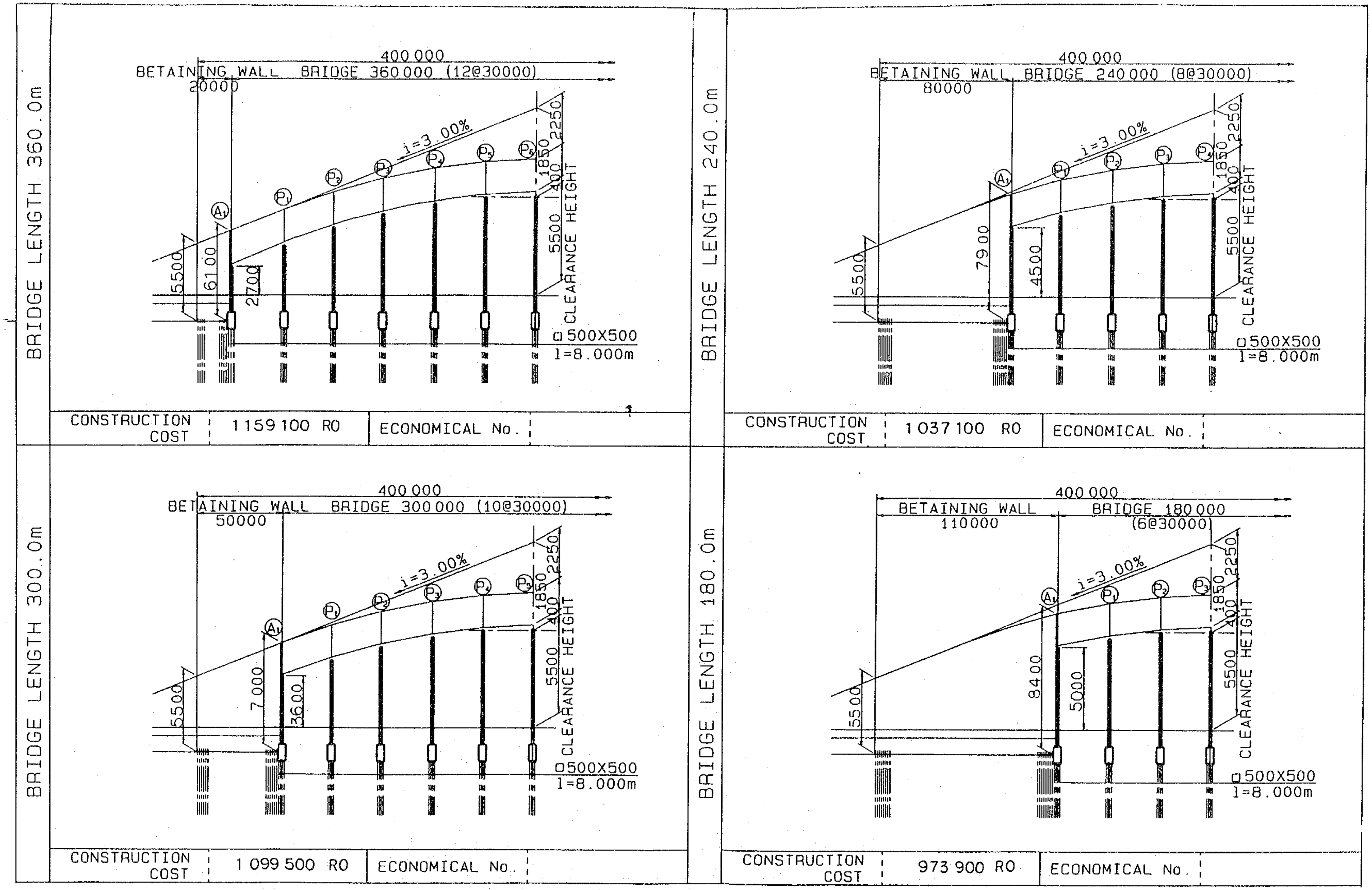
Table 9.11 Relationship between Abutment Height and the Various Types

Type \ Height (m)	5	10	15	20	
Rigid type (15 - 25 m)					
Butress type (12 - 20 m)					
Reverse T-shape (5 - 15 m)					
Semi Gravity type (less than 5 m)					
Gravity type (less than 5 m)					

The height of abutments and the type of structure have been studied for their economic comparison, and the results are given in Fig. 9.11. The most economical abutment height is approximately 8.4 m.

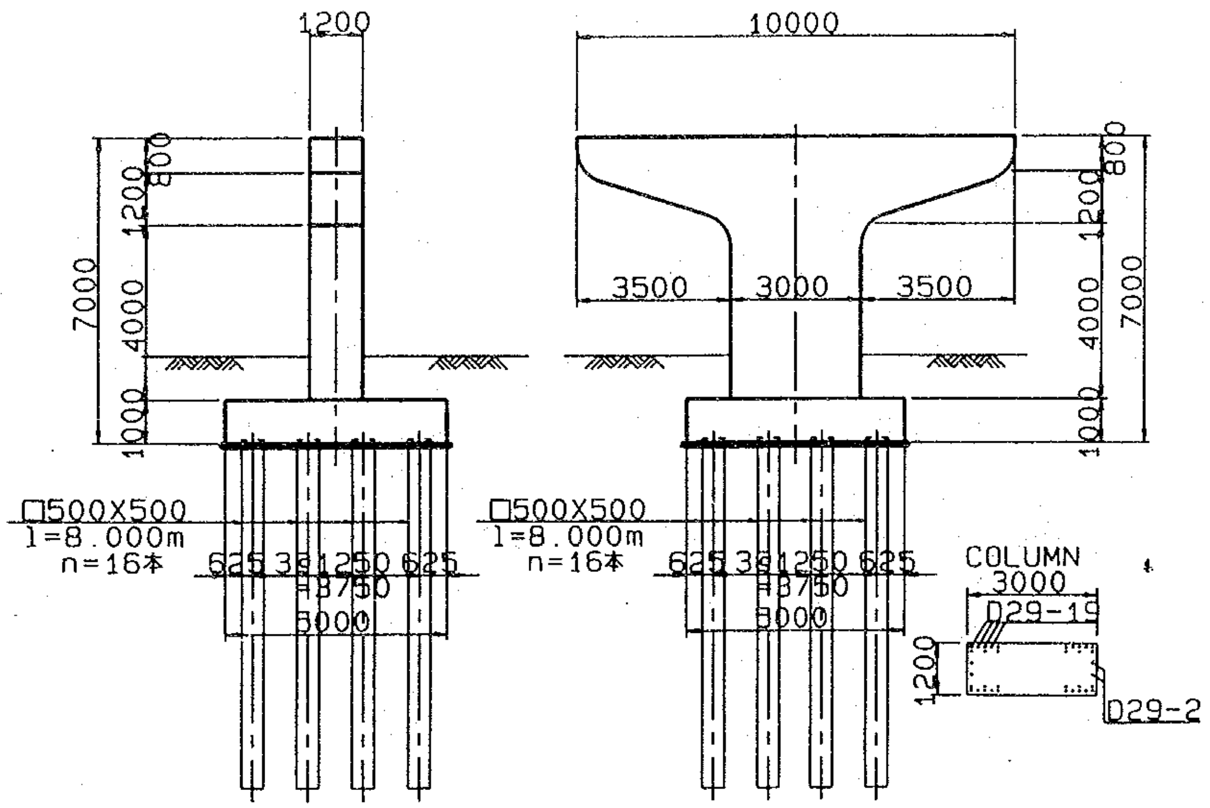
b. Substructure (Pier) for the Elevated Structures

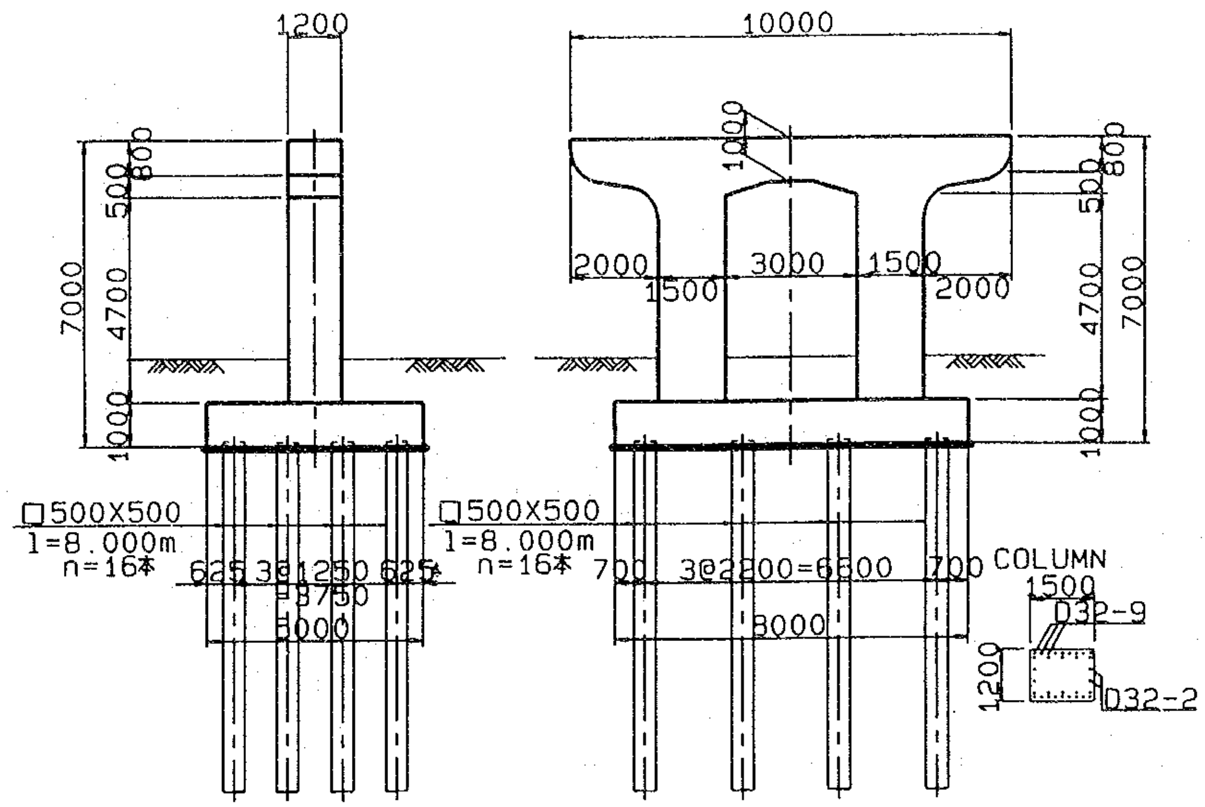
Pier for the elevated structures of this project can be assumed to be either of the Reverse T-Type or of the rigid framed type. Both types were compared and the results are given in Fig. 9.12. There is very little difference in their costs. The final decision for the type to be selected will depend on their appearance.



THE STUDY ON ROAD DEVELOPMENT PROJECT	JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure 9.11 Economic Comparison of Bridge Length**

	CASE-1	CASE-2
PROFILE S=1/150	(drawing below)	(drawing below)





	CASE-1	CASE-2
CONSTRUTION COST	Sub Structure 13 200 RO (Unit price 226.0 RO/m³)	Sub Structure 14 900 RO (Unit price 211.0 RO/m³)

THE STUDY ON ROAD DEVELOPMENT PROJECT	JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure 9.12 Compared with Reverse T-Type and Framed**

(3) Foundation

For the foundation, the pile foundation is most suited due to the depth of the bearing strata. Precast concrete piles locally available in Oman with a square cross section of 500 x 500 mm were selected. The final size will be determined during the preparation of the detailed design stage.

9.5.4 Preliminary Design of the Structural Type for the Flyover

The structural type of flyover selected in paragraph 9.5.3 is shown in Volume IV: Drawings.

9.5.5 Preliminary Bills of Quantities

The preliminary quantities made from the preliminary drawings are given in Table 9.12.

Table 9.12 Preliminary Quantities

Item		Unit	R/A-2	R/A-3	R/A-5	R/A-8	R/A-10	R/A-12	R/A-14	R/A-18
Earthworks	(A)									
Excavation	(Common)	m^3	70	700	100	100	60	300	1,000	0
Embankment	(Borrow)	m^3	79,100	83,500	91,100	73,800	77,300	103,500	98,000	98,900
Incidental Works	(30 %)	LS	1	1	1	1	1	1	1	1
Pavement	(B)									
Subbase Couse		m^3	9,030	9,600	9,310	9,570	9,230	9,580	9,830	9,510
Base Course	(A.C.)	m^3	3,270	3,300	3,390	3,510	3,350	3,470	3,380	3,560
Wearing Course	(A.C.)	m^3	2,410	2,590	2,710	2,560	2,460	2,570	2,670	2,540
Footpath	(with Curbs)	m^3	3,500	3,610	3,660	3,340	3,520	3,690	4,130	0
Drainage	(C)									
RC Pipe Culvert	($D < 0.6$ m)	m	34	70	109	115	72	97	138	0
	(0.6 m $< D <$ 0.9 m)	m	46	10	16	5	40	9	17	0
RC Box Culvert	(2 * 1 m)	m	8	240	122	45	170	370	60	200
Open Channel	($\bar{H}$ = 2 m, $\bar{B}$ = 6 m)	m	0	0	0	0	65	225	0	0
Lined Drains		m	890	904	918	908	905	958	983	0
Slope Protection	(D)									
Retaing Wall	(with Piles)	m	($\bar{H}$ = 5.7 m) 820	($\bar{H}$ = 5.5 m) 800	($\bar{H}$ = 5.6 m) 800	($\bar{H}$ = 5.7 m) 820	($\bar{H}$ = 5.5 m) 800	930	($\bar{H}$= 6.0 m) 920	($\bar{H}$ = 5.9 m) 960
Grounted Rip Rap	(t = 0.3 m)	m^2	0	0	0	0	0	380	380	0
Bridges	(E)									
Superstructure	(Span L = 30 m)	No	2	2	2	2	2	2	2	(for Ramp) 16
Superstructure	(Span L = 25 m)	No	8	8	8	8	8	8	8	0
Superstructure	(Span L = 20 m)	No	16	16	16	16	16	16	16	0
Pier (One Colum Type, with Piles)		No	($\bar{H}$ = 8.3 m) 20	($\bar{H}$ = 7.8 m) 20	($\bar{H}$ = 7.8 m) 20	($\bar{H}$ = 7.9 m) 20	($\bar{H}$ = 7.8 m) 24	($\bar{H}$ = 8.0 m) 12	($\bar{H}$ = 8.5 m) 16	($\bar{H}$ = 8.8 m) 10
(Two Colums Type, with Piles)		No	($\bar{H}$ = 8.4 m) 4	($\bar{H}$ = 7.8 m) 4	($\bar{H}$ = 7.9 m) 4	($\bar{H}$ = 8.0 m) 4	0	($\bar{H}$ = 8.3 m) 12	($\bar{H}$ = 8.6 m) 8	($\bar{H}$ = 9.3 m) 4
Abutment	(with Piles)	No	($\bar{H}$ = 9.1 m) 4	($\bar{H}$ = 8.6 m) 4	($\bar{H}$ = 8.6 m) 4	($\bar{H}$ = 8.7 m) 4	($\bar{H}$ = 8.6 m) 4	($\bar{H}$ = 9.0 m) 4	($\bar{H}$ = 8.5 m) 4	($\bar{H}$ = 8.7 m) 4
Road Furniture	(F)									
Guardrails		m	4,240	4,220	4,140	4,260	4,300	4,390	4,290	6,550
Markings		LS	1	1	1	1	1	1	1	1
Signs		LS	1	1	1	1	1	1	1	1
Lingthing	(G)	LS	1	1	1	1	1	1	1	1
Relocation of Utilities	(H)	LS	1	1	1	1	1	1	1	1
Landscaping	(I)	LS	1	1	1	1	1	1	1	1

CHAPTER 10 PRELIMINARY STUDY OF PEDESTRIAN UNDERPASS

CHAPTER 10

PRELIMINARY STUDY OF PEDESTRIAN UNDERPASS

10.1 General

This chapter studies the implementation of pedestrian underpasses at 12 locations on the Batinah Highway selected in Chapter 8, Selection of Pedestrian Underpass. The survey and geotechnical studies have been conducted for the underpass facilities, and the preliminary design has been prepared in this chapter.

10.2 Investigation of the Natural Conditions

Investigation of the Natural Conditions in this chapter are described Chapter 9.2.1 (Topographic Survey) and Chapter 9.2.2 (Soil Investigation).

10.3 Preliminary Design for the Pedestrian Underpasses

10.3.1 General

For the pedestrians to cross over the Batinah Highway, the facilities considered are either the pedestrian underpass or elevated pedestrian bridges.

Although the underground passageway has been selected for pedestrians and livestock to cross the highway, the possibility for an elevated bridge can be considered, therefore the two methods have been compared in paragraph 10.3.3.

10.3.2 Design Standards

The design standards for pedestrian underpasses have already been implemented in Oman and this standard has been prepared based on the facility.

(1) Construction limits and Width

In accordance with Fig. 10.1.

(2) The slopes within the culvert

Cross sectional slope: 2 %

Longitudinal slope: 1 %

(3) Stair Construction

In accordance with Fig. 10.1.

(4) Openings

A ventilating duct will be provided at the median barrier of the highway which will also be a skylight opening.

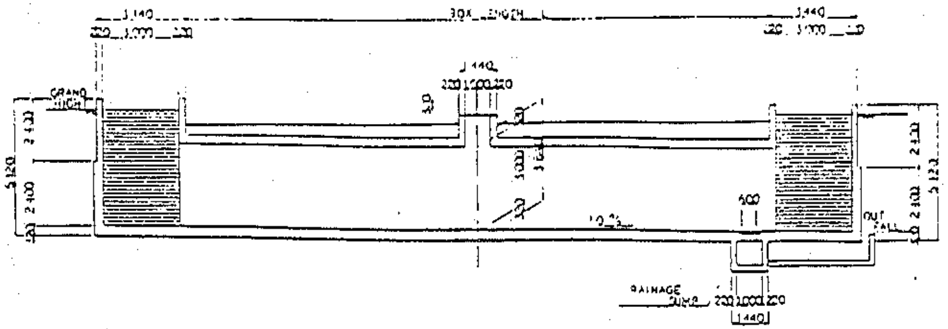
(5) Drainage Facilities

A drainage sump will be provided at the center of the underpass. (0.9* 0.6* 1.00)

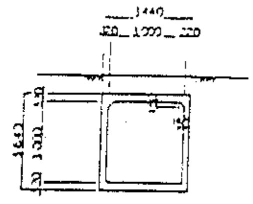
Refer to Fig. 10.1.

(6) Orientation of Stairway

Stairways will be provided in the direction of the residences and shops. The openings for the stairways will differ in their orientation on either side of the Batinah Highway.



SECTION A-A
SCALE 1:200



SECTION B-B
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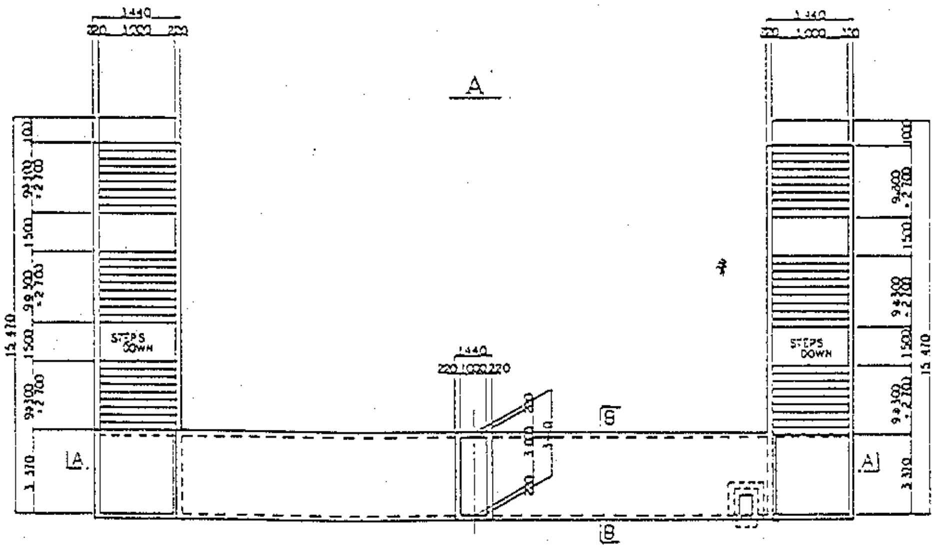


THE STUDY ON ROAD DEVELOPMENT PROJECT	JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 10.1 Design Standard of Pedestrian Underpass

10.3.3 Preliminary Design of Pedestrian Underpass

Pedestrian underpass facilities have already been implemented in Oman and their type of structure has been developed. The standard type of underpass has been developed from the underpasses already developed and is shown in Fig. 10.1.

10.3.4 Preliminary Bills of Quantities

The Preliminary Bills of Quantities has been taken from Table 10.1, and the Preliminary Bills of Quantities has been developed from the preliminary drawings.

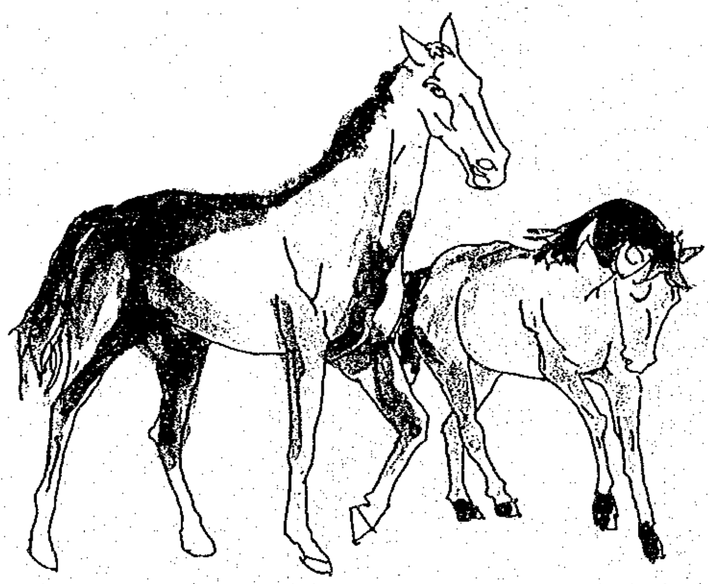
Table 10.1 Preliminary Bills of Quantities for Pedestrian Underpass

Item	Unit	P/U-1 (L = 36 m)	P/U-2 (L = 43 m)	P/U-3 (L = 33 m)	P/U-4 (L = 41.5 m)	P/U-5 (L = 35 m)	P/U-6 (L = 36 m)	P/U-7 (L = 39 m)	P/U-8 (L = 39 m)	P/U-9 (L = 35 m)	P/U-10 (L = 37 m)	P/U-11 (L = 28 m)	P/U-12 (L = 33 m)
Earthworks (A)													
Structural Excavation	m^3	1,100	1,300	1,000	1,200	1,000	1,000	1,100	1,100	1,000	1,100	800	1,000
Incidental Works (100 %)	LS	1	1	1	1	1	1	1	1	1	1	1	1
Concrete Structure (B)													
Concrete (Length of Box 36 m)	m^3	273	298	262	293	270	273	284	284	270	277	245	262
Steel	ton	19	21	18	21	19	19	20	20	19	19	17	18
Incidental Construction (C)	LS	1	1	1	1	1	1	1	1	1	1	1	1
Electrical Installation (D)	LS	1	1	1	1	1	1	1	1	1	1	1	1
Paving Works (Incl. Detour) (E)	LS	1	1	1	1	1	1	1	1	1	1	1	1
Relocation of Utilities (F)	LS	1	1	1	1	1	1	1	1	1	1	1	1

Notes; 1) (L = 36 m) indicates the length of crossing box culvert.

2) Incidental construction consists of gard rail, curbs, highway sign, paint, waterproofing for structure, drainage of structure, mechanical installation for structures and so on.

CHAPTER 11 LANDSCAPE CONSIDERATION



CHAPTER 11

LANDSCAPE CONSIDERATION

11.1 General View of Flyover Aesthetics

Flyover aesthetics generally have a vast effect on the public at roundabout roadways and vicinity areas especially from the view point of landscape. In this regard, every opportunity should be considered to provide attractive flyover structures. To achieve such flyover structures, careful consideration should be taken to the use of fully continuous superstructures.

Most of flyovers generally require their structures to cross roundabout roadways at straight line or a large skew angle, as for longitudinal proportion, more smooth and continuous linear form shall be expected visually. This feature is not only form of the appearances but also it is greatly related with simplification of layout of flyover structure.

A flyover's structure aesthetic shall be considered from several vantage points. For a flyover, the most important vantage point is that of a high-speed vehicle travelling on the highway as it approaches and passes over the flyover.

Also another important thing is the reaction of the driver during passing through the flyover, because any feeling of visual uneasiness on approaching the flyover can so often affect driving behavior and possibly the safety of those on the highway. Therefore it is necessary to obtain the simplest and most uncluttered appearance possible in overall view of a flyover.

On the other hand, roundabout roadway is located at underside area of flyover and the view from the roadway is also strongly affected by the pier's form and location. The roundabout roadway is aligned into a circular curved path and crosses through under the flyover structure, where the series of piers are allocated. The piers' form and their location can adversely affect drivers' reaction in regards to safe driving.

11.2 Aesthetic Perception of Form and Space

The three-dimensional aspects of flyover structures and other related works may be seen as forms. They are perceived as volumes modelled in light and shade or as profiles in silhouette. They are read by the eye as overall massing and, on closer examination, as assemblages of components, each with individual characteristics.

An extensive vocabulary of forms is available to flyovers, as seen in the straight lines and flat planes of slab and beams, simple piers or multi-faced sculptural piers, minimal abutment-bearing seats easing spans into embankments.

Form is seen in the context of space, and in the larger dimension of a design problem, one complements the other. The total visual experience in passage under or over a structure is determined by the character and forms of the structure (spans, piers, abutments, parapets, railings, and appurtenant details); by the geometry and configuration of roadways. Medians, flanking walls, or embankments; by landscape forms; and by the space or sets of spaces that result from these conditions.

11.3 Aesthetic Consideration of Proportion

Proportion is a function of the visual relationships of the components of a flyover structure, each to the other, and of the structure to its setting. It pertains to harmonious rations of lengths to widths to heights of structural members and of openings flyover structures may frame.

It is said that the 'harmony" and "balance" are better indicators of the meaning of proportion. The depths of spans in relation to their lengths and to the sizes and shapes of piers, the ratios of solid masses to voids or openings, the relative dimensions of openings and the comparative amounts of light and shadow on structures.

Also another major aspect that should be considered is the use of well-proportioned superstructures and substructures. And use of design ingenuity as well as creativity in the choice of pier and abutment forms will usually provide an attractive structure consistent with the efficient and economical use of materials.

Reducing the apparent depth of the superstructure compared with a vertical face is essentially important to give a impression of well balanced form of the flyover.

11.4 Aesthetic Consideration of Substructures

Concerning with the nature of design constraints such as economy, efficiency, and time available components, the substructures of a flyover structure may be offered the much flexibility to express its individuality. Comparatively little additional investment in forming and materials is required to the flyover structure design into a pleasing eye-catcher.

Achieving an appropriate and attractive substructure is quite important. There are some generally accepted guidelines in selecting type of substructure for a particular flyover structure site. In addition to a consideration of appropriate proportions, the following may be essential items:

(1) Non-integral Substructure Piers

Since the proposed flyover is considered with non-integral substructure to be used, hammerhead or T-piers offer more freedom for design expression and a less cluttered appearance than multiple-column bents.

(2) Singly Braced Pier Columns

Singly braced pier columns clearly convey vertical emphasis, especially proportional height of flyover is rather lower, whereas singly braced pier columns do not emit conflicting messages.

(3) Application of Flair to the Piers

In order to present a more attractive appearance, attention to detail and application of flair are able to turn the ordinary structure into a visual experience. Introduction of Islamic graphic element to the piers can create spatial identification to the specific location.

(4) Combination of Curvatures and Straight Lines

Expressing of tender and soft appearance, some curvature elements may be introduced into small portions of the structures. Curvature elements also give a "slender" effect to the structural form. And combination of some curvature elements into rigid straight lines offer balanced proportion of the structures.

(5) Abutment Features

Vertical-faced abutments shall appear strong and give a heavy impression in comparison with piers and columns. Some surface textured abutments add much greater interest to vertical-faced abutments where they are rather high in the structure. Some series of slits and/or engraved simple pattern graphics will soften the solid surface of abutments and give a visual sense of continuity to the piers and columns.

(6) Underside Appearance of the Flyover

Underside appearance of the superstructure is also important for roundabout roadway drivers as well as for the vicinity area of roundabout, so that this underside appearance of the flyover may not be ignored. It is much better that individual beams or bracing are not visible. A clean underside appearance of the flyover is also virtually expected.

(7) Aesthetic Design Remarks

Flyover structures are generally appearing somewhat heavier in regards with the present necessary emphasis on durability, safety, and higher loadings. Under these conditions, extra attention for flyover shall always be required to obtain the aesthetic balance of span layouts, depth-to-span ratios, and pier size.

In order to reduce the depth of superstructure, it is important for visual perception that main beams be set back relative to the inner side, so that appearance of depth of the superstructure may come to appear less than actual depth.

11.5 Design Policies of Flyover

11.5.1 Proportional Balance of Superstructure and Substructure

In the aspect of aesthetic appearance of the flyover, following items shall be considered.

(1) Visual Component of Superstructure of Flyover

Facade or side view appearance of the flyover is the most important visual factor to give impression of the whole silhouette of the flyover. The facades of flyover appears as a long horizontal expansion of concrete which contains the superstructure of the flyover. This superstructure portion is composed of series of beams and parapet of the roadway.

(2) Proportional Balance

Regarding the proposed flyover, the concrete thickness of superstructure portion comes to be 2.3 meters and it may giving a quite strong and heavy appearance to the roundabout vicinity area. The horizontal concrete portion is composed of thickness of beam structure and parapet of the road way. This total depth may express the visual appearance of the flyover. For horizontal expanded length of flyover of approximately 300 meters, proportional ratio of superstructure depth and flyover length becomes 1 : 130 and this ratio makes appearance of the flyover quite a slender silhouette.

Another important visual component is the proportional balance between superstructure and substructure. Major components of substructure are series of piers and abutments. The clearance height of piers are an approximate range of 4.5 to 5.5 meters above ground level. Therefore when visual appearance is considered, proportional ratio between superstructure depth and substructure height eventually becomes 1.95 to 2.4.

As regarding piers, proportional ratio of piers also gives visual impression. Proposed clearance height of beam is 4.5 to 5.5 meters on the project. This proposed piers are basically T-head forms and the T-head pier consists of a hammerhead portion on the top and rectangular column on the bottom. Visual appearance of piers is also recognized as the proportional balance with column width and pier clearance height. When this proportion becomes more than 1 : 2, the whole pier comes to be appear more slender.

Proposed pier width in longitudinal section is 1.2 meters and column height above ground is 3.0 meter in maximum, so that proportional ratio comes to be 1 : 2.5 and appears slender.

11.5.2 Consideration of Parapet Height

It is recognized that one of the most important appearance factors of the flyover is the proportional balance of the facade of superstructure's beam depth to parapet height.

The superstructure thickness should be balanced properly with the longitudinal expansion length. Parapet height can be made to appear lower when using railing instead of a solid concrete structure. When concrete parapet is made lower, required height can be acquired by use of railing.

11.5.3 Consideration of Pier Design

In considering design in terms of pier shape, a more elegant, light, and slender appearance of piers can be anticipated since the proposed pier design is for non-integral T-head shape structure.

(1) Making more Slender Shape of Piers

Introducing round corners at each edge of the pier column will reduce thickness of concrete volume and whole appearance of pier comes to be more slender than rectangular shaped ones.

Introducing some slits or engraved flair at longitudinal face of column is an effective solution for making more slender appearance. These slits or engraved flair are recommended to have Islamic architectural forms.

(2) Effective Distribution of Piers Location

In general, central area of roundabout is always facilitated with a monument or major landscape focus as to be established as a symbolic landscape. Under these conditions, location of flyover piers shall be considered to have clear open view to the scenic objectives. In this regard, for obtaining wider openings at central area of roundabout, longest beam span between piers shall be applied at the center and major scenic objective would be maintained as anticipated.

Whereas flyover is crossing the roundabout roadway, spatial opening condition at the roadway depends upon the pier location of flyover. It is much safer and easier for the driver's reaction when adjacent piers are situated at sufficient intervals. Some important consideration need be made for drivers visibility at the flyover cross points in roundabout roadways.

Piers' allocation shall be proposed with wider span range at central area of roundabout and less wide range towards both ends of abutment. In this regard, the total appearance of the flyover shall be emphasized as a dynamic perspective visual effect to the vicinity.

(3) Visual Continuity

Continuous repeating of the series of standing columns in rows will be a aesthetic component. The appearance of series of columns may be rhythmical and more see-through spatial gradation may create attractive visual continuity.

A symmetrical distribution of columns from center of roundabout to abutments at both ends of the flyover may appear visually as well as proportioned sequential continuity.

11.5.4 Expression of Flyover Silhouette

The proposed flyovers have long horizontal expanded form with series of piers. These flyovers are almost all straightly allocated following the line of the highway. These flyovers are relatively gigantic structures in their length and height when crossing over the roundabout areas. They will be easily recognized and appear as an elegant silhouette.

Most of these roundabout vicinity areas have visual expansion of rather low buildings with a flat ground environment, and there are not many competitive visual object against the flyover structures. Under these circumstances, the flyover structure itself become an appearance of distinctive silhouette as well as a symbolic location identification object at each vicinity areas.

In this regard, these flyovers shall be assigned another function, that is, to contribute establishment of an aesthetic symbol monument.

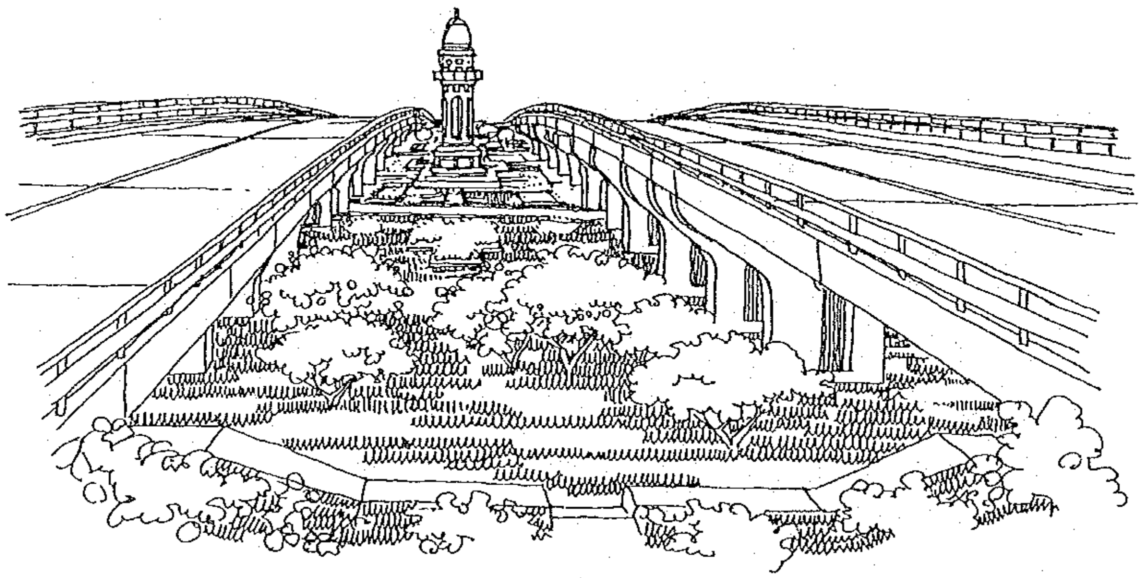
11.6 Landscape Integration of Flyover and the Roundabout Scenery

There are 8 of roundabouts and junctions that are proposed with higher priority to facilitate the flyovers. Following are major items for landscape integration of flyover at objective roundabouts and junctions.

11.6.1 Naseem Garden R/A:

Since there is plane ground on the roundabout, a proposed type-A flyover shall be recommended, and the flyover would be a new symbol of the roundabout. Image of this roundabout shall be a white flyover on the green expanded ground. The type-A flyover shall be recommended with double columns piers at central area as creating scenic focus and most of other piers shall be single column type.

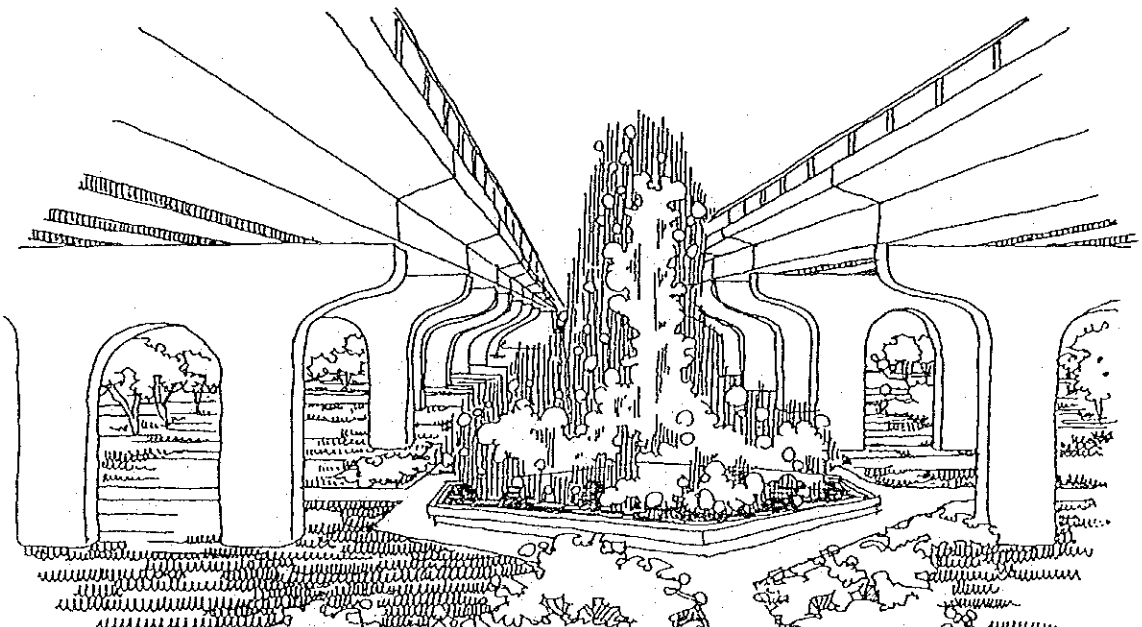
Landscaping of roundabout shall be recommended to provide a white garden tower surrounded by flyover belts for establishing more visual focus, which represents the location and image of Naseem Garden environment.



11.6.2 Barka R/A

A type-A flyover shall be recommended to cross over the existing water fountain. The water fountain can be clearly seen through the openings between flyover piers, and water fountain appears with somewhat of a white and elegant silhouette. So that allocation of double-column type piers at both sides of the fountain shall be recommended in order to harmonize with the design concept of elegance. And single column type piers shall be allocated on the other part of area.

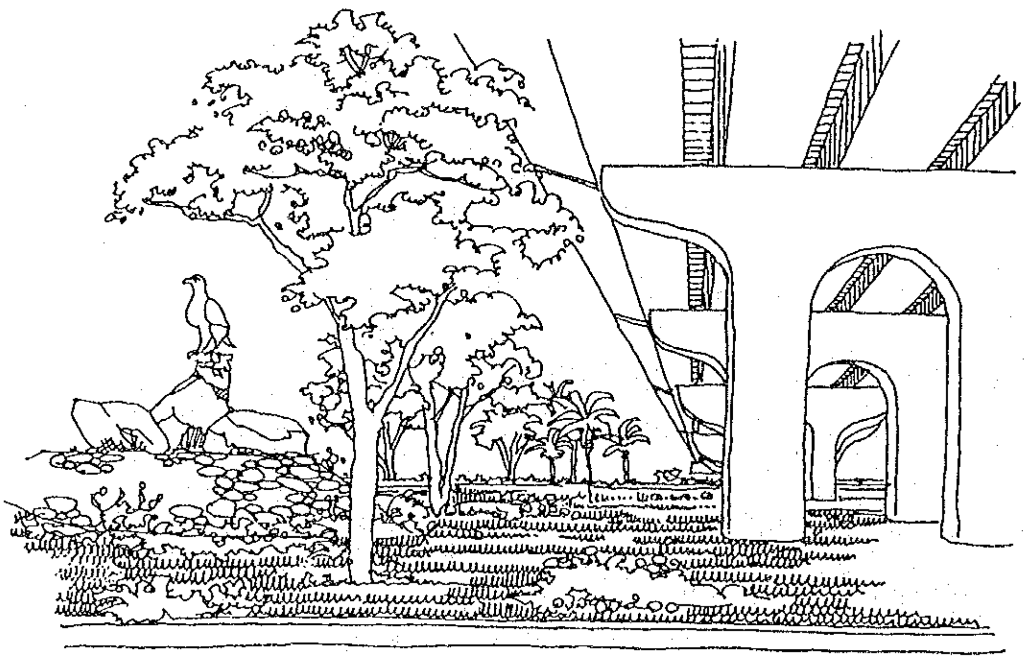
The existing flowering plants and small shrubs where piers are to be facilitated shall be transplanted to the perimeter of the roundabout in the same manner as originally planted. In so doing, the original landscape features would be maintained without much changes.



11.6.3 Al Muladdah Junction

Landscape focus of this junction is a pair of falcons as a small monument distributed at both sides of access roadway and these function as a location identification of the area. Under these existing conditions, the type-A flyover shall be recommended with double-column type piers at the central area as a focus establisher and single column type piers shall be allocated to the other parts of area, so that the flyover silhouette may be come a new symbolic monument of the vicinity.

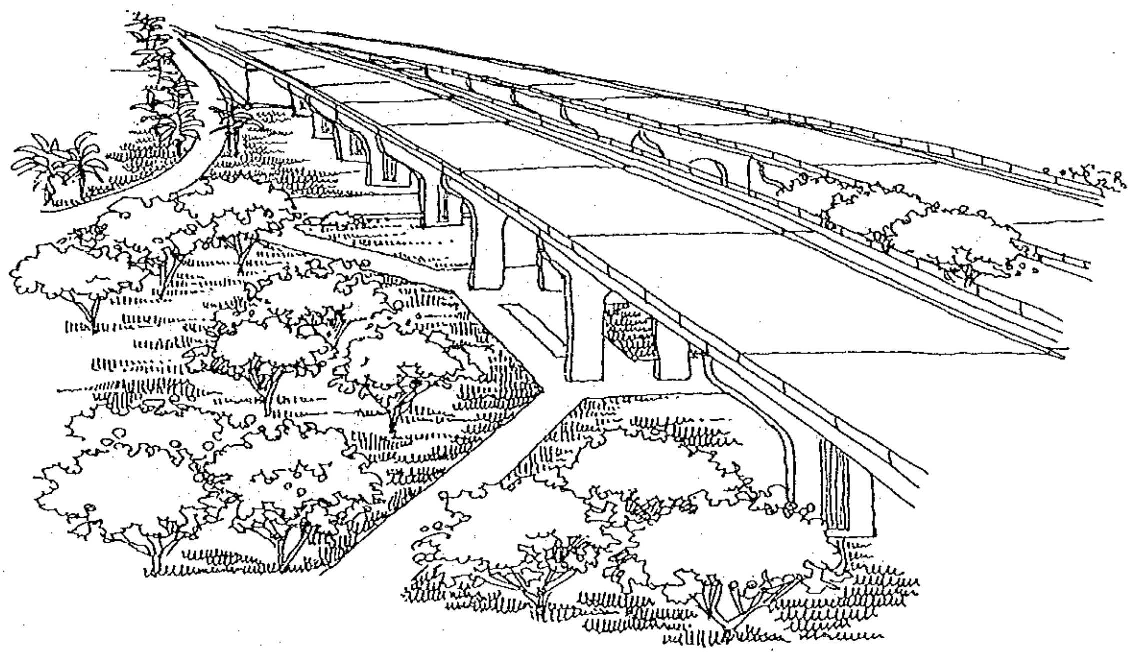
Since there is very little landscape planting on this junction, a new landscape of this area shall be organized in reflection with flyover structure and relocation of the pair of falcons shall be effectively executed near the access roadway as a location identification. New planting shall be recommended with threes and shrubs instead of ground cover plants.



11.6.4 Khabura R/A

Existing landscaping of the roundabout is formulated on slightly mounded ground with flowering plants in the center and the proposed type-A flyover will cross over this planted area. This group of flowering plants shall be easily observed under openings of the bridge spans.

Some symbolic large-crowned trees may be recommended to plant additionally at the center of roundabout for a more emphatic visual impression. Double-column type piers at the central area shall be recommended for incorporating a harmonious and integrated landscape. Single-column type piers shall be allocated to other major areas.

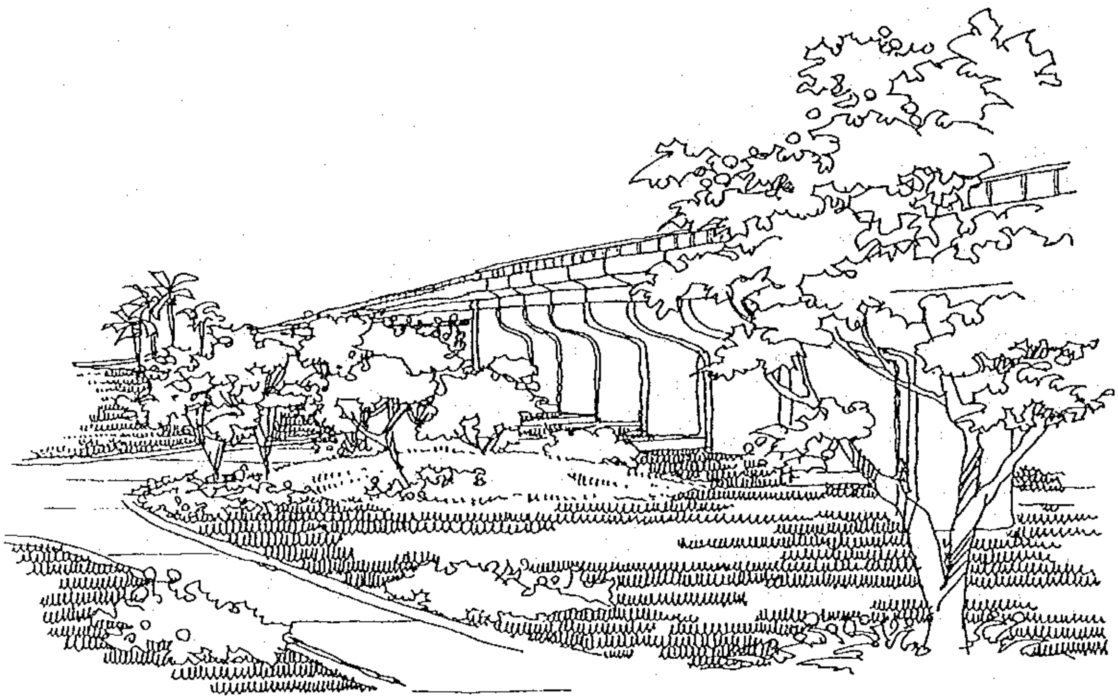


11.6.5 Saham R/A

Existing landscaping of the roundabout is formulated into two parts of slightly hilly mounded ground with shrub and tree plantings. The proposed type-A flyover will cross over these hilly mounds. Some of this group of shrubs and trees will need to be to transplanted to avoid such large plantings under flyover structure.

Maintaining the visual appearance of the original hilly grove scenery, shrubs and trees which are directly affected by the course of the projected flyover will be transplanted in a new arrangement to the areas between course of flyovers and adjacent area within the roundabout.

New proposed landscape appearance will retain the sense of continuation of grove of shrubs and trees. Thus, the whole landscape image will become a flyover passing through a foliated grove area. The single-column piers of flyover are recommended for emphasis of more visual continuity to reflect the original landscape scenery.



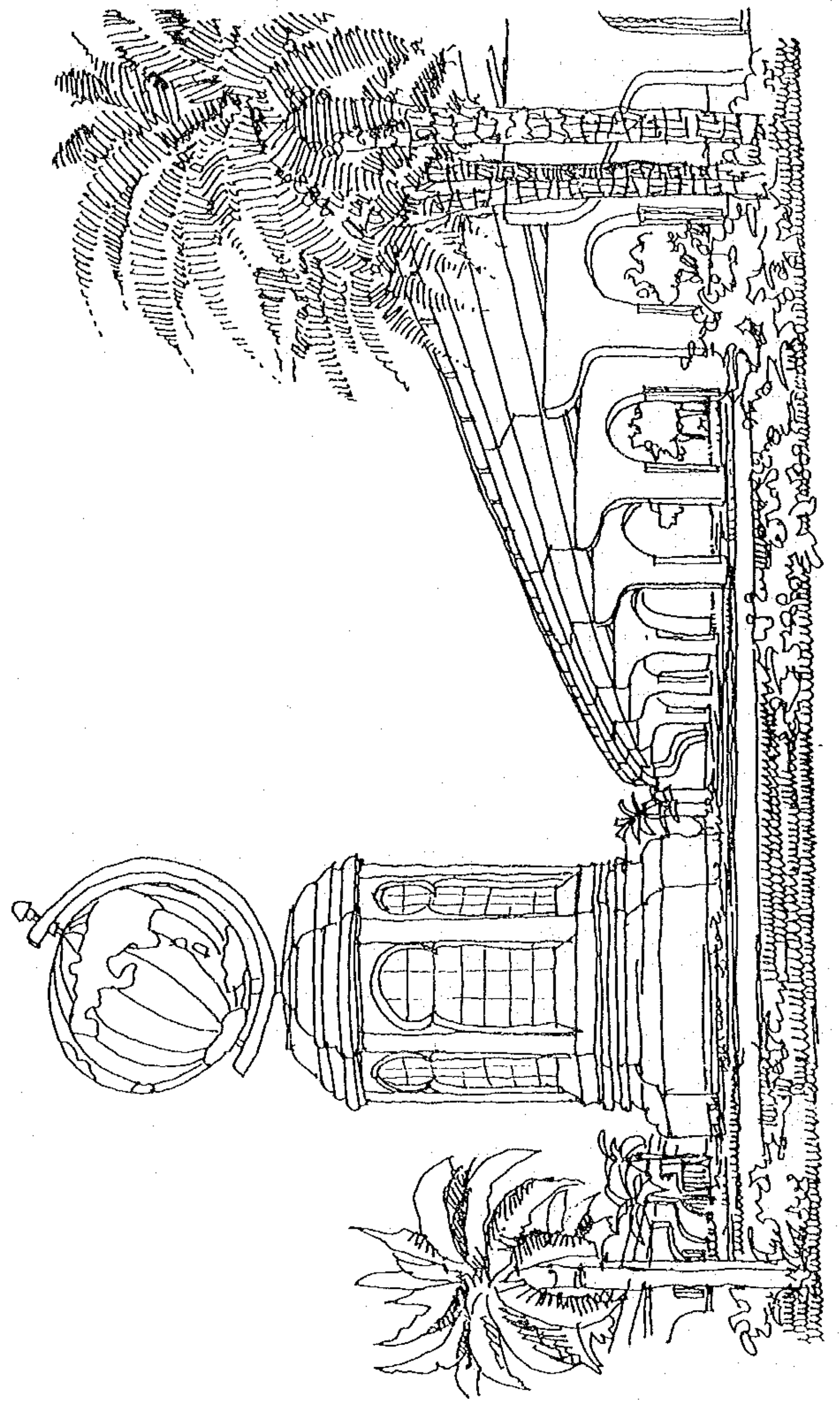
11.6.6 Sohar R/A

A new symbolic monument for this roundabout has been studied and proposed by Muscat Municipality to replace the existing one. The new proposed monument will be an approximately 40 -meter-high Islamic-designed tower which is intended to come to represent Sohar as a significant landmark. In this regard, the flyover will be considered as two kinds of visual point of view.

Especially for highway drivers to observe clearly the new proposed monument, a type-B is recommended with high priority. This visual observational opportunity is essential for highway drivers in recognizing the location identification and sense of arrival, also observation from vicinity peoples would be obvious because of large scale and presence of the proposed monument.

In this case, design of the flyover piers become to be a most essential component for harmonizing and integrating the monument design features. Double-column type piers shall be considered to be allocated at entire roundabout area incorporating design elements of the proposed monument, and the flyover landscape would be integrated to the monument.

While as another alternative priority, type-D would be recommendable for obtaining clear appearance of new monument without any visual disturbance for the neighboring residents of Sohar. The highway would run under the roundabout. In this situation, however, the highway drivers would not be able to observe the monument directly from near distance.

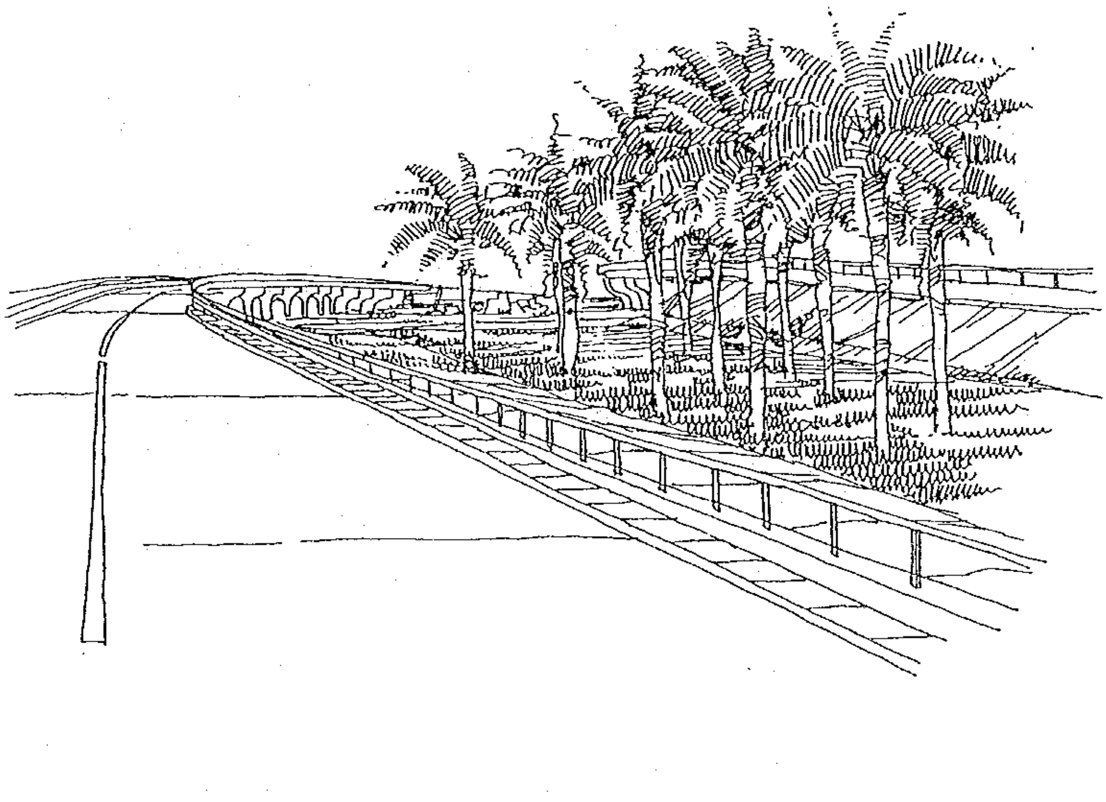


11.6.7 Falaj Al Qabail R/A

Existing landscaping of the roundabout is composed of rock hill with waterfall and some wild animal sculptures, while Muscat Municipality is considering a modification of this monument into something more substantial as a future development scheme. However, there have not been particular proposals made yet at this writing.

In this regard, the original layout concept of the monument which is located in the center of roundabout would be respected. Under these situations, consideration must be taken that the flyover type-B shall be recommended for obtaining a future spatial flexibility for the location layout of the future monument to be modified.

Consideration of design integration for the future monument, double-column type piers would be recommended inside of the roundabout area and single column type piers would be facilitated at other areas.

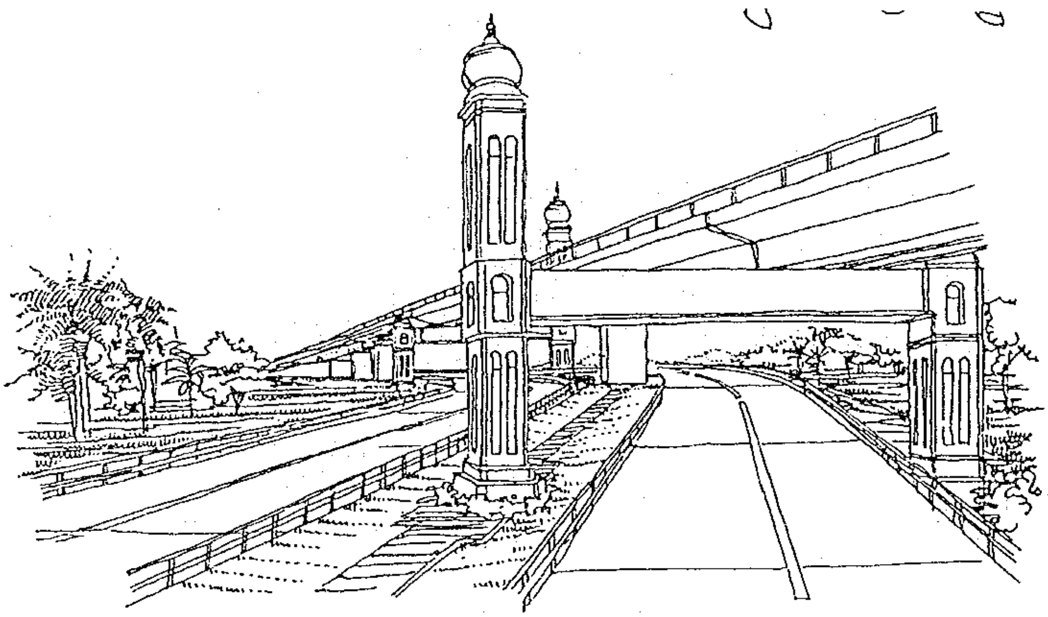


11.6.8 Aqr R/A

Since proposed highway alignment will be allocated with large scale of curvature toward the inland, the existing landscaping of the roundabout composing with terraced gardens shall be remained without any affections.

Newly proposed two junction points will be facilitated to cross existing roadway. On these areas, two flyovers of single lane for local traffic shall be newly allocated to cross over the newly proposed highway alignment. Under this situation, these flyovers shall be a special type not included in types A, B, C or D.

In this regard, consideration may be taken at each junction area for establishing impressive landmarks important as visual location information to drivers. At the areas where flyover structures cross over highway course diagonally, longer cross beamed piers may be required. Some considerations shall be made that design of these pier columns may be made somewhat taller as symbolic appearances.

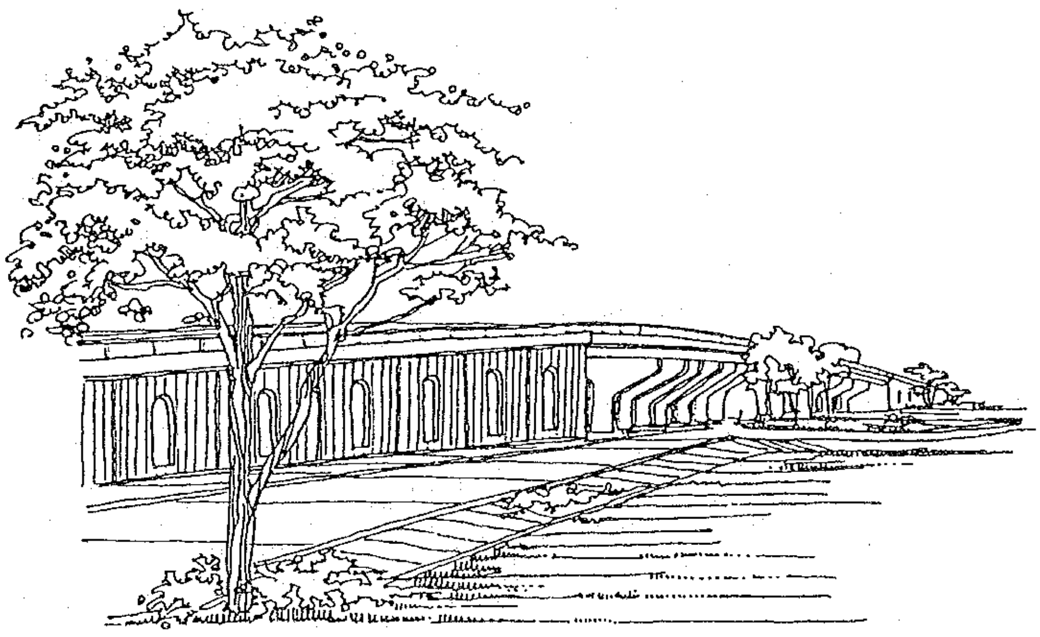


11.7 Design Policies of Other Facilities

11.7.1 Retaining Walls

Retaining walls are proposed as vertical-faced type of approximately 200 meters in length and 4.5 to 5 meters in height at abutment end-connections. Whole side view proportion of the retaining walls appear as slender triangle shapes with 3 % slope, however at the abutments location, vertical-faced solid walls may appear strongly impressive.

As for the establishment of visual continuity of the vertical-faced retaining wall, simplified Islamic architectural forms will be introduced to project on the surface of the walls. Engraved slender design forms shall be proposed and this continuous repeating design will be display light and shadow patterns in an elegant manner.



11.7.2 Entrance Facilities of Pedestrian Underpass

Pedestrian underpasses are proposed at 12 critical points throughout the Batinah highway. Facility entrance is an access point to introduce residents to the pedestrian underpass. Thus, the design of the entrance facility should have some aspects to encourage community people to utilize the pedestrian underpass Major design aspects are considered as follows.

(1) Location Identification

Location identification of the entrance of the pedestrian underpass is an essential element, therefore the entrance facility needs to have an easily identifiable appearance to the community to encourage use.

A clean silhouetted structure may be most preferable for the entrance facility.

(2) Community Amicable Appearance

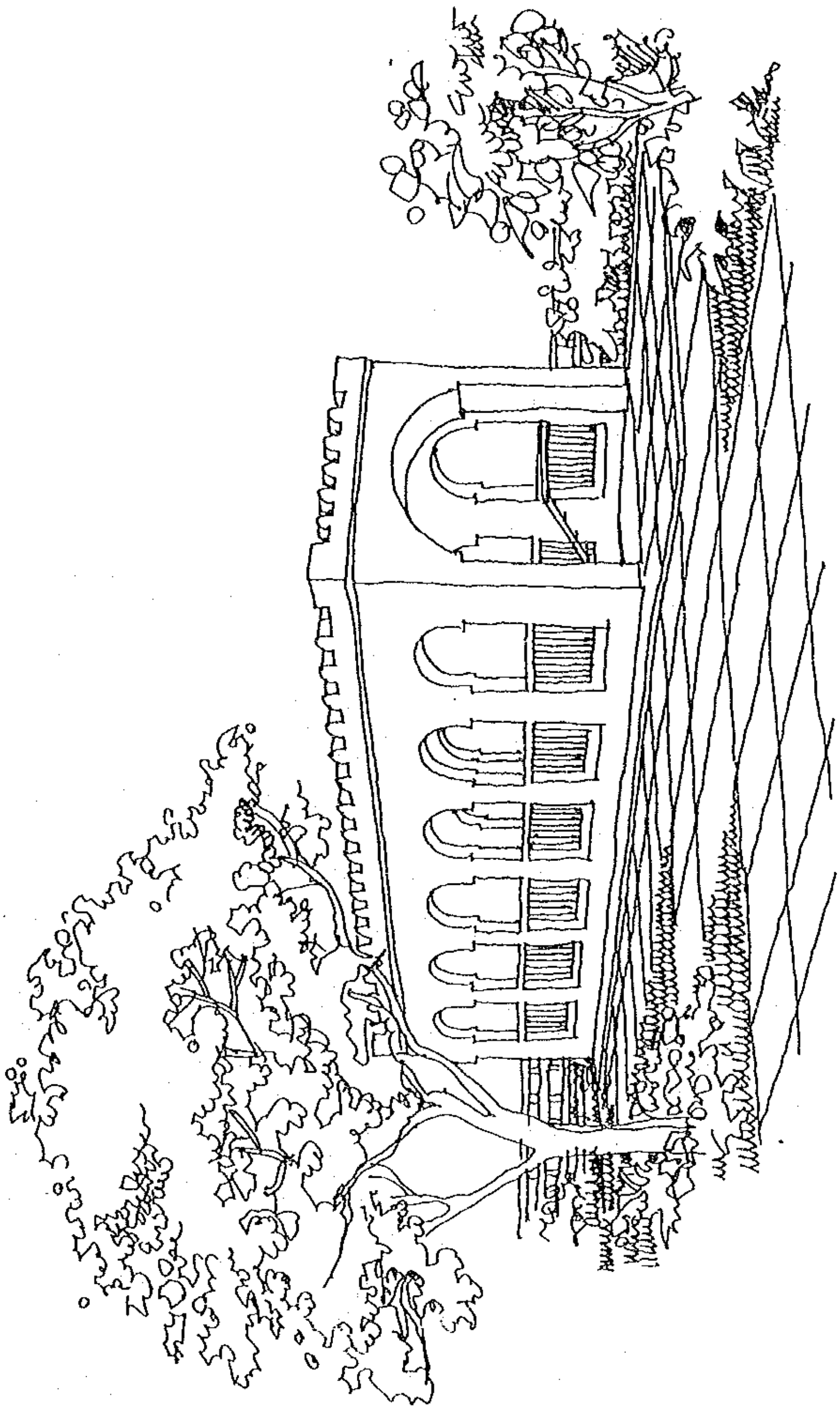
Daily use of pedestrian underpass should be projected as a community integrated facility. Thus, the entrance facility requires a design manner with community amicable appearance.

Design of wall openings will be the key to represent amicable appearance. Designs integrating well-proportioned Islamic arch-type openings may be introduced and create varieties of outlooks for each location of pedestrian underpass.

(3) Attractive Atmospheric Space

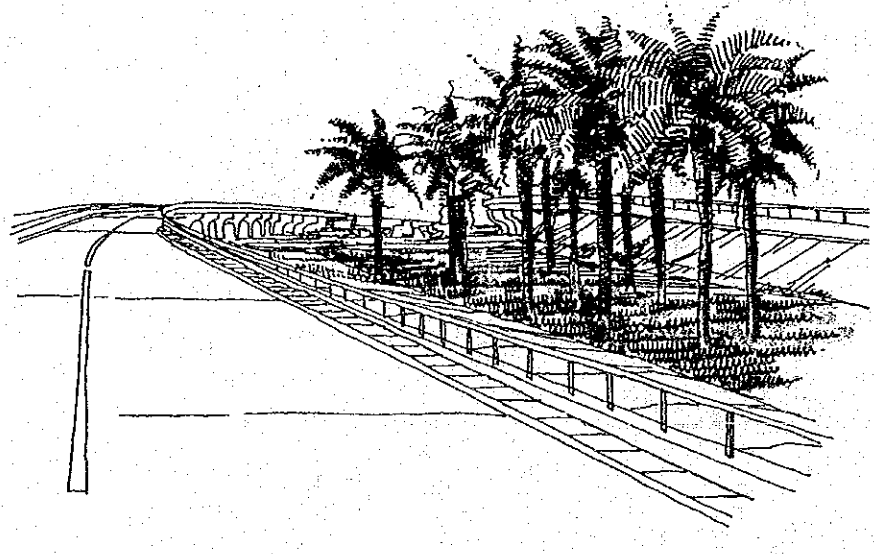
Surrounding space of the entrance facility is also quite important in establishing an attractive atmosphere and environment. When the space of the entrance facility has attractive features which encourage people to make use of it, people would eventually come to use it as a gathering point and even associate it with enjoyment, therefore frequent usage would be practically guaranteed.

Small plaza-type spaces will be considered at the entrance front. Attractive pavement, street furniture equipment and shade-providing landscape objects are very helpful.



Entrance Facilities of Pedestrian Underpass

CHAPTER 12 ENVIRONMENT



CHAPTER 12

ENVIRONMENT

12.1 Introduction

As a rule, JICA projects intend to simultaneously attain two goals; namely, economical development and environmental conservation. For the achievement of the former, various aspects of technical consideration have been already developed in the previous subsection of this report. For the achievement of the latter target, there will be presented a basic consideration in this subsection.

Batinah Highway has always played an more important role as a major interurban highway network connecting major cities and neighboring countries. This role will continue to grow in the future.

On the other hand, Oman has set an example to the world by maintaining a judicious balance between the needs of development and the environment. Therefore, environmental consideration in the implementation of any development project is needed.

12.2 Procedure for No Environmental Objection

Oman had a licensing system in which an Environmental Impact Statement is required (hereinafter referred to as 'EIS') for a statement on impact on the environment caused by the project. This statement now needs to be accompanied by a No Environmental Objection (N.E.O.) decision issued by the Ministry of Environment and Ministry of Water Resources.

An N.E.O. decision can only be issued after the ministry has been given sufficient information about a proposed development and about the likely environmental impacts of the projects. The EIS prepared by the developer will provide much of the information on which the ministry's decision will be based. The ministry will need to be satisfied that environmental impacts are acceptable before an N.E.O. decision is issued.

In order to make clear the relation between EIS system in Oman and our project, JICA Study Team is needed to survey more closely concerning to the resettlement activities by Land Acquisition for Road Construction. Therefore, the issue will be described in Chapter 12.6 (Conclusions and Recommendations).

12.3 Environmental Impact of the Project

Hereupon, the study is not for construction of a new road, but for improvement and repair of the existing highways.

Environmental Impact Assessment for the road study was undertaken based on the environmental condition of the study road which was clarified in the conceptual design stage and the information about the structural design.

The study road facilities are:

1) grade separation at 18 roundabout intersections of Batinah Highway.
2) pedestrian underpass to separate vehicular traffic from pedestrians and animals

As for the grade separation (see 1 above) several plans were examined in the conceptual design stage.

Environmental Impact Assessment was undertaken for the plan that is considered to be most influential to the environments.

Pedestrian underpasses are necessary facilities to separate vehicular traffic on highways from pedestrians from safety viewpoint. They will contribute greatly to the reduction of accidents caused by uncontrolled crossing of pedestrians (including animals) at grade. However, as for the environmental impact, the area of influence will be limited. Therefore, this Environmental Impact Assessment mainly deals with grade separations.

12.4 Basic Laws for Pollution Control

The existing laws and decrees concerning pollution control have been established for each source as shown in Table 12.1.

Table 12.1 Laws and Decrees and the Competent Ministry

Competent Ministry	Name of Law	Law & Decrees
Ministry of Environment and Ministry of Water Resources	Law on the conservation of the Environment and Prevention for pollution: Regulation for External Building Drainage	Royal Decree No. 10/82 Ministry Decision 5/82 17 May, 1986
Ministry of Regional Municipalities and Environment	Regulation for the Management of Hazardous Waste	Royal Decree No. 10/82 Ministry Decision 18/93
Ministry of Regional Municipalities and Environment	Regulation for the Management of Solid Non-Hazardous Waste	Royal Decree No. 10/82 Ministry Decision 17/93
Ministry of Environment and Ministry of Water Resources	Law on the Conservation of the Environment and Prevention of Pollution: Regulation for Air Pollution Control from Stationary Sources	Ministry Decision 5/86
Ministry of Environment and Ministry of Water Resources	Law on the Conservation of the Environment and Prevention of Pollution: Regulation for Waste Water Re-Use and Discharge	Royal Decree No. 10/82 Ministry Decision 5/86
Ministry of Environment and Ministry of Water Resources	Law on the Conservation of the Environment and Prevention of Pollution: Regulation for Septic Tanks and Holding Tanks	Royal Decree No. 10/82 Ministry Decision 5/86

12.5 Identification of Environmental Impact

12.5.1 Background

In the Study of the road development project, the alternate plan of overpass and underpass for grade separation is examined. Overpass plan is further divided into a few cases with difference of environmental elements and environmental impacts. Therefore, environmental considerations of our project are discussed in the most severe cases which may have a significant effect.

Environmental considerations of pedestrian underpass are discussed on the location where a former community was separated by the Batinah Highway.

The procedure of Environmental Impact Assessment of the Study will follow the Environmental Consideration Guidelines of JICA (Section of Road Planning) and is carried out in the scope of work of Environmental Impact Assessment (hereinafter referred to as 'EIA').

12.5.2 Project Description and Site Description

To conduct the EIA, it is essential at the outset to fully understand the Project Description (PD) and Site Description (SD). The PD includes the contents and features of the project, such as its background, objectives, study area, competent ministry, number of beneficiaries, and type of the project, etc. The SD includes the present conditions of the natural and social environment. Table 12.2 and 12.3 show project description and site description for the planning of flyovers and pedestrian underpasses.

Table 12.2 Project Description

Items	Contents
Project Name	The Study on the Road Development Project
Background	Batinah Highway is a well-travelled high speed road. There are no facilities for pedestrian crossing. There are increasing risks to the safety of people and livestock who cross.
Objectives	1. To carry out a feasibility study on the construction of flyover and pedestrian underpasses along the Batinah Highway. 2. To transfer technology to the counterpart engineers.
Study Area	250 km stretch along the Batinah Highway between Seeb and Aqr.
Competent Ministry	Ministry of Communications, Directorate General of Roads
Number of Beneficiaries	Unknown
Characteristic of the Project	
Type of the Project	New/[Improvement]
Rank of the Project	[Highway]/Ordinary, Urban/[Rural], [Flat]/Rolling
Target Year/Traffic Demand	A.D. 2010 vehicle per day
Length/Width/Number of Lines	250 km/33.4 m/4 lane
Structure of the Project	Embankment/Flyover/Underpass/Depressed
Ancillary Facility	Monument, Roundabout/Intersection (18 locations)
Special Items	Aesthetic harmony of existing monument and flyover

Table 12.3 Site Description

Items		Contents
Project Name		The Study on the Road Development Project
Socio-economic Environment	Inhabitants (Settled people/Indigenous people/ Problem consciousness, etc.)	There are several villages scattered along the highway. Low population density
	Land Use (Urban/Rural/Cultural property/ Hospital, etc.)	Environmental Buffer Zone of about 30 m on the both sides. Several date plantations on both sides.
	Economic/Traffic (Commercial/Farm/Fishery/ Industry estate, etc.)	Some small-scale commercial areas on both sides.
Natural Environment	Topography/Soil condition (Especially on a Slope/Soft ground/ Wetland/Fault, etc.)	Flat topography Along the coast
	Fauna/Flora (Great natural wealth/Forest, Endemic species/Animals Amphibians, etc.)	Pasturing of camel, goat and sheep shrubby growth
Livelihood Environment	Situation of pollution	None
	Receipt of complaints (Countermeasure of system/ Compensation, etc.)	None
Special Items	Solid waste collection and disposal systems are carried out on the highway. Care plants is thoroughly undertaken.	

12.5.3 Screening

All the environmental elements which would be affected by the project are listed and discussed in relation to the project activities on a so-called check list for evaluation of EIA. The column heads show 'Items', 'Description', 'Rating' and 'Remarks' while, the columns show the environmental elements to be affected. The cause-and-effect relationships will be explained with a mark at each corresponding cell of the check list. In the "Rating" column, '1' means the related project may cause a significant effect on the environmental element, '2' indicates no influence, and '3' means unknown. In this checklist, both positive and negative impacts are listed. Tables 12.4 and 12.5 show construction stage for the planning of grade separation and pedestrian underpasses. Similarly, Tables 12.6 and 12.7 show operation stage of the respectively planning. By using the check list, the critical environmental impact elements which may be affected by the project, are screened.

Table 12.4 Check List of Flyover in Construction Stage

	Items	Description	Rating	Remarks
	1. Resettlement	Resettlement by the project	① 2 3	Impact on by the case of flyover
	2. Economic Activity	Change of economic activity	1 ② 3	
	3. Traffic and Public Facilities	Influence on school, hospital and religious facilities	1 ② 3	
	4. Splitting of Communities	Community Split due to the project	1 ② 3	
	5. Cultural Property	Cultural property/archaeological sites	1 ② 3	
	6. Water Right/Right of Common Use	Use of spring/river/lake/sea water	1 ② 3	
	7. Public Health Condition	History of epidemic disease	1 ② 3	
	8. Waste	Solid waste/waste dumps/disposal system	1 ② 3	
	9. Hazard	Increased risk of landslide or collapsing slope	1 ② 3	
	10. Topography/Soil Condition	Change of topography & geological	1 2 ③	Impact from underground construction
	11. Soil Erosion	Soil erosion by the project	1 ② 3	
	12. Groundwater	Change of groundwater by the project	1 ② 3	
	13. Hydrology	Change of water level of rivers & lakes	1 ② 3	
	14. Coastal Zone	Change of oceanological such as littoral drift	1 ② 3	
	15. Flora and Fauna	Affect on valuable animals and plants in the area	1 ② 3	
	16. Meteorology	Change of wind direction and temperature by the project	1 ② 3	
	17. Landscape	Change of important landscape, scenery for tourism and/or religion by the project	① 2 3	Needed a judicious step
	18. Air Pollution	Generation of air pollution by the project	① 2 3	Generate of fugitive dust by construction machines
	19. Water Pollution	Generation of water pollution by the project	1 2 3	
	20. Soil Contamination	Generation of soil contamination by the project	1 2 3	
	21. Noise and Vibration	Generation of noise & vibration by the project	① 2 3	Generate of noise and vibration by the construction machines
	22. Ground Subsidence	Generation of ground subsidence by the project	1 2 3	
	23. Offensive Odor	Generation of offensive odor by the project	1 ② 3	

Table 12.5 Check List of Pedestrian Underpass in Construction Stage

Items	Description	Rating	Remarks
1. Resettlement	Resettlement by the project	1 ② 3	
2. Economic Activity	Change of economic activity	1 ② 3	
3. Traffic and Public Facilities	Influence on school, hospital and religious facilities	1 ② 3	
4. Splitting of Communities	Community Split due to the project	1 ② 3	
5. Cultural Property	Cultural property/archaeological sites	1 ② 3	
6. Water Right/Right of Common Use	Use of spring/river/lake/sea water	1 ② 3	
7. Public Health Condition	History of epidemic disease	1 ② 3	
8. Waste	Solid waste/waste dumps/disposal system	1 ② 3	
9. Hazard	Increased risk of landslide or collapsing slope	1 ② 3	
10. Topography/Soil Condition	Change of topography & geological	1 ② 3	
11. Soil Erosion	Soil erosion by the project	1 ② 3	
12. Groundwater	Change of groundwater by the project	1 2 ③	Impact from underground construction
13. Hydrology	Change of water level of rivers & lakes	1 ② 3	
14. Coastal Zone	Change of oceanological such as littoral drift	1 ② 3	
15. Flora and Fauna	Affect on valuable animals and plants in the area	1 ② 3	
16. Meteorology	Change of wind direction and temperature by the project	1 ② 3	
17. Landscape	Change of important landscape, scenery for tourism and/or religion by the project	1 ② 3	
18. Air Pollution	Generation of air pollution by the project	① 2 3	Generation of dust by construction machines
19. Water Pollution	Generation of water pollution by the project	1 ② 3	
20. Soil Contamination	Generation of soil contamination by the project	1 ② 3	
21. Noise and Vibration	Generation of noise & vibration by the project	① 2 3	Generation of noise and vibration by construction machines
22. Ground Subsidence	Generation of ground subsidence by the project	1 ② 3	
23. Offensive Odor	Generation of offensive odor by the project	1 ② 3	

Table 12.6 Check List of Flyover in Operation Stage

	Items	Description	Rating	Remarks
	1. Resettlement	Resettlement by the project	1 ② 3	
	2. Economic Activity	Change of economic activity	① 2 3	Advance of economic activity by improved traffic
	3. Traffic and Public Facilities	Influence on school, hospital and religious facilities	① 2 3	Great contribution to reduction of traffic accidents
	4. Splitting of Communities	Community Split due to the project	1 ② 3	
	5. Cultural Property	Cultural property/archaeological sites	1 ② 3	
	6. Water Right/Right of Common Use	Use of spring/river/lake/sea water	1 ② 3	
	7. Public Health Condition	History of epidemic disease	1 ② 3	
	8. Waste	Solid waste/waste dumps/disposal system	1 ② 3	
	9. Hazard	Increased risk of landslide or collapsing slope	1 ② 3	
	10. Topography/Soil Condition	Change of topography & geological	1 ② 3	
	11. Soil Erosion	Soil erosion by the project	1 ② 3	
	12. Groundwater	Change of groundwater by the project	1 ② 3	
	13. Hydrology	Change of water level of rivers & lakes	1 ② 3	
	14. Coastal Zone	Change of oceanological such as littoral drift	1 ② 3	
	15. Flora and Fauna	Affect on valuable animals and plants in the area	1 ② 3	
	16. Meteorology	Change of wind direction and temperature by the project	1 ② 3	
	17. Landscape	Change of important landscape, scenery for tourism and/or religion by the project	① 2 3	Maintaining a judicious balance between the existing monument and the development project
	18. Air Pollution	Generation of air pollution by the project	① 2 3	Reduction of amount of exhaust gas in control traffic
	19. Water Pollution	Generation of water pollution by the project	1 ② 3	
	20. Soil Contamination	Generation of soil contamination by the project	1 ② 3	
	21. Noise and Vibration	Generation of noise & vibration by the project	① 2 3	Generation of traffic noise by junction part and flyover
	22. Ground Subsidence	Generation of ground subsidence by the project	1 ② 3	
	23. Offensive Odor	Generation of offensive odor by the project	1 ② 3	

Table 12.7 Check List of Pedestrian Underpass in Operation Stage

Items	Description	Rating	Remarks
1. Resettlement	Resettlement by the project	1 ② 3	
2. Economic Activity	Change of economic activity	① 2 3	Advance of economic activity by improved access of people and animals
3. Traffic and Public Facilities	Influence on school, hospital and religious facilities	① 2 3	Great contribution to the reduction of traffic accidents
4. Splitting of Communities	Community Split due to the project	① 2 3	Great contribution to community integration
5. Cultural Property	Cultural property/archaeological sites	1 ② 3	
6. Water Right/Right of Common Use	Use of spring/river/lake/sea water	1 ② 3	
7. Public Health Condition	History of epidemic disease	1 ② 3	
8. Waste	Solid waste/waste dumps/disposal system	1 ② 3	
9. Hazard	Increased risk of landslide or collapsing slope	1 2 ③	Floods may obstruct passage of people and animals
10. Topography/Soil Condition	Change of topography & geological	1 ② 3	
11. Soil Erosion	Soil erosion by the project	1 ② 3	
12. Groundwater	Change of groundwater by the project	1 ② 3	
13. Hydrology	Change of water level of rivers & lakes	1 ② 3	
14. Coastal Zone	Change of oceanological such as littoral drift	1 ② 3	
15. Flora and Fauna	Affect on valuable animals and plants in the area	1 ② 3	
16. Meteorology	Change of wind direction and temperature by the project	1 ② 3	
17. Landscape	Change of important landscape, scenery for tourism and/or religion by the project	① 2 3	Impact on new ancillary facility of Batinah Highway
18. Air Pollution	Generation of air pollution by the project	1 ② 3	
19. Water Pollution	Generation of water pollution by the project	1 ② 3	
20. Soil Contamination	Generation of soil contamination by the project	1 ② 3	
21. Noise and Vibration	Generation of noise & vibration by the project	1 ② 3	
22. Ground Subsidence	Generation of ground subsidence by the project	1 ② 3	
23. Offensive Odor	Generation of offensive odor by the project	1 ② 3	

12.5.4 Scoping

Scoping is defined clearly in the Environmental Consideration Guidelines of JICA (Section of Environmental Aid Report) in all the significant elements which may be affected by the project. As mentioned above, all the environmental elements in the project activities were listed by the Screening and will be clearly explained by the Scoping. Although there are several methods of scoping for the procedure of Environmental Impact Assessment, the scoping of this study has adopted the check list method which is generally used. The format for the check list of scoping is same as used by screening. In column of rating of the check list, 'A' means the related project may cause a most significant effect on the environmental element, 'B' indicates slight influence, 'C' means unknown and no mark indicates no influence. In this check list of scoping, only negative impacts are listed.

12.5.5 Major Issues to be Handled

Tables 12.8 and 12.9 show the check list of grade separation and pedestrian underpasses. By using the scoping checklist, the study has been conducted to evaluate the expected impacts of the project and to recommend necessary measures against adverse impacts.

Major issues among those impacts are as follows;

1) Impact of earth work on air quality
2) Impact on air quality by gas emission from motor vehicle in Operation
3) Impact on resettlement by land acquisition for road construction

The issues 1) to 3) are to be discussed in Chapter 12.6 (Conclusions and Recommendations).

Table 12.8 Check List of Grade Separation

Environmental Items	Major Facilities/Activities Activities which may have impact	Roads/Roadside Facilities/Construction Roads					
		Overall Evaluation	Construction Stage		Operation Stage		
			Reclamation and Spatial Occupancy	Operation of Construction Equipment	Occupancy of Land	Operation of Vehicles	Accumulation of People and Goods
Socio-economic Environment	1. Resettlement	B	B				
	2. Economic Activity						
	3. Traffic and Public Facilities						
	4. Splitting of Communities						
	5. Cultural Property						
	6. Water Rights/Rights of Common Use						
	7. Public Health Condition						
	8. Waste						
	9. Hazard (Risk)						
Natural Environment	10. Topography and Geology						
	11. Soil Erosion						
	12. Groundwater	C	C				
	13. Hydrological Situation						
	14. Coastal Zone						
	15. Flora and Founa						
	16. Meteorology						
	17. Landscape	C	C	C	C	C	C
Human Environment	18. Air Pollution	B		B		B	
	19. Water Pollution						
	20. Soil Contamination						
	21. Noise and Vibration	C		C		C	
	22. Land Subsidence						
	23. Offensive Odor						

Table 12.9 Check List of Pedestrian Underpasses

Environmental Items \ Major Facilities/Activities Activities which may have impact		Roads/Roadside Facilities/Construction Roads					
		Overall Evaluation	Construction Stage		Operation Stage		
			Reclamation and Spatial Occupancy	Operation of Construction Equipment	Occupancy of Land	Operation of Vehicles	Accumulation of People and Goods
Socio-economic Environment	1. Resettlement						
	2. Economic Activity						
	3. Traffic and Public Facilities	C	C	C			
	4. Splitting of Communities						
	5. Cultural Property						
	6. Water Rights/Rights of Common Use						
	7. Public Health Condition						
	8. Waste	C	C				
	9. Hazard (Risk)						
Natural Environment	10. Topography and Geology						
	11. Soil Erosion						
	12. Groundwater	C	C				
	13. Hydrological Situation						
	14. Coastal Zone						
	15. Flora and Founa						
	16. Meteorology						
	17. Landscape						
Human Environment	18. Air Pollution	C	C	C			
	19. Water Pollution						
	20. Soil Contamination						
	21. Noise and Vibration	C	C	C			
	22. Land Subsidence						
	23. Offensive Odor						

12.6 Conclusion and Recommendation

12.6.1 Tentative Countermeasure for Air Pollution (Dust) by Earth Work

Harmful dust may be generated by construction machines through the earth work. Coarse particles settle down in a short time due to gravitational effect, while finer particles (smaller than 10 μm) have a longer stagnate period of time. Some substances from the soil have bad influence on human health through contamination in bronchus and lungs. Generation of dust can be prevented to some extent by periodical sprinkling around the construction area.

12.6.2 Recommendation on Future Investigation

1) Impact on Air Quality by Gas Emission from Motor Vehicle in Operation

(1) Cause of Impact

In the present study, the future traffic demand of the target year 2010 is estimated at a daily traffic volume of about 60,000 v/day, or peak hourly distribution of daily traffic volume of about 5,500 v/hour. Therefore, locations of high volume traffic may have air pollution problems in the future. Air pollutants are generated by internal combustion of motor vehicles. Internal combustion engine are roughly classified into two types; gasoline-engine and diesel-engine. Type of engines and related major pollutants are shown in Table 12.10.

Table 12.10 Type of Engines and Typical Related Pollutants

Pollutants	Type of Engine	
	Gasoline-Engine	Diesel-Engine
Nitrogen Oxides (NOx)	○	○
Sulfur Oxides (SOx)		△
Carbon Monoxide (CO)	○	
Carbon (C)		○
Suspended Particulate Matter (SPM)	△	○
Toxic Substances	○	○

Recently, new problems in air pollution have been observed, such as toxic substances in tires treated with pyrolyzates generated by vehicle traffic.

(2) Environmental Effect

Air pollutants invade the human body through various channels and affect it, particularly the respiratory system. Nitrogen oxides will affect the plants. Cadmium and lead in toxic substances are sources of water and soil pollution rather than air.

(3) Countermeasures

(a) Environmental Buffer Zone

Batinah Highway already has a substantial existing environmental buffer zone and green belts. Environmental impact from motor vehicles is somwhat mitigated. As a matter of course, the control of the environmental buffer zone will be taken on a continual basis.

(b) Monitoring of Ambient Air Quality

i) The Purpose of Monitoring Station

Mobile sources of the exhaust smoke are shipping traffic and motor vehicle traffic; most significantly motor vehicle traffic in the Batinah Coastal Region. Therefore, the measurement of air pollution from motor vehicles will be needed.

ii) Measurement Items at Monitoring Station

The purpose of monitoring stations is to collect the necessary basic information. The information will be utilized for implementation of proper measures to keep the local environmental air clean.

The measurement items at the monitoring stations vary according to purpose as follows:

The general atmospheric environment items are SOx, NOx, CO, Ox, and Suspended Particulate Matter (SPM). Particularly for the purpose to investigate pollution caused by motor vehicles, main items are SOx, NOx, SPM and CO. The environmental assessment for areas of motor vehicle traffic is commonly carried out regarding these 4 items.

In addition, it is also necessary to measure wind direction, wind speed, temperature, solar radiation and other meteorological observations.

iii) Structure of Monitoring Stations

A part of an existing building may be utilized as a fixed station. A fixed station is usually unmanned, and should preferably be made of Ferro-concrete, but it may be of concrete block or prefabricated.

In the case of a prefabricated building, the use of heat insulating materials and air condition system are essential and windows should be made as small and few as possible (A temperature higher than 30 °C is undesirable for an ordinary measuring apparatus).

iv) Standing Monitoring Center of Air Pollution

Data obtained at the aforementioned monitoring stations are transmitted by the telemeter system to the central station, where these data are processed, recorded and displayed with a computer on a sequential basis in compliance with the purposes.

Regarding the control system by a computer, a micro-computer-based-air-pollution-monitoring-system was developed, and the system comprises a micro-computer unit, modem units, data logger, and public telephone lines. The telemeter system collects the data from the monitoring station once an hour, immediately processes and outputs tables and graphics.

The system suited for a small scale monitoring system may be sufficient for the purposes. An example of the monitoring system is illustrated in Fig. 12.1

2) Impact on Resettlement by Land Acquisition for Road Construction

(1) Cause of Impact

Resettlement will occur by land acquisition for road construction. This resettlement will cause the loss of living foundation of inhabitants to be resettled. In our study, resettlement will occur at few locations complying to the geometric design standard and judicious balance of existing Monument and Flyover.

(2) Procedure of Environmental Impact Statement in Oman

The JICA Study Team and DGR have been following up the matters which are to be settled or informed of according to 'EIS' in Oman'. Particularly, concerning to the Resettlement Activities problems, it becomes necessary to clarify the significant Environmental Impact which would be affected by the project.

The JICA Study Team understands that the procedure of 'EIS' in Oman are to be carried out by the following form.

The first step, the major infrastructure projects are required to prepare EIS because of the significant environmental impacts such as Resettlement by Land Acquisition for Road Construction. The developer should submit the same to EIS-Review-Committee (hereinafter referred to as 'EIS-RC').

The EIS-RC examines the EIS and determines to be registered by the Ministry of Environment and the Ministry of Water-Resources, if it conforms with the prescribed outline. Subsequently, Royal Decree will be issued in accordance with the Law concerning the Land Acquisition. The procedures listed below are the basic elements that should be considered during the preparation and formulation of such an action plan.

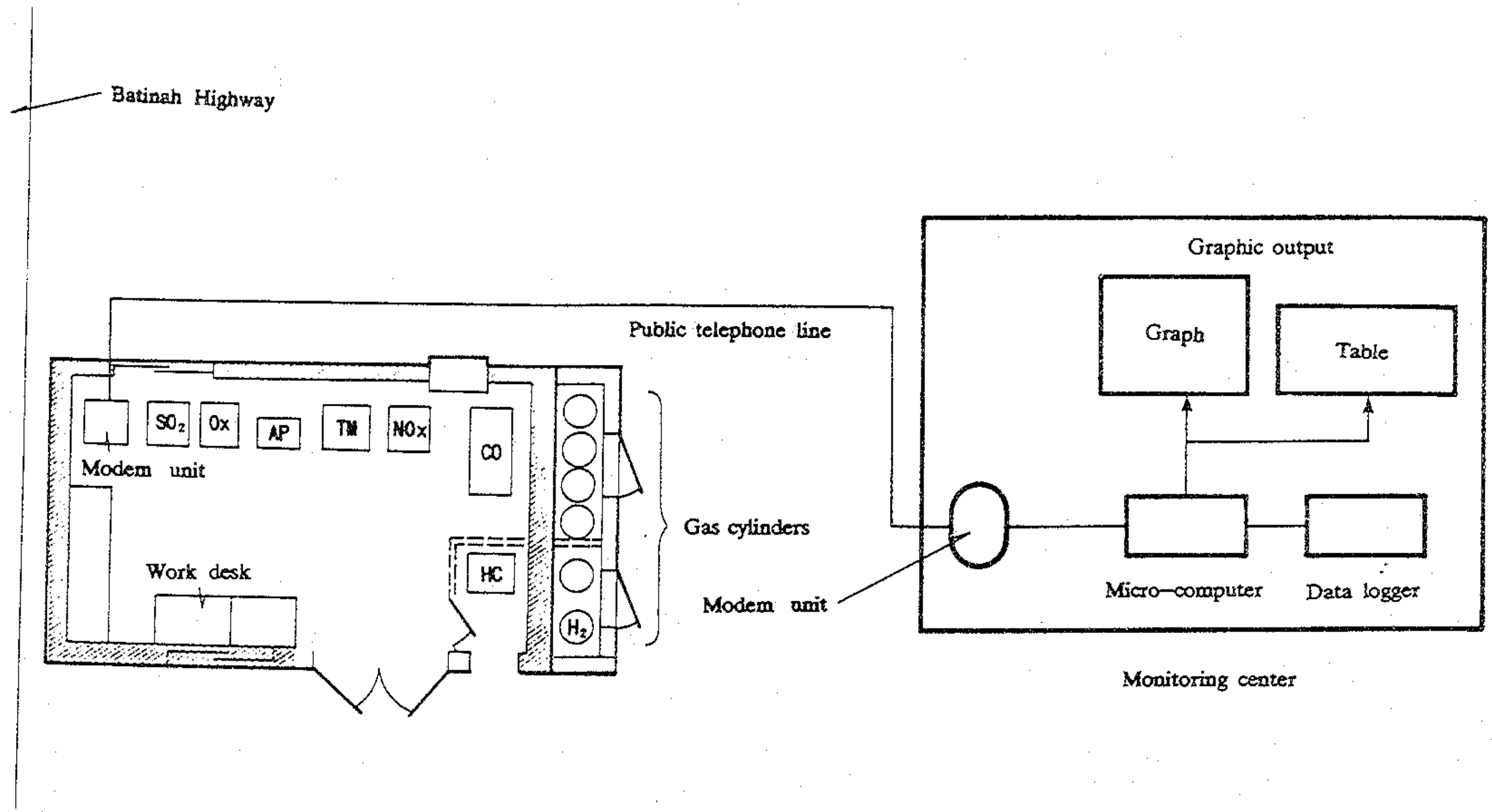
(a) land acquisition
(b) topographic survey and detail construction map
(c) valuation and compensation for lost assets
(d) cost estimates (reflecting economic, social and ecological costs)

On the basis of these procedures, all cost will be estimated in accordance with suitable cost estimation procedure in Oman. The flow-chart of EIS system is shown in Fig. 12.2.

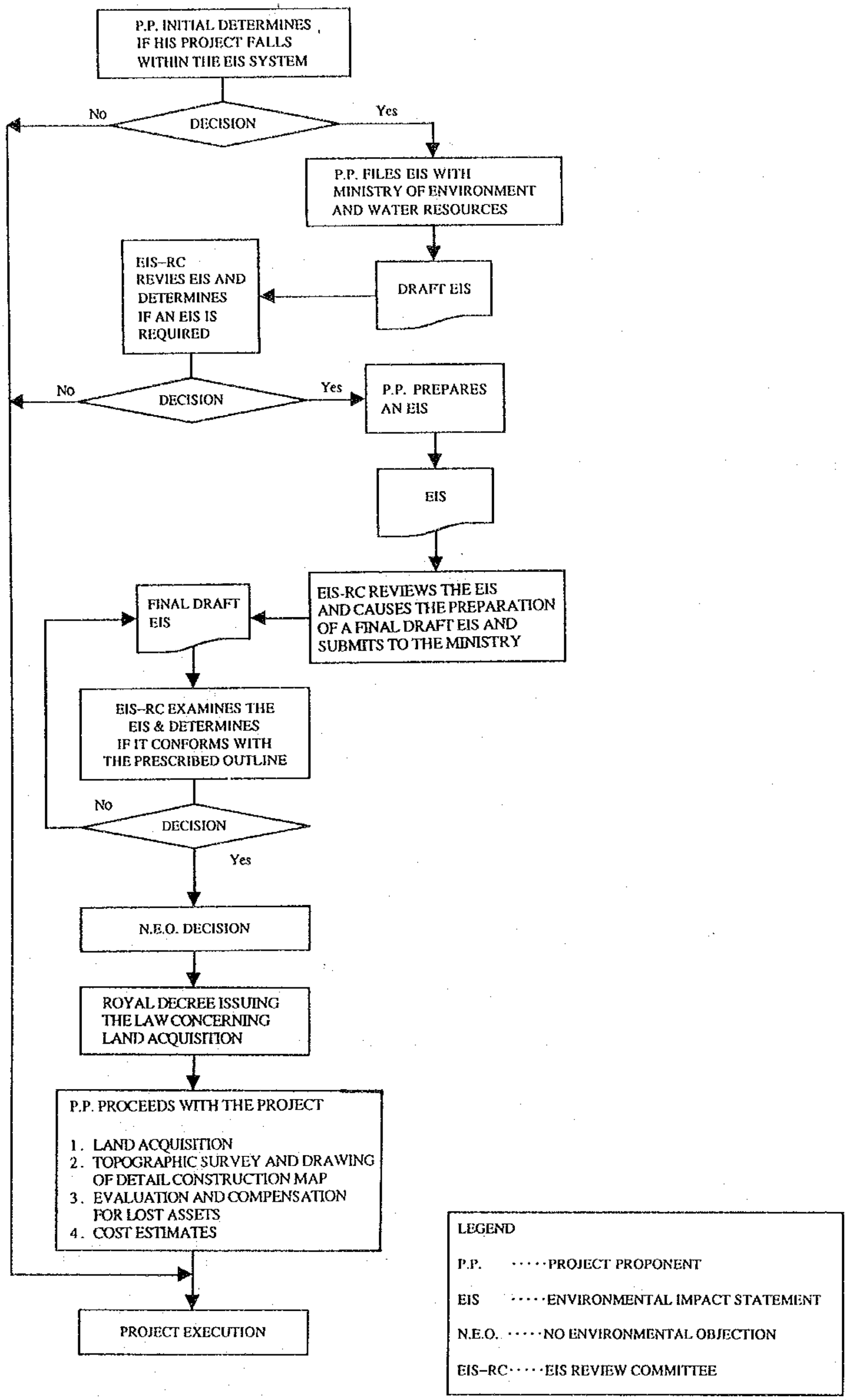
(3) Countermeasures

Alternatives to displacement and resettlement will be fully considered before decision on displacement and resettlement are taken. Involuntary displacement and resettlement should be treated as an integral part of project decision from the earliest stage of project preparation.

The projects should be screened for potential resettlement issues. Involuntary population displacement should be avoided or minimized whenever feasible by exploring all viable alternative project designs.

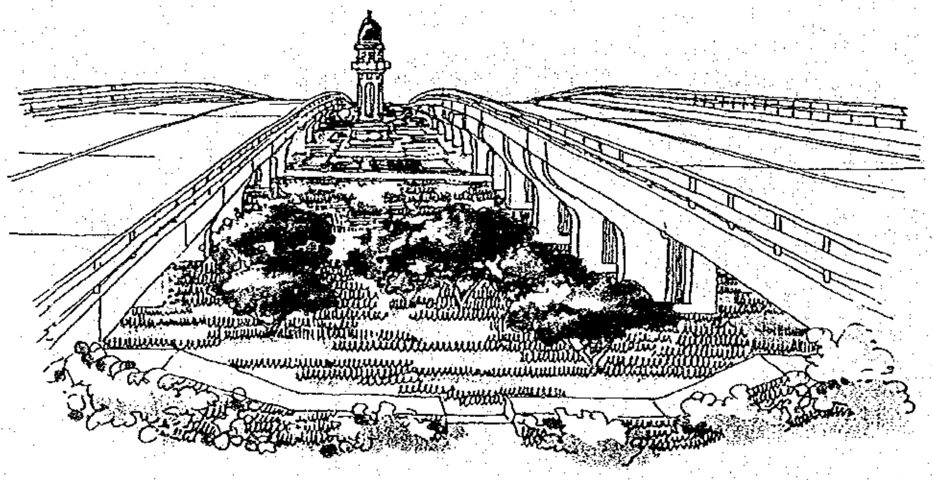


THE STUDY ON ROAD DEVELOPMENT PROJECT	JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 12.1 Telemeter System of Airpollution Monitoring Station



THE STUDY ON ROAD DEVELOPMENT PROJECT	JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 12.2 The Flow-chart of EIS System in Oman

CHAPTER 13 PROJECT COST ESTIMATE



CHAPTER 13

PROJECT COST ESTIMATE

13.1 General

The project cost estimate is carried out on each grade separation or pedestrian underpass at the preliminary design study stage in Japan.

The initial project cost will consist of the construction costs, contingency costs, technical engineering costs, and land acquisition costs. On the other hand, the running expenses of this project will be the maintenance cost.

13.2 Unit Cost

13.2.1 Methodology

The construction cost was estimated by obtaining quantities from the preliminary design drawings, and by the application of unit rates which were derived from a study of recent tendered prices. In order to establish unit costs for the estimation of this study, tender prices of four road project contracts over the period 1988 - 1994 were examined, and tender prices of flyover project contract in 1985 and the estimation for F/S of road projects including bridges in 1992 were referred to.

13.2.2 Unit Cost Estimation

The unit costs for major work items were estimated at the financial values in 1994 as a result of the above estimation methodology.

Unit costs were derived for the following items.

(1) Earthworks

Earthworks were classified and costed as follows:

Excavation (Common)	1.3 RO/m^3
Excavation (Rock)	4.1 RO/m^3
Embankment (Borrow)	1.2 RO/m^3
Incidental Works*	[Earthworks] x 30 %/LS

Note: * Incidental works consist of diversions, site clearance and demolition of structures etc.

(2) Pavements

Pavements are executed for carriageways, shoulders and footpaths. The structure of carriageway was the same as original one which was constructed of 40 mm asphalt concrete wearing course over 80 mm asphalt concrete base course over 150 mm granular material subbase. The shoulder consisted of a 40 mm asphalt concrete wearing course and 150 mm granular material base course. The footpath width was taken as a 1.0 m, and the footpath consisted of coloured blocks surface and curbs on both sides.

The unit rates of each pavement are shown below.

Subbase Course	2.3 RO/m^3
Base Course (A.C.)	19.9 RO/m^3
Wearing Course (A.C.)	22.2 RO/m^3
Footpath (With Curbs)	14.9 RO/m^2

(3) Drainage

Drainage works consist of a pipe culvert, a box culvert, open channel and lined drains. Drainage costs were estimated on the basis of a length of the above each work inclusive of excavation, pipe or box, inlet and outlet structures and protection works.

The unit rates of drainage are:

RC Pipe Culvert ($D \leq 0.6$ m)	43.1 RO/m
RC Pipe Culvert ($0.6 < D \leq 0.9$ m)	64.7 RO/m
RC Box Culvert (2 x 1 m)	210.0 RO/m
Open Channel ($\bar{H} = 2$ m, $\bar{B} = 6$ m)	48.1 RO/m
Lined Drains	3.4 RO/m

(4) Slope Protection

Slope protection works, namely retaining walls with pile foundation at the approach roads to flyovers, and grouted rip-raps between abutments in case of type B were planned.

The unit rates of slope protection are estimated as follows:

Retaining Wall ($\bar{H}$ = 5.7 m)	547 RO/m
Grouted Rip-Rap (t = 0.3 m)	4.4 RO/m^2

(5) Bridges

Bridge works consist of a superstructure of PC box girders, an abutment of reversed T-type with pile foundation and a pier of with pile foundation.

The unit rates of bridges include all concrete, reinforcement, formworks bearings, expansion joints, girder erection, excavation and other miscellaneous bridge works. Additionally, the unit rates of the above works differ with each flyover.

The average unit rates are:

Superstructure	(Span L = 30 m, B = 12.7 m)	74,200 RO/No.
Superstructure*	(Span L = 30 m, B = 8.25 m)	45,800 RO/No.
Superstructure	(Span L = 25 m, B = 12.7 m)	57,300 RO/No.
Superstructure	(Span L = 20 m, B = 12.7 m)	42,100 RO/No.
Abutment	($\bar{H}$ = 8.7 m, B = 12.7 m)	26,600 RO/No.
Abutment*	($\bar{H}$ = 8.7 m, B = 8.25 m)	21,200 RO/No.
Pier	(One Colum Type $\bar{H}$ = 8.0 m)	11,900 RO/No.
Pier	(Two Colums Type $\bar{H}$ = 8.2 m)	13,200 RO/No.
Pier*	(Wall Type $\bar{H}$ = 8.8 m)	15,200 RO/No.
Pier*	(Portable Bracing Type $\bar{H}$ = 9.4 m)	16,600 RO/No.

Note: * These items apply to R/A-18.

(6) Road Furniture

Road furniture consists of guardrails, markings and signs, and the unit rates of each item are shown below:

Guardrails	17.7 RO/m
Markings	20,000 RO/LS
Signs	10,000 RO/LS

(7) Lighting

The cost of lighting was estimated as 100,000 RO per roundabout.

(8) Relocation of Utilities

The telephone, electric and water utilities are to be relocated. The total cost of these utilities was estimated at 50,000 RO per roundabout.

(9) Landscaping

The landscaping was classified into the following types of grade separation and estimated as shown below:

Type A	100,000 RO/LS
Type B	150,000 RO/LS

(10) Preliminaries

An allowance of 10 % of the total of the above items was made for preliminaries.

(11) Contingency

The contingency cost was assumed at 10 % of the construction costs.

(12) Design and Supervision

The technical costs consisted of consultant's cost for preparation of the detailed design drawings and construction supervision costs, and was assumed as 10 % of the total of the construction cost and the contingency.

13.3 Construction Cost

13.3.1 Grade Separation Construction Cost

The grade separation construction cost of each R/A is given in Table 13.1.

Table 13.1 Construction Cost

(Financial Cost Unit: 1,000 RO)

		Earth Work	Pavement	Slope Protection	Bridges	Others	Construction Amount
R/A - 2	Barka	124	191	390	1,653	634	2,992
R/A - 3	Naseem Garden	131	199	375	1,650	693	3,048
R/A - 5	Al Muladdah	142	204	354	1,618	661	2,979
R/A - 8	Khaburah	115	198	476	1,693	664	3,146
R/A-10	Saham	121	195	447	1,721	693	3,177
R/A-12	Sohar	162	203	535	1,708	820	3,428
R/A-14	Falaj Al Qabail	155	211	618	1,708	746	3,438
R/A-18	Aqr	154	149	555	1,036	671	2,565
Average		138	194	469	1,598	698	3,097
(Average excluding R/A-18)		(136)	(200)	(456)	(1,679)	(701)	(3,172)

13.3.2 Land Acquisition Cost

The land acquisition cost of each R/A is given in the Table 13.2. This cost is not applied to the pedestrian underpass, because the construction is to be executed in the right of way.

Table 13.2 Land Acquisition Cost

R/A No.	Wilayat	Land use	Unit Cost (RO/m^2)	Quantity (m^2)	Total Cost (RO)	Amount (RO)
2	Barka	Residential Area	5 - 8	330	2,640	
		Commercial Area	10 - 15	0	0	2,640
3	Barka	Residential Area	5 - 8	0	0	
		Commercial Area	10 - 15	0	0	0
5	Al Musnaah	Residential Area	5 - 8	500	4,000	
		Commercial Area	7 - 12	0	0	4,000
8	Al Khaburah	Residential Area	5 - 8	0	0	
		Commercial Area	7 - 12	410	4,920	4,920
10	Saham	Residential Area	5 - 8	0	0	
		Commercial Area	7 - 12	420	5,040	5,040
12	Sohar	Residential Area	5 - 10	1,310	13,100	
		Commercial Area	10 - 20	0	0	13,100
14	Liwa	Residential Area	4 - 6	0	0	
		Commercial Area	7 - 10	7,150	71,500	71,500
18	Shinas	Residential Area	5 - 8	24,200	193,600	
		Commercial Area	10 - 16	0	0	193,600

Notes;
1) Unit cost is classified into three categories (Town center, Outskirts, Other areas). The adopted unit cost is of Outskirts, because roundabouts are almost always located in the outskirts.
2) To calculate the total cost, the upper unit cost is applied.
3) The source of unit cost is MOC.

13.3.3 Maintenance Cost

The maintenance work is applied to the grade separation project. The work consists of routine maintenance, periodic maintenance, rehabilitation and reconstruction. The implementation years in the project life (25 years) and unit costs are given in Table 13.3. Additionally, the actual implementation dates of each R/A follow the "Implementation Plan" mentioned in Chapter 14.

Table 13.3 Implementation Year and Unit Cost

Type of Maintenance	Implementation Year	Unit Cost (RO/m^2)
Routine Maintenance	Every year	0.10
Period Maintenance	5th and 15th year after opening to traffic	3.50
Rehabilitation	10th years after opening to traffic	5.50
Reconstruction	20th year after opening to traffic	7.00

Notes: Unit costs depend on DGR's data.
Yearly Inflation Rate: 2 %

The type of grade separation at this time is classified into two categories. One is the flyover of main traffic road such as R/A-2, 3, 5, 8, 10, 12 and 14 (Type I), and the other is the flyover of secondary traffic road such as R/A-18 (Type II), the objective area and cost for maintenance differ by the above type shown in Table 13.4.

Table 13.4 Maintenance Cost

Type of Grade Separation	Type I	Type II
Objective Area	47,000 m^2	45,000 m^2
Routine Maintenance	4,700 RO	4,500 RO
Periodic Maintenance	164,000 RO	157,000 RO
Rehabilitation	258,000 RO	247,000 RO
Reconstruction	329,000 RO	315,000 RO

Notes: The object area consists of carriageway including bridge deck.

13.3.4 Pedestrian Underpass Construction Cost

The pedestrian underpass construction cost for each location is given in Table 13.5.

The grade separation construction cost at this time and the result of tender for pedestrian underpass in 1994 were referred to in calculation of the construction cost.

Table 13.5 Construction Cost

(Financial Cost)

	Earth Work	Concrete Structure	Others	Construction Amount
P/U - 1	2,900	23,100	68,600	94,600
P/U - 2	3,400	25,300	72,200	100,900
P/U - 3	2,600	22,100	67,400	92,100
P/U - 4	3,100	25,100	72,100	100,300
P/U - 5	2,600	23,000	68,500	94,100
P/U - 6	2,600	23,100	68,600	94,300
P/U - 7	2,900	24,100	69,800	96,800
P/U - 8	2,900	24,100	69,800	96,800
P/U - 9	2,600	23,000	68,500	94,100
P/U-10	2,900	23,400	68,600	94,900
P/U-11	2,100	20,700	65,000	87,800
P/U-12	2,600	22,100	67,400	92,100
Average	2,800	23,200	68,900	94,900

13.4 Project Cost

13.4.1 Grade Separation Project Cost

The initial project cost of each grade separation is shown in Table 13.6.

Table 13.6 Grade Separation Project Cost

(Financial Cost Unit: 1,000 RO)

Type of Cost	R/A-2	R/A-3	R/A-5	R/A-8	R/A-10	R/A-12	R/A-14	R/A-18
Construction Cost	2,992	3,048	2,979	3,146	3,177	3,428	3,438	2,565
Contingency	299	305	298	315	318	343	344	257
Design & Supervision	329	335	328	346	349	377	378	282
Land Acquisition	3	0	4	5	5	13	72	194
Project Cost	3,623	3,688	3,609	3,812	3,849	4,161	4,232	3,298

13.4.2 Pedestrian Underpass Project Cost

The project cost of each pedestrian underpass is shown in Table 13.7.

Table 13.7 Pedestrian Underpass Project Cost

(Financial Cost Unit: 1,000 RO)

Type of Cost	P/U-1	P/U-2	P/U-3	P/U-4	P/U-5	P/U-6	P/U-7	P/U-8	P/U-9	P/U-10	P/U-11	P/U-12
Construction Cost	95	101	92	100	94	94	97	97	94	95	88	92
Contingency	9	10	9	10	9	9	10	10	9	9	9	9
Design & Supervision	10	11	10	11	10	10	11	11	10	10	10	10
Project Cost	115	122	111	121	114	114	117	117	114	115	106	111

13.4.3 Grade Separation Project Cost of Type A, B, C and D

The average project cost of each grade separation type is shown in the following table.

Table 13.8 Grade Separation Project Cost

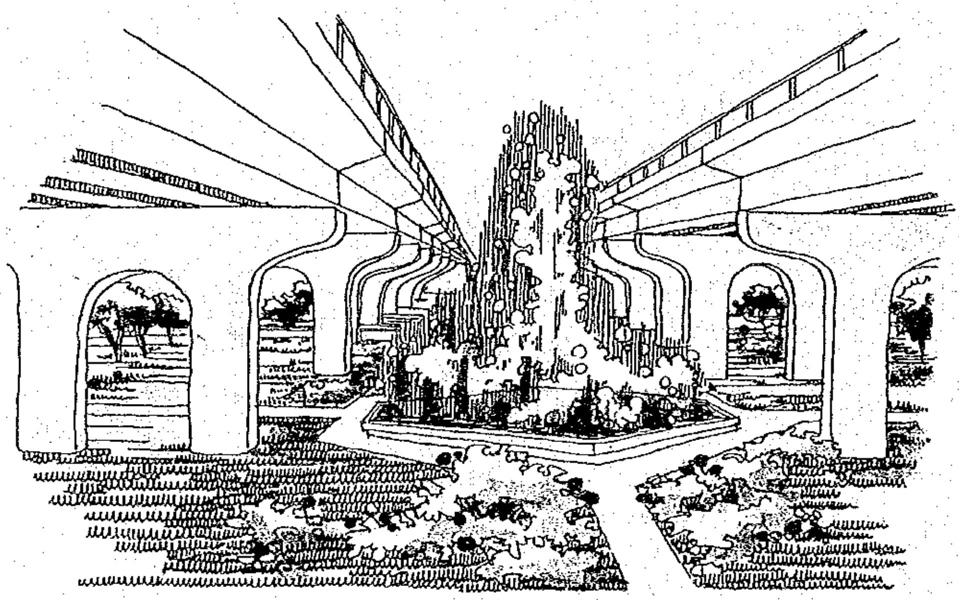
(Financial Cost Unit: 1,000 RO)

Item	Type A	Type B	Type C	Type D
Construction Cost	3,068	3,433	3,581	2,988
Contingency	307	343	358	299
Design & Supervision	338	378	394	329
Land Acquisition	3	43	100	200
Project Cost	3,716	4,197	4,433	3,816

Note: 1. The costs of type A and B were derived from the result of preliminary design.

2. The costs of type C and D were calculated by the examined unit cost on the basis of the conceptual design.

CHAPTER 14 CONSTRUCTION PLANNING AND IMPLEMENTATION PLANNING



CHAPTER 14

CONSTRUCTION PLANNING AND IMPLEMENTATION PLANNING

14.1 General Description

The construction works will consist of flyover construction at 8 sites and pedestrian underpasses at 12 locations. Project organization will consist of preparation for the construction of the flyover and the pedestrian underpasses and grasping of the overall scope of work.

The project will generally consist of the following works:

- Construction of flyovers
- Construction of underground pedestrian underpasses
- Rehabilitation of roundabouts
- Construction of approach roads
- Other related construction works

In performing the implementation of the works, coordination meetings will have to be held with the Omani officials. The 5th Five Year Plan will start in 1996, so bearing this in mind, the project will be implemented as follows:

Implementation Plan :	1996 ~ 2000 :	Construction of 8 flyovers. Construction of one pedestrian underpass per year.

14.2 Construction Planning, Basic Conditions

In accordance with the surveys conducted, the implementation of this project was planned to conform with the construction capabilities in Oman.

14.2.1 Construction Materials

Procurement of Materials

The main materials that are available in Oman are as follows:

a. Earthfill Materials

Earthfill materials can be obtained from borrow pits at the foot of the Hajar Al Gharbi mountain range within a distance of 20 km from the project sites.

b. Aggregates

Stones for gabions and rip-rap, and gravels for pavement are available in the wadis adjacent to the project sites. Aggregates for concrete and pavements can be obtained by erecting temporary crushing plants in the vicinity of wadis or procured from existing plants located in Sohar and Muscat.

c. Cement

Portland cement can be obtained in Oman. Cement plants are located in Salalah and the suburbs of Muscat. The cement production almost meets the domestic needs for cement in Oman.

d. Ready-Mix Concrete and Asphalt Concrete

Ready-mix concrete and asphalt concrete can be procured from existing plants located in Sohar and Muscat. They can also be produced from plants temporarily set up near the project sites.

e. Steel and Lumber

Structural steel and lumber for construction can be procured from overseas sources. Construction materials took up about 15 % of total imports to Oman as shown in the following table.

Constr Mtls	1992		1991		1990	
	x 1,000 t	%	x 1,000 t	%	x 1,000 t	%
Struc Steel	105.6	66.3	86.7	57.3	70.2	52.1
Lumber	38.3	24.0	51.5	34.0	44.3	32.9
Cement	-	-	-	-	7.0	5.2
Other Mtls	15.5	9.7	8.7	8.7	13.3	9.8
Totals	159.4	100.0	151.3	100.0	134.8	100.0

Source: Statistics Year Book

The importing port for this project will be Mina Sultan Qaboos which is in the suburbs of Muscat.

14.2.2 Construction Equipment

The principal items of construction equipment required for the project are listed in Table 14.1 to Table 14.3 by the type of work. The equipment is available from Sohar and Muscat.

(1) Earthworks Equipment

Table 14.1 Earthworks Equipment

Main Works	Equipment	
	Hauling distance less than 100 m	Hauling distance more than 100 m
Clearing and Grubbing*1	Bulldozer	
Removal of pavement, etc.	Rock breaker*2	
Excavation	Bulldozer	Tractor Shovel/Back Hoe
Loading	Bulldozer	Tractor Shovel/Back Hoe
Hauling	Bulldozer	Dump Truck
Spreading	Bulldozer/Motor Grader	
Compaction	Tamping Roller/Tire Roller, Road Sprinkler	

*1 Existing trees are to be transplanted.

*2 A rock breaker will be procure in the case of rock excavation.

(2) Paving Work Equipment

Table 14.2 Paving Work Equipment

Main Work	Equipment
Subgrade Preparation	Motor Grader, Tire Roller, Macadam Roller
Subbase course*	Motor Grader, Tire Roller, Macadam Roller, Road Sprinkler
Base Course	Motor Grader, Tire Roller, Macadam Roller, Road Sprinkler
Prime/Tack Coat	Asphalt Distributor
Binder/Surface Course	Asphalt Finisher, Macadam Roller, Tire Roller

* In the case of granular material or crushed stone.

(3) Concrete Bridge/Underpass (Box Culvert) Construction Equipment

Table 14.3 Concrete Bridge/Underpass Construction Equipment

Main Work	Equipment
Structural Excavation	Back Hoe (Rock Breaker), Dump Truck
Foundation	Transit Mixer, Pile Driver
Substructure	Transit Mixer, Concrete Pump, Mobil Crane
Superstructure	Transit Mixer, Concrete Pump, Prestressing Machine Crawler Crane, Mobile Crane
Box Culvert	Transit Mixer, Mobile Crane

14.2.3 Construction Bills of Materials

See Chapter 9.5, Preliminary Design of Bridges, and paragraph 10.3, Preliminary Design of Pedestrian Underpass for the bills of quantities for the 8 flyovers at the roundabouts and the 12 pedestrian underpasses.

14.3 Construction Methods

Construction method (Type A, B) of roundabout is shown in Figure 14.1.

14.3.1 Grade Separation

(1) Flyover Construction Works

a. Superstructure

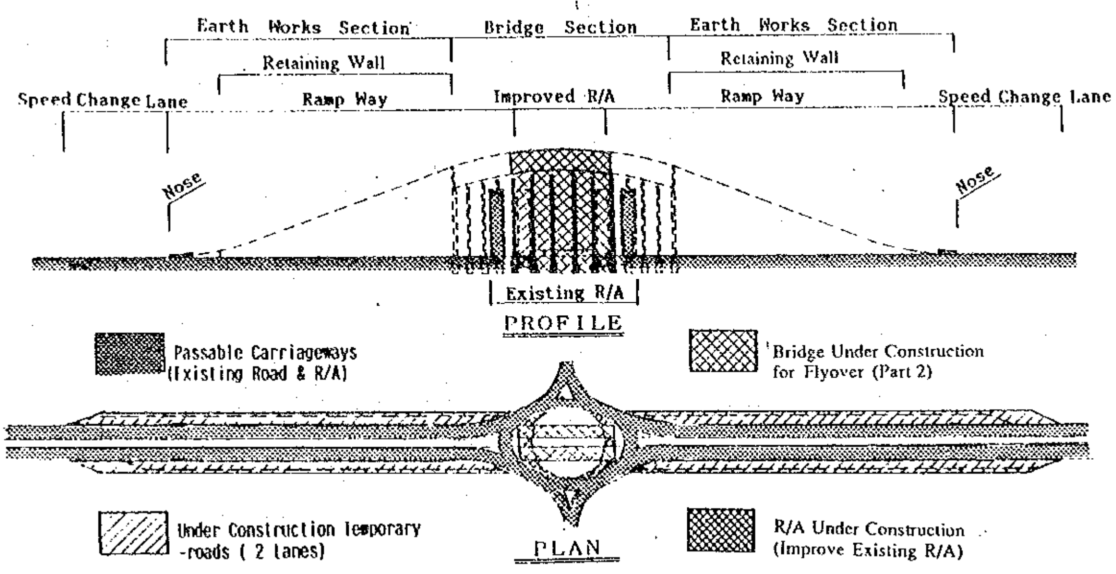
The superstructure of the flyover will be a PC box girder and will be constructed in accordance with the precast concrete methods.

The precast segments will be cast in a plant near the job site then assembled in place by hoisting into their final place in the flyover.

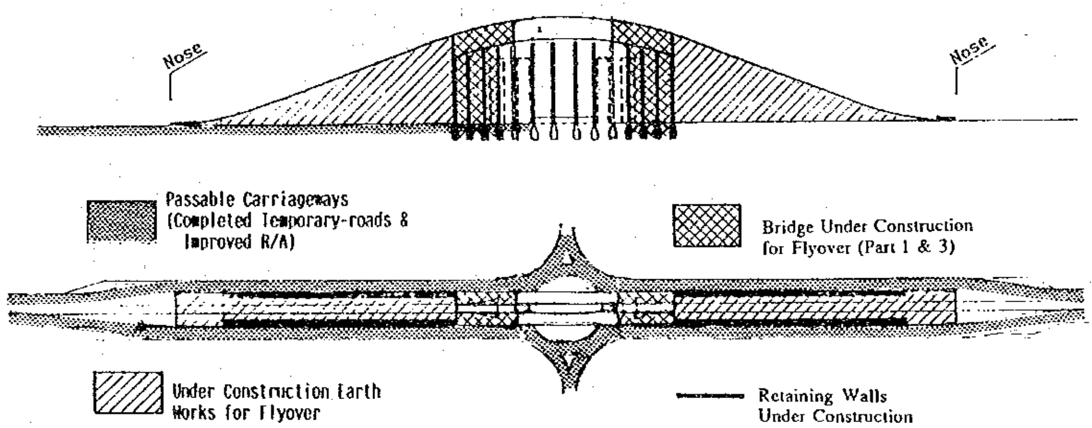
The problems of segmental box girders are as follows:

Type A, B

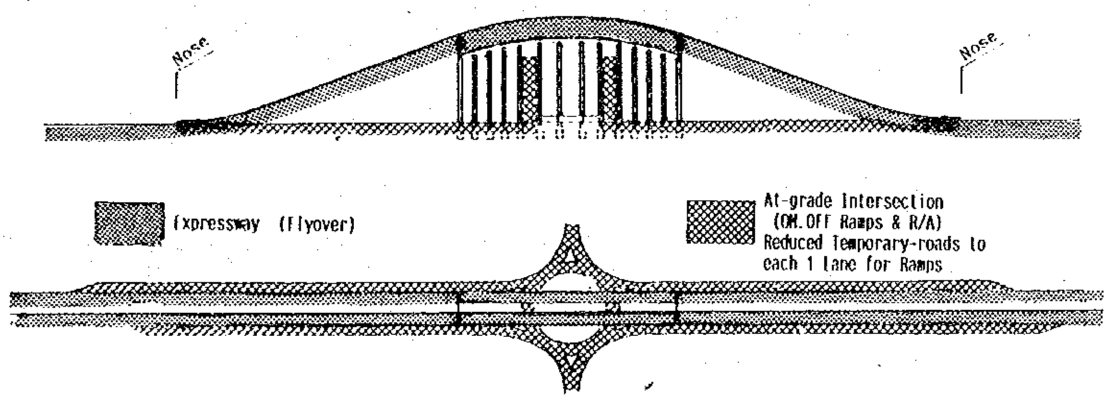
① FIRST STAGE



②. SECOND STAGE



③ COMPLETION



THE STUDY ON ROAD DEVELOPMENT PROJECT	JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 14.1 Construction Method

1) In selecting the segment casting yard, the location of the yard, yard size, the number of casting moulds, and the type of structure will have to be considered. The number of segments to be cast will have a bearing on the project schedule, the number of moulds required, the erection method which should be well planned.

2) The storage yard for the segments, the distance to the erection site, method of transportation should be well planned.

3) The method of hoisting the segments into place should be coordinated with the erection site, the structure of the box girder, the number of segments, the weights, and the type of substructure. They should be well coordinated, and the most suitable method should be selected. Some of the important points to be considered are described as follows:

   - The segment should be designed keeping in mind beforehand the erection method, embedding the necessary connection hardware, design lift points and the supporting points.

   - Checking the substructure while the segments are being manufactured at the plant.

   - Methods to prevent the overturning of the segment during the erection should be established.

   - The effect of the erection equipment on the existing girders or deck shall be studied to see that no undesirable loads are placed supporting points should be decided.

   - The existing roads should be protected so that they will not be damaged by the transport of the segments.

   After the PC box girders have been hoisted in place, the bridge deck works will be resumed.

b. Substructure

The abutment and supports will be constructed of reinforced concrete and should not present any problems. The results of the geological survey show that the soils in the project area are sandy, so the open cut method will be used. The work should generally be as follows:

- Preparatory work
- Excavation
- Reinforcing steel work
- Concrete forms and false supports
- Concrete work

Concrete work in the summer season will require casting of concrete in high temperatures and curing in the same weather. Care must be exercised in concreting.

c. Foundations

Precast concrete piles will be used for the foundation and the footings. A pile casting yard will be constructed near the project site, where the piles will be fabricated, stored, and hauled to the site, and driven with diesel hammer. Soil investigation results indicate that the piles will be less than 10 m long and it is not expected that piles will require extensions.

Other related matters will generally be in accordance with Item (a) for Superstructures.

(2) Access Road Works to the Bridge and Reconstruction of Roundabouts

a. Construction of Retaining Walls

This work will be similar to Item (b), Substructures Item (c) Foundations.

b. Approach Roads and Reconstruction of Roundabouts

After construction of flyover and abutments connecting to the flyovers, the approach, rampway (earthfill, pavement) will be constructed.

Reconstruction of roundabout will be carried out while the construction of flyover at roundabout.

(3) Other Related Work

In addition to the above work the following additional work will be required.

- Extension or detour of existing box and pipe culverts.
- Other related drainage systems.
- Relocation of public utilities such as water distribution pipelines, electric underground cable system, telephone lines, and other related works.
- Construction of other roads.

14.3.2 Construction of Pedestrian Underpass

Many actual designs of pedestrian underpasses have been seen to date. There is no problem in application, but the following points should be considered for this project.

- The underpasses will be constructed at 4-lane highways with median dividers where there is heavy traffic, so they should be constructed to pass under a set of 2-lanes each.

- The water table is low so drainage facilities will not have to be provided during construction.

- The concrete for the underpass work can be cast-in-situ.

- A turn around road should be provided during construction.

14.4 Construction Time Requirements

14.4.1 Flyover Construction Time Requirements (for one flyover)

(1) Conditions for Calculation

a. Working Day

In the Sultanate of Oman the normal working day is seven (7) hours. However at construction sites, the average actual working time is found to range from 7 to 10 hours per day.

The actual working day per month can be calculated as follows:

Description	Days/Month
Number of holidays	8
Number of actual working days	22
Working efficiency per month	73 % (22/30)

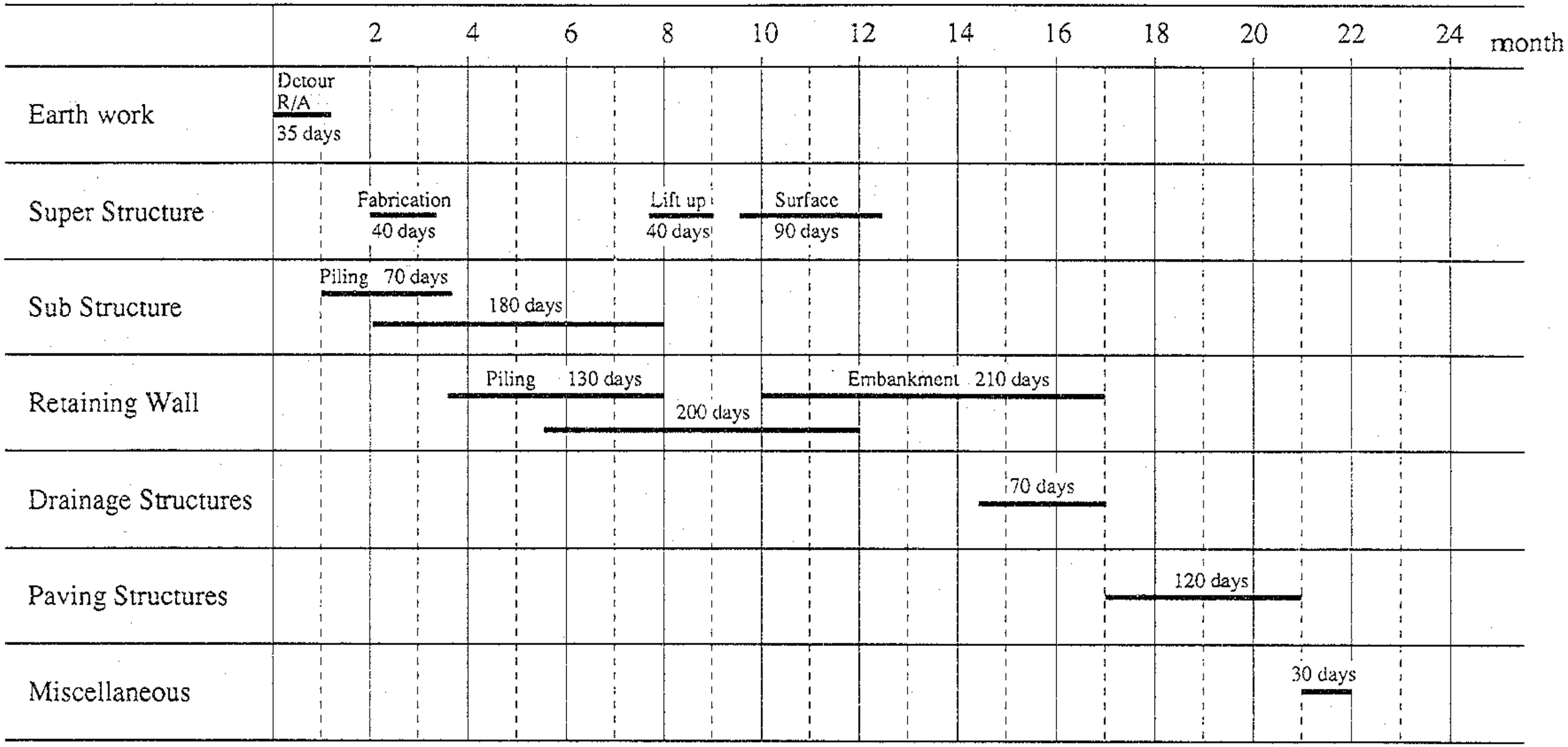
b. Work Efficiency, Per/Day

1) Flyover at Roundabout

- Detour	
Temporary Road	25 m/day
Roundabout	50 m/day
- Superstructure	
Fabrication	5 beams/day
Hoisting	5 beams/day
Surface Work	1 span/5 day
- Substructure	
Concrete placing	30 m^3/day
Pile Driving	10 piles/day
- Retaining Wall	
Concrete placing	30 m^3/day
Pile driving	10 piles/day
- Drainage Structures	
Embankment	400 m^3/day
Structure	30 m/day
- Access Road	
Embankment	400 m^3/day
Paving Work	150 m^3/day
- Miscellaneous Work	
Miscellaneous work	30 days

(2) Construction Schedule

R/A Flyover



The following quantities have been assumed

- Detour temporary Road 250 m
- Roundabout 700 m
- Concrete volume (Super structure) 6,400 m^3
- Concrete volume (Sub structure) 4,000 m^3
- Concrete volume (Retaining wall) 4,000 m^3
- Piling work (Sub structure) Σl = 3,600 m (520 pieces)
- Piling work (Retaining wall) Σl = 6,800 m (970 pieces)
- Earthwork 30,500 m^3
- Pavement 15,400 m^2 (4,600 m^2)
- Miscellaneous Lump Sum

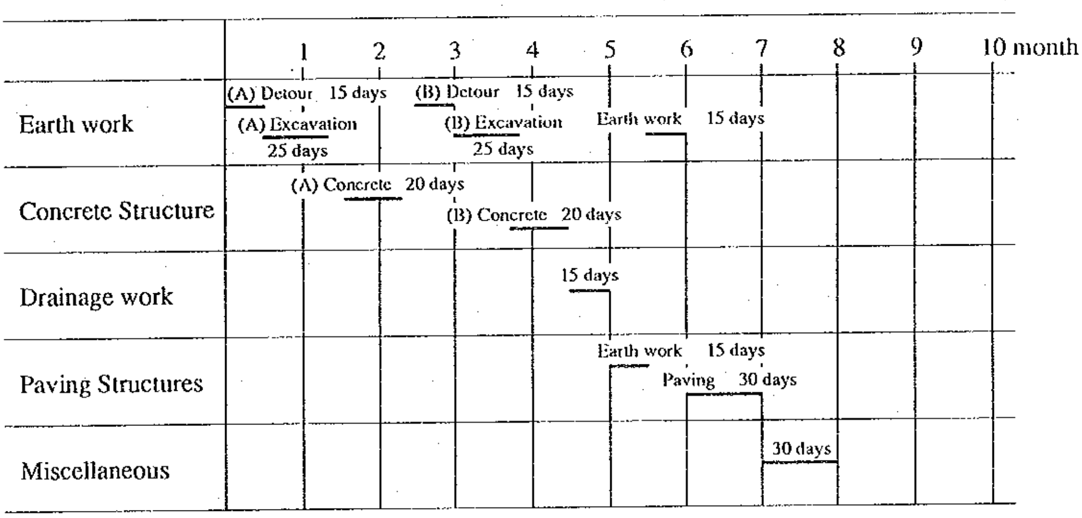
14.4.2 Pedestrian Underpass Construction Time Requirements (For One Underpass)

(1) Conditions for Calculation

Earthwork

(Step I, II)	Detour temporary work	15 m/day
	Excavation	40 m^3/day
Concrete Work		15 m^3/day
Drainage Work		15 m/day
Paving Work		15 m^3/day
Miscellaneous		30 days

(2) Construction Schedule



The following quantities have been assumed.

- Detour temporary road 300 m
- Excavation 1,200 m^3
- Concrete 230 m^3
- Drainage 50 m
- Pavement 250 m^2 (120 m^3)
- Miscellaneous Lump Sum

14.5 Project Schedule

Two schedules are proposed for the project as follows:

Implementation Schedule : Eight (8) flyovers are proposed to be constructed during the 5th Five-Year Plan, (1996 - 2000) for grade separation of the roundabouts. The two pedestrian underpasses that have high priority will be implemented immediately, and the remaining pedestrian underpasses (10 locations) will be constructed at 3 locations in 1997 and 1998, and 2 places in 1999 and 2000 in order of priority. The remaining pedestrian underpasses will be constructed on the basis of one per year.

Implementation Plan

			Implementation Plan					
			1995	1996	1997	1998	1999	2000
Final Engineering Design								
Flyover	Barka Roundabout	R/A						
	Sohar	R/A						
	Naseem Garden	R/A						
	Al Mulladah	J/C						
	Saham	R/A						
	Khaburah	R/A						
	Falaj Al Qabail	R/A						
	Aqr	R/A						
Pedestrian Underpass	Priority 1							
	Priority 2							
	Priority 3, 4, 5							
	Priority 6, 7, 8							
	Priority 9, 10							
	Priority 11,12							

14.6 Maintenance Plan

Construction of flyovers and pedestrian underpasses are proposed to be constructed on Batinah Highway (Route 1). The maintenance for the bridges will commence with the completion of all the bridge structures.

In order to preserve the road structures, to maintain a secure transport system and play a part in the economy of the country, proper maintenance will be an important function. Details of the maintenance system will be described in Volume III (Part B).

(1) Road Register

In order to perform proper maintenance of the road systems, in addition to keeping a file of the design documents (road drawings and design analyses), it is most important to keep a file of all the road structures.

1) Bridge Inventory
2) Pedestrian Underpass Inventory
3) Maintenance Record of the above

(2) Preparation of Inspection Guidelines

A guideline for the maintenance of the bridges describing the daily inspection items, periodic inspection, spot inspection, movement inspections, detail inspections, and thereby uncover latent defects at an early stage and make the necessary repairs to maintain the road facilities in good operating condition.

(3) Maintenance and Operation of Pedestrian Underpasses

a. Items of Inspection:

The inspection of the pedestrian underpasses will have to be maintained in order to provide a safe and secure passage for the local residents.

1) Inspection of Box Culverts

Inspect the concrete walls and ceilings: Check for cracks, spalls, delamination, exposed reinforcing steel, voids, popouts, leaks, efflorescence, scaling, joint disorders.

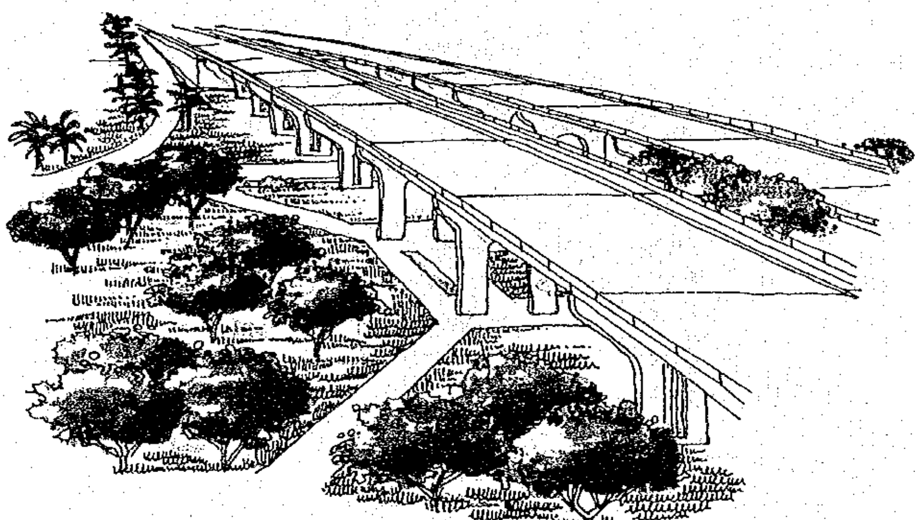
2) Inspection of Safety Features:

Inspect Safety Features	:	Lighting, drainage facilities.
Inspect Other Facilities	:	Inspect for squatters and preserve order.

b. Inspection Method:

Daily Inspection	:	Approach structure and inspect visually.
Periodic Inspection	:	Prepare a list of items to inspect, the types of inspection to perform, and the instruments to use in the inspection.

CHAPTER 15 ECONOMIC ANALYSIS



CHAPTER 15

ECONOMIC ANALYSIS

15.1 General

In this chapter economic evaluations deriving from the construction of flyovers and pedestrian underpasses are carried out.

Traffic cost is based on a report written in Oman "Highway User Cost Updated 1992" (HUC 1992) and "Road Transport Investment Model" (RTIM 2) included in the report.

15.2 Factors of Vehicle Operating Cost

In this economic analysis, economic benefits are defined by reduction of vehicle operating cost. The vehicle operating cost consists of only running cost and time cost; traffic accident cost, opportunity cost of vehicles, and other factors which are not considered here.

(1) Running Cost

Running cost is divided into cost on distance and cost on time. The cost on distance is composed of fuel cost, oil cost, tire cost, maintenance & repair cost, and vehicle depreciation cost. Meanwhile, the cost on time consists of vehicle depreciation cost and maintenance cost.

(2) Time Cost

Time cost is defined as time evaluation for drivers and fellow passengers on private cars and bus passengers.

15.3 Running Cost

In this section, those factors concerned with running cost (on distance and time) are examined in detail.

15.3.1 Running Cost on Distance

(1) Fuel Cost

The price of fuel is shown in Table 15.1. Since fuel consumption rate would change according to running speed and gradient of highway, Table 15.2 shows fuel consumption rate with vehicle running speed of each vehicle type. Although calculation of the fuel consumption is based on RTIMS 2 Model, revising adjustment is made to consider high popularity of air-conditioners in Oman.

Fuel costs are calculated by following formula.

Fuel Cost = UCF x FC

where;

UCF = fuel cost per kilo meter shown in Table 15.1

FC = fuel consumption based on running speed shown in

Table 15.1 Economic Fuel Price

Unit : Bz/liter

Fuel Type	Gasoline	Diesel
Price	76.4	61.7

Note: Caltex Bahrain Posted Product Price
Source: Highway User Cost

Table 15.2 Fuel Consumption

(Litres/1,000 km)

Speed (km/h)	Vehicles Type						
	Cars	Light Goods	4-WD	Mini Buses	Medium Goods	Heavy Goods	Large Buses
5	282.5	282.5	282.5	353.6	615.1	534.8	668.5
10	157.7	157.7	157.7	226.0	328.7	285.3	357.3
15	117.0	117.0	117.0	184.1	235.9	205.1	256.4
20	97.8	97.8	97.8	163.8	192.4	167.3	209.1
25	87.5	87.5	87.5	152.5	169.5	147.4	184.3
30	81.8	81.8	81.8	145.7	157.6	137.0	171.2
35	79.1	79.1	79.1	141.7	152.4	132.5	165.6
40	78.3	78.3	78.3	139.6	152.0	132.2	185.2
45	79.0	79.0	79.0	138.8	155.2	134.9	168.7
50	80.8	80.8	80.8	139.0	161.3	140.3	175.3
55	83.7	83.7	83.7	140.1	169.9	147.8	184.7
60	87.5	87.5	87.5	141.9	180.7	157.1	196.4
65	92.0	92.0	92.0	144.3	193.5	168.3	210.3
70	97.3	97.3	97.3	147.8	208.1	181.0	226.2
75	103.3	103.3	103.3	150.7	224.5	195.2	244.0
80	109.8	109.8	109.8	154.7	242.6	210.9	263.7
85	117.0	117.0	117.0	159.1	262.2	228.0	285.0
90	124.8	124.8	124.8	163.9	283.4	246.4	308.0
95	133.2	133.2	133.2	169.2	306.1	266.2	332.7
100	142.2	142.2	142.2	174.8	330.3	287.2	359.0
105	151.7	151.7	151.7	180.8	356.0	309.6	386.9
110	161.7	161.7	161.7	187.3	383.1	333.1	416.4
115	172.3	172.3	172.3	194.0	411.6	357.9	447.4
120	183.4	183.4	183.4	201.2	441.6	384.0	480.0

(2) Oil Cost (Lubrication Oil)

Oil cost, as shown in Table 15.3 (1), and Table 15.3 (2) is calculated by oil consumption by kilometer considering relatively low significance of this elements tax is taken to be negligible and is ignored.

Table 15.3 (1) Lubricating Oil Price

(R.O./Liter)

Vehicle Type	Light Vehicles	Heavy Vehicles
Price	0.582	0.465

Table 15.3 (2) Lubricating Oil Price

(Liters/1,000 km)

	Vehicle Type						
	Cars	Light Goods	4-WD	Mini Buses	Medium Goods	Heavy Goods	Large Buses
Consumption	1.2	1.8	1.8	4.0	4.0	4.0	4.0

(3) Tire Cost

Tire cost is calculated by the price of tire and tire wear as shown in Table 15.4.

Table 15.4 Type Consumption

	Vehicle Type						
	Cars	Light Goods	4-WD	Mini Buses	Medium Goods	Heavy Goods	Large Buses
Tire Cost (R.O)	27.5	19.8	40.3	29.0	73.8	139.3	104.2
No. of Tires	4	4	4	6	6	18	6
Consumption (RO/km)	0.139	0.139	0.139	0.139	0.078	0.424	0.140

(4) Maintenance and repair cost

Maintenance and repair cost of the running distance is divided into two costs: material cost and labor cost. The material cost is calculated by RTIM Model which takes account of running distance, pavement, and gradient as the factors.

The labor cost for maintenance and repair is determined by working time per kilometer, which is calculated by RTIM 2, and hourly labor cost.

Table 15.5 (1) Spare Parts Cost

	Vehicle Type						
	Cars	Light Goods	4-WD	Mini Buses	Medium Goods	Heavy Goods	Large Buses
Vehicle Price (R.O)	5,901	4,068	7,864	9,153	9,023	37,465	46,948
Parts Cost (Bz/km)	13.0	9.2	21.9	29.2	25.4	67.9	21.0

Table 15.5 (2) Labour Cost

	Vehicle Type						
	Cars	Light Goods	4-WD	Mini Buses	Medium Goods	Heavy Goods	Large Buses
Labour Cost (Bz/km)	11.3	11.6	14.2	13.8	7.3	8.4	1.9

(5) Vehicle depreciation value

The cost of vehicle depreciation is considered as the vehicle cost excluding tire cost and scrap cost shown below. The scrap cost is assumed as 10 % of the difference of vehicle cost and tire cost, as shown below.

the cost of vehicle depreciation

= (vehicle cost) - (tire cost) - (scrap cost)

scrap cost

= (vehicle cost - tire cost) x 0.1

Vehicle depreciation value is considered in terms of "loss by distance" and "loss by time". Their component ratio assumes that loss by distance is 75 % while loss by time is 25 %. Table 15.6 shows vehicle depreciation value according to vehicle type.

15.3.2 Running Cost on Time

(1) Vehicle Time Cost

Vehicle time cost is a fixed cost for vehicle owner, which includes vehicle depreciation value, personnel expenses, interest cost, and indirect cost, as shown in Table 15.7. Vehicle time cost is calculated in each vehicle type by annual running time and pattern of use.

Table 15.6 Depreciation Value

Vehicle Type	Vehicle Cost R.O	Tyres R.O	Scrap R.O	Depreciable Cost R.O	Vehicle Life		Depreciation	
					Years	km	Time R.O/Yr	Use Bz/km
Cars	5,901	110	579	5,212	10	200,000	130	20
Light Goods	4,068	79	399	3,590	8	200,000	112	13
4-WD	7,864	161	770	6,933	6	240,000	289	22
Mini Buses	9,153	174	898	8,081	5	275,000	404	22
Medium Goods	9,013	440	858	7,722	8	280,000	241	21
Heavy Goods	37,465	2,506	3,496	31,463	12	660,000	655	36
Large Buses	46,948	625	4,632	41,691	10	870,000	1,042	36

Table 15.7 Vehicle Fixed Cost

Unit : R.O./Yr

Vehicle Type	Time Depr.	Crew Wage	Interest Chaggs	Vehicle Overheads	Total Fixed Costs
Cars	130	0	369	207	706
Light Goods	112	1,920	254	195	2,481
4-WD	289	1,920	192	526	3,227
Mini Buses	404	2,040	169	1,510	4,423
Medium Goods	241	2,040	361	1,037	3,679
Heavy Goods	655	3,360	2,146	7,323	13,484
Large Buses	1,042	2,220	2,690	5,324	11,276

Table 15.8 Vehicle Fixed Cost

Vehicle Type	Hours per Year	Total Fixed Costs R.O./Hr	Commercial Use %	Utilization Factor %	Vehicle Time Value R.O./Hr	Value of Maintenance Time R.O./Hr
Cars	1,200	0.589	20	50	0.06	0.12
Light Goods	1,800	1.378	80	40	0.44	1.10
4-WD	1,800	1.793	60	45	0.48	1.08
Mini Buses	3,250	1.361	90	80	0.98	1.22
Medium Goods	2,400	1.533	100	70	1.07	1.53
Heavy Goods	3,000	4.495	100	70	3.15	4.49
Large Buses	3,900	2.891	100	80	2.31	2.89

15.4 Time cost

Time cost of drivers and fellow passengers in private cars and bus passengers is calculated by the following items.

Time evaluation of personnel is assumed to be equal typical average wage by the working hour, and the value of non-working time is assumed as 25 % of the that of working time.

Therefore, hourly time values of working and non-working time are defined as follows.

Value of working time 1.00 R.O. (Average wage cost)
Value of non-working time 0.25 R.O.

Hourly vehicle time value is calculated in each vehicle type by the number of average passengers per vehicle and by the ratio of trip purpose to total trip. This time value of each vehicle type is shown in Table 15.9.

Table 15.9 Time Value by Vehicle Type

Vehicle Type	Commercial Use	Occupants	Passenger Journey Purpose		Value of Person Time Per Vehicle
	%		Work %	Non-work %	R.O./Hr
Cars	20	1.94	20	80	0.78
Light Goods	80	3.50	25	75	1.29
4-WD	60	1.94	25	75	0.81
Mini Buses	90	7.00	10	90	2.05
Large Buses	100	21.00	10	90	6.50

15.5 Economic Evaluation of the Alternatives

An economic analysis has been carried out to determine the economic feasibility of the construction of flyovers and pedestrian underpasses. The economic indicators used for this analysis are:

1) B/C ratio (benefit cost ratio)
2) EIRR (economic internal rate of return) and
3) NPV (net present value).

For the computation of these economic indicators, the following conditions are applied:

1) Project cost

   The economic cost of alternative plans is estimated in Chapter 13.4.

2) Construction period

   Construction periods of alternative plans is given in Chapter 14.4.

3) Project life

   20 years

4) Maintenance cost

   Maintenance cost is given in Chapter 14.5.

5) Discount rate

   12 %

15.5.1 Economic Evaluation of Construction of Flyover

Economic benefits derived from the construction of the flyovers are derived from time efficiency and running cost saving. Those factors examined in this chapter are applied for the Calculation.

Time Efficiency

As traffic volume increases, its speed decreases. And when it becomes close to the capacity of the facility, the speed decreases abruptly. But, the traffic using flyovers can enjoy smooth flow without stop. This kind of traffic phenomenon is simulated by the model which was used for traffic assignment. The total vehicle hours of each case are compared and then converted into monetary terms.

It is assumed that the future traffic volume after 2010 will increase slightly, because the Batinah Highway would already be fully loaded and other facilities such as the second Batinah Highway would be constructed.

Running Cost Saving

Reduction of travel length by construction of a flyover is small at 0.02 mile (32 meters), but multiplied by large amount of traffic volume it becomes a considerable amount. Running conditions such as reduction of speed, stop frequency etc. are also considered for the running cost saving.

The alternatives considered in the analysis are:

case 0 : no improvement will be carried out
case 1 : eight flyovers will be constructed by 2000

Case 0 is set up as a benchmark for the other cases of improvement.

The above mentioned economic indicators are as follows:

	economic cost (in thousands R.O.)	Benefit (in thousands R.O.)	IRR (%)	B/C	NPV
case 1	23,848	25,994	12.9	1.09	2.146

According to the results, the indicators show economical feasible. but, that they are not so high might be attributed to the fact that some R/A which were included as network policy do not contribute to raise up the indicators.

This analysis, however, is based on only traffic functions of flyovers. It should be noted that the benefits of this project will become greater if comfort and safety ensured on the flyovers, which are difficult to prove scientifically, are numerically considered as benefits.

15.5.2 Economic Evaluation of Construction of Pedestrian Underpasses

Lower speed regulation of 80 km/h or 50 km/h is currently posted where many pedestrians are crossing on Batinah Highway such as Al Bidaya and Al Tariff, and drivers are trying to slow down for the safety of crossing pedestrians.

Running speed is expected to rise if there are no crossing pedestrians on the carriageway after pedestrian underpasses are constructed. Moreover, there is additional running speedup by deregulation of speed limits which, however, is not considered in this analysis.

According to the sampling survey at Al Bidayah, average vehicle running speed is 84 km/h, while vehicles which are not obstructed by crossing pedestrians are running at speed of 89 km/h.

This analysis assumes that benefits are derived from the speed-up of running vehicles by the construction of underpasses, which segregate obstructing pedestrians from highway traffic.

	economic cost (in thousands R.O.)	Benefit (in thousands R.O)	IRR (%)	B/C	NPV
case 1	1,055	915	10.4	0.87	-140

According to the results, neither case is feasible, however, this analysis does not consider some vague but important factors such as pedestrians' waiting time for crossing or reduction of traffic accidents. With increasing future traffic volume, segregation between pedestrians and vehicular traffic is crucial for Batinah Highway.

Especially at Al Bidayah, where many pedestrians are crossing, and at Al Tarif, where visibility is bad, the construction of flyovers is urgently needed.

15.5.3 Sensitivity Analysis

The economic indicators are further examined by the sensitivity analysis, by changing the conditions from which they are derived.

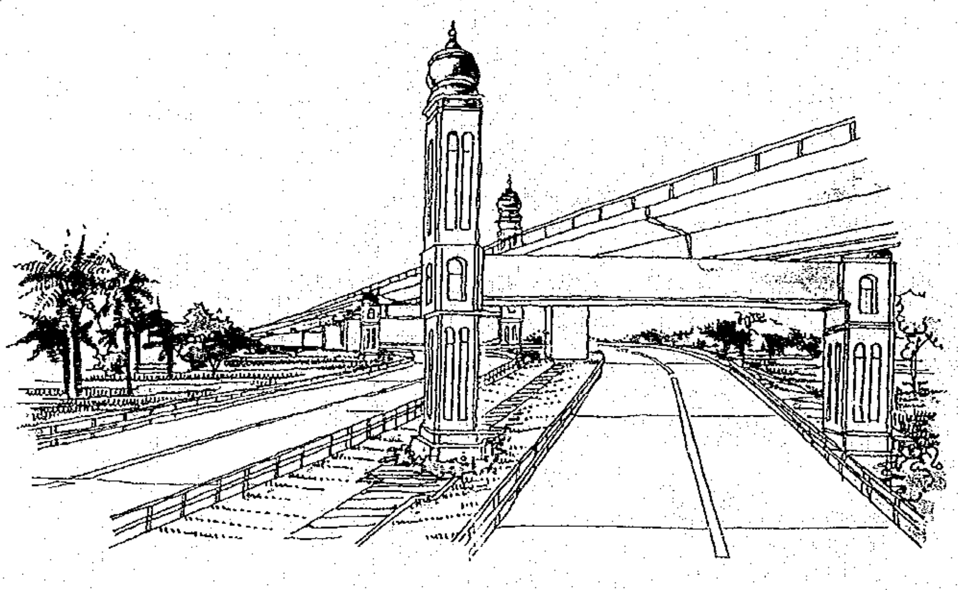
The changing factors considered here are

construction cost ±10 %
traffic volume ±10 %

		IRR			B/C		
		Traffic Volume			Traffic Volume		
		+10 %	0 %	10 %	+10 %	0 %	10 %
Construction Cost	+10 %	16.2	11.9	8.3	1.50	0.99	0.68
	0 %	17.2	12.9	9.2	1.65	1.09	0.75
	10 %	18.4	13.9	10.2	1.83	1.21	0.83

According to the table, traffic volume has more influence on sensitive indicators than construction cost has. As regards to traffic volume, increasing traffic volume changes indicators more than decreasing volume. In the most favourable case, EIRR rises up to 18.4 % and B/C to 1.83, but in the adverse case EIRR becomes 8.3 % and B/C becomes 0.68.

CHAPTER 16 CONCLUSION AND RECOMMENDATION



CHAPTER 16

CONCLUSION AND RECOMMENDATION

16.1 Conclusion

16.1.1 Necessity of the Project

There are many benefits of this project which are important for the development of local communities as well as the economy of the Batinah region. The grade separation of roundabouts ameliorates traffic function by reducing accidents involving pedestrians or between vehicles, as well as creating a safer driving environment for higher-speed traffic. Furthermore, the construction of pedestrian underpasses not only integrates communities separated by the highway, but will ease highway crossing particularly for the elderly and children.

Most importantly, however, with the construction of these two types of facilities, the following roles may be considered as the most important of all:

- The strengthening of intercity infrastructure and development of an economic sphere centered in Muscat, not to mention inclusion in the larger economic sphere of the Gulf. Thus, the Batinah region would better realize its potential as a role-player in the Sultanate's development.

- Within the Batinah region, communities on both sides of the highway could form new social and economic relations. Integration of communities could also promote growth on a wider scale.

16.1.2 Future Traffic Volumes

Present traffic volume on the Batinah Highway decreases as one gets further from Muscat. For example, Bait Al Barakah Roundabout reaches approximately 20,000 vehicles per day in traffic while Aqr Roundabout remains at approximately 5,000 per day. This demonstrates the gravitational effect Muscat has in the area.

According to results of an analysis on the social and economic framework. The population of Batinah region in the year 2010 will reach 808,000, or approximately 1.39 times the 1990 population. At the same time, with the number of registered automobiles growing at a rate of 7.9 % a year, it is predicted that their number may reach 975,000 by 2010, or an overall increase rate of 3.6 %.

Traffic volume along the Batinah Highway is growing at a rate of 4.66 % yearly. However, population and automobile registration statistics are growing at an even greater rate: furthermore, increases in per capita mobility are also predicted. The amount of predicted overall traffic volume was calculated by taking the average of the yearly traffic volume growth rate (4.66 %) and yearly growth rate of automobile registration (7.9 %), which comes out to 6.28 %. The final figure of 210,000 vehicles predicted for 2010 is nearly triple the figure of 69,000 vehicles for 1993.

Translating this into volume per traffic circle on the Batinah Highway, Bait Al Barakah Roundabout would receive approximately 59,000 vehicles per day, while Aqr Roundabout would receive about 16,000. Many of the roundabouts as they exist at present, particularly ones with high volumes of cross traffic, would not be able to accommodate such traffic volume efficiently.

16.1.3 Grade Separation

(1) Types of Grade Separation

a. Four Basic Types of Grade Separation

There are four basic patterns for grade separation of roundabouts. These four proposed types satisfy driving conditions of the Batinah Highway and have been assigned to each roundabout according to its character (size and shape of monument, surrounding land usages, etc.). The four basic patterns of grade separation are shown in Table 7.2.

b. Proposal of Grade Separation Type by Roundabout (18 Locations)

Types of grade separation for each roundabout along Batinah Highway, considering the above-mentioned characteristics as well as scenic value, are proposed in Table 7.3.

(2) Selection of Highway-Priority Locations for Grade Separation Facilities

Among the eighteen roundabouts, certain locations were selected as demanding more attention than others in regards to priority of construction. Such prioritizations were based on the following list of evaluation standards. Eight locations which were selected as a result are presented in Table 7.23.

a. Batinah Highway's traffic volume at the point of the roundabout
b. Traffic-handling capability of roundabout at point of entrance
c. Role in the road network
d. Role in local community integration
e. Supporting role in development plans

(3) Design Overview

a. The Batinah Highway was designed for speeds (V) of V = 120 km/h. Interchange ramps will be designed for speeds of 80 km/h in consideration of vehicles which will be existing to and entering from connecting roads.

b. Based on forecasts of future traffic demands, the number of necessary lanes along the Batinah Highway will for the time being remain at four. The number of lanes for ramps will be one per direction at each roundabout, with the exception of the ramp connecting National Route 13 with Muscat-bound lanes on the Batinah Highway (Barka Roundabout), which will be two lanes.

c. Change in Roundabout Shape

The roundabouts at present are all designed in an elliptical shape to accommodate traffic traveling along Batinah Highway, but this will be changed to a circular design with construction of grade separation.

d. Bridge Planning

Bridge planning was conducted applying the design standards formulated by the Government of Oman, and considering existing construction conditions.

The main planning items are listed below:

-	Design live load:	AASHTO HS-20 x 2, or 60-ton truck weight load.	
-	Superstructure design:	Simple box-beam bridge of pre-stressed concrete.	
-	Standard span length:	20 m	
-	Substructure design:	abutment;	reinforced concrete reversed T-type
		piers;	Same as above or rigid frame π shape pier
-	Foundation:	Reinforced concrete piles, 500 x 500 square	

e. Regulating Conditions to be Considered in Planning Grade Separation

1) Planned area should be retained within present right-of-way as much as possible.

2) Emphasis to be placed on scenic value.

16.1.4 Pedestrian Underpasses

(1) Candidate Locations for Pedestrian Underpasses

The users of the underpasses will be a limited number of people living and/or working along the Batinah Highway; mostly those within walking distance of the underpass itself. This distance is assumed 200 m.

Forty different locations have been chosen as candidates for underpasses, in consideration of inhabited area mass within a 200 m sphere as well as presence of school, mosque, etc.

(2) Selection of Highway-Priority Locations for Pedestrian Underpasses

Among the forty locations chosen in Table 8.1, those with communities on both sides of the highway and those with schools nearby were selected, while those in proximity to a priority roundabout were omitted, leaving twelve high-priority locations. According to the plan, locations which coincide with priority grade separation roundabouts will be provided with crossings under the ramps at ground level. The twelve priority locations for underpasses are shown in Table 8.2.

(3) Design Overview

The structures will be planned according to existing design standards see by the Government of Oman.

Dimensions of internal section of underpass: 3,000 x 3,000.

16.1.5 Environmental Impact

This project is basically amelioration project of existing highway; therefore it will not be cause of major impact on natural environment such as geophysical condition and flora and fauna against a peripheral area of Batinah Highway.

This project is to improve a running condition of Batinah Highway and deemed to contribute reduction of pollutant exhaust.

However, impact of atmospheric pollution that faces a peripheral area are thought about, as a estimated traffic volume is quite large, approximately 60,000/day. Therefore monitoring station is recommended to be facilitated to monitor a contamination condition. As for socio-economic environment there might be a relocation of a highway peripheral resident but at this stage of preliminary design the influence can not be determined exactly. In future, at a detail design stage, geometric design of flyover will be so made to minimize the influence to relocation of the dweller along the highway.

16.1.6 Aesthetics

Roundabouts and junctions have been landscaped by government authorities with several impressive monuments and gardens along the Batinah Highway. Construction of grade separation facilities at these locations may have adverse effects on landscape aesthetics. In order to minimize negative impact on the landscape, a number of grade separation types (A, B, C, D) have been established and assigned according to appropriateness in each site, evaluated in terms of aesthetics, function, and structure.

(1) Evaluation According to Basic Structure Type

The amount of negative impact a grade separation may have on existing monuments differ depending upon size, height, length and/or direction of the monument itself. For example, monuments which are relatively low but with some width are more affected by the number of piers rather than the entire bridge itself, while a monument whose appeal depends upon its height will be more aesthetically affected by the thickness of the bridge's superstructure. As drivers tend to grasp the structure from afar, the overall visual effect will depend upon the width between the separated carriageways. Considering these points and others, four patterns have been formulated according to environmental factors.
Type A, B, C, D

(2) Three Major Factors Considered in Structural Planning

- Planning should be conducted with consideration of the balance between superstructure and substructure.

  The balance between bridge length and thickness of superstructure (including handrailing), as well as the balance between the thickness of the superstructure and height of piers should be considered. In other words, it is most important to impress the thickness of superstructure by visually.

- Consider substructure design

  The substructure is especially important designwise, as it is the part of the entire structure which is most apparent to the surrounding area. Piers which are long and slender would be the most recommended structural factor, these arranged in a fashion that would most effectively bring out the beauty of the monument.

- Consider aesthetic design for the retaining walls

  The retaining wall is of substantial length, and often carries a monotonous image. To soften this image, a harmonious and flowing design needs to be considered.

  See recommendation in Table 7.3.

16.1.7 Traffic Safety

Although the incidence of traffic accidents in Oman has gone down after peaking in 1985, but still there are 11,754 accidents occurred in 1993. A great number of these occur in the Batinah region, which includes the Batinah Highway. The most common causes of these accidents have been speeding, negligence, and poor driving, which together make up 90 % of the cases. Accidents involving pedestrians are not unusual: children under the age of ten are the most common victims.

The number of accidents at different roundabouts are shown in Table 7.25 in order of frequency. Roundabouts with high numbers of accidents are, in turn, high-priority locations. Although there is no exact data available on numbers and locations of accidents involving pedestrians along the highway, on-site surveys indicated that immediate attention is required for procuring pedestrian crossing at Al Bidayah and Al Tarif. Other places with high traffic volume share similar situations, indicating urgency of facility construction at such locations.

16.1.8 Project Cost

The project cost of the eight (8) priority roundabouts and twelve (12) priority underpasses is shown below, estimated at 1993 prices.

Grade Separation Project Cost

(Financial Cost Unit: 1,000 RO)

Type of Cost	R/A-2	R/A-3	R/A-5	R/A-8	R/A-10	R/A-12	R/A-14	R/A-18
Construction Cost	2,992	3,048	2,979	3,146	3,177	3,428	3,438	2,565
Contingency	299	305	298	315	318	343	344	257
Design & Supervision	329	335	328	346	349	377	378	282
Land Acquisition	3	0	4	5	5	13	72	194
Project Cost	3,623	3,688	3,609	3,812	3,849	4,161	4,232	3,298

Pedestrian Underpass Project Cost

(Financial Cost Unit: 1,000 RO)

Type of Cost	P/U-1	P/U-2	P/U-3	P/U-4	P/U-5	P/U-6	P/U-7	P/U-8	P/U-9	P/U-10	P/U-11	P/U-12
Construction Cost	95	101	92	100	94	94	97	97	94	95	88	92
Contingency	9	10	9	10	9	9	10	10	9	9	9	9
Design & Supervision	10	11	10	11	10	10	11	11	10	10	10	10
Project Cost	115	122	111	121	114	114	117	117	114	115	106	111

16.1.9 Economical Conclusion

The economic analysis calculated the Internal Rate of Return, Net Present Value and Cost Benefit Ratio according to the Cash-Flow method which is a standard method employed; to lean the effects of the charge in traffic flow after construction of flyover. The Quantitative economic benefit is the saving benefit of combining vehicle operating cost and vehicular time.

The results of the analysis indicate that the project is feasible from an economic viewpoint.

Economic Internal Rate of Return (EIRR) : 12.9
Net Present Value (NPV) : 2,146 (1,000 RO)
Cost Benefit Ratio (B/C) : 1.09

Further more, according to a sensitivity analysis in which construction costs and traffic volume were raised or lowered by 10 %, the following results were obtained. When the construction costs are raised the economic index decreases, and when the traffic volume is raised the economic index rises as well. The best combination of construction costs and traffic volume would be EIRR at 18.4 % and B/C at 1.83 %, while the worst combination would be EIRR at 8.3 % and B/C at 0.68 %.

A feasibility study was also conducted for underpasses in the same manner as for flyovers, but no cases were deemed economically sound. However, this analysis took only traffic functions into consideration, so this project is delivered to hold sufficient merit out when the safety of pedestrians is considered.

16.2 Recommendation

16.2.1 Actualization of Project

The results of this survey indicate that this project is feasible both from a technological viewpoint we well as an economic one. Aside from the direct benefits to be gained by the region as a whole, a number of indirect benefits are also expected to bolster the economy of the Batinah region. Judging from the EIRR value, financial feasibility is not necessary high, but there are sufficient expectations towards indirect benefits coming out of the actualization of the project. We hereby propose the priority actualization of grade separation for the following roundabouts: Barka Roundabout, Sohar Roundabout, Al Muladdah Roundabout, Saham Roundabout, and Naseem Garden Roundabout. All of these locations are expected to become overcrowded within the next few years and demand priority actualization.

An analysis was also conducted for underpasses in the same manner as for flyovers, but they were not deemed economically sound. However, this analysis took only traffic functions into consideration, so this project is believed to hold sufficient merit out when the safety of pedestrians is considered.

[Effects of the Project]

Grade separation of the roundabouts will not only ameliorate traffic function by promoting safer high-speed travel, but will also reduce accidents among vehicles and pedestrians, more closely integrate communities on either side of the Batinah Highway, will guarantee safe crossing for children and the elderly. All of these factors will work together to improve the quality of life in the region. Furthermore, accompanying the construction of these two types of facilities, fulfillment of the roles described below will also be attained:

- Straightening of the intercity infrastructure, further development of economic sphere centered in Muscat, strengthening of transportation network with neighboring countries, increasing Batinah region's potential as an important role-player in the development of the Sultanate.

- Forming of new economic and social relations of communities on both sides of the highway.

- Widened social and economic integration of communities on both sides of the highway.

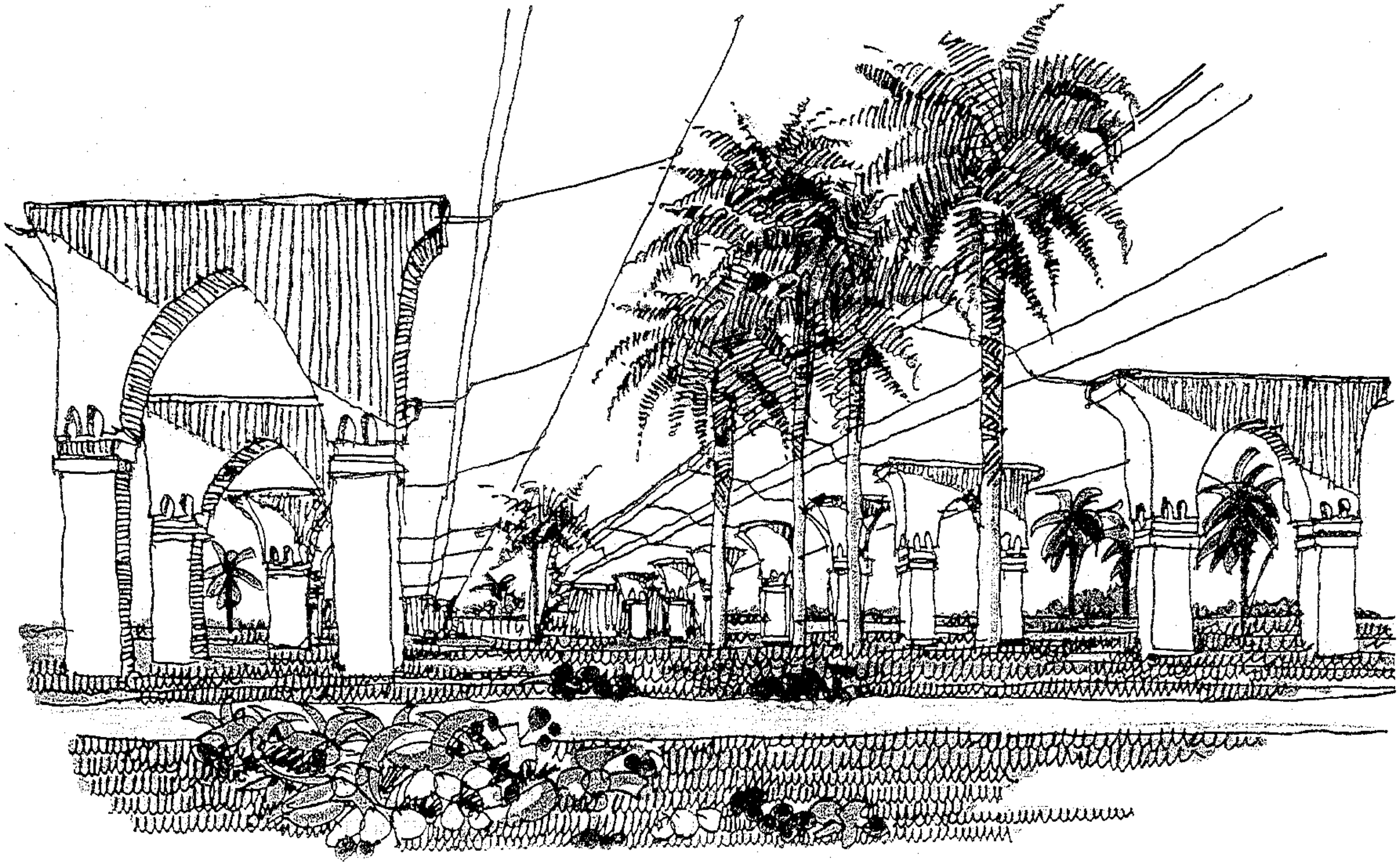
16.2.2 Aesthetic Considerations

There are countless monuments along the Batinah Highway apart from the roundabouts, which would be impossible to ignore when considering the aesthetics of planning various facilities. In conjunction with this project, it is necessary to not only consider monuments as landmarks for drivers, but also whether they are objects acceptable to residents of the community.

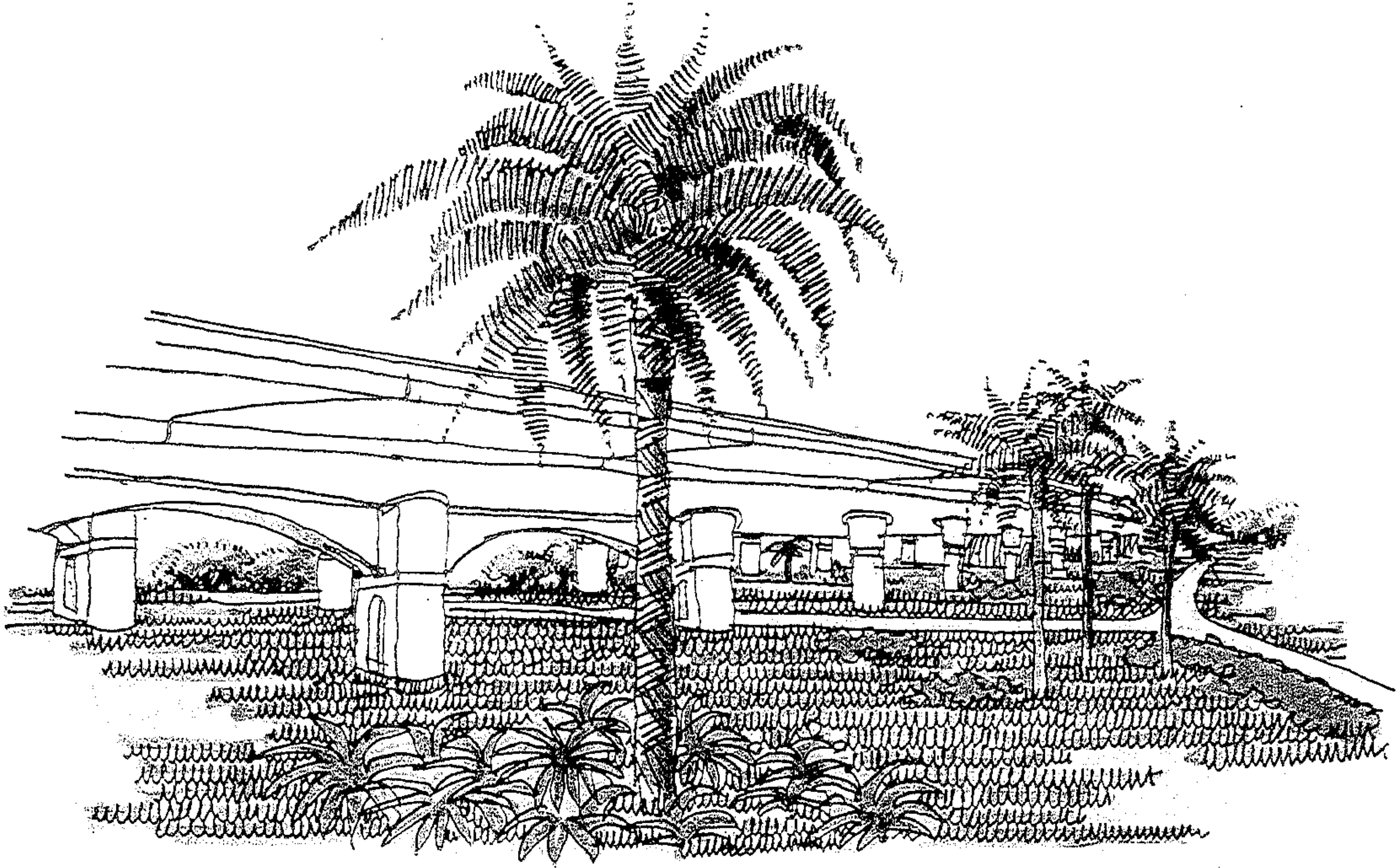
The preliminary design of the Flyover in this study was conducted with major concern placed upon the selection of structure scale and economic analysis. We propose to place greater weight on the aesthetic considerations in planning when conducting the detailed design.

At that time, superstructure and substructure of flyovers will be designed according to Islamic cultural themes. As reference, we have conducted drafts of five proposals as follows.

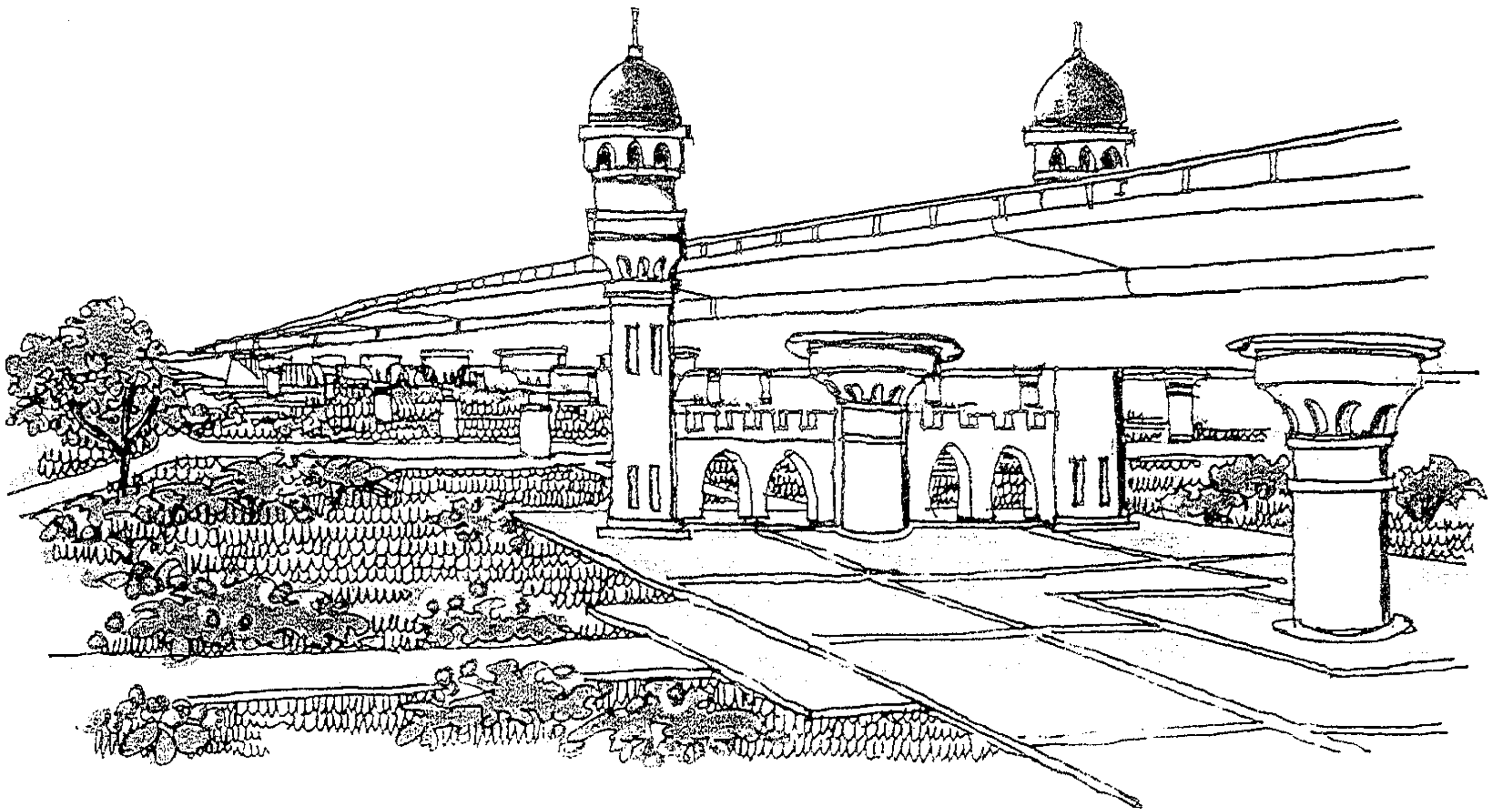
- Islamic arch-type and single-column piers
- Ornamental arch at center of Roundabout and single-column piers
- Single-column piers with gate-type monument
- New roundabout symbol and single-column piers
- Islamic arch-type piers



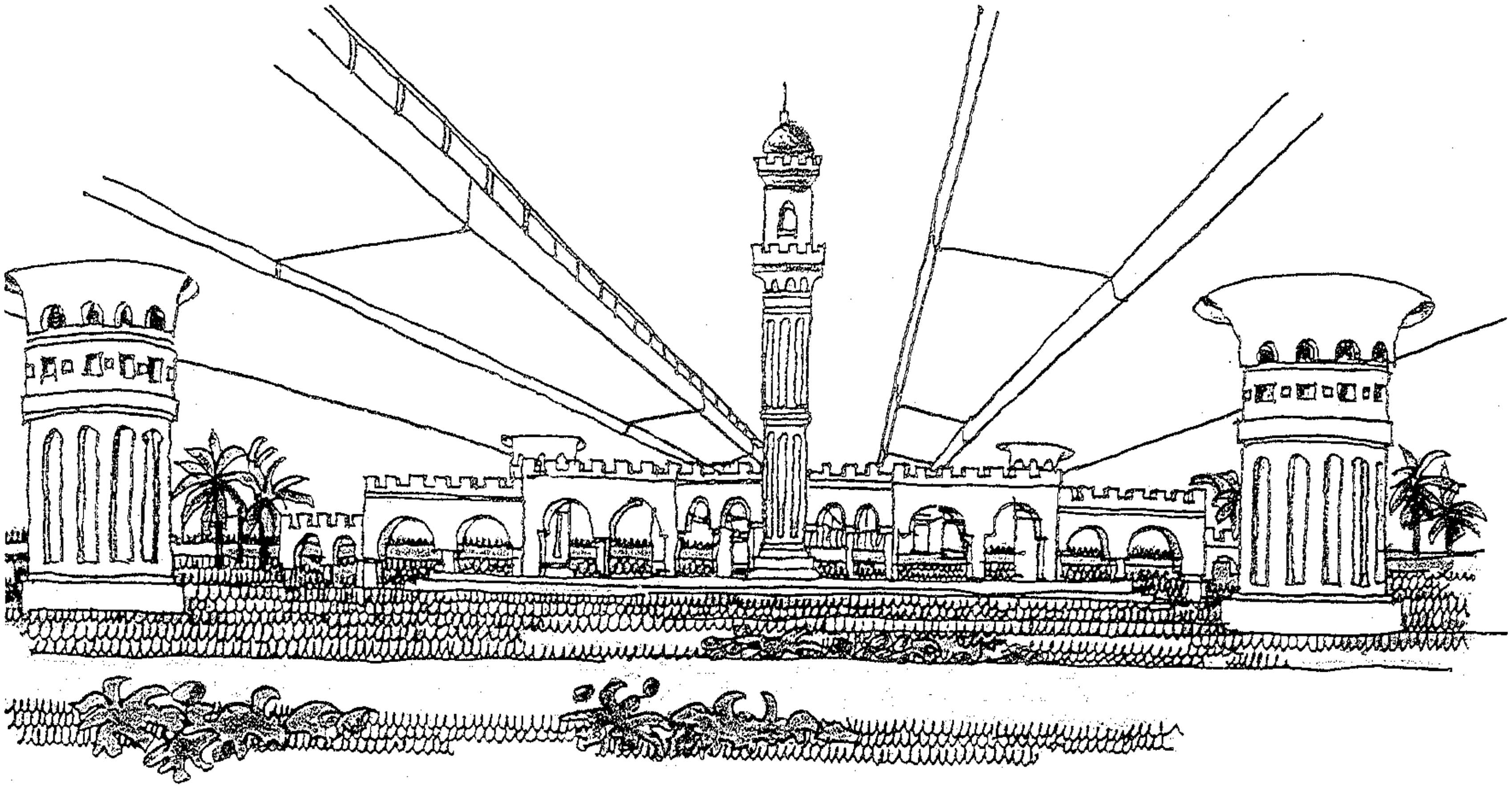
ISLAMIC ARCHES AND SINGLE COLUMN PIERS



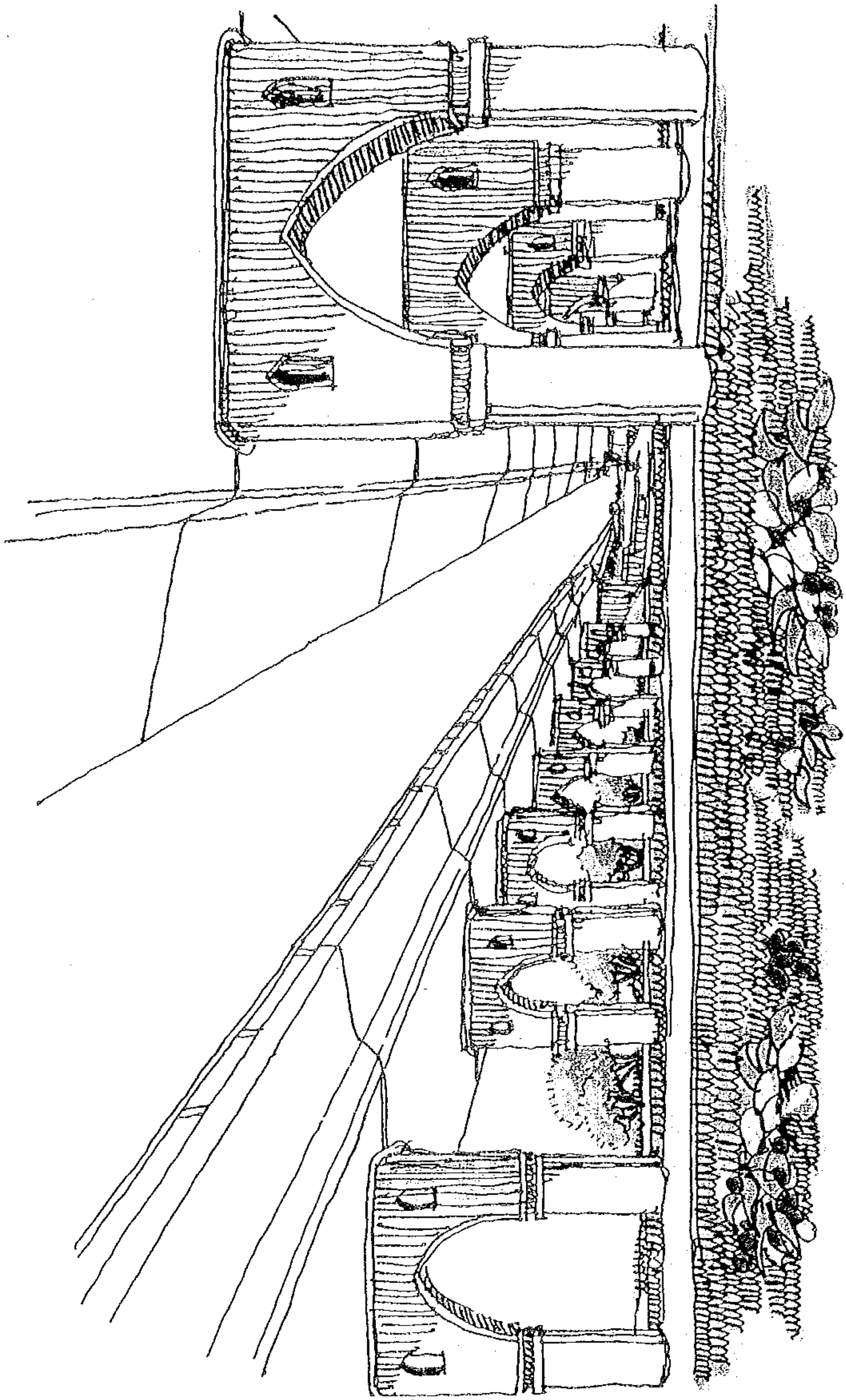
ORNAMENTAL ARCHES AT CENTER OF ROUNDABOUT AND SINGLE COLUMN PIERS



SINGLE COLUMN PIER WITH GATE TYPE MONUMENT



NEW ROUNDABOUT SYMBOL AND SINGLE COLUMN PIERS



ISLAMIC ARCH TYPE PIERS

16.2.3 Consideration for Implementation of Detailed Design

Consideration of the situation of facilities, manpower, etc. in Omani as expressed in the following items; is necessary upon implementation detailed design for the project:

- Number of available engineers and their capabilities; e.g., construction management, quality control, etc.
- Present situation of available materials, equipment, and facilities in Oman.
- Facilities and capabilities of domestic contractors
- Climatic conditions
- Relationship between economic feasibility and aesthetics (monuments, etc.)
- Future situation of bridge design and construction technology in Oman; consideration of design standardization.

16.2.4 Overall Traffic Operation of the Batinah Highway

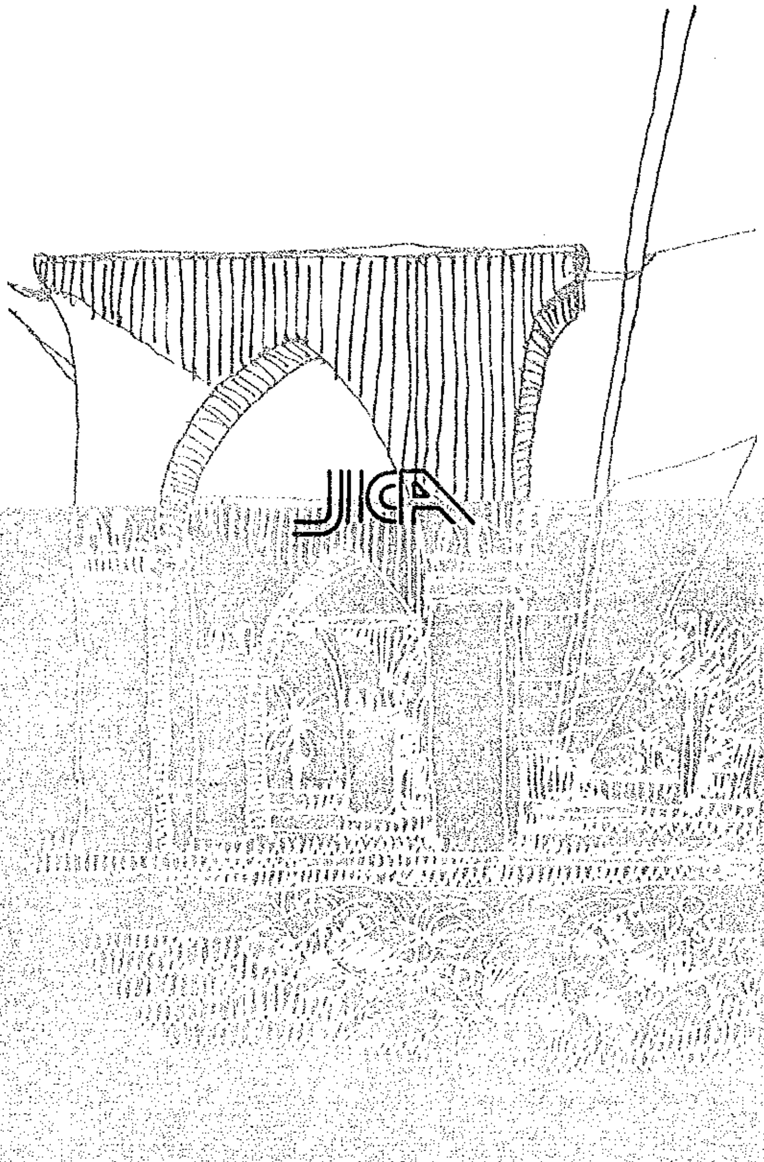
1) Amelioration of Irish Crossings

Areas which experience high frequency of inundation should be provided with culverts and/or bridges. Other areas should be provided with flood-warning systems.

2) Amelioration of Intersections

Communities along the Batinah Highway need access to it in the forms of intersection and left-turn lanes, which are provided as openings in the median. However, the vehicles using these intersection facilities easily miscalculate the speed of oncoming vehicles along the highway, which makes for an extremely dangerous situation.

To improve this situation, at certain intervals or at major communities, the pedestrian underpass could be widened to accommodate vehicles if deemed appropriate. The possibilities of placement of such a facility should be seriously considered.



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