landscape layout of the roundabout shall be established in accordance with design of flyover structure. However some of the original design components and materials would be better reused if possible.

(5) New Establishment of the Roundabout Monument

Some of the roundabout and junction areas are on plane ground, and awaiting establishment of roundabout landscaping with some symbolic monument for the local vicinity areas.

For such roundabouts and junctions, flyover structure design may be considered to meet establishment of new individual monuments on the sites. Major objective of landscaping of the areas may be proposed that these flyovers themselves come to be aesthetic landmarks with some design elements reflecting new landscape design concept.

7.2.4 Evaluation of the Comparative Types A, B, C and D

The comparative Types A, B, C and D will be evaluated from their aesthetics, road alignment, roundabout configuration, and support column arrangement.

(1) Basic Aesthetic Consideration of Flyover Types

Following are 4 types of flyover classification in accordance with 5 categories of landscape consideration and monument criteria.

Landscape analysis and study for flyovers at roundabouts and junction is shown in Table 7.3 (1) ~ 7.3 (2).

① Flyover Type-A

Flyover Type-A will be formulated in a straight overpass over the center of the roundabout or junction. This is the lowest priority for the preservation criteria on the existing monument and roundabout. The construction of flyover will chiefly directly affect landscaped areas. Therefore major landscaped objects must either be relocated or rearranged in order to fix the new layout of the roundabout and flyover structure.

Table 7.3 (1) Landscape Analysis and Study for Flyover at Roundabouts and Junctions

R/A & JN	Location	Monument and Landscape Components at R/A and JN					Vicinity Landscape Components			Flyover Type Consideration				Recommended Flyover Type
	Super-intendency	Characteristics	Direction	Dimension	Perception	Visibility	Characteristics	Locality	Continuity	Type-A	Type-B	Type-C	Type-D	
R/A-1	Bait Al Barakah (M.M)	Traditional Omani citadel arch gate	All directions	H = 12.1 m W = 12.0 m L = 12.0 m	Distinctive monument silhouette	Clear vertical	Flat dry land, Date palms row on the road side, view to Mt.	Even at seaside, Mt. side	Omani arch design element	-	-	* Mt. side	*	Type-D (Type-C)
R/A-2	Maseem Garden (M.P.E.)	Plane ground, Paved sidewalks (Garden reserve site)	-	-	Horizontal expansion	-	Flat dry land, Date palms and groves at medium distance	Habitat at seaside	Palm grove, Arch-type design	*	-	-	-	Type-A
R/A-3	Barka (M.P.E.)	Flat garden and water fountain	All directions	H = 0.5 m W = 15.0 m	Level to downward view	Lower horizontal	Small township with canopy trees	Habitat at seaside	Green and plants	*	*	-	-	Type-A or (Type-B)
R/A-4	Masna'ah (M.P.E.)	Rock piled mound with animal sculptures on the flat garden	All directions	H = 2.5 m W = 15.5 m L = 16.5 m	Level to downward view	Lower horizontal	Flat land with palm grove at Mt. side	Township at seaside	Good view to Mt side	*	*	-	-	Type-B
JN-5	Al Muladdah (M.P.E.)	Plane ground (Garden reserve site)	-	-	Horizontal expansion	-	Township on Mt. side Groves at seaside	Mt. side	Green elements	*	-	-	-	Type-A
R/A-6	Wudam As Sahil (M.P.E.)	Dhow on the water and flat garden surroundings	Dhow faces to the sea	H = 20.0 m W = 15.0 m L = 31.0 m	Distinctive monument silhouette	Clear vertical horizontal	Township on seaside	Township at seaside	Green or horizontal elements	-	-	* Mt. side	*	Type-D or (Type-C)
R/A-7	Suweiq (M.P.E.)	Flower garden on the slight mounded green	All directions	H = 2.0 m Ground level	Level to downward view	Lower horizontal	Township on seaside	Even at both side	Green and flower elements	* Shade prov.	-	-	-	Type-A
R/A-8	Khaburah (M.P.E.)	Green mound with flower bed	All directions	H = 2.0 m Ground level	Level to downward view	Lower horizontal	Township on seaside Groves at Mt. side	Township at seaside	Trees and Palms	* Shade prov.	-	-	-	Type-A
R/A-9	Al Hijari (M.P.E.)	Plane ground	-	-	Horizontal expansion	-	Township on seaside	Even but rather seaside	Trees and Palms	* Shade prov.	-	-	-	Type-A
R/A-10	Saham (M.P.E.)	Mounded garden with shrubs and medium trees	All directions	H = 2.0 m Ground level	Level to downward view	Lower horizontal	Township on seaside	Even but rather seaside	Trees and Palms	* Shade prov.	* Dawn view	-	-	Type-A or (Type-B)

Note: (M.M.) Muscat Municipality
(M.P.E.) Ministry of Provincial Municipality and Environment

Table 7.3 (2) Landscape Analysis and Study for Flyover at Roundabouts and Junctions

R/A & JN	Location	Monument and Landscape Components at R/A and JN					Vicinity Landscape Components			Flyover Type Consideration				Recommended Flyover Type
	Super-intendency	Characteristics	Direction	Dimension	Perception	Visibility	Characteristics	Locality	Continuity	Type-A	Type-B	Type-C	Type-D	
R/A-11	Suweyhrah (M.M.)	Monument of row of palms and water element. Oasis design concept	All directions	H = 12.0 m W = 28.0 m L = 28.0 m	Distinctive monument silhouette	Clear vertical horizontal	Many groves on seaside Access to Sohar	Even but rather seaside	Palms and groves	-	*	* Mt. side	-	Type-C or (Type-B)
R/A-12	Sohar (M.M.)	Blueish globe on the top of triangle tower/Now monument is proposed by Muscat Munic.	All directions	H = 12.3 m W = 12.3 m L = 12.3 m /H=40 m	Light structure silhoette	Clear vertical	Township with much groves on seaside	Seaside	Tree groves	-	*	-	*	Type-B or (Type-D)
R/A-13	Sallan (M.M.)	Islamic Omani designed observation dome on the air and water fountain	All directions	H = 12.0 m W = 20.1 m L = 20.1 m	Distinctive monument silhouette	Clear vertical	Wadi and flat land Expansion of groves	Even but rather seaside	Omani islamic feature	-	*	* Mt. side	-	Type-C or (Type-B)
R/A-14	Falaj Al Qabail (M.M.)	Rock hill with waterfalls and wild animal sculptures on the flat garden	Rock faces to the sea	H = 4.5 m W = 8.0 m L = 15.0 m	Omani nature	Vertical horizontal	Township on both sea and Mt. side. Groves continuity	Even at both side	Horizontal expansion of green	-	*	* Mt. side	-	Type-B or (Type-C)
R/A-15	Majis (M.M.)	Plane ground (Garden reserve site)	-	-	Horizontal expansion	-	Savanna type dry land expansion and Industrial estate at Mt. side	Even at both side	Green elements	*	-	-	-	Type-A
R/A-16	Liwa (M.P.E.)	Monument of white horse on the terraced green	Horse faces to the sea	W = 5.0 m H = 2.5 m W = 10.0 m	Focal statue	Horizontal	Savanna type dry land expansion and wadi	Seaside	Horizontal green elements	*	-	* Mt. side	-	Type-C or (Type-A)
R/A-17	Shinas (M.P.E.)	Grove on stone paved mound and water fountains	All directions	H = 2 + 5 m W = 25.0 m L = 30.0 m	Green grove	Soft horizontal	Township on seaside	Even but rather seaside	Canopy trees and palms	-	*	-	-	Type-B
R/A-18	Aqr (M.P.E.)	Group planting of Shrubs on the terraced green	All directions	H = 3 + 2 m W = 17.0 m L = 30.0 m	Green expansion	Soft horizontal	Township on seaside Savanna type dry land expansion at Mt. side	Even at both side	Horizontal green or focal trees	-	-	* Mt. side	-	Type-C

Note: (M.M.) Muscat Municipality
(M.P.E.) Ministry of Provincial Municipality and Environment

There are other areas for flyover Type-A, which have no existing objects in the roundabout areas but spaces reserved for future landscape. In this case, flyover Type-A will become a new landmark for the vicinity area.

② Flyover Type-B

This is the next lowest priority after Type-A, for preserving a monument at the roundabout. Flyover will be shifted to the one side of the monument.

If monument will be situated under the proposed alignment of the flyover, some portion of the monument will be adjusted to relocate to other place in the roundabout area, and will be rearranged closely to the original layout features of the monument composition.

③ Flyover Type-C

This is the next highest priority after Type-D, for preserving the monument at the roundabout area. Flyover shall be shifted to one side of the monument and the other side will be open to view.

If some portion of the monument will be situated under the proposed alignment of the flyover, that portion of the monument will be relocated to other place within the roundabout area and will be kept in harmony with the original condition of the monument composition.

④ Underpass Type-D

Type-D is proposed as the underpass structure. This type of underpass will be considered when the monument of the roundabout is quite significant and important, and these monuments should be preserved with the highest priority.

Existing scenic conditions and aesthetics of monument and roundabout area will be recognized from all directions. Panoramic view of the site will have important value, and no other obstructing objects should appear around the original monument and surrounding view.

Scenic continuity of the monument and its vicinity are worthy of preservation as the monument itself has become a landmark on the vicinity area.

(2) Evaluation from the Road Alignment Viewpoint

The curve radius of the Batinah Highway surrounding the existing roundabouts are presented in Table 7.4. This table indicates that the curve radius varies from R = 1,000 m to R = 20,000 m. The vertical alignment of Batinah Highway is fairly flat.

From the viewpoint of alignment consideration, there may be no problems to make the grade separation.

Table 7.4 The Relation of Roundabout Site to Horizontal Radius

Roundabout Location	Curve Radius (m)	Roundabout Location	Curve Radius (m)
R/A-1	R = 5,000	R/A-10	R = 4,800
R/A-2	R = ∞	R/A-11	R = 5,000
R/A-3	R = ∞	R/A-12	R = 1,500
R/A-4	R = 20,000	R/A-13	R = 1,000
R/A-5	R = ∞	R/A-14	R = 1,250
R/A-6	R = 20,000	R/A-15	R = ∞
R/A-7	R = ∞	R/A-16	R = ∞
R/A-8	R = ∞	R/A-17	R = ∞
R/A-9	R = ∞	R/A-18	R = ∞

(3) The Configuration of the Roundabout

In order to accommodate smooth flow of the traffic on the Batinah Highway, the shape of the roundabouts are elliptical in shape (long radius 140 m, short radius 80 m). It will not be necessary to retain this configuration for the grade separation facility, therefore it is recommended to make the roundabout circular to improve traffic flow.

The radius of the simple circle on each roundabout is fixed by following items.

: To plan within right of way limit
: To accommodate the span of the grade separation facility

(4) The Pier for the Grade Separation Structure

In making plans for the pier of the grade separation structures within the roundabout, consideration should be given to the monuments, fountains, sodding, and pump rooms. The following consideration should be made in planning the piers within the roundabout:

- when dealing with roundabout aesthetics, prevent the pier from blocking view of the monuments.

7.3 Selection of Grade Separation Facility within Roundabout

The recommended types are shown below. There are 8 Type A, 4 Type B, 3 Type C, 2 Type D, and 1 Special Type, for a total of 18.

The selection of the type of grade separation will be given as shown in Table 7.5 to Table 7.21.

Intersection	Name	Recommended Type
R/A-1	Bait Al Barakah	D
R/A-2	Naseem Garden	A
R/A-3	Barka	A
R/A-4	Masna'ah	B
R/A-5	Al Muladdah Junction	A
R/A-6	Wudam As Sahil	D
R/A-7	Suweiq	A
R/A-8	Khaburah	A
R/A-9	Al Hijari Junction	A
R/A-10	Saham	A
R/A-11	Suwayhrah	C
R/A-12	Sohar	B (D)
R/A-13	Sallan	C
R/A-14	Falaj Al Qabail	B
R/A-15	Majis	A
R/A-16	Liwa	C
R/A-17	Shinas	B
R/A-18	Aqr	Special

Note: ( ) indicates second priority

Table 7.5 SELECTION OF FLYOVER (R/A-1)

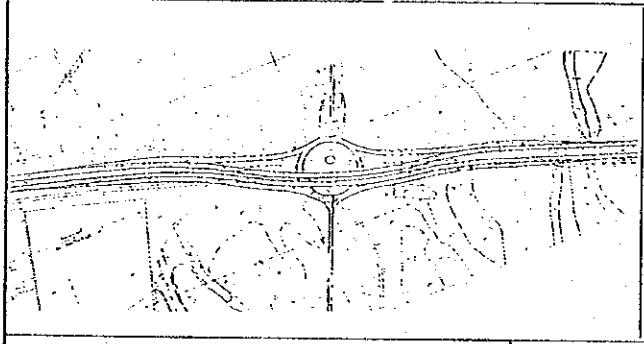
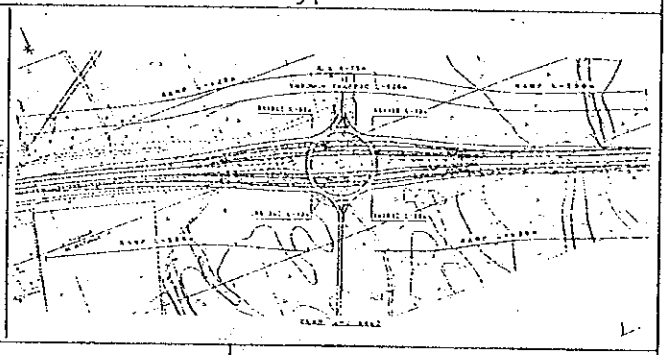
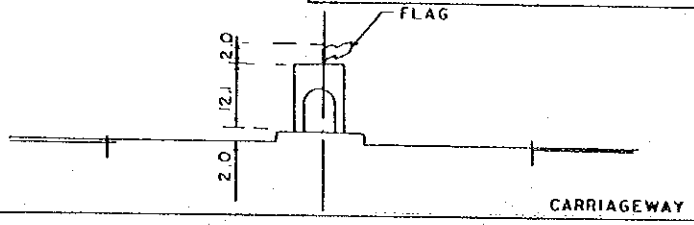
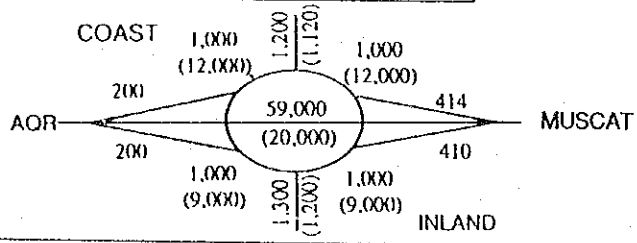
Name and Location of R/A	Bait Al Barakah (0 + 000)
C- Type	D-Type
	
Type of Structure in R/A	Sketch Of Monument
Religious Monument	
Landuse in the Vicinity	Royal palace and Official Royal Guard Facility
Access to Town or Other Areas	Private access road to Palace and Official Royal Guard Facility
Traffic Volume in 2015,(1994)	Pedestrian Volume
	Nil
Other / Remarks	Need to preserve aesthetic of R/A
Set up of Alternative Type	
Traditional Omani citadel arch gate is considered as a significant monument, and the distinctive silhouette of the monument should be preserved with high priority with little or no scenic disturbance. This shall meet with the requirements for Type-D. However, as another alternative consideration, at least one side of the roundabout should be kept open to the monument view and for the preservation of aesthetic aspects. This shall be met with Type-C.	
Selection of Flyover Type	
The monument and surrounding area within the roundabout should be preserved as it is now, as this significant landmark is a symbol of Bait Al Baraka. Type-D shall be recommended, and underground pass box culvert type is recommended.	

Table 7.5-I SELECTION OF FLYOVER (R/A-2)

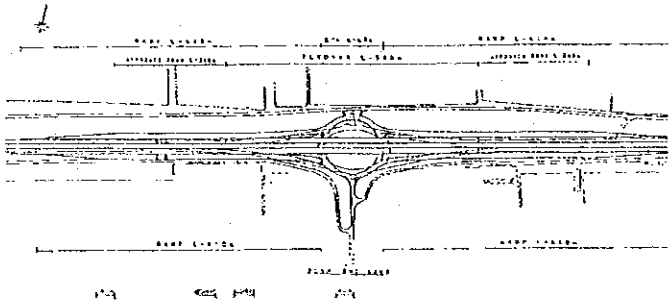
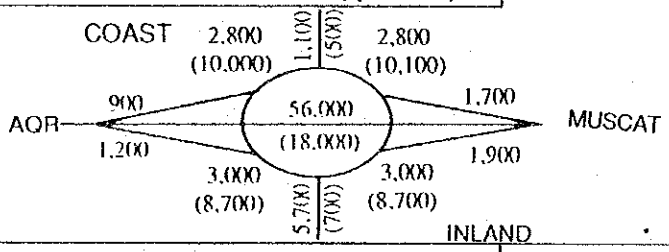
Name and Location of R/A	Naseem Garden R/A (5 + 100)
A- Type	
	
Type of Structure in R/A	Sketch Of Monument
Land grading (New R/A)	None
Landuse in the Vicinity	Agriculture and public park
Access to Town or Other Areas	Access to Naseem Garden Park And development area
Traffic Volume in 2015,(1994)	Pedestrian Volume
	Nil
Other / Remarks	
Set up of Alternative Type	
The area of this roundabout is on ground level and awaiting future landscape development. There are no problems for disturbance in scenic value at this monument. So that provision of the flyover shall become a new symbol to this vicinity. This shall be met with Type-A.	
Selection of Flyover Type	
A new proposed flyover structure will become a symbol of the vicinity. Type-A shall be recommended, and some portions of column of the flyover may be designed introducing the some Islamic design element for creating more harmony and enhancing surrounding landscape unity.	

Table 7.6 SELECTION OF FLYOVER (R/A-3)

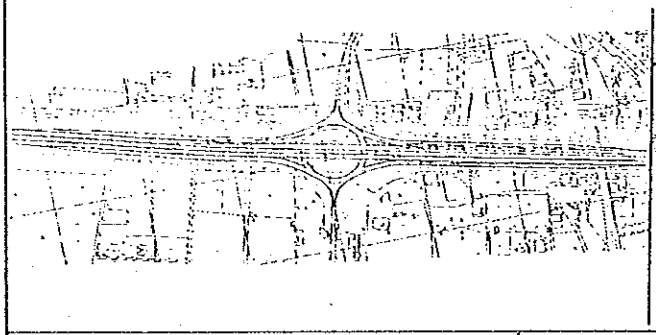
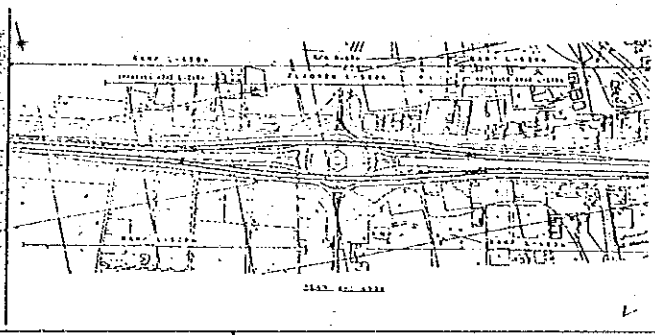
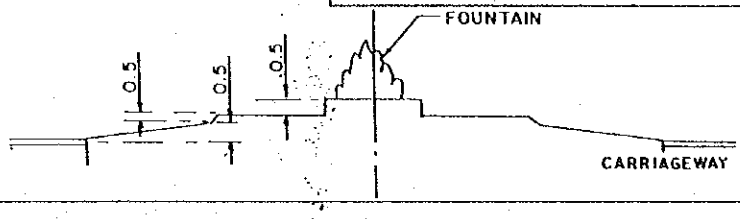
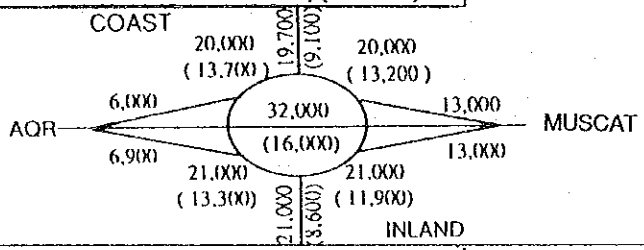
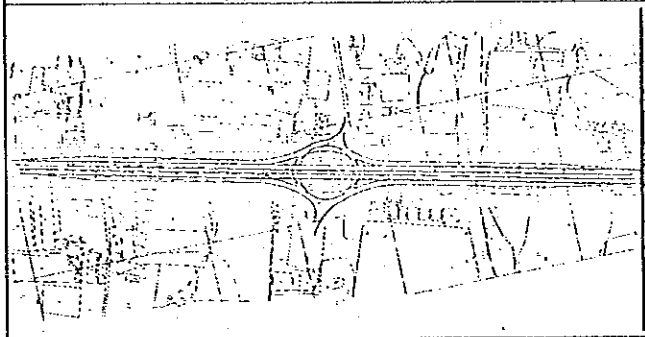
Name and Location of R/A	Barka R/A (20+850)
A- Type	B-Type
	
Type of Structure in R/A	Sketch of Monument
Water fountain and shrubs	
Landuse in the Vicinity	commercial and agriculture
Access to Town or Other Areas	access to Barka coastal town and inland to Rustaq by "Route No. 13" on paved road
Traffic Volume in 2015,(1994)	Pedestrian Volume
	significant
Other / Remarks	major junction to Rustaq from east (Muscat)
Set up of Alternative Type	
Landscape of this roundabout is composed of flat garden with water fountain Existing landscape condition is considered to require some adjustment due to presence of flyover structure. Type-B shall be employed, with maximum preservation of water fountain area. However, location of the flyover shifted to both sides of roundabout may cause some scenic disturbance to the nearest point of vicinity area. Therefore Type-A might be met with a more practical solution and some rearrangement of landscaping of the roundabout could be made.	
Selection of Flyover Type	
Existing major landscape components of the central zone within the roundabout shall be preserved at a maximum to reduce damage of the original form. Type-A will be recommended and the space between carriageways may be maintained.	

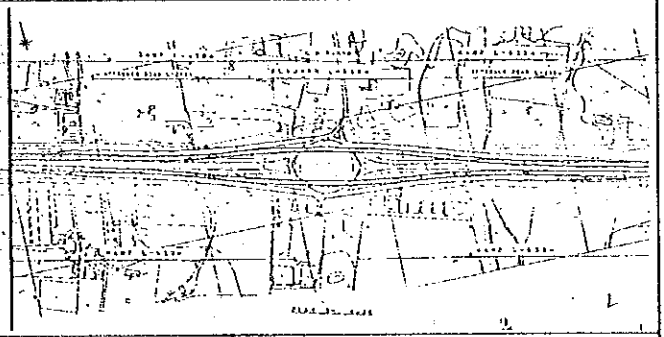
Table 7.7 SELECTION OF FLYOVER (R/A-4)

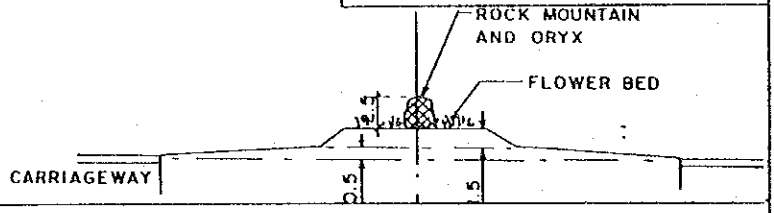
Name and Location of R/A	Masna'ah R/A (46 + 682)

A- Type

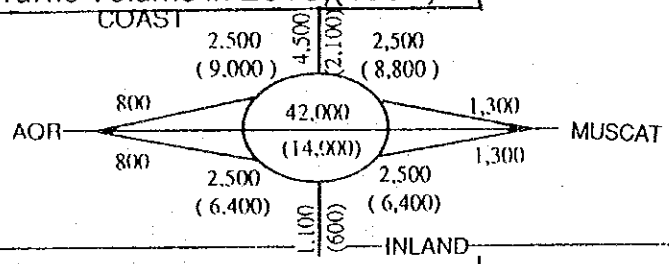


B-Type



Type of Structure in R/A	Sketch Of Monument
Rock garden	

Landuse in the Vicinity	agriculture, some new commercial development
Access to Town or Other Areas	new road to coastal town
Traffic Volume in 2015,(1994)	Pedestrian Volume



sizeable

Other / Remarks	unpaved service road

Set up of Alternative Type

Rock piled mound with animal sculptures on a flat garden is the landscape character of area. This landscape concept expresses some representative Omani natural features. Major portions could be preserved and some of the sculptures could be relocated. This area will do well with Type-A or Type-B.

Selection of Flyover Type

Existing major landscape components in the central zone will be preserved at a maximum and maintained in the original form. Type-B shall be recommended and the space between carriageways could maintain the major original landscape elements of the roundabout, and some of sculptures may be rearranged in their locations.

Table 7.8 SELECTION OF FLYOVER (R/A-5)

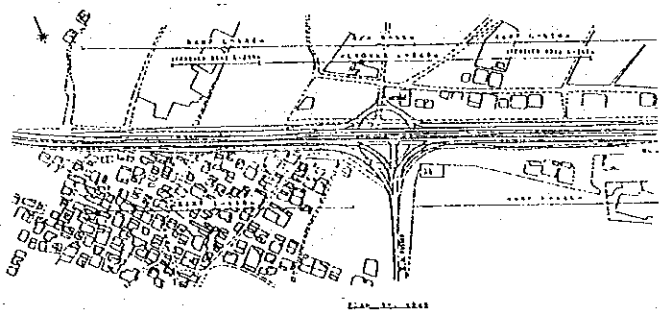
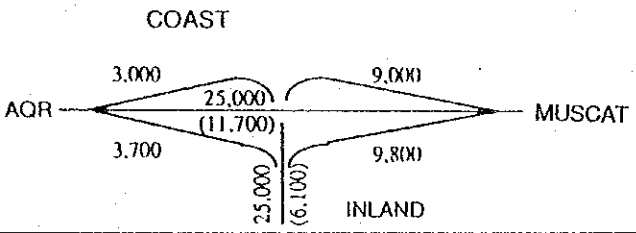
Name and Location of R/A	Al Muladdah junction (54 + 156)
A- Type	
	
Type of Structure in traffic island	Sketch Of Monument
None	None
Landuse in the Vicinity	commercial and residential, informal bus terminal for Rustaq, presence of new development
Access to Town or Other Areas	access to Rustaq by "Route No.11" on paved road
Traffic Volume in 2015,(1994)	Pedestrian Volume
	significant
Other / Remarks	major junction to Rustaq from the west (Sohar)
Set up of Alternative Type	
This junction area is on ground level and awaiting future landscape development, except for two falcon sculptures on the mountain side. The flyover shall become a new symbol to this vicinity. This type will do well with Type-A.	
Selection of Flyover Type	
A new proposed flyover structure shall become the symbol of the vicinity. Type-A shall be recommended, and some portions of the columns of the flyover may be designed referring to Islamic design element for creating more impressive scenery.	

Table 7.9 SELECTION OF FLYOVER (R/A-6)

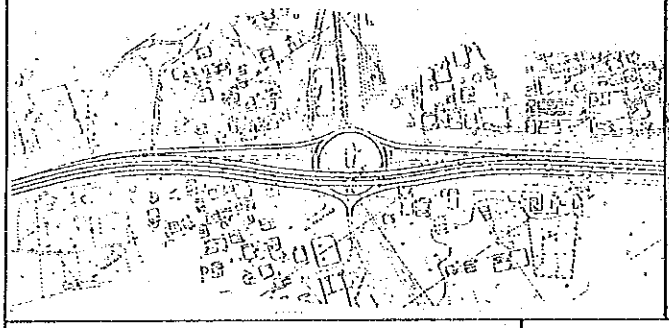
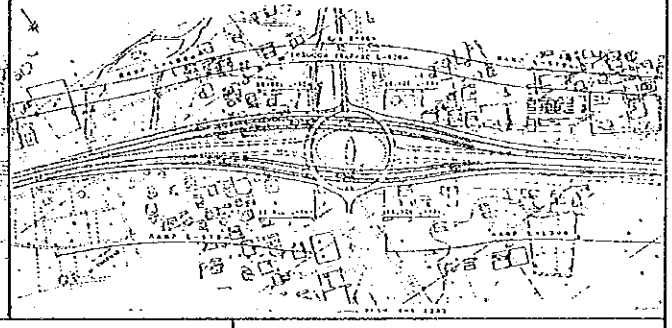
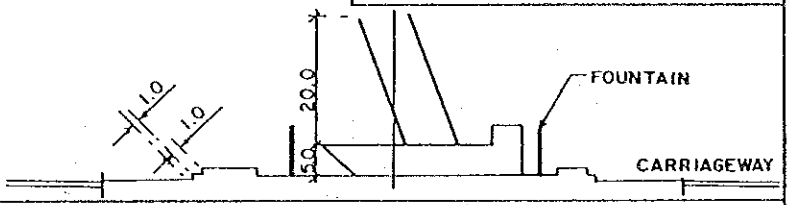
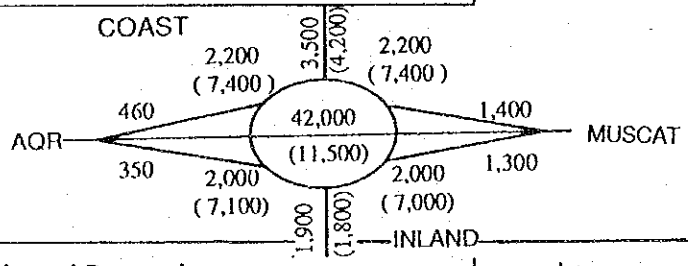
Name and Location of R/A	Wudan Al Sahil R/A (61 + 616)
C- Type	D-Type
	
Type of Structure in R/A	Sketch Of Monument
Cultural Monument (Bat-tail Ship)	
Landuse in the Vicinity	established commercial and residential areas
Access to Town or Other Areas	access to coastal town (unpaved road)
Traffic Volume in 2015,(1994)	Pedestrian Volume
	significant
Other / Remarks	need to preserve monument of R/A
Set up of Alternative Type	
Traditional Dhow ship on water concept is considered as a significant symbolic monument and distinctive silhouette. It should be preserved with high priority and any scenic disturbance not permitted. The position of dhow is facing towards the sea and occupies almost all of the roundabout area. This area shall be meet with Type-D. However as an alternative consideration, Seaside direction should be kept open because of symbolic layout of the ship, in this case flyover shall be allocated on the mountain side, and the roundabout should maintain the monument view for the preservation of the aesthetic aspect. This area shall also be considered to meet with Type-C.	
Selection of Flyover Type	
The Dhow monument and surrounding components within the roundabout should be preserved as they are now, and this significant landmark is the symbol of Wudam Al Sahil. Type-D shall be recommended, and underground pass of box culvert type is recommended.	

Table 7.10 SELECTION OF FLYOVER (R/A-7)

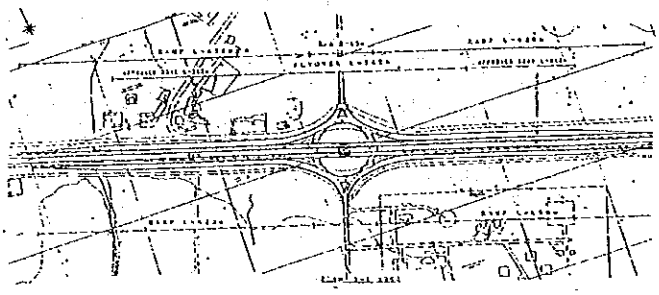
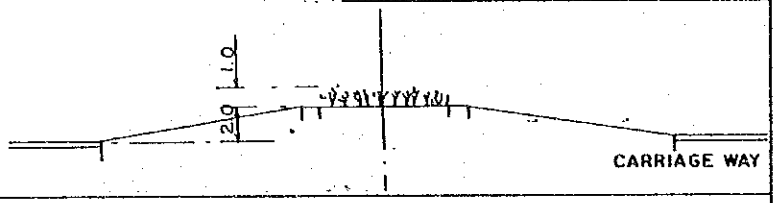
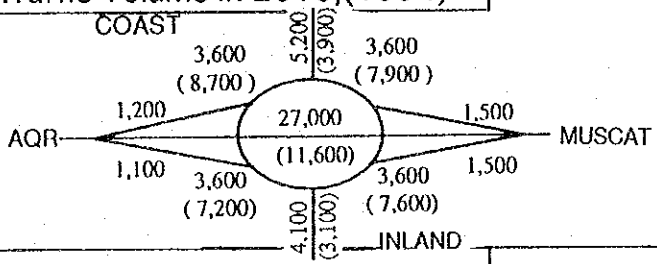
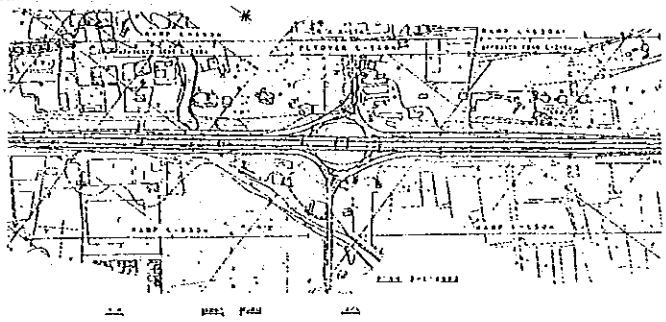
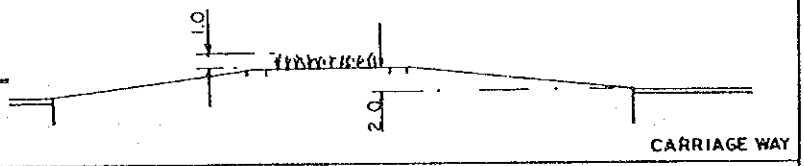
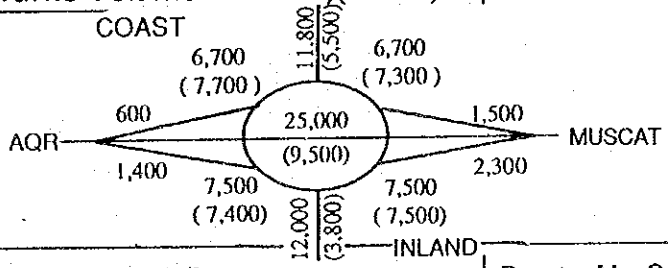
Name and Location of R/A	Suweiq R/A (71 + 946)
A- Type	
	
Type of Structure in R/A	Sketch Of Monument
Shrubs	
Landuse in the Vicinity	public institution, residential (ROP station)
Access to Town or Other Areas	new access roads to coastal town and public institution
Traffic Volume in 2015,(1994)	Pedestrian Volume
	small
Other / Remarks	unpaved roads, ROP station
Set up of Alternative Type	
This area of roundabout consists of flower garden on a slight mound and major objectives are groups of plants. When flyover provision is forecasted for this area, original garden form will be changed. However there are not many problems to disturb scenic value even when these plants are transplanted. The provision of the flyover shall become a new symbol to the readjusted existing garden. This area shall be met with Type-A.	
Selection of Flyover Type	
A new proposed flyover structure will become the symbol of the vicinity. Type-A is recommended, and some portion of column or additional design features to the flyover may be considered incorporated with some components of existing landscape elements.	

Table 7.11 SELECTION OF FLYOVER (R/A-8)

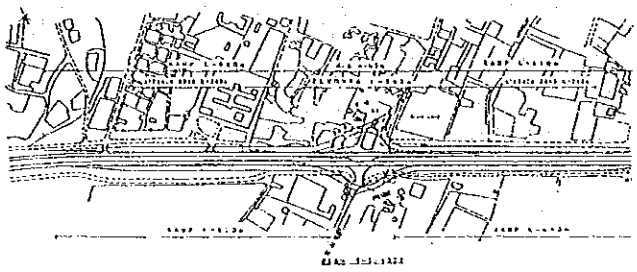
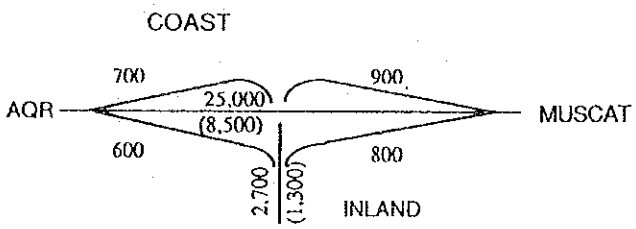
Name and Location of R/A	Khaburah R/A (110 + 016)
A- Type	
	
Type of Structure in R/A	Sketch Of Monument
Lawn	
Landuse in the Vicinity	established commercial and residential area
Access to Town or Other Areas	access to coastal town (unpaved road) and to Rustaq by " Route No.9 " on paved road
Traffic Volume in 2015,(1994)	Pedestrian Volume
	significant
Other / Remarks	Route No.9
Set up of Alternative Type	

This area of roundabout consists of a green mound with flower bed, and major objectives are groups of plants. When flyover provision is forecasted for this area, original garden feature will be slightly changed. There are not so many problems to disturb the scenic values even when these plants are transplanted. The provision of the flyover will become a new symbol to the readjusted existing garden. This area shall be met with Type-A.

Selection of Flyover Type

A new proposed flyover structure shall be large enough and become a symbol of the vicinity. Type-A is recommended, and some portion of columns or additional design features to the flyover may be designed and incorporated with some components of existing landscape elements.

Table 7.12 SELECTION OF FLYOVER (R/A-9)

Name and Location of R/A	Al Hijari Junction (122 + 000)
A- Type	
	
Type of Structure in R/A	Sketch Of Monument
None	None
Landuse in the Vicinity	established commercial and residential areas, agriculture
Access to Town or Other Areas	access to Hijari town and to coastal area (unpaved road)
Traffic Volume in 2015,(1994)	Pedestrian Volume
	sizeable
Other / Remarks	
Set up of Alternative Type	

The area of this roundabout is on ground level and awaiting a future landscape development. There are no problems to disturb scenic values at this moment. The provision of the flyover shall become a new symbol to this vicinity. This shall be met with Type-A.

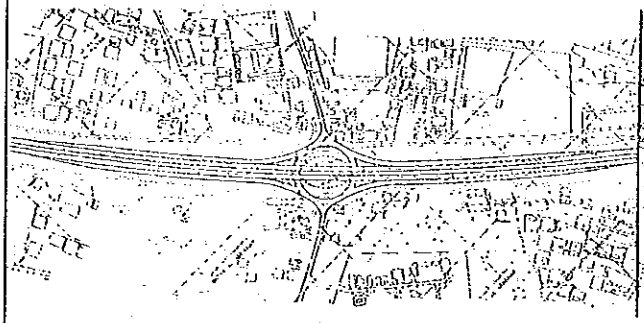
Selection of Flyover Type

A new proposed flyover structure shall be large enough and become a symbol of the vicinity. Type-A is recommended, and some portion of columns of the flyover may be designed referring to Islamic designed element type to create a new scenic impression and amenity.

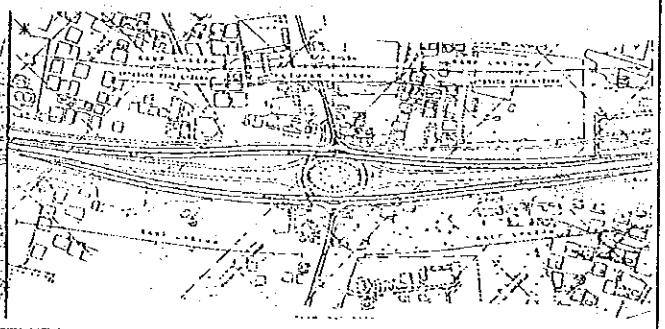
Table 7.13 SELECTION OF FLYOVER (R/A-10)

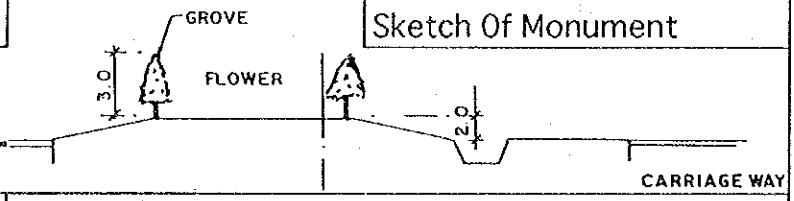
Name and Location of R/A	Saham R/A (139 + 516)

A- Type

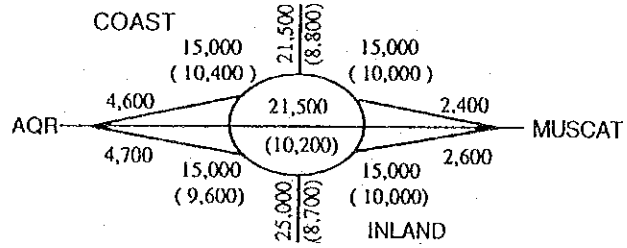


B-Type



Type of Structure in R/A	Sketch Of Monument
Shrubs	

Landuse in the Vicinity	established commercial area, evidence of new development
Access to Town or Other Areas	access to coastal town and to interior Rawdah (unpaved road)
Traffic Volume in 2015,(1994)	Pedestrian Volume



significant

Other / Remarks	
Set up of Alternative Type	

Landscape of this roundabout composes a mounded garden with shrubs and trees, the existing landscape condition is considered to require some adjustment for impacts by construction of flyover structure. Both Type-A and Type-B shall be met in a practical way to reduce major changes of the landscape features. If arrangement of the existing landscape could be made, some major elements of the area shall be adjusted for their location.

Selection of Flyover Type

Existing major landscape component of shrubs and trees within the roundabout shall be generally preserved and minimize damage of the original form. Type-A is recommended and the space around carriageways may be maintained as the major landscape elements of the roundabout.

Table 7.14 SELECTION OF FLYOVER (R/A-11)

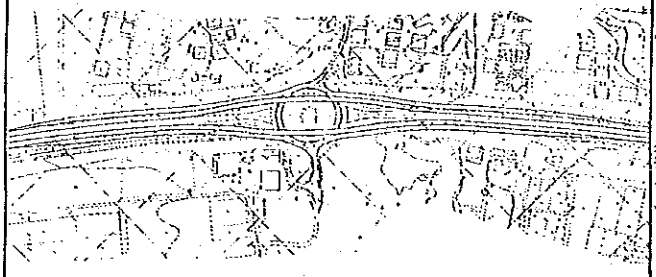
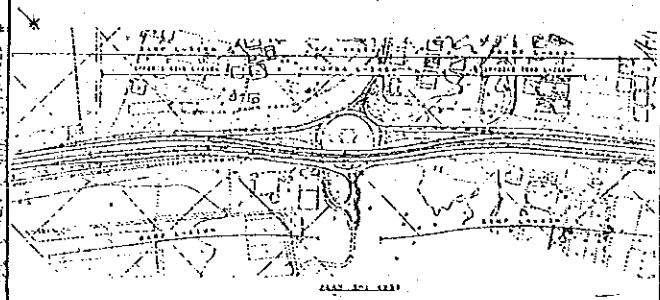
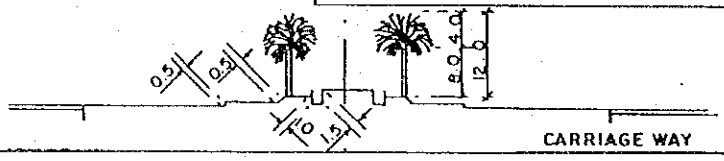
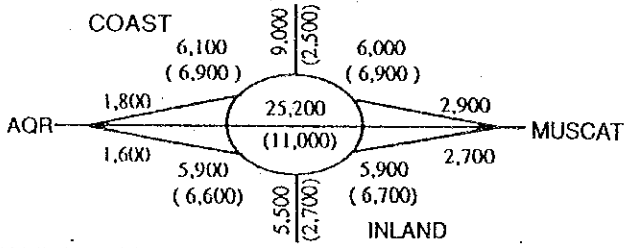
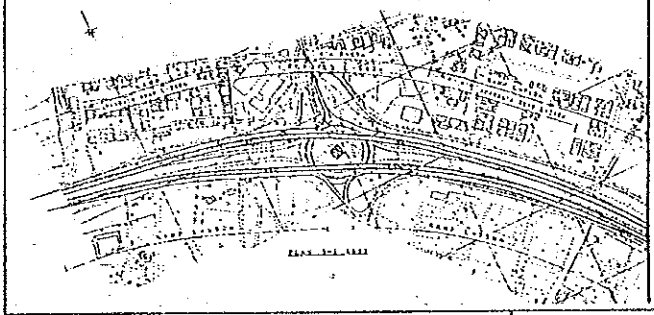
Name and Location of R/A	Suweyhrah R/A (161 + 566)
B- Type	C-Type
	
Type of Structure in R/A	Sketch Of Monument
Cultural monument (date palms & fountain)	
Landuse in the Vicinity	residential and agriculture
Access to Town or Other Areas	access to Sohar (paved & unpaved)
Traffic Volume in 2015,(1994)	Pedestrian Volume
	small
Other / Remarks	preserve monument
Set up of Alternative Type	
Landscape of this roundabout is composed of a monument of a row of palms and water element, called oasis concept, and the existing landscape will require some adjustment for impacts by construction of flyover structure. Type-B shall be met with the major objective preservation of the area. If maximum preservation of the existing landscape is undertaken, major elements of the area shall be opened to the seaside view and vicinity. Type-C could meet with this case and the flyover would be better located on the mountain side.	
Selection of Flyover Type	
Existing major landscape component of the central zone within the roundabout shall be preserved to the maximum to reduce damage of the original form. Type-C is recommended and the space towards the seaside should be kept for its view and spatial expansion.	

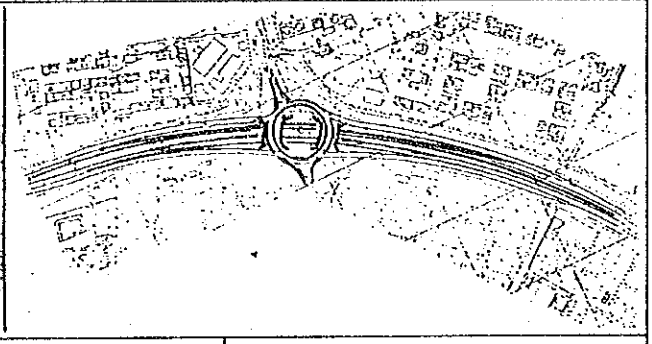
Table 7.15 SELECTION OF FLYOVER (R/A-12)

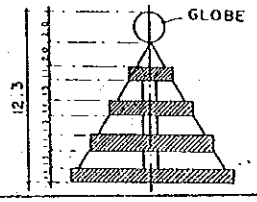
Name and Location of R/A	Sohar R/A (166 + 968)

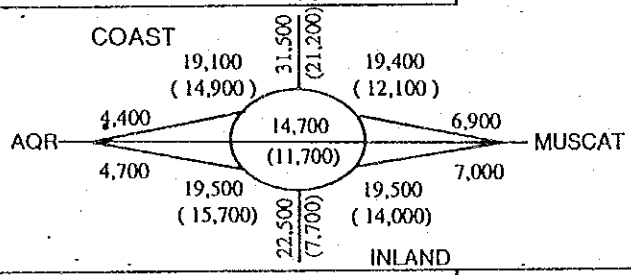
B- Type



D-Type



Type of Structure in R/A	Sketch Of Monument
Cultural monument	
Landuse in the Vicinity	established commercial areas, agriculture
Access to Town or Other Areas	main access to Sohar and to interior Wadi Hibi by "Route No. 8 "
Traffic Volume in 2015,(1994)	Pedestrian Volume



significant

Other / Remarks	need to preserve aesthetic of R/A

Set up of Alternative Type

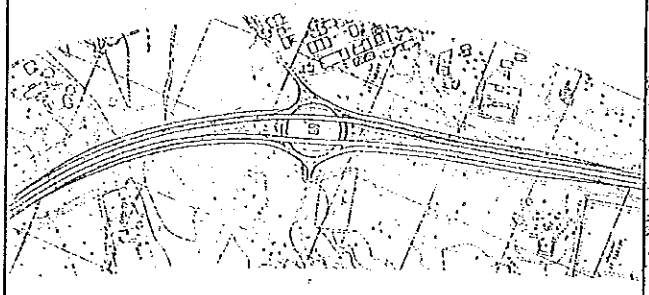
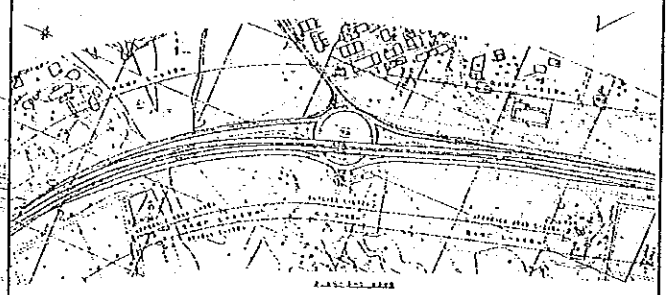
Existing landscape of this roundabout is composed of a monument of a globe on top of a triangular tower. However new proposal of monument has been studied in Muscat municipality, and the scale of the proposed monument is said to be approximately 40 meters in height. Surrounding area of the roundabout is local township with dwellings located towards seaside. Type-B shall meet with the proposed monument of the area. An another alternative maximum scenic observation of the proposed monument from vicinity area could be considered with underpass system. Type-D could be met with this case.

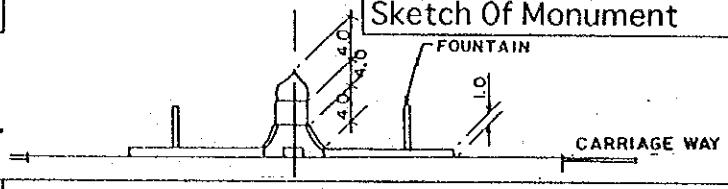
Selection of Flyover Type

Proposed monument can be observed from all directions because of its large scale potential. Most part of the monument can be seen even surrounded by flyover. Type-B is recommended.

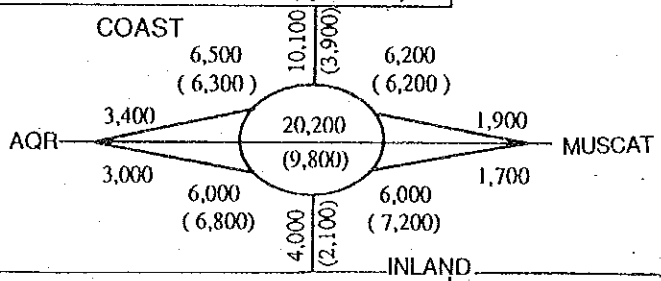
Table 7.16 SELECTION OF FLYOVER (R/A-13)

Name and Location of R/A	Sallan R/A (173 + 016)

B- Type	C-Type
	

Type of Structure in R/A	Sketch Of Monument
Religious monument	

Landuse in the Vicinity	residential areas, agriculture
Access to Town or Other Areas	access to Sohar (unpaved road)

Traffic Volume in 2015,(1994)	Pedestrian Volume
	small

Other / Remarks	need to preserve aesthetic of R/A

Set up of Alternative Type

Landscape of this roundabout is composed of a monument of an Islamic Omani observation dome in the air, and this monument gives a distinctive impression. Nearby this roundabout there is a large wadi located, and the significant monument should have high priority to be preserved as a vicinity landmark. Type-D could be preferrable but the existing wadi shall make a problems to the underground condition. Type-C will meet with the maximum preservation scheme of the area.

Another consideration could be made for the all round preservation concept but it requires the enclosure of the existing monument. Type-B will meet with this case, and the flyover will better allocated on the mountain side.

Selection of Flyover Type

Existing monument can be observed from all directions and the township and dwellings are mostly situated on the seaside. The monument could be observed mostly from the seaside so type-C is recommended. The flyover should be situated on the mountain side in this case.

Table 7.17 SELECTION OF FLYOVER (R/A-14)

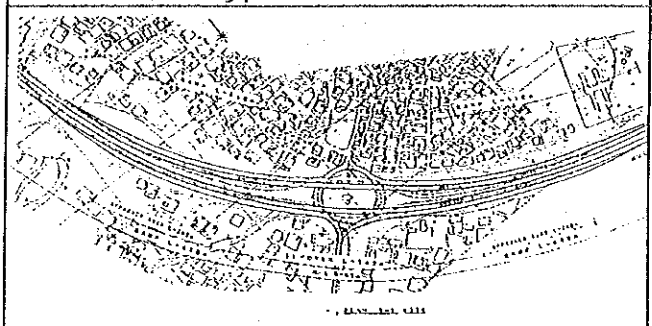
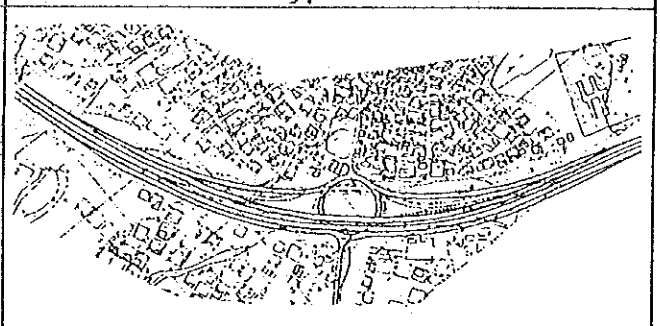
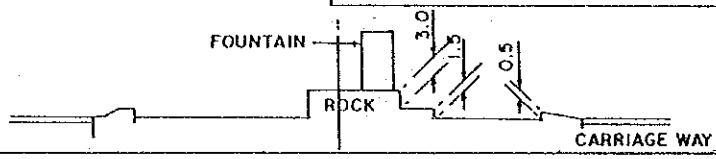
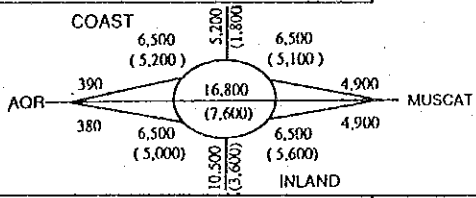
Name and Location of R/A	Falaj Al Qabail R/A (183 + 316)
B- Type	C-Type
	
Type of Structure in R/A	Sketch Of Monument
Rock garden	
Landuse in the Vicinity	established commercial and residential areas
Access to Town or Other Areas	access to Buraimi and to coastal town (paved & unpaved)
Traffic Volume in 2015,(1994)	Pedestrian Volume
	significant
Other / Remarks	: major junction to Buraimi and U.A.E : preserve monument
Set up of Alternative Type	
Landscape of this roundabout is composed of a rock hill with waterfall and animal sculptures; representative of Omani nature. These landscaped natural features are located in the central zone of the roundabout. Type-B meets with the preservation of the monument of the area. An another alternative, maximum preservation of the existing monument could be made so that the monument of the area be opened in view on the seaside. Type-C will meet with this case and the flyover will better located on the mountain side.	
Selection of Flyover Type	
Existing monument is not high so it can be observed from all directions by flyover drivers and vicinity. Type-B is recommended and design of flyover column shall be so arranged for the scenic harmony to the original features.	

Table 7.18 SELECTION OF FLYOVER (R/A-15)

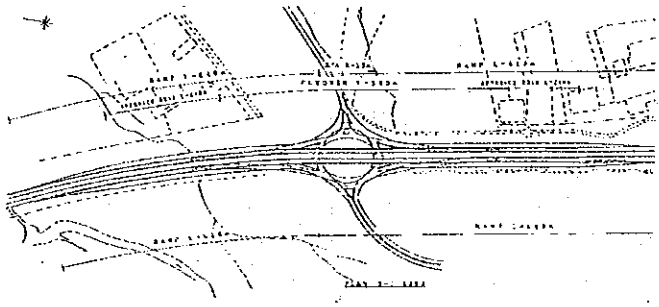
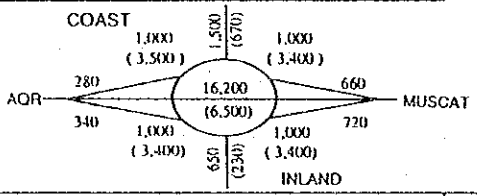
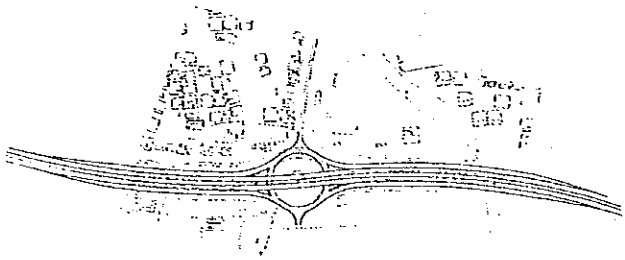
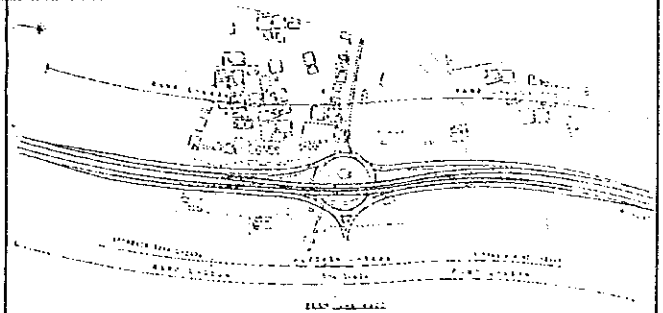
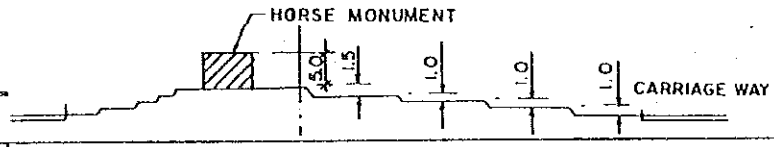
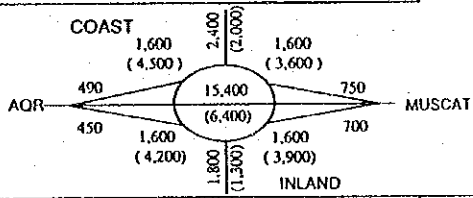
Name and Location of R/A	Majis R/A (184 + 018)
A- Type	
	
Type of Structure in R/A	Sketch Of Monument
Land grading (New R/A)	Non
Landuse in the Vicinity	agriculture and new industrial estate
Access to Town or Other Areas	access to new industrial estate (unpaved)
Traffic Volume in 2015,(1994)	Pedestrian Volume
	Nil
Other / Remarks	access to industrial estate
Set up of Alternative Type	
This area of roundabout is on ground level and awaiting a future landscape development. There are no problems to disturb the scenic value at this moment. The provision of the flyover will become a new symbol of this area. This shall be met with Type-A.	
Selection of Flyover Type	
A new proposed flyover structure will become the symbol of the vicinity. Type-A is recommended, and some portion of columns and some impressive features of the flyover may be designed for creating more amenity and rich surroundings for landscaping.	

Table 7.19 SELECTION OF FLYOVER (R/A-16)

Name and Location of R/A	Liwa R/A (195 + 566)
A- Type	C-Type
	
Type of Structure in R/A	Sketch Of Monument
Shrubs	
Landuse in the Vicinity	commercial on one side and agricalture
Access to Town or Other Areas	access to coastal town (unpaved)
Traffic Volume in 2010,(1994)	Pedestrian Volume
	significant
Other / Remarks	
Set up of Alternative Type	

Landscape of this roundabout is composed of a monument of a white horse on the terraced green, and location of the white horse is on the sea side. Existing landscape requires some adjustment for impacts by construction of a flyover structure. Type-C will meet with the major objective preservation scheme of the area.

Existing landscaping focal point is rather shifted towards sea side. When proposed flyover passes through the central zone of the roundabout, there will not be much damage to the original scenic condition, some of the landscape elements of the area shall be rearranged to fit with original design concept. Type-A could meet with this case.

Selection of Flyover Type

Existing major landscape component on the sea side zone within the roundabout will be preserved to the maximum to reduce damage of the original form. Type-C is recommended and the space towards sea side should be kept in view for spatial expansion.

Table 7.20 SELECTION OF FLYOVER (R/A-17)

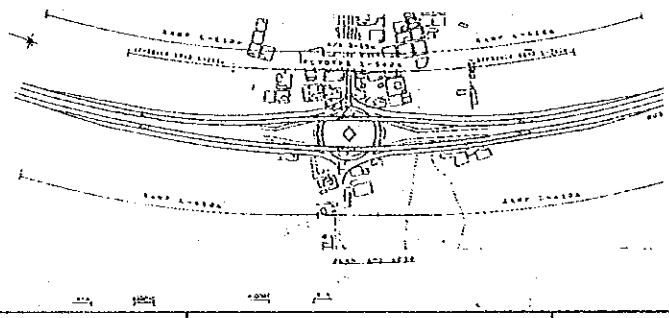
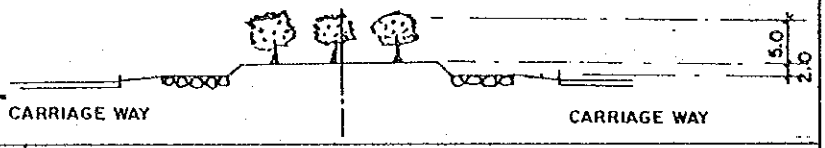
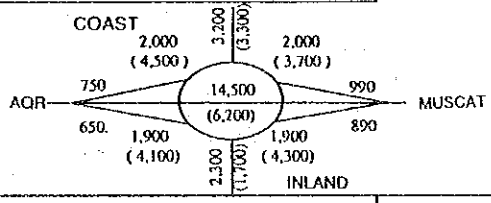
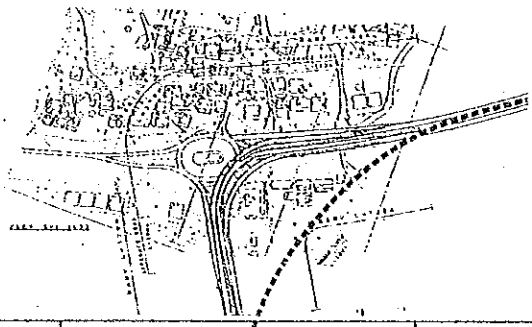
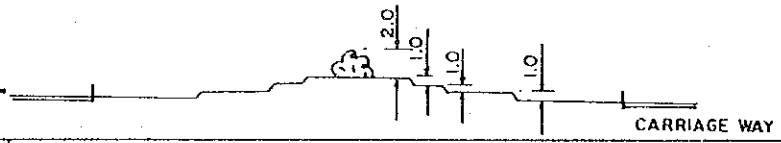
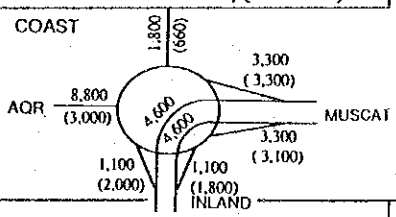
Name and Location of R/A	Shinas R/A (224 + 316)
B- Type	
	
Type of Structure in R/A	Sketch Of Monument
Shrubs and rock garden	
Landuse in the Vicinity	established commercial and residential areas
Access to Town or Other Areas	
Traffic Volume in 2015,(1994)	Pedestrian Volume
	significant
Other / Remarks	
Set up of Alternative Type	
Landscape of this roundabout is composed of groves on a paved mound and water fountain, having some representative scenery of Omani nature. This landscaped feature is located in the central zone of the roundabout. Type-B will meet with the preservation of the monument of the area.	
Selection of Flyover Type	
Existing monument is not so high and can be observed from all directions both from drivers on flyovers and vicinity area. Type-B is recommended and design of flyover column shall be arranged for the scenic harmony to the original features.	

Table 7.21 SELECTION OF FLYOVER (R/A-18)

Name and Location of R/A	Aqr R/A (231 + 316)
Special Type	
	
Type of Structure in R/A	Sketch Of Monument
Shrubs	
Landuse in the Vicinity	established commercial areas and residential
Access to Town or Other Areas	access to coastal Aqr town and U.A.E by " route No. 5 " on paved road
Traffic Volume in 2015,(1994)	Pedestrian Volume
	significant
Other / Remarks	Major access point to U.A.E
Set up of Alternative Type	
This area of roundabout consists of group plantings of shrubs on the terraced garden. When the flyover is proposed for this area, original garden may become lost. There are not so many problems to disturb scenic values if these plants are transplanted. The provision of the flyover will become a new symbol together with the rearranged existing garden. This area shall be meet with Type-S.	
Selection of Flyover Type	
A new proposed flyover structure will become the symbol of the vicinity. Type-S is recommended, and some portion of column of the flyover may be designed to incorporate some Islamic or Omani traditional components.	

7.4 Selection of Construction Priority for the Grade Separation of Roundabout

This study selects the roundabout of high priority for the grade separation facility that should be incorporated with the 5-Year Development Programme for the Oman Road Program to begin in 1996.

The order of priority for the grade separation of roundabout is established according to the following 5 selecting criteria with weight.

The study team recommends the order of priority for grade separation of roundabouts based on discussion with the Government of the Sultanate of Oman.

7.4.1 Selection Criteria of Priority Construction

The selecting criteria of priority for the construction of the grade separation of roundabouts will have the following five items. The following 5 items are based on the function of transport of Batinah Highway, the function of linking cities, and the function of contribution to local community integration and industrial development.

[Items of evaluation for Selecting Criteria of Priority]

1) evaluation from the road capacity (volume/capacity) at roundabout as a weak point of road.
2) evaluation from traffic volume in 2010 on Batinah Highway.
3) evaluation from the importance of national road network connected with the Batinah Highway.
4) evaluation of contribution to local community integration
5) evaluation of contribution to industrial development.

7.4.2 Selection of the Grade Separated Order of Priority

The Order of Priority for 18 roundabouts was calculated from the evaluation items above.

[Amount of weight alotted to each evaluation item]

Each evaluation item was established out of the total amount of 100, having relatively heavy weight to traffic function 1) and network of national road 3), as shown below.

1) Road capacity (volume/capacity), 50%
2) Traffic volume in 2010 on the Batinah Highway, 10%.
3) National road network, 20%.
4) Local community integration, 10%.
5) Industrial development, 10%.

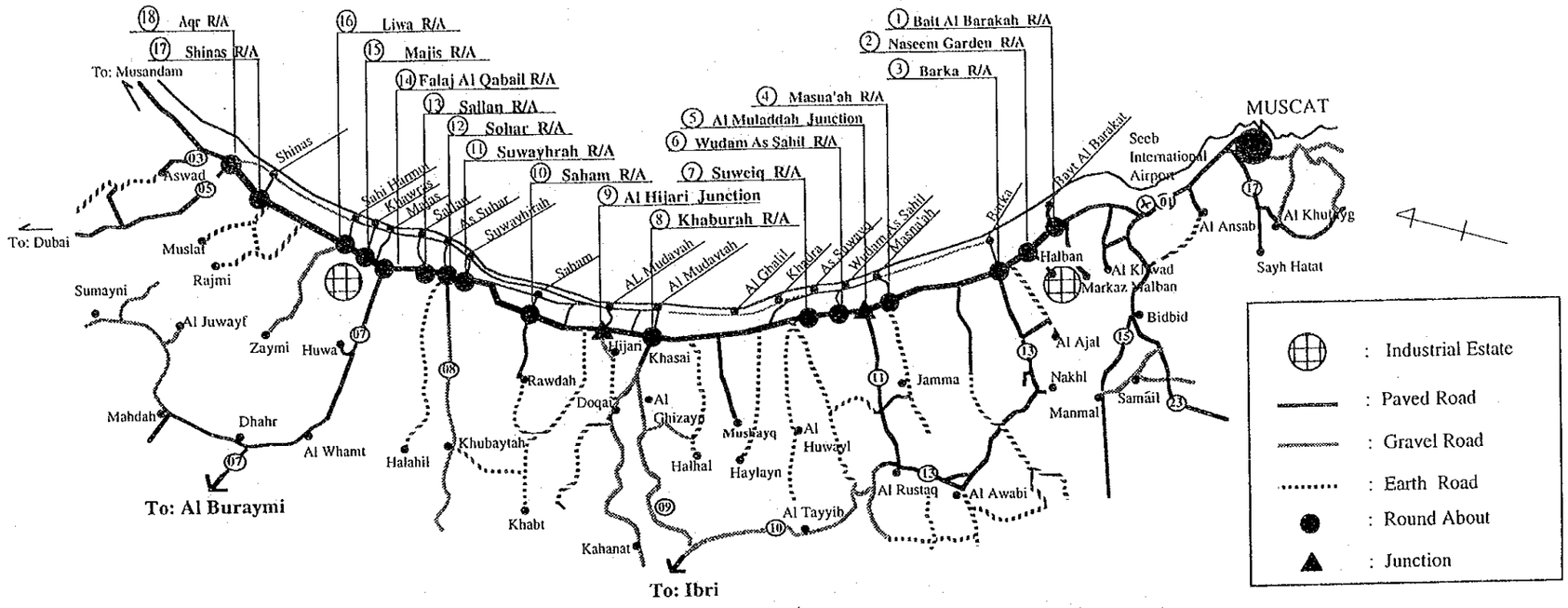
Using the above selecting criteria and amount of weight, the Order of Priority for 18 of roundabouts was calculated as shown in Table 7.22, and listed in Table 7.23.

Roundabout -18 named Aqr, forked to Dubai in UAE though National road NO. 5 and to the Musandam Peninsula of Oman, and also Roundabout -14, named Falaj Al Qabail, forked to Al Buraimi and UAE though National road No. 7 were low ranking (16th and 9th of all), but the study team recommends selecting them in this study as symbols of Oman.

Table 7.22 Calculate for Order of Priority

	Evaluation Item					Total weighted score	Rank
	V/C ratio	Batinah Volume	Highway Network	Local Community	Develop-ment		
Weight	50	10	20	10	10	100	
1. Bait Al Barakah R/A	70 35.0	90 9.0	0.0	0.0	0.0	44.0	8
2. Naseem Garden R/A	75 37.5	85 8.5	0.0	0.0	85 8.5	54.5	3
3. Barka R/A	90 45.0	80 8.0	80 16.0	80 8.0	0.0	77.0	1
4. Masna'ah R/A	60 30.0	75 7.5	0.0	0.0	0.0	37.5	10
5. Al Muladdah Junction	65 32.5	70 7.0	75 15.0	0.0	0.0	54.5	4
6. Wudam As Sahil R/A	40 20.0	65 6.5	0.0	70 7.0	0.0	33.5	11
7. Suweiq R/A	45 22.5	55 5.5	0.0	0.0	0.0	28.0	13
8. Khaburah R/A	55 27.5	50 5.0	70 14.0	0.0	0.0	46.5	6
9. Al Hijari Junction	30 15.0	40 4.0	60 12.0	75 7.5	80 8.0	46.5	7
10. Saham R/A	80 40.0	45 4.5	0.0	85 8.5	0.0	53.0	5
11. Suwayhrah R/A	50 25.0	60 6.0	0.0	0.0	0.0	31.0	12
12. Sohar R/A	85 42.5	35 3.5	65 13.0	90 9.0	0.0	68.0	2
13. Sallan R/A	35 17.5	30 3.0	0.0	0.0	0.0	20.5	15
14. Falaj Al Qabail R/A	25 12.5	25 2.5	90 18.0	65 6.5	0.0	39.5	9
15. Majis R/A	20 10.0	20 2.0	0.0	0.0	90 9.0	21.0	14
16. Liwa R/A	15 7.5	15 1.5	0.0	60 6.0	0.0	15.0	17
17. Shinas R/A	10 5.0	10 1.0	0.0	0.0	0.0	6.0	18
18. Aqr R/A	5 2.5	5 0.5	85 17.0	0.0	0.0	20.0	16

Notes : V/C rate refer to Chapter 5 "Traffic Capacity of Road"
: upper row shows score of each location
: lower row shows the weighted score



Number of R/A			18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Name of R/A or Junction			Aqr R/A	Shinas R/A	Liwa R/A	Majis R/A	Falaj Al Qabail R/A	Sallan R/A	Sohar R/A	Suwayhrah R/A	Saham R/A	Al Hijari Junction	Khaburah R/A	Suweiq R/A	Wudam As Sahil R/A	Al Muladdah Junction	Masna'ah R/A	Barka R/A	Naseem Garden R/A	Bait Al Barakah R/A
Station			231 +316	224 +316	195 +566	186 +018	183 +316	173 +016	166 +968	161 +566	139 +516	121 +750	110 +016	71 +946	61 +616	54 +156	46 +682	20 +850	5 +090	0 +000
Length (km)			7.00	28.75	9.548	2.702	10.30	6.048	5.402	22.05	17.766	11.734	38.07	10.33	7.46	7.474	25.832	15.76	5.09	
Cross Road			N.R 5				N.R 7		N.R 8				N.R 9			N.R 11		N.R 13		
Access	To Interior Town		Dubai				Al Burami		Wadi Hibi		Rawdah	Al Hijari	Rustaq			Rustaq		Rustaq		
Access	To Coastal Town			Shinas	Sahi Harmul	Khawr As Sammi	Majas	Sallan	Suhar	Suwayhrah	Saham	Al Muntenfah	Al Khabourah	Al Suwayq	Wudam As Sahil		Masna'ah	Barka	Naseem Garden Park	Bait Al Barakah
Criteria for Evaluation: Traffic Volume	Batinah Highway	1994	4,500	6,200	6,500	6,600	7,700	9,800	11,700	11,000	10,200	8,600	9,600	11,600	11,500	11,700	13,900	16,200	18,300	20,100
		2010	13,600	16,100	16,600	17,200	22,100	25,200	26,400	29,700	28,700	26,800	27,900	29,200	30,600	37,700	44,300	51,800	58,700	59,700
	Cross Road	2010	5,400	2,300	2,100	1,000	7,700	7,300	27,200	7,400	23,200	1,600	11,300	4,500	2,500	12,100	2,700	21,700	2,900	1,300
	Volume/Capacity (V/C)	2010	0.29	0.31	0.32	0.32	0.61	0.57	1.93	0.68	1.45	0.51	0.74	0.61	0.60	1.05	0.87	2.76	1.16	1.13
Evaluation Lanking	Batinah Highway	2010	18	17	16	15	14	13	12	7	9	11	10	8	6	5	4	3	2	1
	V/C Ratio	2010	18	17	16	15	14	12	2	9	3	13	8	10	11	6	7	1	4	5
	Relation with Road Network		2				1		6			7	5			4		3		
	Local community Integration				7		6		1		2	4			5			3		
	Relation with Industrial Development							1				3							2	
Priority			16	18	17	14	9	15	2	12	5	7	6	13	11	4	10	1	3	8

THE STUDY ON ROAD DEVELOPMENT PROJECT	JAPAN INTERNATIONAL COOPERATION AGENCY	Table 7.23 PRIORITY ON GRADE SEPARATION OF ROUNDABOUT

7.4.3 Consideration from Traffic Safety Viewpoints

The setting of the construction priority of flyover is examined from the viewpoint of traffic safety. To examine the construction priority of flyovers on roundabouts throughout the Batinah Highway, it carried out a method to examine the existing condition of traffic accidents on the roundabouts and junctions on the study highway.

The data - total 357 accident cases at 75 roundabout and junction locations along the Batinah Highway in 1993 - was collected by the DGR are the data source of examination.

Table 7.24 shows the location names and number of accidents, injuries and fatalities in 357 cases. Fig. 7.7 shows the main locations where more than five (5) cases of accidents have occurred.

Based on these data, it is found out that the accident-prone locations which had more than five (5) accidents are determined as the high priority flyovers on the Highway.

Table 7.25 shows the 20 locations which are ranked highest out of 75 accident locations. These 20 locations, then can be recommended as the high-ranking priority locations of flyover construction on the Batinah Highway from the point of traffic safety.

The Table 7.25 also shows that more than 40 percent (152 cases) of total number of accidents (357) are shared by only ten (10) locations out of total 75.

Especially, three (3) main locations; Sohar, Naseem Garden and Saham roundabouts; are identified as the "Black Spots" on the highway.

These three (3) roundabouts show over 20 cases of accidents, which is much higher than other locations on the highway.

Indeed, combined accident numbers of these three places shared more than 20 percent of total accidents on the highway.

From the view point of accident injury, the three (3) locations Naseem Garden Junction (26 injuries), Hai Aasim Junction (15 injuries) and Al Hijari Junction (14) are ranked as high-injury locations.

In order to set priority for a flyover, it can be recommended to emphasize reduction of number of traffic accidents rather than number of injuries.

The fatality rate is calculated as very high at 57.9%, based on the data. The fatality rate on expressways in Japan was calculated as 25.0% in 1993.

As conclusion of above considerations, it can be said that 8 selected locations out of 18 study locations are almost all reasonable settings for construction priority from the viewpoint of traffic safety.

Table 7.24 Accident Number on Batinah Highway (1993) (1)

	Place	No. of Accidents	No. of Injuries	No. of Fatalities	Center
	Misfit Junction	2	8	1	Rustaq
	Wassail Junction	1	2		Rustaq
O	Aqr - R/A	1			Wajajah
O	Naseem Garden Junction	25	26		Barka
	Talaj A'Sharah Junction	2	3		Rustaq
	Abu Mubawat Junction	2	1	2	Musannah
	Marsi Meesi R/A	15	2		Sohar
O	Barka R/A	12	2		Barka
	A'Sawadi Junction	4	8	1	Musannah
	Al Romais Junction	5	4	1	Barka
	Al Hafri Junction	5	2		Rustaq
O	Sallan R/A	2			Sohar
O	Al Mulladah Junction	13	9		Musannah
	Al Bawarih Junction	2	4		Suwaiq
O	Saham R/A	23	5	1	Saham
O	Suwayrah R/A	11	4	1	Sohar
	Outi Junction	6	2		Sohar
	Al Sharmad R/A	5			Musannah
	Al Waqeebah R/A	8	1		Sohar
O	Sohar R/A	29	4		Sohar
O	Al Hijari Junction	6	14		Saham
	Al Haram Junction	5	10		Barka
	Hai Aasim Junction	11	15		Barka
	Wadi Haiby Junction	2			Sohar
	Hazam Junction	3	3		Rustaq
	Majz Al Safry Junction	4			Saham
	Sur Al Shiyadi Junction	6	9		Saham
	Abu Abali Junction	5	16	1	Musannah
	Farfara Junction	4			Khamat
	Saham Hospital Junction	1	1		Saham
	Tow Junction	4			Barka
O	Liwa R/A	5			Sohar
	Al Radat Junction	3	3		Saham
O	Shinas R/A	2	2		Khamat
O	Al Khaburah R/A	7	1		Khaburah
	Wadi Bani Hoof (AWF) Junction	1	1	2	Khaburah
	Diyan Al Jahawer Junction	2	3		Suwaiq
	Al Oohy Junction	1			Sohar
	Al Multaqa Junction	4	5		Sohar

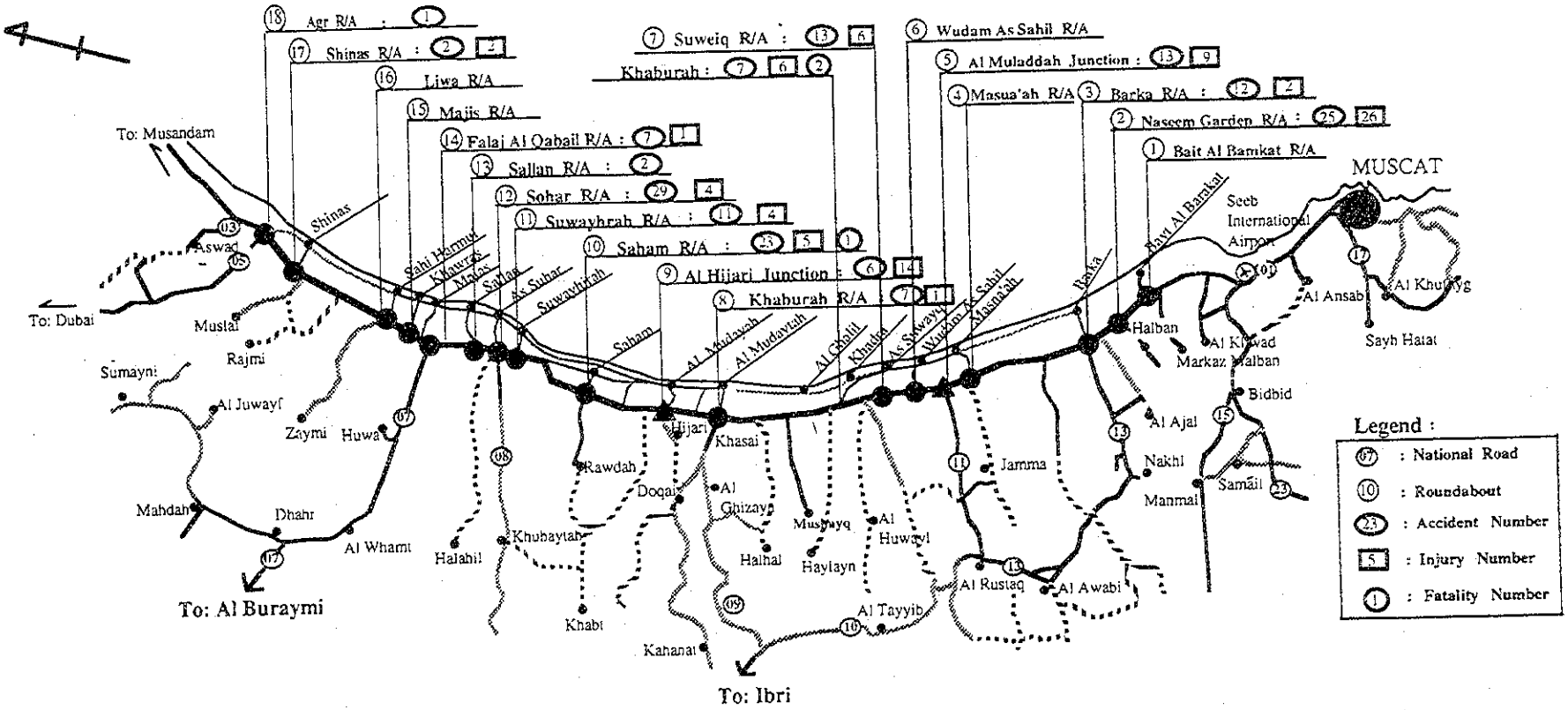
Table 7.24 Accident Number on Batinah Highway (1993) (2)

	Place	No. of Accidents	No. of Injuries	No. of Fatalities	Center
	Al Ooqin Junction	4	1		Suwaiq
	Marjan Junction	1			Wajajah
	B.P. Petrol Station Junction	2	1		Khaburah
O	Suweiq R/A	13	6		Suwaiq
	Suroor Junction	1	1		Barka
	Al Feleij Junction	3			Barka
	Habra Junction	3	2	1	Barka
O	Falaj Al Qabail Junction	7	1		Sohar
	Al Hamiliya Junction	1			Khamat
	A Numan Junction	9	8	1	Barka
	Dabal Abdul Salam Junction	4	4		Saham
	Gheel Al Shubool Junction	3	1		Sohar
	Khamood Al Hamam Junction	5	8		Saham
	Al Kasfa Junction	3			Barka
	Al Sinaiya Junction	6	1		Sohar
	Al Aqda Junction	3	1		Barla
	Wadi Al Hiyool Junction	2	1		Majan
	Hambad Junction	1			Sohar
	Al Alat Junction	1			Rustaq
	Sahil Oman Co Junction	1	2	1	Sohar
	Khadhra Junction	7	6	2	Suwaiq
	Wadi Sahten Junction	1	8		Rustaq
	Majlilf Junction	2	7		Saham
	Ghaleel Junction	4	3		Suwaiq
	Nakhal Junction	2	3		Barka
	New Souq Junction	2			Rustaq
	Al Hooqeen Junction	1			Suwaiq
	Qaseeba Al Busaid Junction	3	5		Khaburah
	Al Fareefah Junction	1			Khamat
	Al Oohy Junction	1	1		Sohar
	Sohar Garden Junction	1	3		Sohar
	Marba'a R/A	2	6		Rustaq
	Al Moutamar Junction	1	4		Suwaiq
	Qashiat Al Zou'Ab Junction	2	3		Khaburah
	Asrar Ban Amer Junction	2	2		Khatmat
	Bahja Al Anthar Junction	3	1	1	Sohar
	Total	357	260	16	-

Remark: O = Grade Separation of Roundabout and Junction Recommended by JICA Study Team

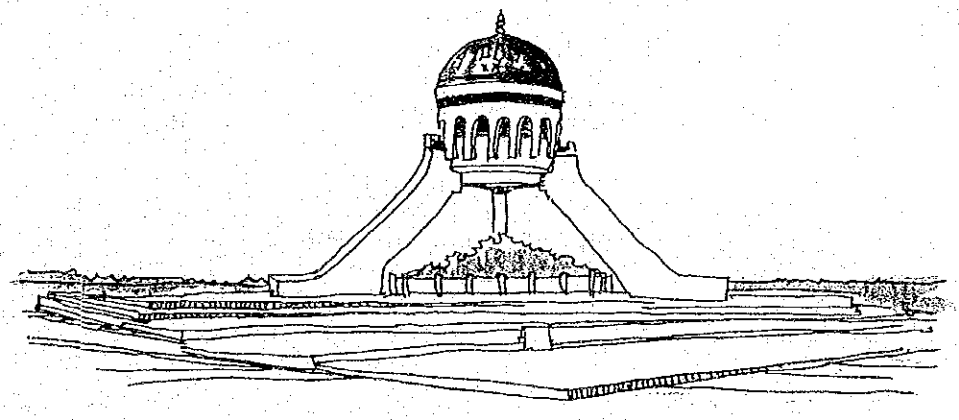
Table 7.25 Worst Ranking Places on Batinah Highway (1993)

S. No.	Place		No. of Accidents	No. of Injuries	No. of Fatalities
1.	Sohar R/A	77 (21.6 %)	29	4	
2.	Naseem Garden Junction		25	26	
3.	Saham R/A		23	1	1
4.	Marsi Meesi R/A		15	2	
5.	Al Mulladah Junction	152 (42.6 %)	13	9	
5.	Suweiq R/A		13	6	
7.	Barka R/A		12	2	
7.	Suwayrah R/A		11	4	1
7.	Hai Aasim Junction		11	15	
10.	A Numan Junction		9	8	1
11.	Al Waqeebah R/A		8	1	
12.	Al Khaburah R/A		7	1	
12.	Falaj Al Qabail Junction		7	1	
12.	Khadhra Junction		7	6	2
15.	Al Hijari Junction		6	14	
15.	Sur Al Shiyadi Junction		6	9	
15.	Al Sinaiya Junction		6	1	
18.	Al Romais Junction		5	4	1
18.	Al Hafri Junction		5	2	
18.	Al Sharmad R/A		5		
Total	20 Places		214	116	6



THE STUDY ON ROAD DEVELOPMENT PROJECT	JAPAN INTERNATIONAL COOPERATION AGENCY	Fig 7.7 Highway Accident Location on the Batinah Highway, 1993

CHAPTER 8 SELECTION OF PEDESTRIAN UNDERPASS



CHAPTER 8

SELECTION OF PEDESTRIAN UNDERPASS

There has been a rapid increase of road traffic on the Batinah Highway in recent years with vehicles running in excess of 100 km/h. There are no grade separations on the highway and no facilities provided for pedestrians to cross the highway within city limits. There are many traffic accidents involving people attempting to cross the highway. In order to reduce the number of accidents involving pedestrians, there is a project under implementation to construct on underpass 67 km from Sohar fowards Muscat at Al Bidaya.

This chapter describes the locations of the pedestrian underpasses similar to the pedestrian underpass described above to be constructed on the Batinah Highway in order to make it safe for pedestrian crossing.

8.1 Candidates for Sites for Pedestrian Underpass

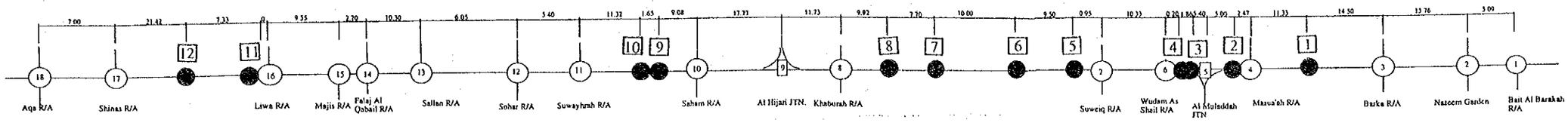
The candidates for the sites for the pedestrian underpasses were selected by considering the following conditions:

(1) Locations where there are facilities on the other side of the highway from settlements which are imminently related with the daily activities, such as farms and stores.

(2) Locations where crossing of the highway is required to attend schools and social gatherings.

(3) Locations where the distance of the settlements and schools from the highways are are within 200 m from the highway. The maximum walking distance for pedestrians will be 500 m (allowing a width of 100 m for the highway.)

Using the above criteria and by selecting the settlements and schools along the Batinah Highway, 40 sites were determined to require crossing underpasses as indicated in Table 8.1.



Location No.	Location Sta. N.o	Name of Settlement	Area (km2) Mountain Side	Area (km2) Sea Side	School	Criteria-1: Settlement area is more than 0.1km2 both side of highway	Criteria-2: There is school at one side of highway	Criteria-3: Side of high priority R/A for flyover	Recommendation
1	Sta. 20+400	As Somhan	0.10	0.26	---	○		R/A-3	
2	Sta. 35+400	Al Billah	0.05	0.06	Sea Side		○		1 ●
3	Sta. 49+200	Al Tarif	0.19	0.14	---	○			2 ●
4	Sta. 55+150	Al Muladdah	0.38	---	---				
5	Sta. 59+600	Al Qart	0.12	0.12	---	○			3 ●
6	Sta. 61+416	Al Tharmad	0.14	0.26	---	○			4 ●
7	Sta. 63+150	Al Manfash	---	0.20	Sea Side				
8	Sta. 72+900	Bataha Hilal	0.04	0.08	Sea Side		○		5 ●
9	Sta. 79+200	Sur Al Hilal	---	0.10	---				
10	Sta. 81+000	Al Uriq	0.08	0.16	---				
11	Sta. 82+350	Al Khadra	0.06	0.03	Sea Side		○		6 ●
12	Sta. 91+700	Dhyan-1	0.20	0.04	---				
13	Sta. 92+400	Dhyan-2	0.04	0.08	Sea Side		○		7 ●
14	Sta. 93+000	Dhyan-3	---	0.06	---				
15	Sta. 100+100	Al Bidayah	0.14	0.12	Sea Side	○	○		8 ●
16	Sta. 110+016	Sur Al Duwahnah	---	0.52	---			R/A-8	
17	Sta. 115+550	Qasbyat Al Hawashnah	0.16	0.09	---				
18	Sta. 139+516	Saham	0.07	0.20	Sea Side		○	R/A-10	
19	Sta. 141+350	Al Badi	---	0.20	---				
20	Sta. 142+400	Al Ghuwaisah	---	0.20	---				
21	Sta. 143+400	Al Hadheeb	---	0.10	---				
22	Sta. 147+500	Hilat Al Rawashid	---	0.10	---				
23	Sta. 148+600	Hilat Al Rawashi 1	0.12	0.22	---	○			9 ●
24	Sta. 150+250	Mujaz As Sughra	0.12	0.14	---	○			10 ●
25	Sta. 159+000	Khor Siyabi	---	1.08	---				
26	Sta. 159+900	Otab	0.06	---	---				
27	Sta. 166+968	Al Waqaybah	---	0.26	Sea Side			R/A-12	
28	Sta. 170+200	Sallan	---	0.80	---				
29	Sta. 174+200	Al Gushbah-1	---	0.30	---				
30	Sta. 175+400	Al Gushbah-2	---	0.10	---				
31	Sta. 176+900	Falaj Al Ouhi	---	0.22	---				
32	Sta. 183+316	Falaj Al Qabail	0.20	0.24	Sea Side	○	○	R/A-14	
33	Sta. 195+766	Liwa	N.a	N.a	---	○			11 ●
34	Sta. 200+850	Liwa-1	---	0.08	---				
35	Sta. 201+750	Liwa-2	---	0.08	---				
36	Sta. 202+900	Liwa-3	0.10	0.13	Sea Side	○	○		12 ●
37	Sta. 221+500	Al Hazari	---	0.18	---				
38	Sta. 212+700	Sur Al Abril	0.30	0.09	---				
39	Sta. 213+800	Sur Bani Gizmah	0.30	0.08	---				
40	Sta. 215+100	Tari Hajih	---	0.30	---				

Legend

● : Recommended Pedestrian Underpass

□ : Recommended Number

THE STUDY ON ROAD DEVELOPMENT PROJECT	JAPAN INTERNATIONAL COOPERATION AGENCY	Table 8.1 SELECTION OF SITE FOR PEDESTRIAN UNDERPASS

8.2 Criteria of Selection for the Pedestrian Underpass Sites

Out of the prospective 40 sites, the following three criteria were established to make the final site determination. See Fig. 8.1 ~ Fig. 8.4.

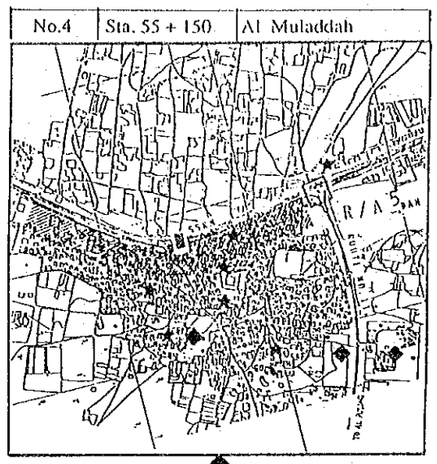
(1) Criteria-1: Settlements where there are large populations and movements of people across the highway. Area-wise approximately the same size as the settlements where the underpass is being constructed in the wilayat of Bidayah. (Area larger than 0.1 km^2 both side of highways)

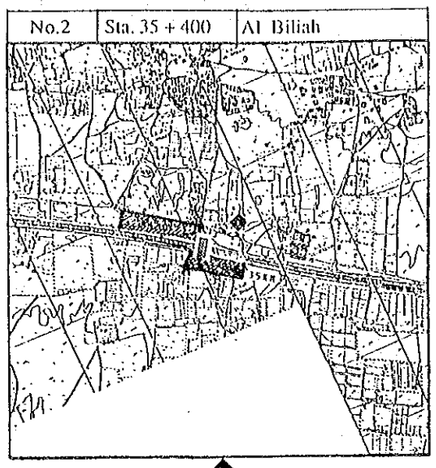
(2) Criteria-2: Commuting routes to schools requiring crossing of the highway for the safety of students, with further recommendation that the school be near the crossing.

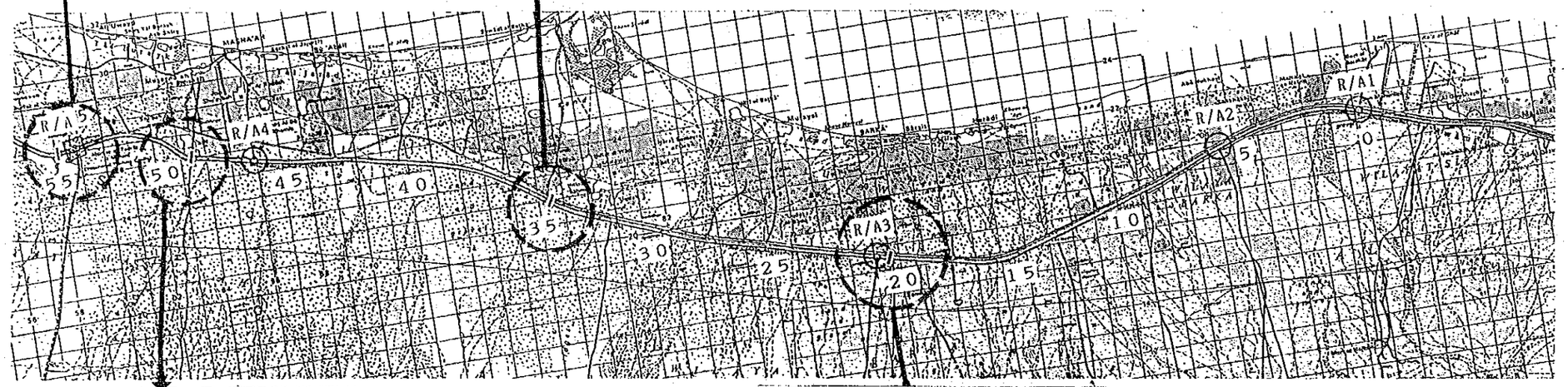
(3) Criteria-3: No pedestrian underpass should be proposed at locations where there is a high possibility of construction of a flyover at roundabouts, as the vehicle traffic will be reduced.

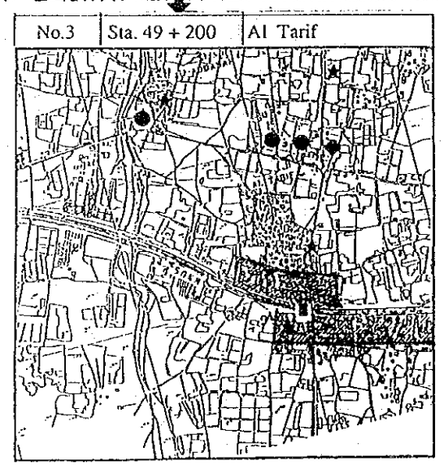
Recommendations: The sites recommended for construction of pedestrian underpasses are the sites selected for Criteria 1 and 2.

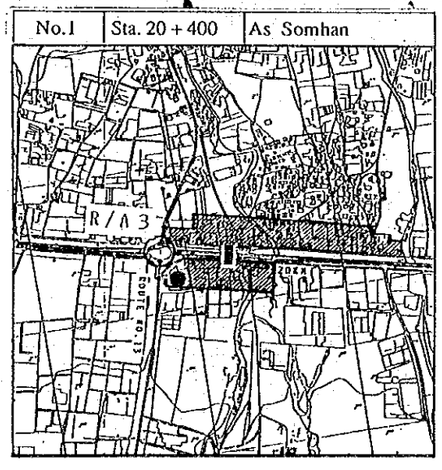
Twelve sites are recommended for construction of the pedestrian underpasses as shown in Table 8.2.



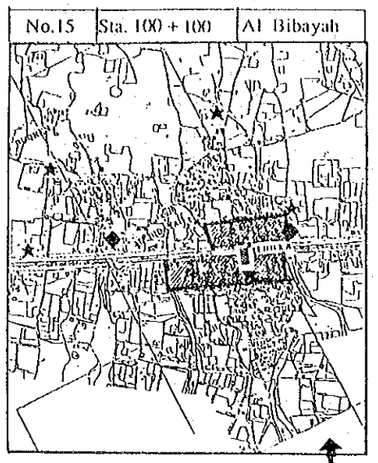


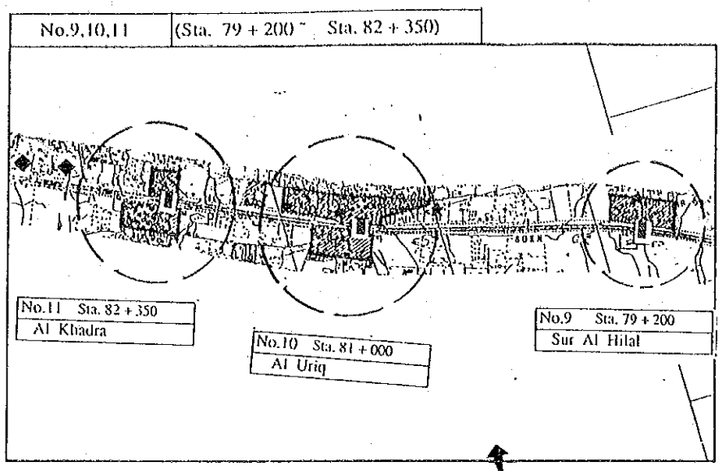


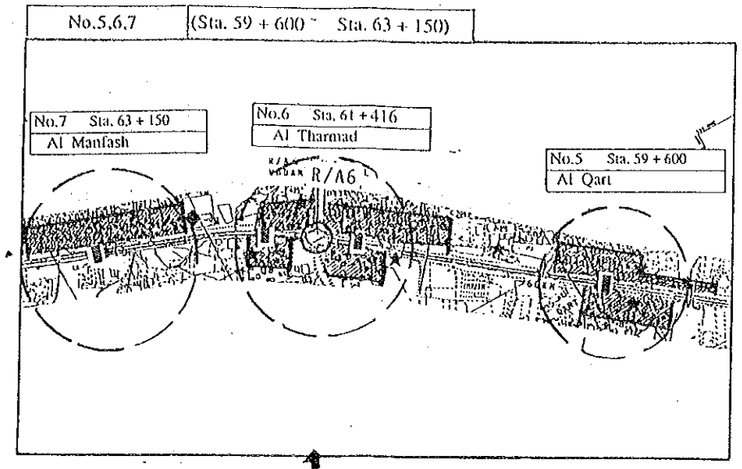


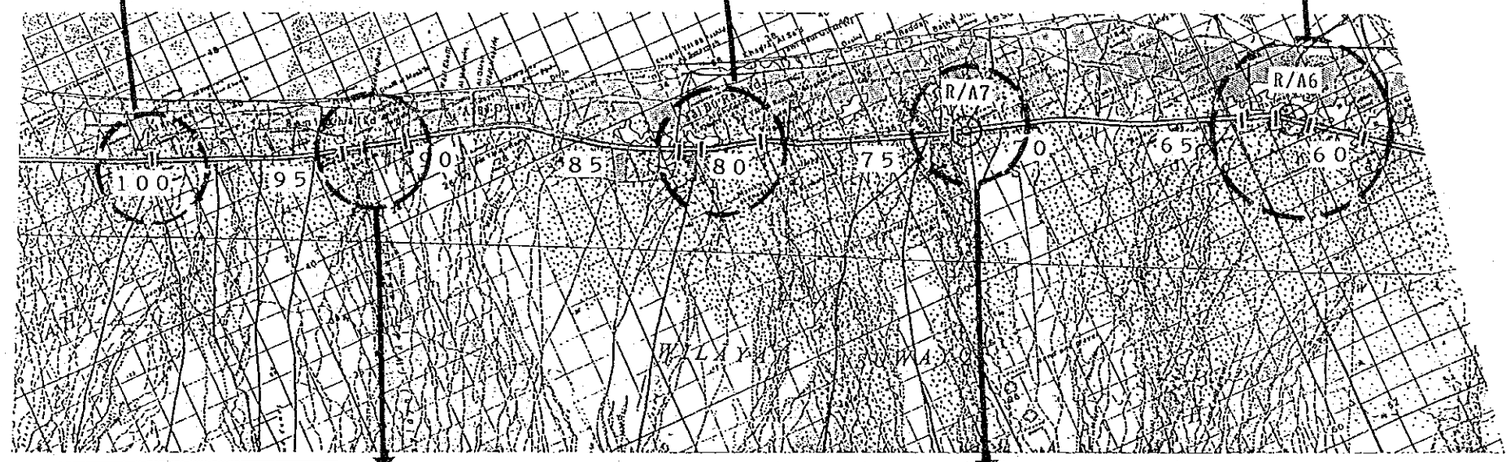


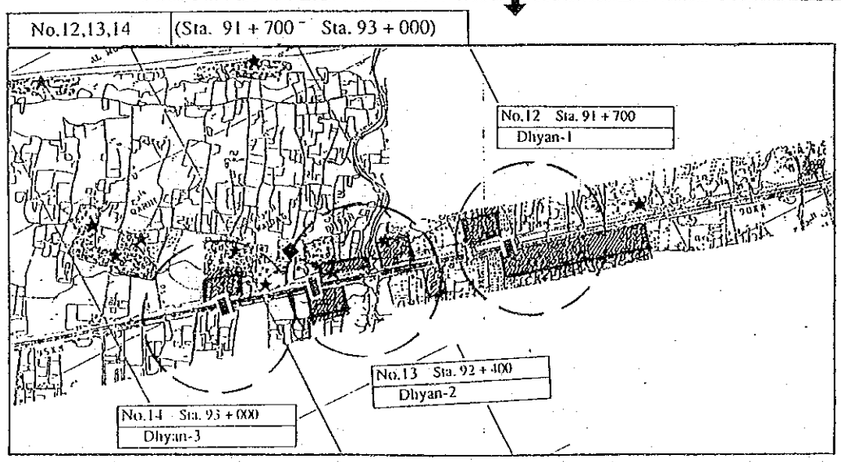
THE STUDY ON ROAD DEVELOPMENT PROJECT	JAPAN INTERNATIONAL COOPERATION AGENCY	Fig 8.1 LOCATION PLAN OF PEDESTRIAN UNDERPASS (1/4)

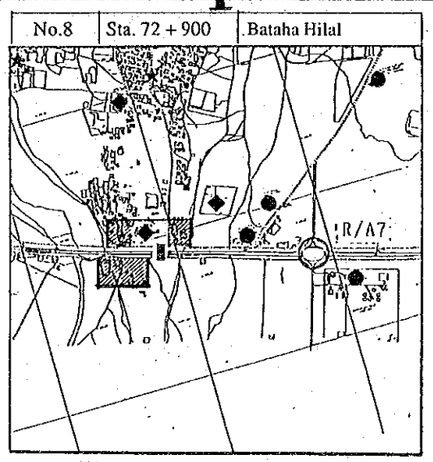




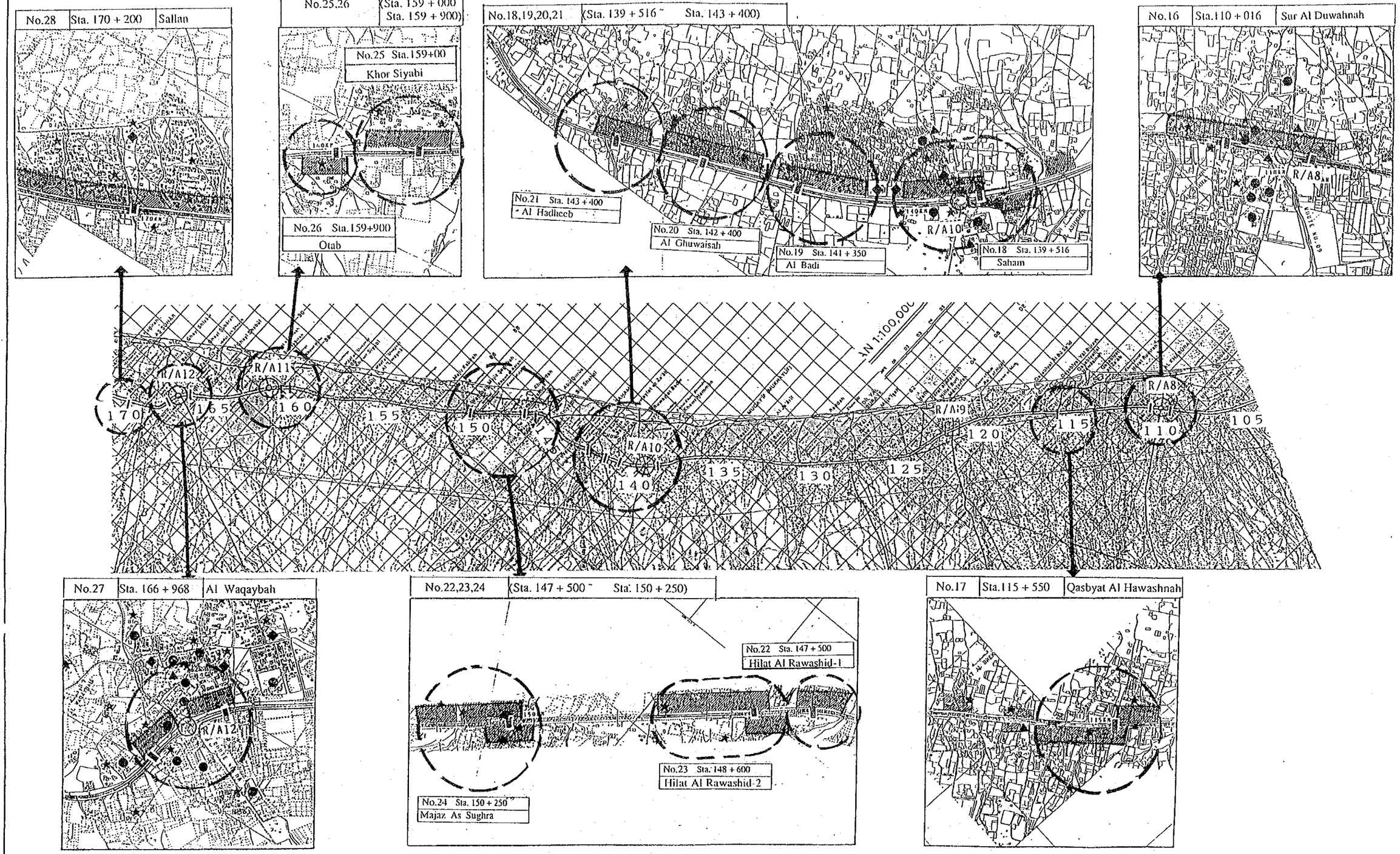




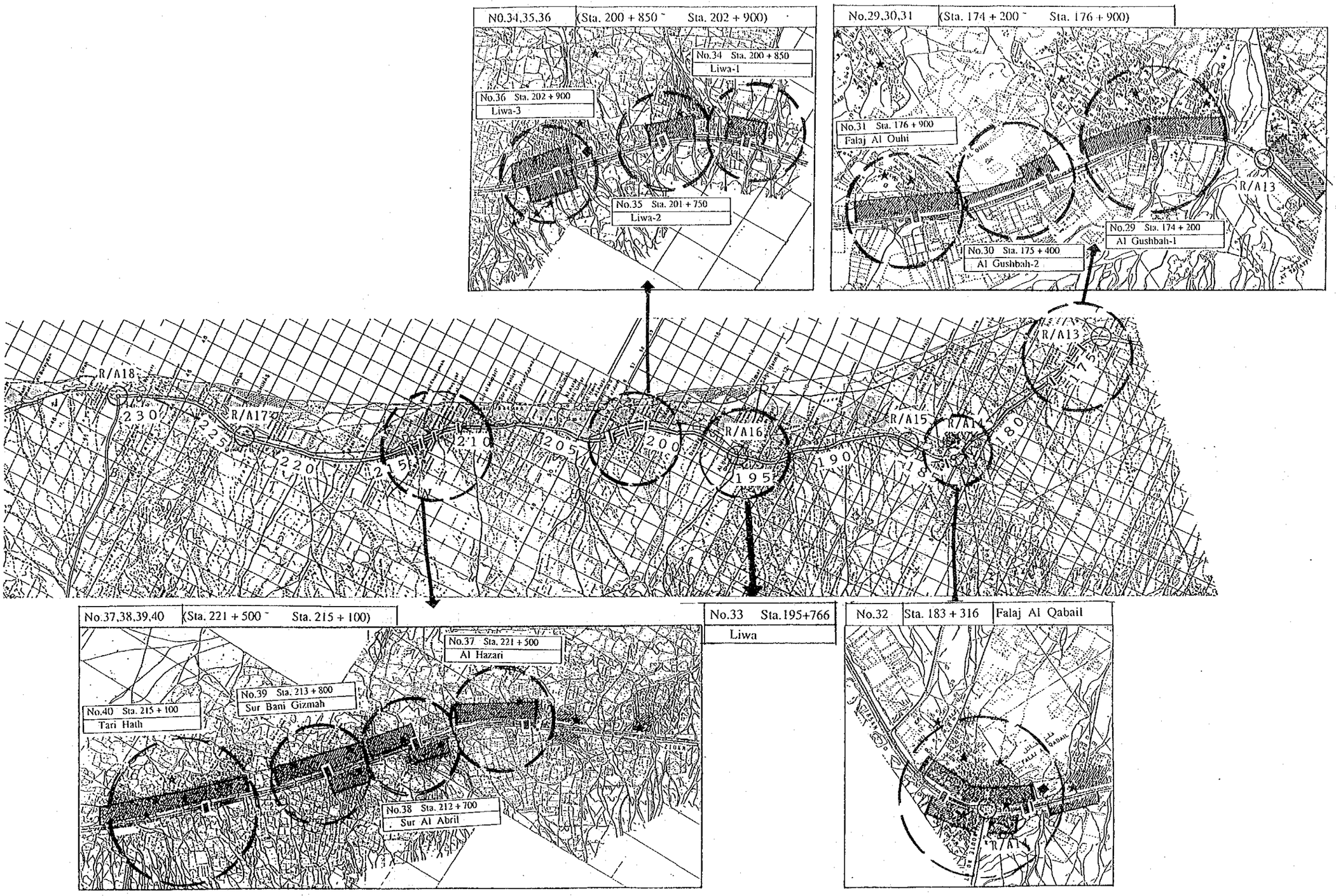




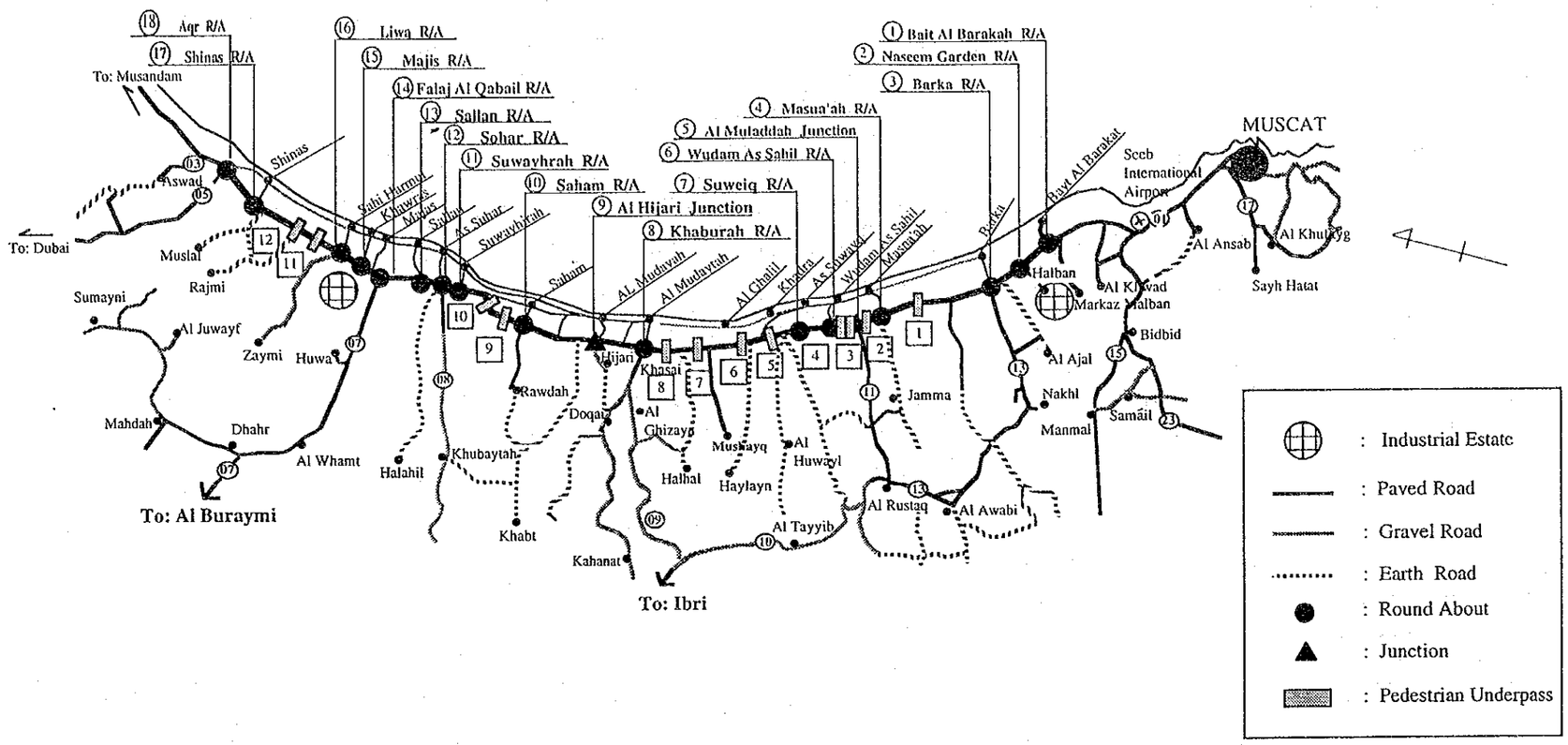
THE STUDY ON ROAD DEVELOPMENT PROJECT	JAPAN INTERNATIONAL COOPERATION AGENCY	Fig 8.2 LOCATION PLAN OF PEDESTRIAN UNDERPASS (2/4)

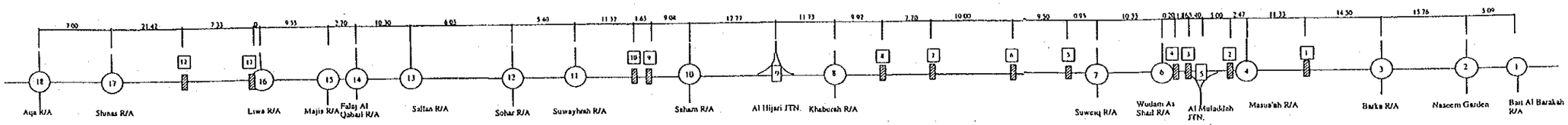


THE STUDY ON ROAD DEVELOPMENT PROJECT	JAPAN INTERNATIONAL COOPERATION AGENCY	Fig 8.3 LOCATION PLAN OF PEDESTRIAN UNDERPASS (3/4)



THE STUDY ON ROAD DEVELOPMENT PROJECT	JAPAN INTERNATIONAL COOPERATION AGENCY	Fig 8.4 LOCATION PLAN OF PEDESTRIAN UNDERPASS (4/4)





Number of Pedestrian Underpass		12	11	10	9	8	7	6	5	4	3	2	1
Name of Pedestrian Underpass		Liwa-3	Liwa	Mujas As Sughra	Hilat Al Rawashid	Al Bidayah	Dhyan-2	Al Khadra	Bataha Hilal	Al Tharmad	Al Qart	Al Tarif	Al Billah
Location		202+900	195+766	150+250	148+600	100+100	92+400	82+350	72+900	61+416	59+600	49+200	35+400
Area (km2)	Coastal Side	0.13	N.a	0.14	0.22	0.12	0.08	0.03	0.08	0.26	0.12	0.14	0.06
	Mountain Side	0.10	N.a	0.12	0.12	0.14	0.04	0.06	0.04	0.14	0.12	0.19	0.05
School		Sea Side	N.a	-----	-----	Sea Side	Sea Side	Sea Side	Sea Side	-----	-----	-----	Sea Side

THE STUDY ON ROAD DEVELOPMENT PROJECT	JAPAN INTERNATIONAL COOPERATION AGENCY	Table 8.2 PROPOSED LOCATION OF PEDESTRIAN UNDERPASS

8.3 Consideration from Traffic Safety View Points

1) Observed Conditions of Crossing Pedestrian

In order to decide the construction priority of pedestrian underpasses from the viewpoint of traffic safety, it is needed and required to analyze the existing conditions of pedestrian accidents on the Batinah Highway. But unfortunately, there is no particular pedestrian accident data or statistics available on the Highway.

It is a serious problem and astonishing and that no pedestrian crossing facilities are observed along the Highway that was constructed with high design speed and operated with high speed of about 110-kph (according to the speed survey).

Therefore, any location basically can be recommended to construct the grade separated crossing facilities along the Highway, even after considering properly the characteristics at the site such as social and cultural conditions based on the activities of adjacent inhabitants.

The following inconvenient and dangerous pedestrian situations in crossing the highway were observed by the site survey of JICA study team.

i) Many people, especially women, aged or handicapped people had very hard times to cross the guardrail on median.

ii) Bicyclers, especially children, had difficulty to pass under the guardrail.

iii) Aged and handicapped people needed long waiting time to cross, the longest time was measured more than five (5) minutes because of the low speed of their crossing and high-speed vehicular traffic.

2) Highly Recommendable Location

The following two (2) locations are urgently recommended as locations to construct pedestrian underpass from viewpoint of safety.

a) Al Bidayah

Al Bidaya is the first priority location to construct pedestrian underpass. There are densely populated villages on both sides of the highway stretching more than one (1) kilometer.

Many pedestrians are observed crossing the Highway. According to the sample survey, the highest pedestrian crossing volume was counted at more than 300 per hour at evening peak hour, as shown in Table 8.3.

Speed of vehicular traffic is observed as considerably high at this location. The speed limit is posted at 50 km/h, although an exact survey was not conducted.

b) Al Tarif

Al Tarif can be the second priority location as there are villages on both side of the Highway stretching more than 500 meter which have a high potential of crossing demands of inhabitants.

Horizontally curved alignment renders poor visibility and worsens the condition, therefore the reason for setting high priority at this location.

Table 8.3 Pedestrian Crossing Volume on Batinah Highway Survey Station Al Bidayah

Direction / Time	Direction A			Direction B			Total/h		
	Part 1	Part 2	Total	Part 1	Part 2	Total			
6:00 ~ 7:00	44	41	85	26	61	87	172	Crossing Volume is Morning Hour	Day Time (12 Hours) Crossing Volume
7:00 ~ 8:00	62	43	105	50	81	131	236	232/Hour	
8:00 ~ 9:00	114	95	209	69	79	148	288		
15:00 ~ 16:00	42	60	102	51	60	111	213	Crossing Volume in Evening Hour	3,064/day time
16:00 ~ 17:00	84	66	150	88	87	175	325		* Estimated Volume
17:00 ~ 18:00	68	56	124	91	83	174	298	278/Hour	
Ave. No./Hour	69.0	60.2	129.2	62.5	75.2	137.7	255.3		

Remarks:

1) Direction A: Pedestrian Crossing from Bus Stop side to Mosque Side
   B: Pedestrian Crossing from Mosque Side to Bus Stop Side

2) Part 1: 250 m Range from Bus Stop to Muscat
   2: 250 m Range from Bus Stop to Aqr

3) Survey Date: July 16, 17 1994

8.4 Type of Pedestrian Crossing Facility

There are two types of pedestrian crossing facilities, namely overpass and underpass. These two types are compared in Table 8.4.

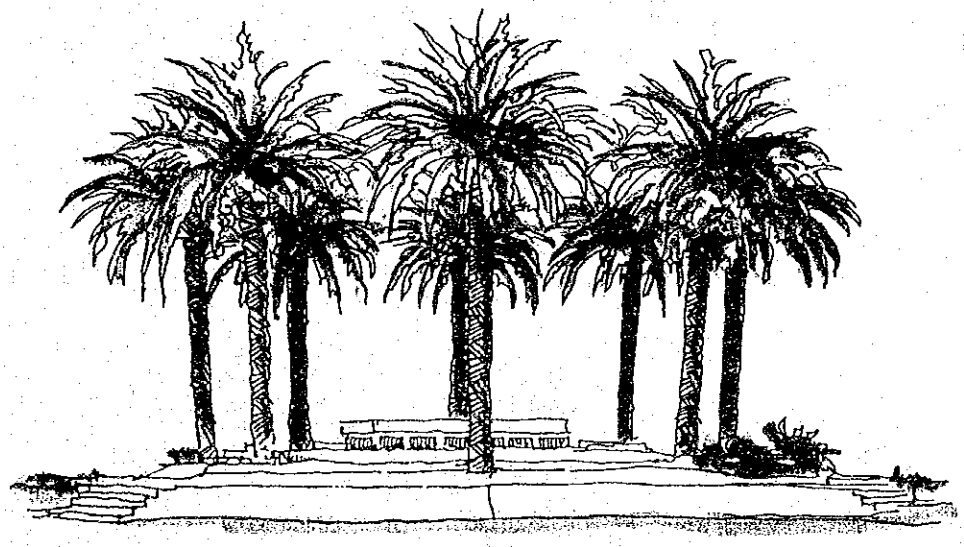
In Oman only the underpass type are used apparently due to aesthetic consideration, also being good refuge from summer heat and provide crossing for livestock. There might be a case in detailed design stage where overpass with necessary shelter will have to be designed because of unfavorable conditions for underpass.

Table 8.4 Comparison of Pedestrian Facility

Criteria	Underpass	
1. User's Convenience	The pedestrians are psychologically liable to use due to less climbing height than flyover	Opposite of underpass due to much more climbing height than underpass
2. Comfort	Good	Fair but bad in summer
3. Crime Prevention	Lighting required and other measures	None required
4. Aesthetic	Good	Required harmony with surroundings
5. Effect on Surroundings	Almost none	Protective measures on highway are required
6. Construction Cost	Low	Slightly High
7. Maintenance	Required	Little
8. Ease of Construction	Normal	Less than Underpass

From the above table, underpass type was selected judging from economical and aesthetic standards.

CHAPTER 9 PRELIMINARY STUDY OF GRADE SEPARATION FACILITIES



CHAPTER 9

PRELIMINARY STUDY OF GRADE SEPARATION FACILITIES

9.1 General

This section describes the results of preliminary study of grade separation facilities for eight (8) selected roundabouts of high priority in Chapter 7 based on the results of traffic demand forecast, topographic survey and soil investigation.

Table 9.1 gives the name, location and structure type of eight (8) roundabouts.

Table 9.1 List of Eight (8) Selected Roundabouts of High Priority

No.	Roundabout	Name	Location	Type of structure
1	R/A - 2	Naseem Garden	5 + 090	A
2	R/A - 3	Barka	20 + 850	A
3	R/A - 5	Al Muladdah JUN.	54 + 156	A
4	R/A - 8	Khaburah	110 + 016	A
5	R/A-10	Saham	139 + 516	A
6	R/A-12	Sohar	166 + 968	B
7	R/A-14	Falaj Al Qabail	183 + 316	B
8	R/A-18	Aqr	231 + 316	Special

9.2 Investigation of the Natural Conditions

In order to obtain more detailed field information for the feasibility study, topographic survey, soil investigation and environment investigation were performed. For a detailed description of the environment impact study, refer to Chapter 12.

9.2.1 Topographic Survey

Topographic survey of the roundabouts and pedestrian underpasses were performed, selected in the study as shown in Chapters 7 and 8.

The field survey was implemented during June and July in 1994.

Name of roundabouts, pedestrian underpasses and description of field survey are shown as Table 9.2A, 9.2B and Table 9.3A, 9.3B. Its details are shown in Table 7.23 and Table 8.2.

Table 9.2A List of Roundabouts for Field Survey

Number of R/A	Station	Name of R/A	Remark
No. 2	5 + 090	Naseem Garden	
No. 3	20 + 850	Barka	Route 13
No. 5	54 + 156	Al Muladdah Junction	Route 11
No. 8	110 + 016	Khaburah	Route 9
No. 10	139 + 516	Saham	
No. 12	166 + 968	Sohar	Route 8
No. 14	183 + 316	Falaj Qabail	Route 7
No. 18	231 + 316	Aqr	Route 5

Table 9.2B List of Pedestrian Underpasses

Number of P/U	Station	Name of P/U	Remark
P/U - 1	35 + 400	Al Billah	
P/U - 2	49 + 200	Al Tarif	
P/U - 3	59 + 600	Al Qart	
P/U - 4	61 + 416	Al Tharmad	
P/U - 5	72 + 900	Bataha Hilal	
P/U - 6	82 + 350	Al Khadra	
P/U - 7	92 + 400	Dhyan-2	
P/U - 8	100 + 100	Al Bidayah	
P/U - 9	148 + 600	Hilat Al Rawashid	
P/U-10	150 + 250	Mujas As Sughra	
P/U-11	195 + 766	Liwa	
P/U-12	202 + 900	Liwa-3	

Table 9.3A Description of Field Survey for Roundabout

Survey Type	Scale	Remark
Centerline and longitudinal	H = 1/500	
Leveling survey	V = 1/100	
Cross section leveling	V.H = 1/100	
Survey		
Plane table survey	1/200, 1/500	0.2 m Contours

Table 9.3B Description of Field Survey for Pedestrian Underpass

Survey Type	Scale	Remark
Centerline and longitudinal	H = 1/200	
Leveling survey	V = 1/200	
Cross section leveling	V.H = 1/100	
Survey Plane table survey	1/200	0.2 m Contours

9.2.2 Soil Investigation

(1) Introduction

The object of the soil investigation is to provide information and data for structure, earthwork and other designs for the feasibility study on the construction of flyovers and pedestrian underpasses along the Batinah Highway. Machine boring, standard penetration tests, samplings, soil laboratory tests, etc., were carried out.

The investigation was carried out for eight roundabouts and three pedestrian underpasses along Batinah Highway from June to July in 1994.

Machine boring was conducted for a total 11 holes (135 m) with 115 standard penetration tests, and before machine boring, survey for buried structure by test pits with depth 2.5 m to 3.0 m was implemented. The samples taken from those surveys were tested.

Summary of field works and laboratory works

1.	Machine boring	11 locations	135 m
	for Roundabouts	8 locations	105 m
	for Pedestrian underpasses	3 locations	30 m
2.	Standard penetration test		115 each
3.	Survey for buried structure by test pits		11 each
4.	Laboratory works		
	Physical test		37 tests

(2) Stratigraphy

1) General

The geology of Batinah coastal plain consists of sedimentary formation of tertiary and quaternary age. Tertiary sedimentary rocks are extensively distributed and form baserock in the area, overlain by quaternary sediments which consist of terrestrial sediment, fans deposit fluviatile deposit and coastal deposit. These are tabulated below.

Explanation of sedimentary rocks

Geological time		Formation	Description
Quaternary	Holocene	Alluvium	Fluviatile deposit, recent fans coastal deposit
	Pleistocene	Diluvium	Fluviatile deposit, old fans terrace deposit
Tertiary	Neocene	Mudstone	Mudstone, Gravely mudstone and marlymudstone, marlystone
	Paleocene	Limestone	Limestone, marlystone

Tertiary formation

Tertiary sedimentary rocks consist of limestone, marlystone, mudstone, gravely mudstone and marlymudstone. According to deep well data, the sedimentary rocks are confirmed from ground surface depth 50 m to 100 m.

In this machine boring survey, Junction white mudstone from ground surface depth 10 meters was confirmed at Al Muladdah.

Diluvium

Diluvium consists of fluviatile deposit, old fans, terrace deposit and is formed of consolidated and unconsolidated silt, sand, gravel and sandy gravel.

Alluvium

Alluvium consists of Wadi fluviatile deposit, recent fans and coastal deposit. These are formed of coastal sand with dunes or barchans and silt of which faces are marked by the intercalations of sand and granule or lamina of silt, clay and granule.

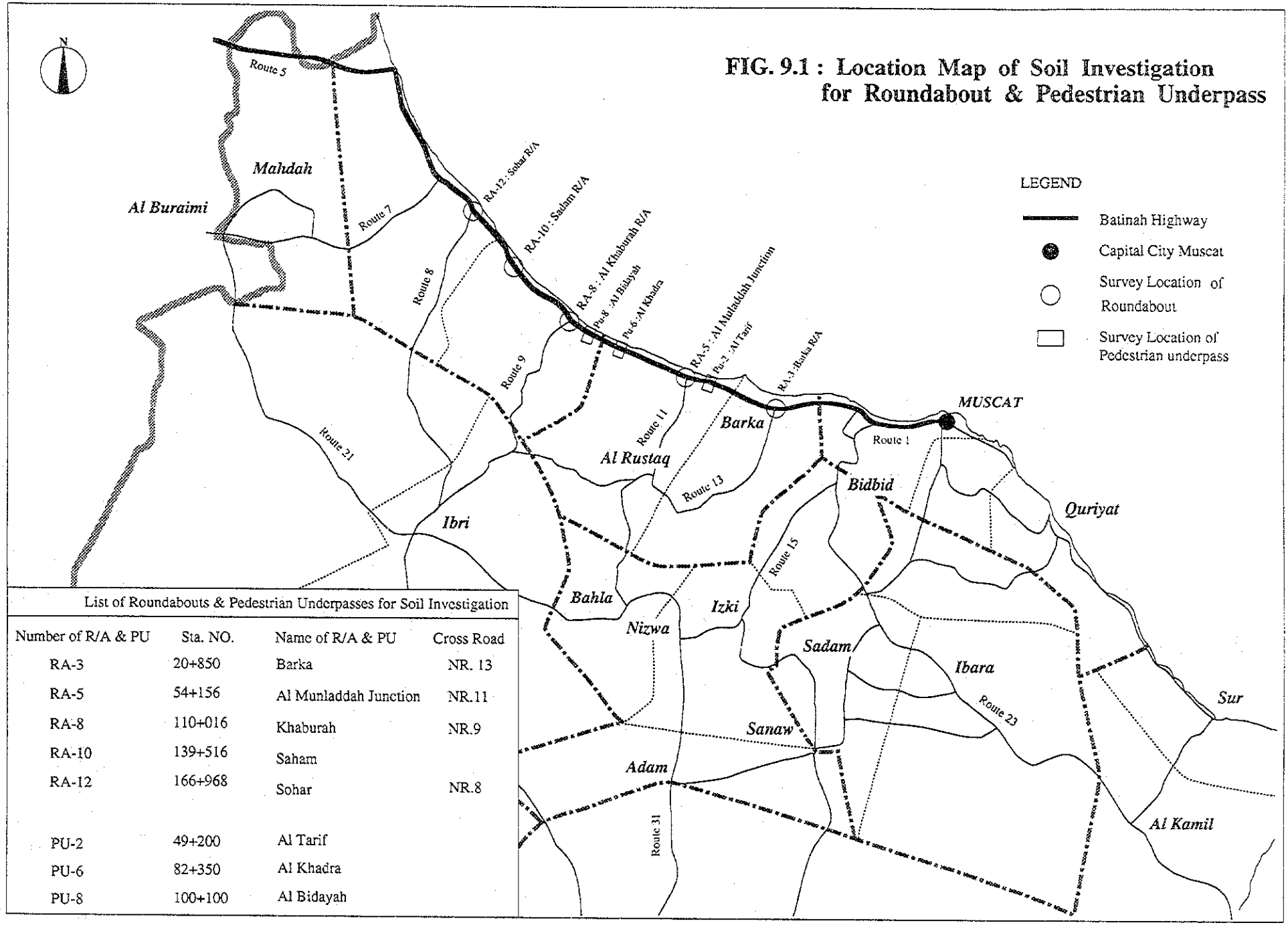
2) Soil Condition of Survey Site

Soil investigation was carried out at five roundabouts and three pedestrian underpasses. Refer to Fig. 9.1 location map of soil investigation for roundabouts & pedestrian underpasses and list of roundabouts & pedestrian underpasses for soil investigation.

a) R/A - 3 Barka

The deposit of the site consists of silty fine sand with rounded gravel and silty fine sand of solid status.

FIG. 9.1 : Location Map of Soil Investigation for Roundabout & Pedestrian Underpass



List of Roundabouts & Pedestrian Underpasses for Soil Investigation

Number of R/A & PU	Sta. NO.	Name of R/A & PU	Cross Road
RA-3	20+850	Barka	NR. 13
RA-5	54+156	Al Munladdah Junction	NR.11
RA-8	110+016	Khaburah	NR.9
RA-10	139+516	Saham	
RA-12	166+968	Sohar	NR.8
PU-2	49+200	Al Tarif	
PU-6	82+350	Al Khadra	
PU-8	100+100	Al Bidayah	

- Upper silty fine sand bed

  From ground surface to 3.0 m depth, is investigated by hand digging test pit. The bed is formed of light brown loose to medium dense silty fine sand (depth 2.2 ~ 2.6 m) and brown dense to very dense silty fine to medium sand (depth 2.2 ~ 3.0 m).

- Lower silty fine sand bed

  The bed is formed of light brown silty fine sand with rounded gravel of diameter 0.5 to 5.0 cm. Thickness of soil bed is 4.0 meters and N-value ranges from 31 to 50/15.

- Fine sand of solid status bed

  This bed is located at a depth of 91.2 m and is formed of light brown silty fine sand of solid status with rounded gravel. Thickness of bed is more than 3.3 meters and N-value ranges from 50 to 50/8.

b) R/A - 5 Al Muladdah Junction

Deposit of the site consists of sandy soil and mudstone. At the time of investigation, the ground water level was confirmed at a depth of 9.8 meters from ground surface.

- Sandy Soil

  From ground surface to 2.2 m depth is investigated by hand digging test pit. The bed is formed of brown loose silty fine sand (depth 0 ~ 0.7 m) and brown medium to dense silty fine sand (depth 0.7 ~ 2.5 m).

  The bed of depth from 2.5 m to 6.5 m is formed of brown silty fine sand of solid status with rounded gravel. N-value range from 36 to 50/15 and thickness of bed is 4.0 meters.

Mudstone

The bed is formed of white mudstone and intercalation of sandy soil of solid status. White mudstone is located at a depth of 93.0 meters to 84.4 meters and N-value range from 44 to 50/7. Intercalation of sandy soil is made up of silty fine to medium sand of solid status with rounded gravel and N-value range from 50/10 to 50/9.

c) R/A - 8 Khaburah

The deposit of the site consists of sandy soil and groundwater level was confirmed at a depth of 10.40 meter from ground surface. Ground surface to 3.0 meters depth is investigated by hand digging test pit. The bed is formed of brown loose silty fine sand (depth to 1.7 m), brown soft sandy silt (depth 1.7 m to 2.7 m) and brown medium dense silty fine sand (depth 2.7 m to 3.0 m).

- Upper sandy soil bed

  The bed is formed of silty fine sand of semi solid status. This is located at a depth of 96.9 m to 93.1 m and thickness of bed is 3.8 meters with N-value ranges from 10 to 31.

- Lower sandy soil bed

  The bed is formed of fine to coarse sand with rounded gravel of diameter 0.5 ~ 5.0 cm max, 10 cm. This is located at a depth of 93.1 m to 84.5 m and thickness of bed is 8.6 m. N-value ranges from 50/29 to 50/8.

d) R/A - 10 Saham

The deposit of the site consists of sandy soil and sand of solid status. At the time of investigation, the groundwater level was not measured at any of the boreholes drilled.

- Upper sandy soil bed

  The bed is formed of brown silty fine sand and is located at a depth of 100 m to 92.6 m. Thickness of bed is 7.0 meters with N-value ranges from 7 to 22.

- Lower sandy soil bed

  The bed is formed of fine to medium sand of solid status with much rounded gravel of diameter 0.5 ~ 3.0 cm. This is located at an altitude from 91.3 m to 86 m and thickness of bed is more than 5.4 meters with N-value ranges from 57 to 50/10.

e) R/A - 12 Sohar

The deposit of the site consists mainly of sandy soil and can be divided into two deposit of upper and lower sandy soil bed, its boundary is at a depth of 87.0 meters. At the time of investigation, the groundwater level was confirmed at a depth of 11.5 meters from ground surface.

- Upper sandy soil bed

  Ground surface to 3.0 meters depth is investigated by hand digging test pit. The bed is formed of light brown silty fine sand and intercalates a brown fine sand bed with gravel. This is located at a depth of 99.5 m to 87.0 m with N-value ranges from 11 to 34. Intercalation of fine sand bed is located an altitude from 93 m to 90 m with N-value from 40 to 50/13.

- Lower sandy soil bed

  The bed is made up of medium to coarse sand with rounded gravel and is located at a depth of 87.0 meters. The N-value ranges from 50 to 50/7 and the bed is reasonable bearing stratum for the structural design.

f) Pedestrian Underpass

Soil investigations for pedestrian underpasses were carried out at three location (Al Tarif, Al Khadrra and Al Bidaya).

Bearing Strafa for pedestrian underpasses from ground surface to about 5 meters down consist of silty fine sand and sandy silt with N-value ranges from 34 to 43.

At the time of investigation, the groundwater level was not measured at any of the boreholes drilled.

PU-1 Al Tarif

The deposit of the site consists of silty fine sand, sandy silt and fine to medium sand with rounded gravel.

- Upper sandy soil bed

  From ground surface to 1.6 meters depth is investigated by hand digging test pit. The bed is formed of light brown silty fine sand and yellowish grey sandy silt from ground surface to 5.5 meters with N-value ranges from 11 to 34.

- Lower sandy soil bed

  The bed is made up of fine to coarse sand with rounded gravel sandy silt and silty fine sand of solid status, this is located at a depth of 93.4 meters to 88.47 meters with N-value ranges from 41 to 50/15.

PU-6 Al Khadra

The deposit of the site consist of silty fine to coarses sand with rounded gravel.

- Upper sandy soil bed

  From ground surface to 2.5 meters depth is investigated by hand digging test pit.

  The bed is formed of brown silty fine sand with partially rounded gravel and is located at a depth of 100.05 meters to 96.7 meters with N-value of 16.

- Lower sandy soil bed

  The bed is made up of silty fine to coarse sand with rounded gravel and is located at a depth of 96 meters to 89.81 meters with N-value ranges from 37 to 50/24.

PU-8 Al Bidayah

The deposit of the site consist of brown silty fine to coarse sand with rounded gravel.

- Upper sandy soil bed

  From ground surface to 2.5 meters depth is investigated by hand digging test pit. The bed is formed of silty fine sand with rounded gravel, and is located at a depth of 99.6 meters to 96.3 meters.

  Thickness of the bed is 3.3 meters and N-value is 26.

- Lower sandy soil

  The bed is made up of fine to coarse sand with rounded gravel and is located at a depth of 96.3 meters to 89.4 meters. Thickness of the bed is 7.0 meters and N-value ranges from 30 to 50/13.

(3) Soil Laboratory Test

1) General

The soils subject to analysis for the earth work design are sandy soil and cohesive soil bed of which a total 37 disturbed samples were taken by split-spoon sampler. Test results are referred to in the analysis as the following soil categories.

Gravelly sand soil	3 samples
Sandy soil	17 samples
Cohesive soil	17 samples
Total	37 samples

Table 9.4 Contents of Laboratory Test

Test	Standard	Unit	Quantities
Natural Water Content	BS 1377: Part 2: 1990: 3.2	Test	37
Specific Gravity	BS 1377: Part 2: 1990: 8.3	Test	20
Grain Size Analysis	BS 1377: Part 2: 1990: 9.2	Test	20
Atterberg Limit Determination	BS 1377: Part 2: 1990: 4.3	Test	4
In-Situ Dry Density	BS 1377 (1990) "method of test for soils for Civil Engineering Purposes"	Test	22

2) Soil Laboratory Test Result

A) Particle Size Gradation

The gradation of three categories is shown in Table 9.5 and Fig. 1-1 in Appendix.

The deposit of sandy soil contains coarse particles more than 76.4 ~ 90.6% and cohesive soil contains fine particles of clay and silt more than 64.2% of total weight.

Table 9.5 Result of Particle Size Gradation

Items of Gradation and Average / Deposit	Gravel (%)	Sand (%)	Silt - Clay (%)	No. 10 (2.00 mm) (%)	No. 40 (0.425 mm) (%)	No. 200 (0.075 mm) (%)
	Average Value	Average Value	Average Value	Average Value	Average Value	Average Value
	Representative Range	Representative Range	Representative Range	Representative Range	Representative Range	Representative Range
Gravelly Soil	41.7	48.9	9.4	58.3	42.5	9.4
	35.6 ~ 47.8	42.1 ~ 55.7	8.4 ~ 10.4	52.2 ~ 64.4	32.5 ~ 52.5	8.4 ~ 10.4
Sandy Soil	9.0	67.4	23.6	91.0	83.6	23.6
	1.3 ~ 19.5	57.7 ~ 76.9	12.9 ~ 34.3	80.4 ~ 100	68.8 ~ 98.4	12.9 ~ 34.3
Cohesive Soil	5.3	30.5	64.2	94.7	93.6	64.2
	1.6 ~ 9.0	17.8 ~ 43.2	51.9 ~ 76.5	90.9 ~ 98.5	89.7 ~ 97.8	51.9 ~ 76.5

B) Character of Consistency

The objective of the test is to classify soil by Particle Size Gradation. The character of consistency is summarized in Table 9.6 and is shown Fig. 1-2 in Appendix.

- No change of consistency is observed with increasing depth below ground.
- According to the consistency chart, cohesive deposit is to be classified into ML or CL.
- Colloidal activity

  Cohesive deposits are to be classified as non-active clay (mainly kaolinite) and ordinary clay (mainly illite).
- Cohesive deposits are classified as being in a stable condition as WL > Wn and Ic = 1.04 (0.90 ~ 1.18).

Table 9.6 Result of Consistency

Items of Consistency / Deposit	Wn (%)	Wl (%)	Ip	If	It	Ic	Activity Ratio
	Average Value	Average Value	Average Value	Average Value	Average Value	Average Value	Average Value
	Representative Range	Representative Range	Representative Range	Representative Range	Representative Range	Representative Range	Representative Range
Cohesive Soil	16.9	34.5	9.9	-	-	1.04	0.72
	8.5 ~ 25.3	32.9 ~ 36.1	9.0 ~ 10.8	-	-	0.90 ~ 1.18	0.58 ~ 0.82

Note:
CH: High plasticity and cohesive clay, non organic
OH: Organic clay with medium plasticity
MH: Non-organic silt, mica or diatomaceous fine sand/silt and elastic silt
ML: Non-organic silt, fine sand, silty or clayey fine sand
OL: Low to medium plasticity non-organic silt, sandy clay low-cohesive clay
CL: Low to medium plasticity silt, clay with sand or gravel, and low cohesive clay
Wn: Natural water content
WL: Liquid limit
Ip: Plasticity index
If: Flow index
It: Toughness index (It = Ip/If)
Degree of shear strength at plastic limit

Ic: Consistency index (Toughness and stability of cohesive soil)
Ic = WL - Wn/Ip
Ic ≥ 1 Stable condition
Ic = 0 Unstable condition: Liquidizes by disturbance

Colloidal activity: Colloidal activity has deep ties with clay mineral and geological condition of sediment, and is defined by Skempton.

Clay is classified into four groups from non-active clay to high active clay as more than 2. It is shown as the following formula.

$$\text{Colloidal activity} = \frac{\text{Plasticity index Ip}}{\text{Soil particle (\%) of less than } 2\mu}$$

Table 9.7 Classification by Colloidal Activity

Activity Ratio	Kind of Cohesional Soil by Activity Ratio	Main Clay Mineral	Deposit Condition
A < 0.75	Non active clay	Kaolinite	• Clay of aqueous and fresh water sediment • Clay of marine deposit which has been leached.
A = 0.75 ~ 1.25	Ordinary clay	Illite	Clay of marine and estuarine deposit
A > 1.25	Active clay	• Including organic colloid • A = 2 is including Montmorillonite	—

C) Specific Gravity, Wet Density and Void Ratio

The above are summarized in Table 9.8.

Table 9.8 Result of Gs γ t e

Items of Soil Properties / Deposit	Specific Gravity Gs	Wet Density γ t (t/m³)	Void Ratio e
	Average Value	Average Value	Average Value
	Representative Range	Representative Range	Representative Range
Gravelly Soil	2.524 2.422 ~ 2.626	-	-
Sandy Soil	2.538 2.448 ~ 2.628	1.832 1.702 ~ 1.962	0.447 0.350 ~ 0.544
Cohesive Soil	2.440 2.380 ~ 2.500	1.750 1.649 ~ 1.851	0.479 0.405 ~ 0.553

- Specific Gravity

  The test results yield reasonable value with standard deviation of less than 0.090.

- Wet Density

  The tests was carried out by in-situ dry density with test pit and test results was obtained reasonable value.

  Other factors are shown in the following formula:

$$\gamma t = \frac{1 + Wn/100}{\frac{1}{Gs} + \frac{Wn/100}{Sr/100}} \cdot \gamma w$$

where, γ t: Wet density of soil (t/m³)
Wn: Natural water content (%)
Sr: Degree of saturation (%)
γ w: Density of water (= 1.00 t/m³)
Gs: Specific gravity

The average values are shown below:

Deposit	Dry Density $\gamma d(t/m^3)$	Wet density $\gamma t\ (t/m^3)$	Degree of Saturation Sr
Sandy Soil	1.76	1.83	10.9
Cohesive Soil	1.52	1.75	30.5

- Void Ratio

The average values of void ratio are shown below:

Sandy Soil $\bar{e} = 0.447$
Cohesive Soil $\bar{e} = 0.479$

(4) Foundation Strata for Structural Design

A) Criteria and Distribution of Bearing Strata

The load bearing strata for structures is assessed depending on importance of the structure and the longitudinal forces to be carried by the structure.

In general, the criteria for spread or piled foundations of bridge abutments and piers is defined as the following N-values:

Sandy Soil $N > 30$
Cohesive Soil $N > 20$

Result of soil investigation, the depth of bearing strata of the above N-values and more than 50 are shown as Table 9.9.

Table 9.9 Bearing Strata for Structural Design

Site	Bearing Strata			
	N-Value more than 30		N-Value more than 50	
	Depth (Altitude)	Soil Bed	Depth (Altitude)	Soil Bed
Barka R/A	3.0 ~ 3.5 (95.5 ~ 96.5)	Silty fine sand	3.0 ~ 6.0 (93.5 ~ 96.5)	Silty fine sand
Al Muladdah Junction	3.0 (97.0)	Silty fine sand	4.0 (95.5)	Silty fine sand
Khabu Rah R/A	5.0 (94.5)	Silty fine sand	6.0 (93.5)	Silty fine sand
Saham R/A	7.0 (92.5)	Silty fine sand	8.0 ~ 9.0 (9.5)	Fine to medium sand
Sohar R/A	5.0 ~ 6.0 (92.5 ~ 93.5)	Silty fine sand	12.0 ~ 13.0 (86.5)	Medium to coarse sand
Al Tarif P/U	5.0 (94.0)	Sandy site	6.0 (93.0)	Fine to medium sand
Al Khadra P/U	4.0 (96.0)	Silty fine sand	6.0 (94.0)	Silty fine sand
Al Bidaya P/U	4.0 (96.0)	Silty fine sand	7.0 (93.0)	Medium to coarse sand

B) Soil Values of Bearing Strata

Soil values to decide the bearing strata for structures are summarized in Table 9.10.

Table 9.10 Soil Values of Bearing Strata

Division of Soil	Wet Density γt (t/m3)	Cohesion of the First Stage c (t/m^2)	Internal Friction Angle Ø (Degree)	Modulus of Elasticity Eo (kg/cm^2)
Sandy Soil	1.83	-	Fig. 9.2	-
Cohesive Soil	1.75	0.625N	-	28N

Note: N-value and ground water level are shown in the soil profile.

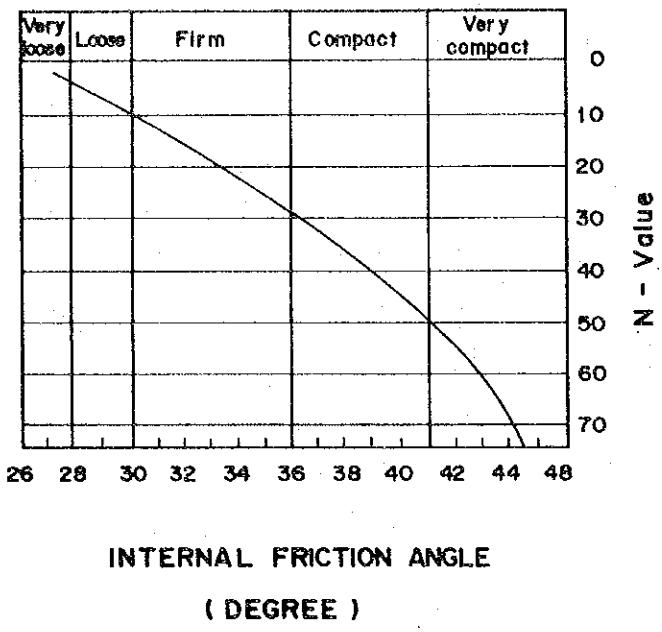


Fig. 9.2 Relative Chart for N-Value and Internal Friction Angle

9.3 The Required Number of Lanes

The number of lanes will be determined from the ratio of Traffic Demand Forecast (refer to Chapter 5) and the Traffic Capacity (refer to Chapter 6) of the Batinah Highway.

In this Study the number of lanes will be planned in the following manner in consideration of the present number of lanes and the planned traffic volume.

- Main Highway

  The design traffic volume on the Batinah Highway in 2010 was forecast from 59,000 to 13,700 pcu/day, and the maximum design traffic volume is predicted to be 60,000 pcu/day, so it has been determined to plan for 4 lanes the same as for the present Batinah Highway.

- Interchange Ramps

  The forecast traffic volume on the Muscat-side of the Barka Roundabout (R/A-3) is 13,000 pcu/day, and 9,000 to 400 pcu/day for the others. The maximum traffic volume is forecast for 12,000 pcu/day, so the number of lanes for the Muscat-side of the Barka Roundabout (R/A-3) has been decided as 2, with the others planned as one lane.

- Section of Inflow of Roundabout

  The width of the connection of the inflow lane and the roundabout will be w = 9 m.

9.4 Geometric Design of Grade Separation Facilities

9.4.1 General

The horizontal and vertical alignment for the grade separation facilities to be used at the eight selected roundabouts will be as follows while making use of the design criteria, survey data, and results of the geological (soils) data in Paragraph 9.2.

9.4.2 Horizontal and Vertical Alignment

(1) Horizontal Alignment

The horizontal alignment will be designed as follows:

- Changes in horizontal and vertical alignment will be gradual for safe travel at high speeds (120 km/h).
- Horizontal alignment will be planned so that the grade separation facilities can be designed within the right-of-way of the present roadways and roundabouts.
- The roundabout will be planned so that all intersection facilities can be confined within the outer circle of the present roundabout; therefore the connections of ramps with the intersecting roads and roundabout as well as the spacing of the footings and foundations, can all be contained within the circular space. The sight distance in the vicinity of the intersection (where there will be no supports) shall be greater than those shown in Fig. 9.3 for the Stopping Sight Distance on Horizontal Curve.

The grade separation facility (flyover) for Roundabout R/A-18 will have a special shape. Refer to paragraph 9.4.3 for a comparison of the alternate proposed structures.

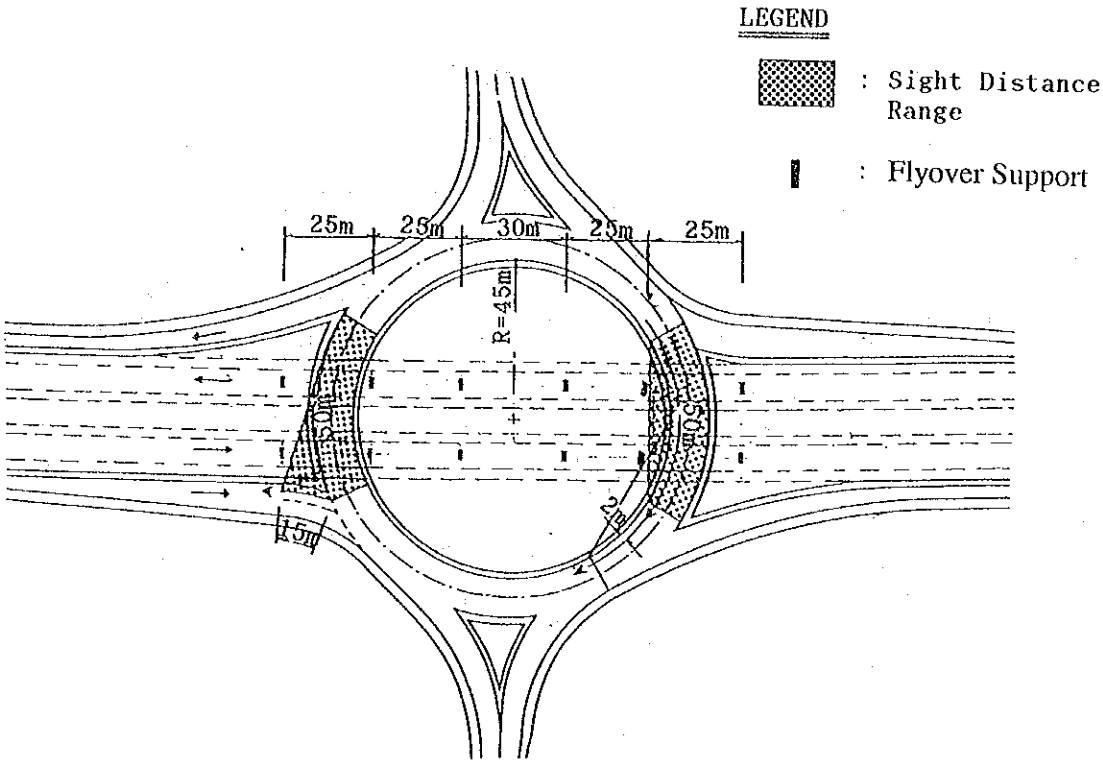
(2) Vertical Alignment

- The vertical alignment for a vehicle travelling at 120 km/h with grades of 3 %, 4 % and 5 % are given in Fig. 9.4.
- Of the alternate grades, the one with the lowest height of grade separation facility will be selected.

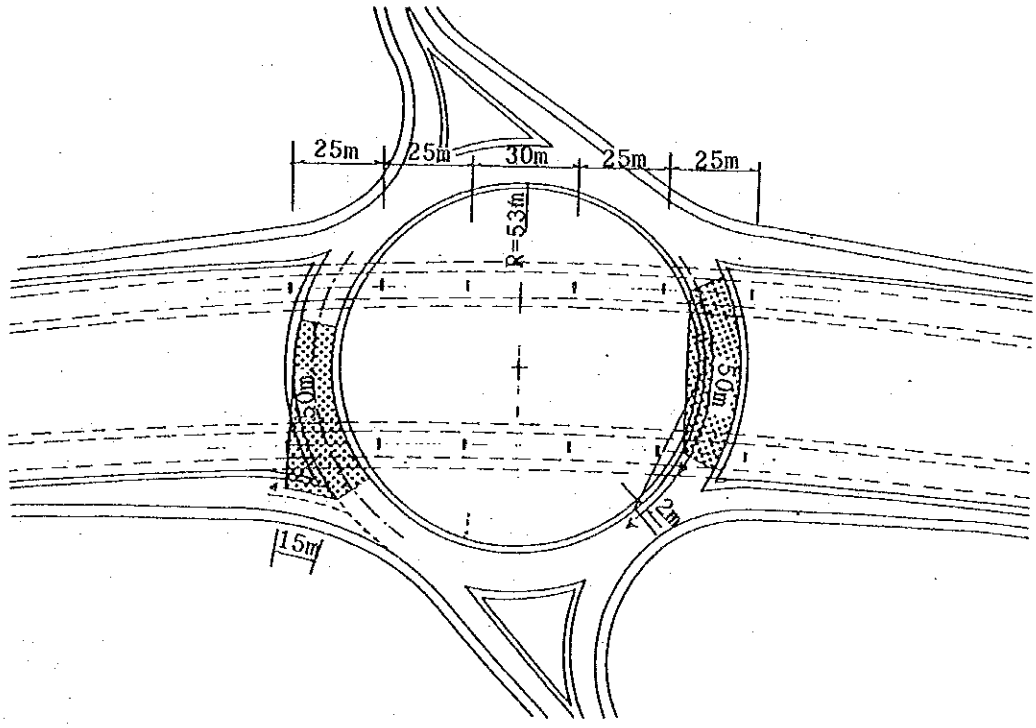
(3) Location for the Pedestrian Walkway.

The pedestrian walkway will be planned for the convenience of the villagers while keeping in mind the concepts given in Chapter 8.

Grade Separation Type A

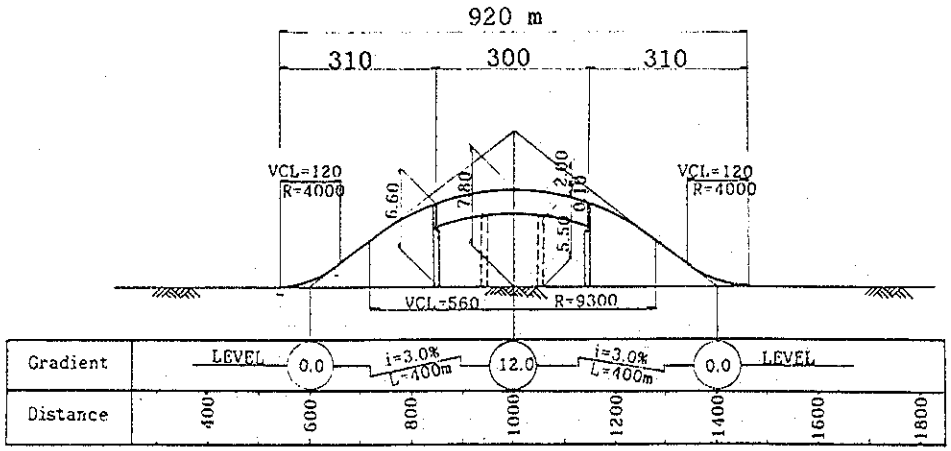


Grade Separation Type B

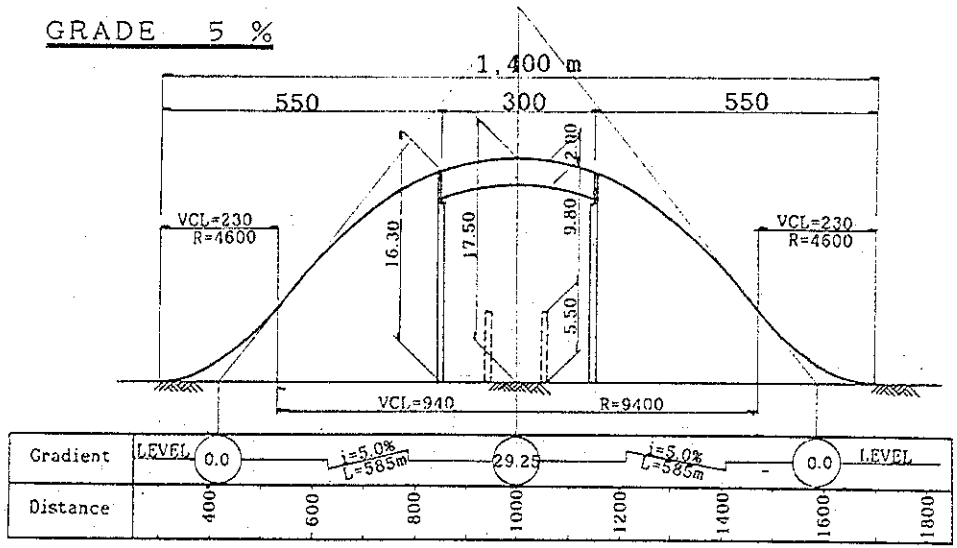


THE STUDY ON ROAD DEVELOPMENT PROJECT	JAPAN INTERNATIONAL COOPERATION AGENCY	Fig.9.3 Sight Distance Related to Roundabouts

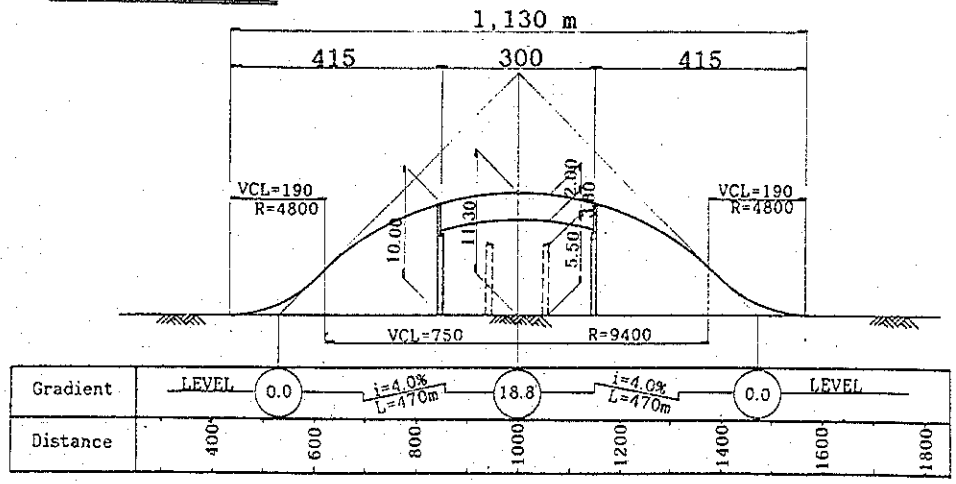
GRADE 3 %



GRADE 5 %



GRADE 4 %



Alternative of Vertical Alignment

Gradient		3 %	4 %	5 %
Vertical Curve (Crest)	Length	560 m	750 m	940 m
	Radius	9,300 m	9,400 m	9,400 m
Vertical Curve (Sug)	Length	120 m	190 m	230 m
	Radius	4,000 m	4,800 m	4,600 m
Flyover Length	Total	920 m	1,130 m	1,400 m
	Approach Bridge Approach	310 300 310	415 300 415	550 300 550
Crest Height		7.80 m	11.30 m	17.50 m
Recommend		○	—	—

Notes:
1. Design Speed 120km/h
2. Vertical Curve Length
   Crest: VCL=AS/426
   Sug : VCL=2S-(152.4+3.5S)/A

THE STUDY ON ROAD DEVELOPMENT PROJECT	JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 9.4 Vertical Alignment

9.4.3 Preliminary Design for Grade Separation Facility

The preliminary design for the grade separation facility based on the above consideration is as shown in Volume IV: Drawings.

9.4.4 Alternate Plans for Grade Separation Facilities

The proposed basic plan for the grade separation facility is given in paragraph 9.4.3. Alternate plans are made for R/A-5 (Al Muladdah Junction), and R/A-12 (Sohar), and R/A-18 (Aqr) which have been provided. These alternate plans should be given further consideration with the development of project and its implementation.

(1) Roundabout R/A-5

The Proposed Concept.

R/A-5 is presently of the T-shaped junction configuration. In view of the traffic conjunction in this area, the Oman Government has already planned work to improve the intersection. The preliminary plan given in paragraph 9.4.2, based on this concept is a grade separated version.

Alternate Plan

Compared to the other roundabouts, the volume of traffic on R/A-5 has a large volume of traffic in the directions of Muscat and Al Rustaq (Route 11). One concept proposed places emphasis on this traffic. The plan placing emphasis on the Muscat - Al Rustaq traffic (Route 11) is based on the following concept:

- To allow passage of the heavy traffic without obstructing other traffic and allowing smooth passage;
- Mandatory stopping for secondary traffic;
- To clarify the primary and secondary traffic flows.

Comments:

The above two comments have the following merits:

- The proposed plan permits the traffic from the village to flow smoothly through the roundabout.
- The alternate plan allows the largest flow of traffic to flow smoothly.

The two proposals above possess the following characteristics:

1) The original proposal enables the roundabout to ameliorate traffic from the neighboring community.

2) The comparative proposal prioritizes major traffic directions other than the trunk line for smooth flow.

Either of the above proposals call for a grade separation of the Batinah Highway, leaving the role of the ground level lanes to be one of service to the local community. Appropriate planning should be conducted to ensure maximum convenience.

The Fig. 9.5 gives a comparative plan which gives priority to the traffic on Batinah Highway and Route 11.

(2) Roundabout R/A-12

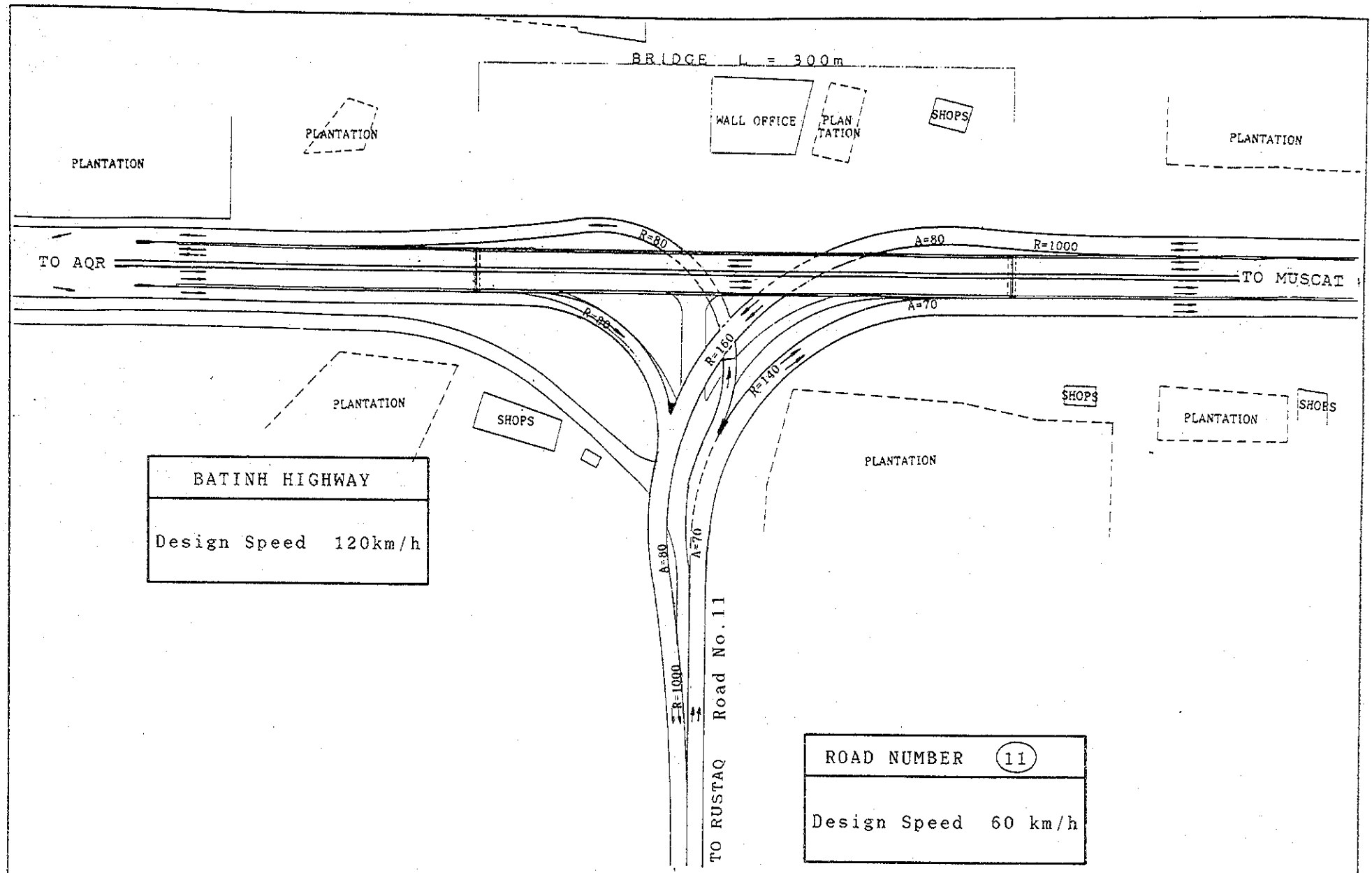
The proposed concept

The location of R/A-12, Sohar, will be sited in the center of the Batinah Highway where the land around the roundabout is most advanced. There is an existing monument, but after completion of the study a new monument will be erected by the government, and will be one of the most important roundabouts in the government.

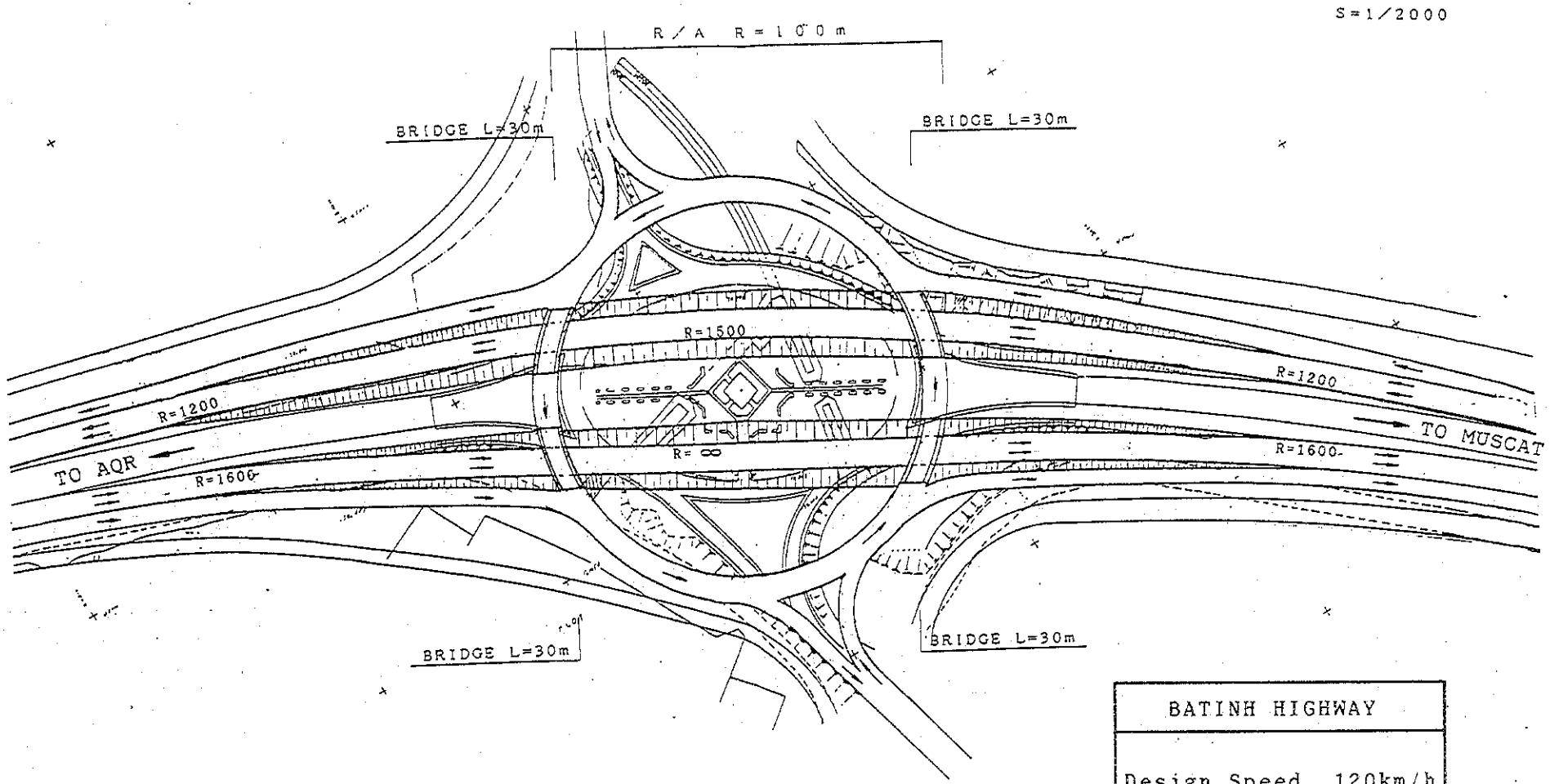
For these reasons the proposed monument and grade separation facilities will become one of the most outstanding landmarks in the Sultanate.

Alternate plan

From the point of aesthetics, it has been proposed to construct the grade separation an underground facility. The underground facility for the grade separation will make the monument stand out but will required special studies for the concentration of the various structures. For the local residents it will not be possible to cross over the Batinah Highway in the vicinity of the grade separation facility except at the intersecting highway. Fig. 9.6 shows the proposed underground plan.



THE STUDY ON ROAD DEVELOPMENT PROJECT	JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure 9.5 Alternate Plan of R/A 5**



THE STUDY ON ROAD DEVELOPMENT PROJECT	JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure 9.6 Alternate Plan of R/A 12**

Comments

The new proposed monument is expected to be some 40 m high and is expected to be visible by both drivers and local residents and is not considered to obstruct the view.

(3) Roundabout R/A-18 (Aqr)

Proposed plan

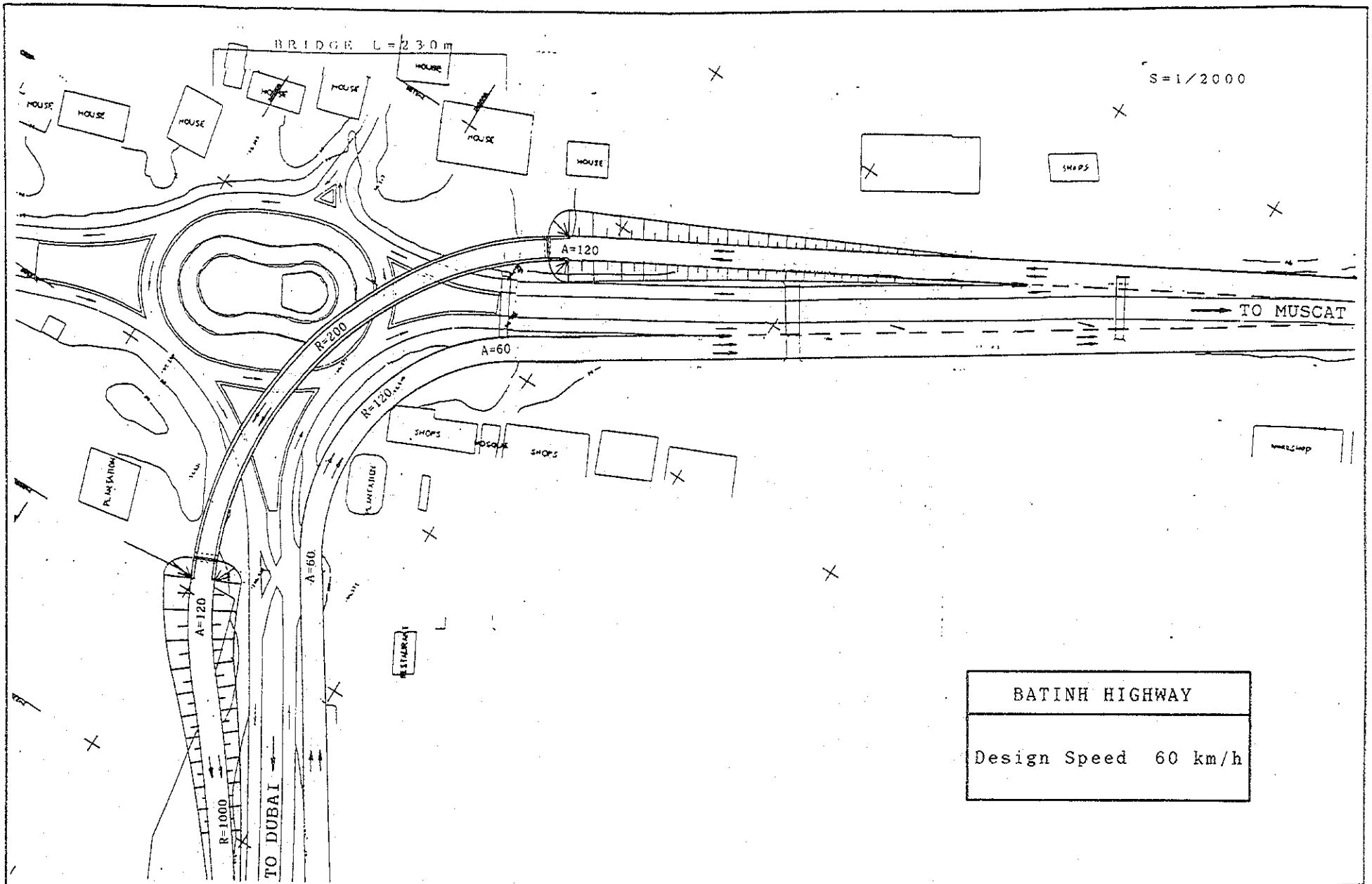
The main flows of traffic at R/A-18 (Aqr) are towards Dubai and Muscat, and it is proposed to make the grade separation facility in those directions. Therefore, the plan proposed in paragraph 9.4.2 places emphasis in the Muscat and Dubai directions and the interconnection therewith. It is a shortcut route which allows traffic to move at 120 km/h, and requires no relocation of the local residents. It will be necessary to elevate the grade separation facility at 2 locations, one on the Batinah Highway side, and the other on the Route No. 5 side.

Alternate plan

The comparative plan is to make maximum use of the existing roadway for the grade separation facility. In order to keep the relocation of local residents to a minimum, it will be necessary to reduce the design speed (60 km/hr) of the vehicles. Fig. 9.7 gives a plan of the comparative concept.

Comments

R/A-18 (Aqr) is the branch-off junction for the Dubai and Musandam directions, and is an important symbol for Oman. For this reason, for its importance as an interconnection to Muscat and Dubai the speed of 120 km/h has not been changed, and as a symbol a new grade separation facility with a monument is recommended to be built at this intersection.



THE STUDY ON ROAD DEVELOPMENT PROJECT	JAPAN INTERNATIONAL COOPERATION AGENCY	**Fig. 9.7 Alternate Plan of R/A 18**

9.5 Preliminary Design of Bridges

9.5.1 General

In paragraph 9.4, (Geometric Design of Grade Separation Facilities) the type of facility structure was determined at the time the field survey and boring for the foundations was conducted at the project roundabout structures. Preliminary design for a total of eight roundabouts was performed. After the type of structure was determined, the aesthetics were considered.

After the evaluation of bridge, types was determined, preliminary design was performed, preliminary quantities were estimated, cost estimates were performed as described in another chapter, construction planning/implementation planning prepared, and the data for economic analysis was obtained.

The flow chart for the grade separation structure together with the selection of scale was determined in accordance with the following flow chart in Fig. 9.8.

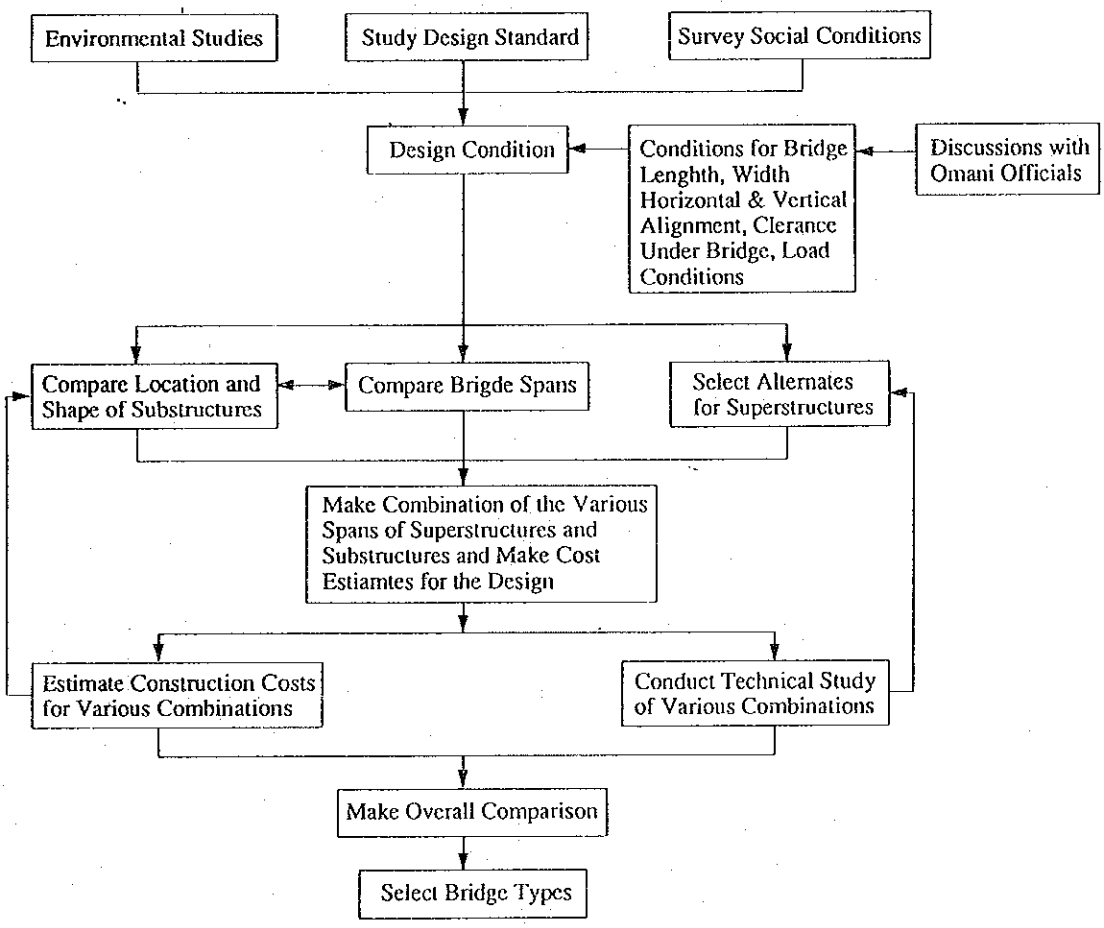


Figure 9.8 Flow Chart for Selection of Flyover

9.5.2 Bridge Design Criteria

The Bridge Design Criteria used in this study is as follows:

(1) Superstructure

Bridge Type : RC or PC Bridge

Bridge Live Load : Omani Standards, revised in 1994 (refer to Chapter 6.2)

Bridge Width : 12.7 m

Material Strength

Concrete : σ_{28} = 350 kg/cm^2 (precast)
: σ_{28} = 350 kg/cm^2 (precast)

Reinforcing Bar : σ_1 = 1,800 kg/cm^2
: σ_1 = 1,400 kg/cm^2 (bridge slab)

(2) Substructure

Abutment : Inverted T-Type, RC Abutment

Pier : Inverted T-Type, or Rigid Frame π Shape Pier

Material Strength

Concrete : σ_{28} = 240 kg/cm^2 (precast)
: σ_{28} = 80 kg/cm^2 (precast)

Reinforcing Bar : σ_1 = 1,800 kg/cm^2

(3) Foundation

The foundation will be constructed with RC piles locally available.