JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
DIRECTORATE GENERAL OF ROADS
MINISTRY OF COMMUNICATIONS
THE SULTANATE OF OMAN

THE DETAILED DESIGN STUDY ON ROAD DEVELOPMENT PROJECT

FINAL REPORT

EXECUTIVE SUMMARY

MARCH 1997

PACIFIC CONSULTANTS INTERNATIONAL
FUKUYAMA CONSULTANTS INTERNATIONAL

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NOTE

The following exchange rate was adopted through this report:

US$1.00 = R.O. 0.381 = Yen 108.81 (August 1996)

PREFACE

In response to a request from the Government of the Sultanate of Oman, the Government of Japan decided to conduct the Detailed Design Study on ROAD DEVELOPMENT PROJECT IN THE SULTANATE OF OMAN and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent a study team to the Oman between December 1995 and December 1996. The study team was headed by Mr. Yoshimi TAKAI and composed of members of Pacific Consultants International and Fukuyama Consultants International.

The team held discussions with the officials concerned of the Government of Oman, and conducted the field surveys at the study area. After the team returned to Japan, further studies were made and present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Sultanate of Oman for their close cooperation extended to the team.

March 1997

Kimio Fujita

Kimio FUJITA
President
Japan International Cooperation Agency

March 1997

Mr. Kimio FUJITA
President
Japan International Cooperation Agency
Tokyo, Japan

Dear Mr. Fujita

Letter of Transmittal

We are pleased to submit you the detailed design report on the Road Development Project in the Sultanate of Oman. The report contains the advice and suggestions of the authorities concerned of the Government of Japan and your Agency as well as the formulation of the above mentioned project. Also included are comments made by the Ministry of Communications, the Sultanate of Oman during technical discussions on the draft final report which were held in Muscat.

This report presents a scheme for construction of flyovers and pedestrian underpasses.

In view of the urgency of the road development plan in the Sultanate of Oman and of need for socio-economic development of Oman as a whole, we recommend that the Sultanate of Oman implement this project as a top priority.

We wish to take this opportunity to express our sincere gratitude to your agency and the Ministry of Foreign Affairs. We also wish to express our deep gratitude to the officials concerned of Ministry of Communications, the Japanese Embassy at Oman for the close cooperation and assistance extended to us during our investigation and study.

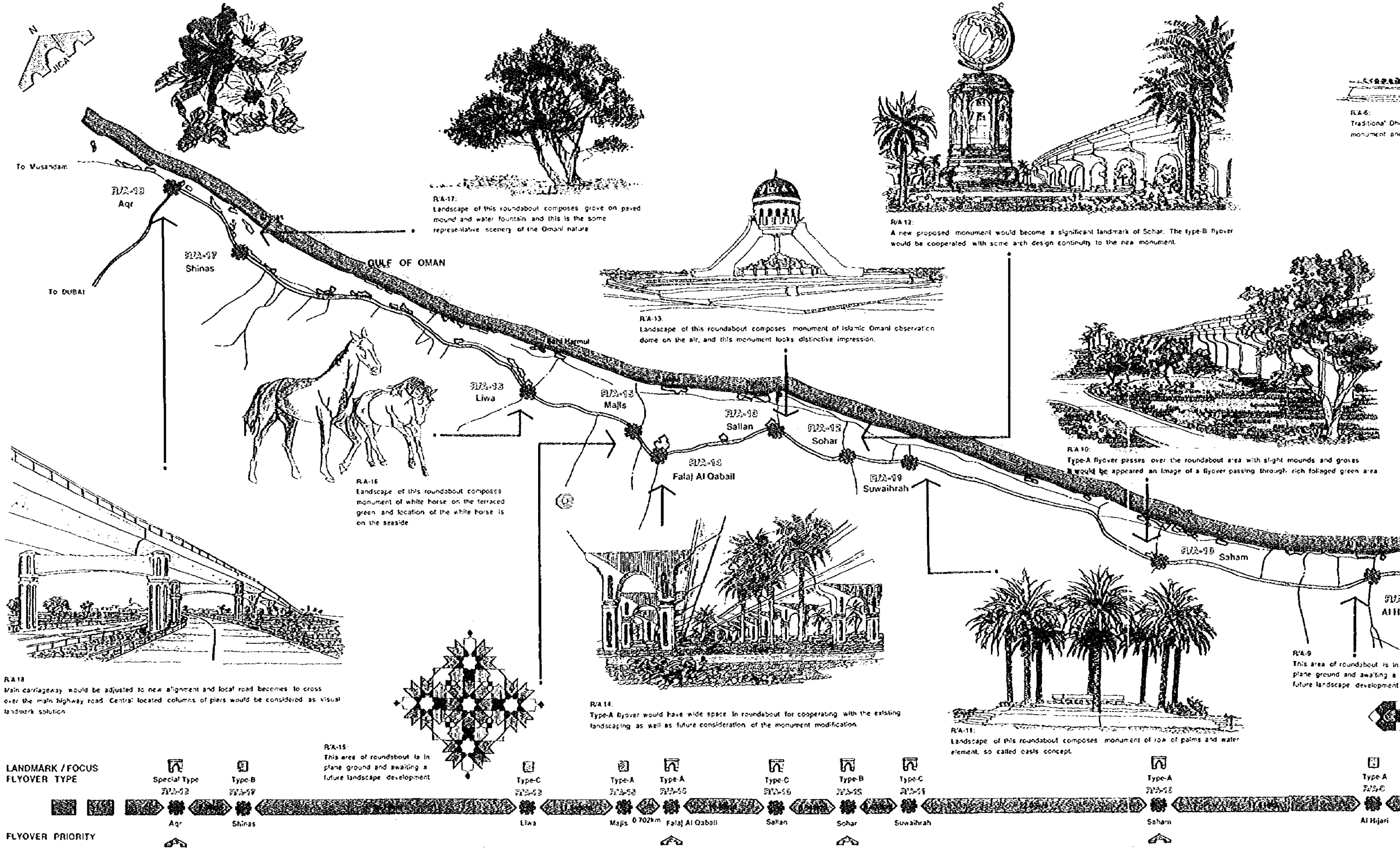
Very truly yours,

Y. Takai

Yoshimi TAKAI
Team Leader
The Study on the Road Development Project
in the Sultanate of Oman

THE STUDY ON ROAD DEVELOPMENT PROJECT

LANDSCAPE PLAN FOR FLYOVERS AND ROUNDABOUTS THROUGH BATINAH HIGHWAY



R/A-17:
Landscape of this roundabout composes grove on paved mound and water fountain and this is the some representative scenery of the Omani nature

R/A-13:
Landscape of this roundabout composes monument of Islamic Omani observation dome on the air, and this monument looks distinctive impression.

R/A 12:
A new proposed monument would become a significant landmark of Sohar. The type-B flyover would be cooperated with some arch design continuity to the new monument.

R/A-6:
Traditional Oh… monument and…

R/A-16
Landscape of this roundabout composes monument of white horse on the terraced green and location of the white horse is on the seaside

R/A 10:
Type-A flyover passes over the roundabout area with slight mounds and groves. It would be appeared an image of a flyover passing through rich foliaged green area

R/A 18
Main carriageway would be adjusted to new alignment and local road becomes to cross over the main highway road. Central located columns of piers would be considered as visual landmark solution

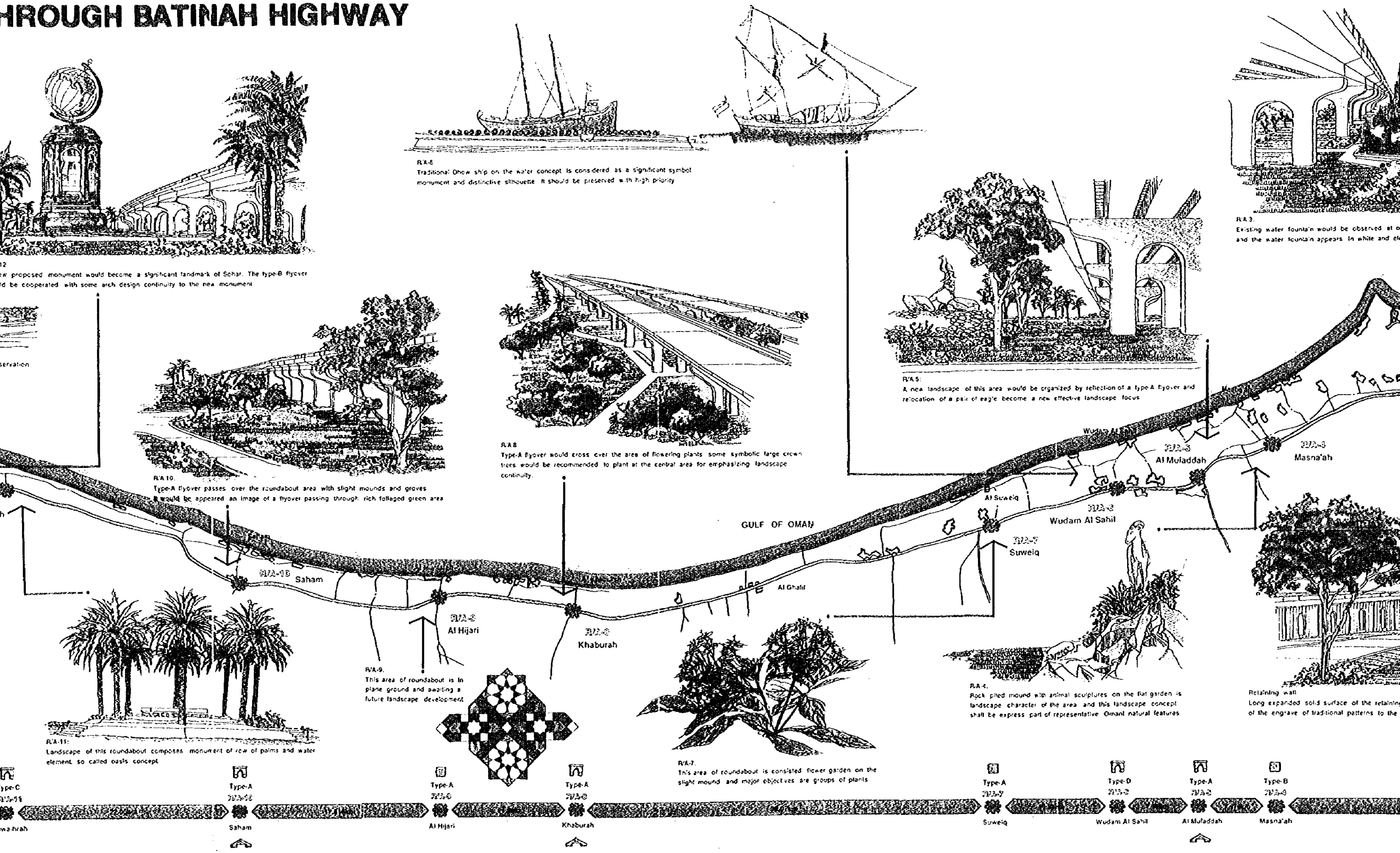
R/A 14.
Type-A flyover would have wide space in roundabout for cooperating with the existing landscaping as well as future consideration of the monument modification.

R/A-9
This area of roundabout is in plane ground and awaiting a future landscape development

R/A-15
This area of roundabout is in plane ground and awaiting a future landscape development

R/A-11:
Landscape of this roundabout composes monument of row of palms and water element, so called oasis concept.

OJECT
HROUGH BATINAH HIGHWAY



R/A-12
…ew proposed monument would become a significant landmark of Sohar. The type-B flyover …ld be cooperated with some arch design continuity to the new monument

…servation

R/A-6
Traditional Dhow ship on the water concept is considered as a significant symbol monument and distinctive silhouette. It should be preserved with high priority

R/A 10.
Type-A flyover passes over the roundabout area with slight mounds and groves. It would be appeared an image of a flyover passing through rich foliaged green area

R/A 8
Type-A flyover would cross over the area of flowering plants. some symbolic large crown trees would be recommended to plant at the central area for emphasizing landscape continuity.

R/A 5:
A new landscape of this area would be organized by reflection of a type-A flyover and relocation of a pair of eagle become a new effective landscape focus

R/A 3.
Existing water fountain would be observed at o… and the water fountain appears in white and el…

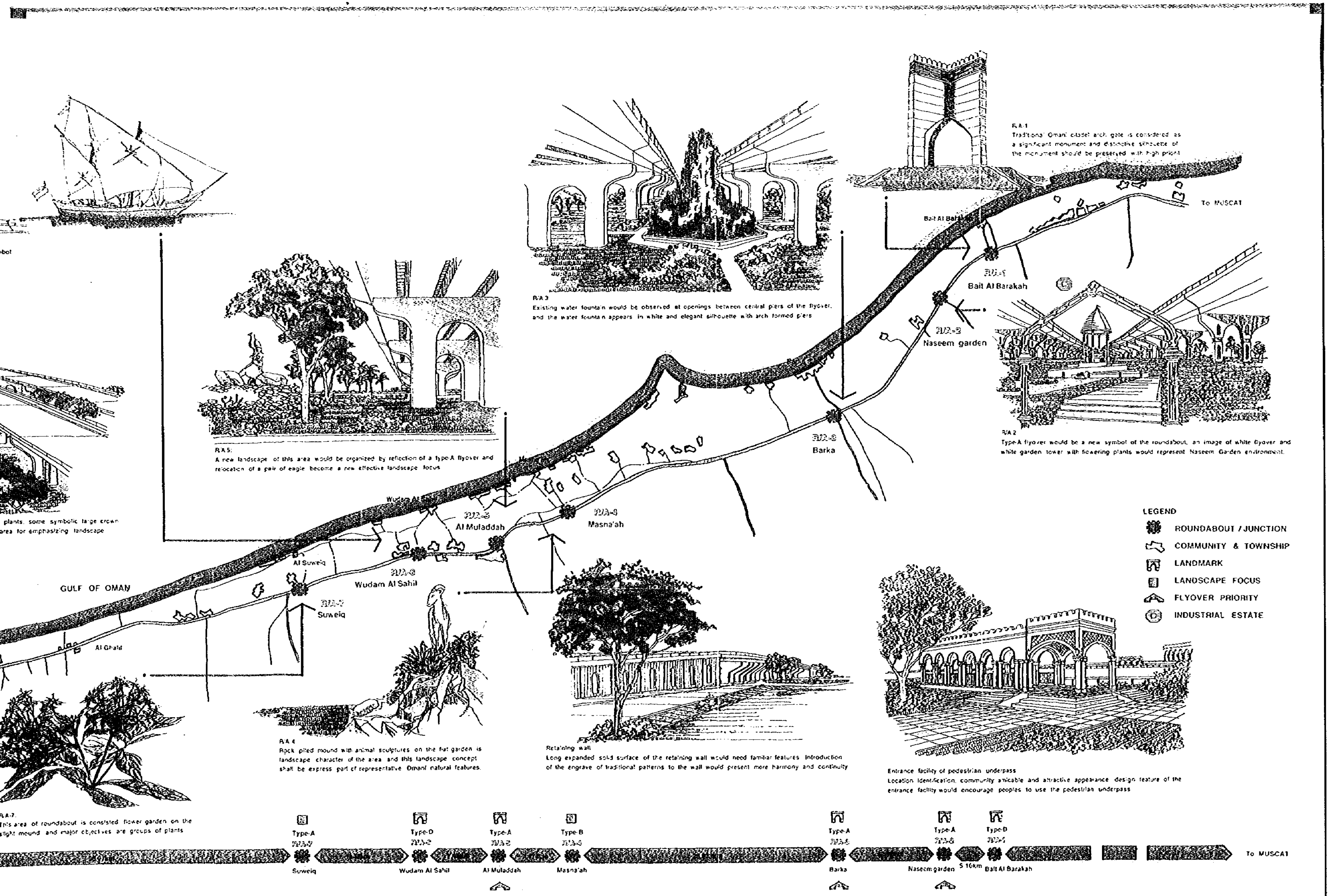
R/A-11:
Landscape of this roundabout composes monument of row of palms and water element, so called oasis concept.

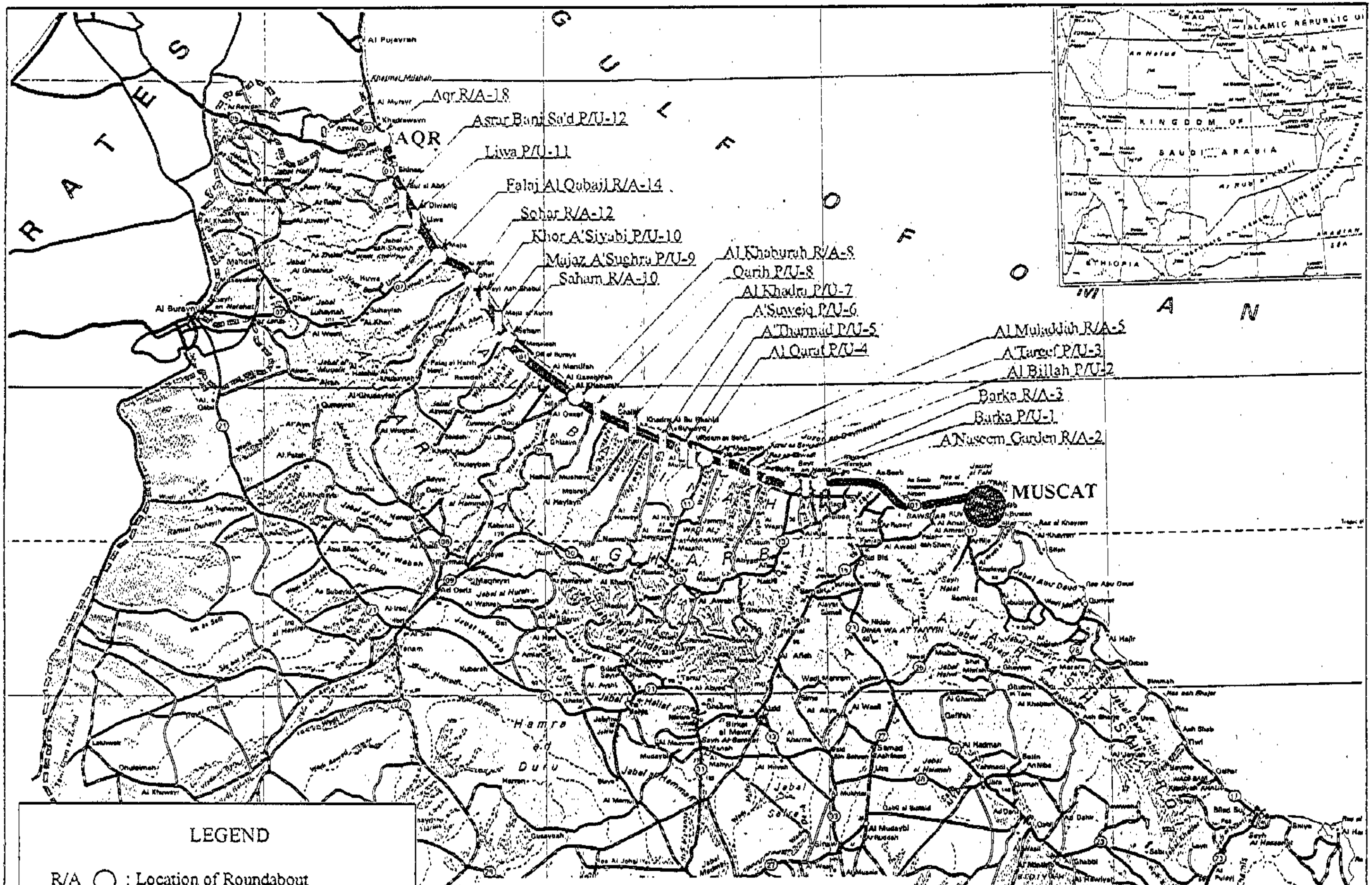
R/A-9.
This area of roundabout is in plane ground and awaiting a future landscape development

R/A-7.
This area of roundabout is consisted flower garden on the slight mound and major objectives are groups of plants

R/A 4.
Rock piled mound with animal sculptures on the flat garden is landscape character of the area and this landscape concept shall be express part of representative Omani natural features

Retaining wall
Long expanded solid surface of the retaining … of the engrave of traditional patterns to the …


R/A 1
Traditional Omani citadel arch gate is considered as a significant monument and distinctive silhouette of the monument should be preserved with high priority
To MUSCAT
Bait Al Barakah
R/A-1
Bait Al Barakah
R/A 3
Existing water fountain would be observed at openings between central piers of the flyover, and the water fountain appears in white and elegant silhouette with arch formed piers
R/A-2
Naseem garden
R/A 2
Type-A flyover would be a new symbol of the roundabout, an image of white flyover and white garden tower with flowering plants would represent Naseem Garden environment.
R/A-3
Barka
R/A 5
A new landscape of this area would be organized by reflection of a type-A flyover and relocation of a pair of eagle become a new effective landscape focus
Wudam Al Sahil
R/A-5
Al Muladdah
R/A-4
Masna'ah
plants, some symbolic large crown
area for emphasizing landscape
Al Suweiq
GULF OF OMAN
R/A-6
Wudam Al Sahil
R/A-7
Suweiq
Al Ghaid
LEGEND
ROUNDABOUT / JUNCTION
COMMUNITY & TOWNSHIP
LANDMARK
LANDSCAPE FOCUS
FLYOVER PRIORITY
INDUSTRIAL ESTATE
R/A 4
Rock piled mound with animal sculptures on the flat garden is landscape character of the area and this landscape concept shall be express part of representative Omani natural features.
Retaining wall
Long expanded solid surface of the retaining wall would need familiar features. Introduction of the engrave of traditional patterns to the wall would present more harmony and continuity
Entrance facility of pedestrian underpass
Location identification, community amicable and attractive appearance, design feature of the entrance facility would encourage peoples to use the pedestrian underpass
R/A-7.
This area of roundabout is consisted flower garden on the slight mound and major objectives are groups of plants
Type-A
R/A-7
Suweiq
Type-D
R/A-6
Wudam Al Sahil
Type-A
R/A-5
Al Muladdah
Type-B
R/A-4
Masna'ah
Type-A
R/A-3
Barka
Type-A
R/A-2
Naseem garden
5 10km
Type-D
R/A-1
Bait Al Barakah
To MUSCAT



PROJECT LOCATION MAP

Summary

The Batinah Highway begins in the capital Muscat and traverses along the coast of the Gulf of Oman over a stretch of 274 km to the border of the United Arab Emirates at Khatmat Malahah as an expressway with a maximum speed limit of 120 kph. The expressway runs roughly parallel to the Hajar Mountain Range in Oman's north. Land use north of this range (towards the coast) concentrates on agriculture (cash crops), while on the inland side of the ranges, date farming is prevalent. The Batinah Highway is one of the most important routes in the Sultanate, connecting the capital Muscat with the neighboring United Arab Emirates.
Although the Batinah Highway is an expressway, there are practically no grade separations; thus pedestrians are forced to cross the highway itself where vehicles are traveling often more that 100 kph. Needless to say, there occur a large number of vehicle/pedestrian accidents and communities which are divided by this expressway daily face risks in crossing. The introduction of grade separations as well as pedestrian underpasses at important locations along the Highway has been of great significance in ensuring smooth vehicle movement as well as in upgrading pedestrian safety.

As stated above, the two following issues have been important problems along the Batinah and other neighboring highways:

- Dangers and problems occurring from reduction of speed at roundabouts
- Pedestrian crossing

The Sultanate of Oman is presently in the midst of implementing Five-year Plan policies which aim to prevent Oman's over-dependency on oil economy as well as promote "Omanization". As a part of the present Fifth Five-year Plan (began in 1996) and the following Sixth Five-year Plan, the Ministry of Communications, which is the executing agency of road projects in the Sultanate, has adopted a plan to grade separate the eight highest priority roundabouts out of the eighteen along the highway in addition to implementing twelve pedestrian underpasses in priority locations where communities have been divided by the Highway. The Ministry intends to conduct the project as far as possible throughout the two Five-year Plans.

This study, upon reviewing the results of the feasibility study, conducts the final design plan of prioritized eight (8) grade separations and twelve (12) pedestrian underpasses.

The final design is conducted based on survey work and geological data compiled in the first year of the project for grade separation and underpass sites which were agreed upon at that time; tender documents and contracts are then drawn up. Furthermore, an Environmental Impact Assessment is made regarding the construction involved. In addition, transfer of engineering skills to Omani counterparts through the implementation of the project was another objective of the study.

(1) Detailed Design for Flyovers and Pedestrian Underpasses

a) Review of Feasibility Study

It is suggested that the Government of the Sultanate of Oman shall proceed with plans to implement the project within the fifth and sixth Five-year Plans (1996-2005) based on the Feasibility Study conducted in 1994-1995 for the construction of flyovers and pedestrian underpasses along the Batinah Highway.

Socioeconomic Frame and Future Traffic Volume

Present traffic volume in the section nearest the capital Muscat is about 21,000 vehicles per day, demonstrating the attracting force of the city. From a socio economic frame analysis, the population of the Batinah region for the year 2010 will reach 808,000 people and the number of registered vehicles will be 3.6 times of that of today, at 975,000. Translating this figure into traffic demand along Batinah Highway, traffic capacity will be exceeded and it will be nearly impossible to handle efficiently.
Therefore, in order to ensure smooth flow of traffic in the future, grade separation of the major routes is an urgent issue, as is the implementation of pedestrian underpasses. At the point of highest numbers of pedestrian crossings per day, 2,600 people per day were found to be crossing with no pedestrian facilities at one point near the capital, proving that this project covers a very important area in this field.

Review of Priority for the Project

The priority ranking of locations for eight flyovers and twelve pedestrian underpasses was based on a review of the following points:

(Flyovers)
- Future traffic volume

- Relationship of traffic volume along the Batinah Highway and traffic volume of major intersecting routes
- Relationship to the overall road network
- Contributions to local society
- Relationship to development of regional industries
- Relationship to international route

(Pedestrian Underpass)

- Populated area of community along the Highway
- Presence of school(s)
- Presence of public facilities, hospital or mosque
- Avoid location of priority flyover

(Flyover Location) (Order of priority)

R/A No.	Roundabout
R/A-3	Barka
R/A-12	Sohar
R/A-2	A' Naseem Garden
R/A-5	Al Muladdah
R/A-10	Saham
R/A-8	Al Khaburah
R/A-14	Falaj Al Qabail
R/A-18	Aqr

(Pedestrian Underpass Location) (Order of priority)

P/U No.	Pedestrian Underpass
P/U-1	Barka
P/U-3	A' Tareef
P/U-5	A' Tharmad
P/U-6	A' Suweiq
P/U-2	Al Billah
P/U-7	Al Khadra
P/U-9	Majaz A' Sughra
P/U-8	Qarih
P/U-4	Al Qarat
P/U-12	Asrar Bani Sa'd
P/U-11	Liwa
P/U-10	Khor A' Siyabi

<u>Site Works</u>

As part of the final design study, topographic survey, geological and material surveys as well as supplementary traffic survey were conducted between December 1995 and March 1996. An environmental survey was conducted between May and August 1996.

Topographic Survey .... Preparation of topographical maps needed for final design (1:500 scale): 8 flyover locations, 12 underpass locations

- Setting of survey points
- Multi-angle survey
- Measurement of topography by Total Station System
- Drafting
- On-site confirmation of survey results; supplementary survey

Geological and Materials Survey.......... Survey of items related to the foundations and subsurface structures of each flyover and underpass

- Standard penetration test
- Pressure meter test
- Aquifer (subterranean water) tests
- Laboratory testing of soil samples (water ratio, specific gravity, granularity, pH balance, chlorides, sulfuric chlorides, etc.)
- Materials testing (compaction test, CBR, granularity, pH balance, etc.)

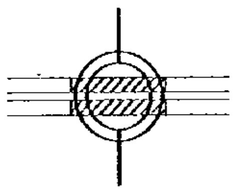
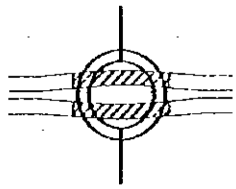
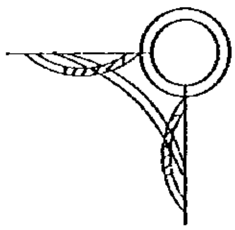
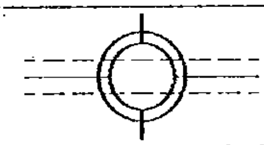
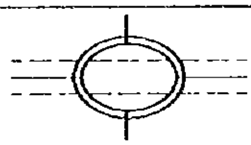
Supplementary Traffic Volume Survey... In order to supplement and update the results of the feasibility study, surveys were conducted at the eight flyover sites and twelve underpass sites as basic data for the final design.

- Traffic volume according to direction, and number of crossing pedestrians at each flyover

Environmental Survey...................... May occur during construction or in the future. Study conducted at three flyover sites and two underpass sites with regards to environmental laws and standards and Environmental Impact Assessment is conducted according to the results of study with regards to adverse influences which may occur during construction or in the future.

Selection of Flyover / Underpass Type

Three types of alignment are adopted for the flyovers with consideration to the scenic environment, presence or absence of monument, land use, expropriation of the land surrounding the roundabout, as well as attention paid to ease in construction. These three alignment types and two shape types are shown below.

	Type A	Type B	Special Type
F/O Alignment			
F/O Applied	Barka, Al Muladdah, Saham, Al Khaburah, Faraj Al Qabail	Sohar, A' Naseem Garden	Aqr
	Circular	Elliptical	Non-Modified
R/A Shape			
R/A Applied	Barka, Faraj Al Qabail, Saham, Al Khaburah	Sohar, Al Muladdah, A' Naseem Garden	Aqr

Selection of alignment type was conducted with high regard to economic feasibility, structural feasibility, and constructability in light of the situation in Oman. In addition, environmental and ascetic considerations have been reviewed throughout the study, from the feasibility study to the final design stages.

Types of pedestrian underpasses are standardized in the Sultanate and these standards will be the base of the applied standards for the project underpasses which will be planned further considering aesthetics, utilizability, etc.

b) Outline of Detailed Design

An outline of the design and applied standards of the project flyovers and underpasses is shown below.

Applied standards

- Highway Design Manual, February 1994, Sultanate of Oman
- Standard Specifications for Highway Bridges, 1990 American Association of State Highway and Transportation Officials
- Specifications for Highway Bridges, February 1994, Japan Road Association

Road Design

- Design speed: Main way 120 kph; Ramp way 60 kph

Bridge Design

- Design load: Special Truck Load Type A & B (Oman)
  HS 20-44 increased 100% (AASHTO)

- Structure type:

	Superstructure	:	Pre-stressed concrete box-type girder bridge
	Standard span	:	26m, 30m, 32m, 35m
	Substructure	:	Abutment: reinforced concrete reverse "T" type
			Pier: reinforced concrete reverse "T" type
			reinforced concrete two-column rigid-frame
	Retaining wall	:	reinforced concrete reverse "T" type
			non-reinforced concrete gravitational type
	Foundation work	:	Cast-on-site reinforced concrete
			(reverse circulation piling method)
			Ø1.0m, Ø0.6m
		:	Spread footing type

Pedestrian Underpass Planning

- Design load: Special Truck Load Type A & B (Oman)
  HS 20-44 increased 100% (AASHTO)

- Planned width: Construction limit height = 3.0m width = 3.6m

- Type: reinforced concrete culvert (shell)
  reinforced concrete (stairs, roof, etc.)

Construction Planning

Construction planning involves planning of materials, construction machinery, construction equipment, construction methods, temporary works, road for implementing construction, temporary buildings/equipment (office, accommodations, electricity, water drainage, sanitary facilities, etc.), also careful examination of construction process and phases with basic considerations made to accommodate laws and regulations pertaining to civil engineering works and conditions pertinent to each site (climate, topography, geology).

i) Conditions of construction pertaining to specific site (climate, terrain, geology, obstacles: e.g., construction in summer heat)
ii) Safe and sure construction, early completion
iii) Procurement of materials and equipment to each specific site
iv) Utilization of local materials, etc.
v) Order of priority of facility construction (fifth and sixth Five-year Plans beginning in 1996)
vi) Observation of rules and regulations of the Sultanate
vii) Social environment of the specific site

c) Environmental Survey / Aesthetic Design

Environment

The Omani government is earnestly concerned about the country's environment, and has issued an environmental protection law. Therefore, as a part of this study, evaluations have been made pertaining to any unfavorable environmental impacts during or following the implementation of the project as well as any environmental improvements that may result.
The Environmental Impact Assessment based on the Environmental Impact Statement form has been conducted for this study.
The following items were studied at three (3) flyovers and two (2) underpasses:

- Social environment (Land acquisition, traffic facility, cultural assets, disaster, etc.)
- Natural environment (Terrain, geology, landscaped and natural trees/plants, soil erosion)
- Pollution (Noise, vibration, vehicle emissions, water/soil quality)

Aesthetics

In and around many of the roundabouts and junctions of the Batinah Highway one can see the results of the scenic development through the use of monuments, plantation, and fountains, etc., which serve as community landmarks and strengthen local identity. Such aesthetics are representative of the efforts which the Sultanate of Oman is putting out for major public facilities and roadside areas. Therefore, the flyovers and underpasses in this project are designed in consideration to their surroundings wherever possible.

(2) Implementation Programme for Flyovers and Pedestrian Underpasses

a) Cost Estimation

Project Cost of Flyovers

(Unit: 1000 R.O)

Project Ranking	F/O	Project Cost	Project Ranking	F/O	Project Cost
1	Barka	3,184	5	Saham	4,020
2	Sohar	4,496	6	Al Khaburah	3,363
3	A'Naseem Garden	3,208	7	Falaj Al Qabail	3,030
4	Al Muladdah	3,290	8	Aqr	3,494
Total Cost for Flyovers					28,085

Project Cost of Pedestrian Underpasses

(Unit: 1000 R.O)

Project Ranking	P/U	Project Cost	Project Ranking	P/U	Project Cost
1	Barka	108	7	Majaz A' Sughra	103
2	A' Tareef	113	8	Qarih	102
3	A' Tharmad	114	9	Al Qarat	102
4	A' Suweiq	109	10	Asrar Bani Sa'd	102
5	Al Billah	105	11	Liwa	104
6	Al Khadra	103	12	Khor A' Siyabi	101
Total Cost for Flyovers					1,266

(Unit : 1,000 R.O.)

Combined Project Cost for Flyovers and Pedestrian Underpasses	29,351

b) Project Implementation Programme

The implementation of this project is being drawn up according to Oman's Fifth Five-year Plan (1996-2000) and Sixth Five-year Plan (2001-2005) as a long term project. Therefore, considering that the Omani government will place orders for the project immediately following the completion of the final design; the following project implementation plan has been drawn up as a result of discussions with the Omani authorities regarding the timing of budget execution, time of order-placing, actual construction schedule, order of implementation, division of construction sectors, etc. of the Omani government.

Proposed Project Implementation Plan

			Fifth Five Year Plan					Sixth Five Year Plan				
			1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Final Engineering Design				12months								
(1) Flyover												
Preparation for documents				4		5	3	3 3	3		3	
Construction	Priority	Name of R/A										
	1	R/A-3 Barka				20						
	2	R/A-12 Sohar						24				
	3	R/A-2 A'Naseem Garden					20					
	4	R/A-5 Al Muladdah							20			
	5	R/A-10 Saham							20			
	6	R/A-8 Al Khaburah									20	
	7	R/A-14 Falaj Al Qabail									20	
	8	R/A-11 Aqr								24		
(2) Pedestrian Underpass												
Preparation for documents				2	2	2	2	4	4	4	4	
Construction	Priority	Name of P/U										
	1	P/U-1 Barka		8								
	2	P/U-3 A'Tareef				8						
	3	P/U-5 A'Tharmad					8					
	4	P/U-6 A'Suweiq						8				
	5	P/U-2 Al Billah							8			
	6	P/U-7 Al Khadra							8			
	7	P/U-9 Majaz A'Sughra								8		
	8	P/U-8 Qarih								8		
	9	P/U-4 Al Qarat									8	
	10	P/U-12 Asrar Bani Sa'd									8	
	11	P/U-11 Liwa										8
	12	P/U-10 Khor A'Siyabi										8

c) Tender/Contract Documents

The implementation of the project will be initiated using tender documents related to the following items and compiled based on the tender and contract document forms presently employed by The Directorate General of Roads of the Ministry of Communications of Oman.

List of Items for Tender/Contract Documents

Document item	Items in common	Items by construction type
Pre Qualification	O	
Instruction to Tenderers	O	
Form of Tender Form of Agreement Form of Tender Bond Form of Performance Bond	O	
General Condition of Contract Special Condition of Contract	O O	
Bill of Quantity		O
General Specification Special Specification	O	 O
Drawings		O

(3) Conclusion and Recommendations

Considering future traffic forecasts and increases of population due to the development of regional economy and industries, the grade separation of existing roundabouts will play an important role in improving traffic function in the future as well as reducing accidents, while the construction of pedestrian underpasses will serve to reconnect severed communities and reduce pedestrian accidents.

The realization of these construction projects will contribute to the economic development involving not only the Batinah region, but the entire Sultanate and neighboring countries as well. The final design has been conducted in careful consideration of economic feasibility, aesthetics, and the present situation in Oman in terms of capabilities in facilities and construction.

The construction phase of the final design will take place over a ten-year period covering the Fifth Five-year Plan (1996-2000) and Sixth Five-year Plan (2001-2005). As a long-span implementation project, it will hopefully progress steadily involving each flyover and pedestrian underpass in order of priority.

Regarding the transferal of skills to Oman, since the beginning of the feasibility study in 1994 through to the final design stages several meetings have been held with counterpart members of the Directorate General of Roads discussing technical aspects of the project. Furthermore, as job training, certain transfer of skills were carried out in Oman as well as in Japan from feasibility study to final design. In addition to these, thorough and consistent skill transfer involving the entire construction and operation will be attained in the case that construction of the flyovers and pedestrian underpasses is realized.

Table of Contents

1. Introduction

This report is a summarization of the results of Sultanate of Oman Road Development Detailed Design Study carried out between December 1995 and March 1997.

1.1 Background of the Study

The Batinah Highway begins in the capital Muscat and traverses the Gulf of Oman over a stretch of 274 km to the border of the United Arab Emirates at Khatmat Malahah.
Although the Batinah Highway is an expressway, there are practically no grade separations; thus pedestrians are forced to cross on the highway itself where vehicles are traveling often more that 100 kph. Needless to say, there occur a large number of vehicle/pedestrian accidents; and communities which are divided by this expressway daily face risks in crossing. The introduction of grade separations as well as pedestrian underpasses at important locations along the Highway has been of great significance in ensuring smooth vehicle movement as well as in upgrading safety.

As stated above, the two following issues have been important problems along the Batinah and other neighboring highways:

- Dangers and problems occurring from reduction of speed at roundabouts
- Pedestrian crossing

In order to resolve the above problems, the Government of the Sultanate of Oman requested the Government of Japan to conduct a feasibility study, which was carried out between February 1994 and January 1995.
The Sultanate has been actively pursuing domestic economic development since 1970, and has spent a large amount of its oil revenues on infrastructural development. The First Five-year Development Plan was initiated and carried out beginning in 1976. At present, the Fifth Five-year plan is in progress. The details of the First to Fourth Five-year Plans are shown in Table 1.

Table 1 Five-year Development Plans

Plan	Period	Outline
First Five-year Plan	1976 - 1980	- Promotion of agriculture and industries; infrastructure development
Second Five-year Plan	1981 - 1985	- Development of Muscat area; road development in capital area
Third Five-year Plan	1986 - 1990	- Promotion of agriculture and industries to avoid over-dependency on oil; development of under-developed areas - Development of water sources and infrastructure as fundamental conditions of national development
Fourth Five-year Plan	1991 - 1995	- Attainment of actual GNP of 6.3% per year - Alleviate over-dependency on oil - Promote free competition by introduction of market economy system; protect private enterprise - Development of basic infrastructure

As in previous five-year plans, further development of the transportation infrastructure continues to be of top priority in the Fifth Five-year Plan. Therefore, the Directorate General of Roads of the Ministry of Communications, having drawn up a long-term plan for the construction of flyovers and pedestrian underpasses along the Batinah Highway to continue throughout the Fifth and Sixth Five-year Plans, requested the Japanese Government to conduct detailed design work. This detailed design work was conducted by the Japanese Government as this project between December 1995 and December 1996.

1.2 Objectives of the Study

Based on the request of the Omani government as stated above, This study was conducted according to the following objectives.

- To carry out the final design for the construction of eight flyovers and twelve pedestrian underpasses along the Batinah Highway to ensure smoother traffic and improve safety for citizens, based on the results of the previously conducted feasibility study.
- To conduct site surveys, soil and material studies as well as supplementary traffic volume surveys while reviewing the results of the feasibility study.
- To conduct final design for flyovers and pedestrian underpasses and prepare tender and contract documents.

- To conduct an Environmental Impact Assessment
- To conduct transfer of skills to engineer counterparts in the Directorate General of Roads

1.3 Study Area

The area covered by the study is the vicinities of eight (8) flyovers and twelve (12) pedestrian underpasses over a 230 km stretch of the Batinah Highway between Bait al Barakah and Aqr.

1.4 Scope and Contents of Study

This study reviews the results of the previously conducted feasibility report, confirms the priority ranking and conducts the final design of the eight flyovers and twelve underpasses.
An outline of the contents of the study are as follows:

<First year>

- Collection and analysis of related data; review of feasibility study
- Site reconnaissance (Road conditions, flyover/underpass planning, materials/equipment survey)
- Site survey (surveying, soil/materials survey, supplemental traffic survey, environmental survey)

<Second year>

- Detailed design for eight flyovers and twelve underpasses
- Environmental survey and aesthetic designing
- Drawing up of construction plan
- Estimation of project cost, project implementation planning, and preparation of tender documents

1.5 Study Organization

The organization of the Oman side and Japan side for the study is as shown in Figure 1 below.

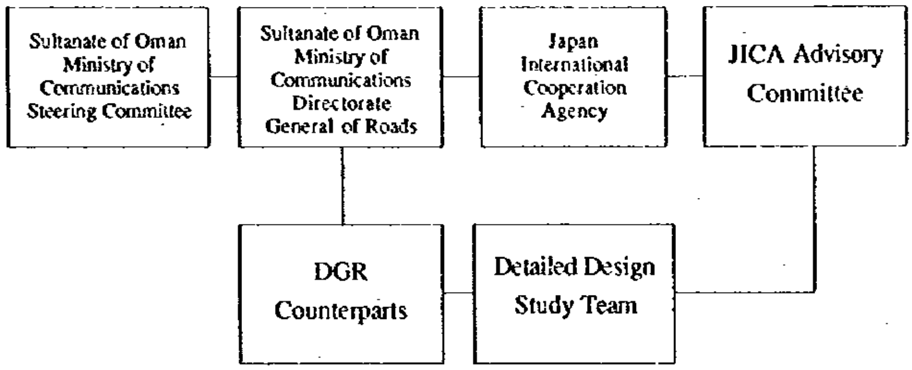


Figure 1 Organization of Study

2. Review of Feasibility Study

Upon reviewing the Feasibility Study conducted according to the request of the Government of the Sultanate of Oman, it is important to keep in mind the remarkable economic growth that the country has made over the past few years. Furthermore, it is vital to accurately grasp the gaps which have come to exist between the times of the initial feasibility study and this study. Enlargement of residential, commercial, and industrial areas in the cities has brought changes to the flow of vehicular traffic, and distribution factors of national income and gross national product also influence traffic planning. Therefore, the present situation should be analyzed and updated from the data obtained by the feasibility study and applied to the alignments of flyovers and underpasses as well as priority ranking.

2.1 Socioeconomic Frame and Traffic Volume

From a socio economic frame analysis, the population of the Batinah region for the year 2010 will reach 808,000 people and the number of registered vehicles will be 3.6 times of that of today, at 975,000. Translating this figure into traffic demand along Batinah Highway, traffic capacity will be exceeded and it will be nearly impossible to handle efficiently. Therefore, in order to ensure smooth traffic flow in the future, grade separation of roundabouts along major highways is an urgent matter.

In addition to this, the growth of commercial and industrial areas along the Batinah Highway leads to a further increase of population bringing with it an increase of road crossings on the expressway. It has been confirmed through review of previous Study that the procurement of pedestrian safety is an issue of high priority in this project.

2.2 Contents and Application of Works in Oman

Site surveying, soil tests, and traffic survey were conducted in the previous feasibility study. For the purposes of the Detailed Design Study, more detailed surveys of the same subject matter as well as material survey were carried out. In addition to these, an environmental survey was carried out between May and August of 1996

- Topographic Survey

Preparation of topographical map (1:500) necessary for final design for eight (8) roundabouts and twelve (12) underpasses.

Including: Setting Survey Points, multi-angle surveying, measurement of terrain and facilities using total station system, drafting, on-site verification/ supplementary surveying.

- Geological (soil) survey/ materials survey:

Survey of items related to the foundations and subsurface structures in the vicinities of the eight (8) roundabouts and twelve (12) underpasses.

Including: Standard penetration test, Pressure meter test, Aquifer (subterranean water) tests, off-site testing of soil samples (water ratio, specific gravity, granularity, pH balance, chlorides, sulfuric chlorides, etc.), materials testing (Compaction test, CBR, granularity, pH balance, etc.)

- Supplementary traffic volume survey:

In order to supplement and update the results of the feasibility study, surveys were conducted at the eight flyover sites and twelve underpass sites as basic data for the final design.

- Environmental survey:

Study conducted at three flyover sites and two underpass sites with regards to environmental laws and standards of Oman. Environmental Impact Assessment conducted with an understanding of the present environmental situation and with regards to adverse influences which may occur during construction or in the future.

- Locations surveyed (for pollution impacts)

  Three (3) flyovers: Barka, Khaburah, Sohar

  Two (2) pedestrian underpasses: A'Tareef, Majaz A'Sughra

- Survey items

  Social environment (Land acquisition, road facilities, cultural assets, disaster, etc.)

  Natural environment (Terrain, geology, landscaped and natural trees/plants, soil erosion)

  Pollution (Noise, vibration, vehicle emissions, water/soil quality)

- Outline of survey results

  Regarding "social environment", some commercial facilities near the proposed flyovers will be displaced, leading to issues of resettlement and compensation accompanying land acquisition; however, such issues can easily be handled by the government's Compensation Committee. Also, any contamination or refuse which may result from the construction will be managed according to the system customarily deployed by the local authorities. Regarding "natural environment", existing trees will be protected or transplanted when possible, and/or new trees be planted wherever the construction deems such action necessary. Regarding "pollution", from the forecast of traffic volume for the year 2010, air pollution levels are expected to be somewhat lower than the standard set by WHO. Noise levels are also expected to be lower than the standard figure of 70, therefore not posing any problems.

2.3 Determination of Locations of Flyovers and Pedestrian Underpasses

As shown in Table 2, eight flyovers and twelve pedestrian underpasses were determined as candidates for detailed design based on review of the following factors:

(Factors involved in priority ranking)

<Flyovers>

- Future traffic volume
- Relationship of traffic volume along the Batinah Highway and traffic volume of major intersecting routes/
- Relationship to the overall road network
- Contributions to local society
- Relationship to development of regional industries
- Relationship to international route

<Pedestrian Underpass>

- Land area of populated area of community along the Highway
- Presence of school(s)
- Presence of public facilities, hospital or mosque
- Avoid location of priority flyover

Table 2 Names/Locations of Detailed Design Flyovers and Pedestrian Underpasses

(Flyover Location)

R/A No.	Roundabout
R/A-3	Barka
R/A-12	Sohar
R/A-2	A' Naseem Garden
R/A-5	Al Muladdah
R/A-10	Saham
R/A-8	Al Khaburah
R/A-14	Falaj Al Qabail
R/A-18	Aqr

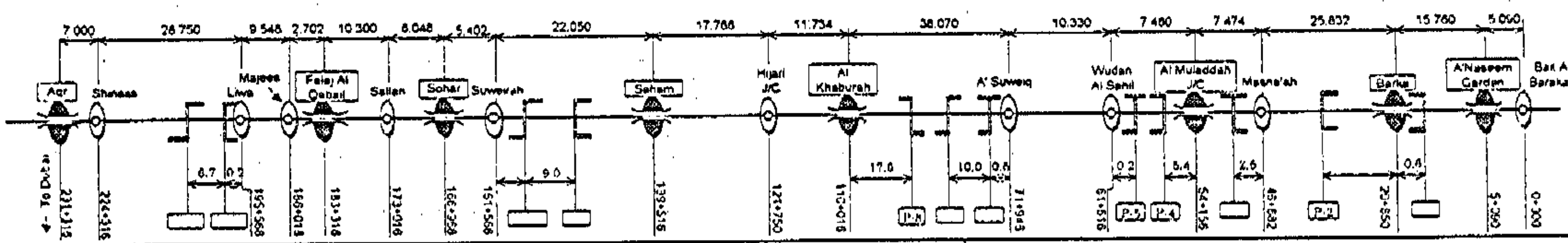
(Pedestrian Underpass Location)

P/U No.	Pedestrian Underpass
P/U-1	Barka
P/U-3	A' Tareef
P/U-5	A' Tharmad
P/U-6	A' Suweiq
P/U-2	Al Billah
P/U-7	Al Khadra
P/U-9	Majaz A' Sughra
P/U-8	Qarih
P/U-4	Al Qarat
P/U-12	Asrar Bani Sa'd
P/U-11	Liwa
P/U-10	Khor A' Siyabi

The following Tables 3 and 4 show the breakdown of determination of priority ranking for flyovers and underpasses.

Table 3 Priority Ranking of Flyovers

Table PRIORITY RANKING OF FLYOVERS ON ROUNDABOUTS AND JUNCTION



Result of Feasibility Study

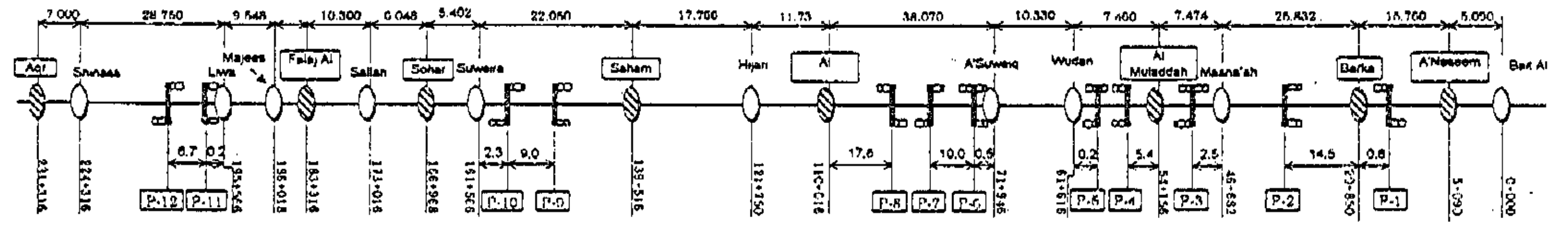
No.	Station No.	Name	Access: Cross Road	Access: To Coastal Town	Access: To Interior Town	Traffic Volume: Batinah Highway 1994	Traffic Volume: Batinah Highway 2010	Traffic Volume: Cross Road 2010	Volume/Capacity (V/C) 2010	Evaluation Ranking: Batinah Highway 2010	Evaluation Ranking: V/C Ratio 2010	Relation with Road Network	Local Community Integration	Relation with Industrial Development	Priority
1	No. 0 + 000	Bait Al Barakah R/A		Bait Al Barakah		20,100	60,700	1,300	1.13	1	5				8
2	No. 5 + 050	A'Naseem Garden R/A		Naseem Garden Park		18,300	58,700	2,000	1.10	2	4			2	3
3	No. 20 + 850	Barka R/A	N.R 13	Barka	Rustaq	16,200	51,600	21,700	2.70	3	1	3	3		1
4	No. 46 + 682	Masna'ah R/A		Masna'ah		13,900	44,300	2,700	0.87	4	7				10
5	No. 54 + 156	Al Muladdah J/C	N.R 11		Rustaq	11,700	37,700	12,100	1.05	5	6	4			4
6	No. 61 + 616	Wudan A'Sahil R/A		Wudan A'Sahil		11,600	30,600	2,500	0.60	6	11		5		11
7	No. 71 + 940	A'Suweiq R/A		A'Suweiq		11,600	29,200	4,500	0.61	8	1				13
8	No. 110 + 016	Al Kahurah R/A	N.R 9	Al Kaburah	Rustaq	9,800	27,900	11,300	0.74	10	8	6			6
9	No. 121 + 750	Hijari J/C		Al Muntenfah	Al Hijari	8,600	26,800	1,600	0.61	1	13	7	4	3	7
10	No. 139 + 616	Saham R/A		Saham	Rawdah	10,200	28,700	23,200	1.45	9	3		2		5
11	No. 161 + 566	Suwerah R/A		Suwerah		11,000	29,700	7,400	0.68	7	9				12
12	No. 166 + 968	Sohar R/A	N.R 8	Sohar	Wadi Hibi	11,700	26,400	27,200	1.93	12	2	6	1		2
13	No. 173 + 016	Sallan R/A		Sallan		9,800	25,200	7,300	0.57	13	12			1	15
14	No. 183 + 316	Falaj Al Qabail R/A	N.R 7	Majas	Al Bunam	7,700	22,100	17,200	0.61	1	14	1	6		9
15	No. 186 + 018	Majees R/A		Khawr As Sammi		6,600	17,200	1,000	0.32	15	15				14
16	No. 195 + 566	Liwa R/A		Sahi Harumul		6,500	10,000	2,100	0.32	16	16		7		17
17	No. 224 + 316	Shinas R/A		Shinas		6,200	10,100	2,300	0.31	17	17				18
18	No. 231 + 316	Aqr R/A	N.R 6		Duhan	4,500	13,600	5,400	0.20	18	18	2			16

DETAILED DESIGN STUDY

No.	Name	Result of Field Reconnaissance	Traffic Volume: Batinah Highway 1996	Traffic Volume: Batinah Highway 2010	Traffic Volume: Cross Road 2010	Volume/Capacity (V/C) 2010	Evaluation Ranking: Batinah Highway 2010	Evaluation Ranking: V/C Ratio 2010	Relation with Road Network	Local Community Integration	Relation with Industrial Development	Priority
1	Bait Al Barakah R/A											
2	A'Naseem Garden R/A	New Monument Constructed	21,210	61,280	6,600	1.26	1	4		7	1	3
3	Barka R/A		16,570	58,000	21,800	3.03	2	1	4	3		1
4	Masna'ah R/A											
5	Al Muladdah J/C	R/A under Construction	16,043	44,600	26,000	1.23	3	5	3	8		4
6	Wudan A'Sahil R/A											
7	A'Suweiq R/A											
8	Al Kahurah R/A		11,178	30,850	18,800	0.96	5	6	5	4		6
9	Hijari J/C											
10	Saham R/A		12,382	32,060	20,500	2.34	4	3		2		5
11	Suwerah R/A											
12	Sohar R/A	New Monument under Construction	10,560	29,700	30,800	2.73	6	2	6	1		2
13	Sallan R/A											
14	Falaj Al Qabail R/A		11,457	28,770	11,600	0.61	7	7	1	6		7
15	Majees R/A											
16	Liwa R/A											
17	Shinas R/A											
18	Aqr R/A		5,700	19,030	10,000	0.32	8	8	2	6		8

Table 4 Priority Ranking of Pedestrian Underpasses

Table PRIORITY RANKING OF PEDESTRIAN UNDERPASSES



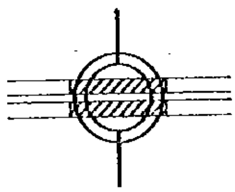
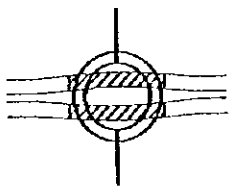
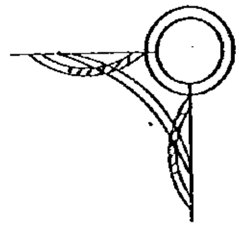
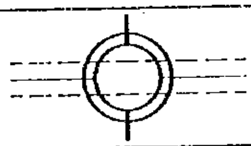
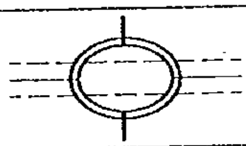
Result of Feasibility Study					DETAILED DESIGN STUDY							
Candidates of Selection			Recommendation		Result of Field Reconnaissance	Adjusted Location			Criteria-1 Pedestrian Volume(12hrs)	Criteria-2 School, Mosque, Public Facility	Criteria-3 Traffic Volume(12hrs)	Priority
Location		Name of Settlement				Location		Name of Location				
No.	Station No.		No.	●		No.	Station No.					
1	No 20 + 400	As Somhan			Replaced	P- 1	No. 20 + 300	Barka	2,603	2-Mosques, Souq	11,280	1
2	No. 36 + 400	Al Billah	1	●	⇨	P- 2	No. 36 + 400	Al Billah	772	School, Bus shelter	8,850	6
3	No. 49 + 200	A'Tareef	2	●	⇨	P- 3	No 49 + 200	A'Tareef	2,345	2-Mosques, Banks	9,590	2
4	No 65 + 150	Al Muladdah										
5	No 59 + 600	Al Qarat	3	●	⇨	P- 4	No. 59 + 600	Al Qarat	460	Mosque, Bus shelter	9,124	9
6	No 61 + 416	A'Thamad	4	●	Adjusted	P- 5	No. 61 + 200	A'Thamad	1,133	Mosque, Bus shelter, Bank	9,647	3
7	No. 63 + 150	Al Manfash										
8	No 72 + 900	Batsha Hilal	5	●	Adjusted	P- 6	No. 72 + 400	A'Suwaiq	2,074	2-Schools, Hospital, Welfare, Bus shelter	8,215	4
9	No 79 + 200	Sur Al Hilal										
10	No 81 + 0	Al Uriq										
11	No 82 + 350	Al Khadra	6	●	Adjusted	P- 7	No. 82 + 400	Al Khadra	1,110	School, Bus shelter	7,220	5
12	No. 91 + 700	Dhiyan-1										
13	No. 92 + 400	Dhiyan-2	7	●	Change Name	P- 8	No. 92 + 400	Qarih	603	School, Mosque, Bus shelter	6,987	8
14	No. 98 + 0	Dhiyan-3										
15	No. 100 + 100	Al Hidayah	8	●	Under Construction							
16	No. 110 + 16	Sur Al Duwehnah										
17	No 115 + 560	Qashyat Al Hawashnah										
18	No 139 + 610	Saham										
19	No. 141 + 350	Al Badi										
20	No. 142 + 400	Al Ghuwaisah										
21	No. 143 + 400	Al Hedhaah										
22	No. 147 + 600	Hilat Al Kawashid										
23	No. 148 + 600	Hilat Al Kawashid	9	●	To be replaced							
24	No. 160 + 250	Majaz A'Sughra	10	●	Adjusted	P- 9	No 160 + 200	Majaz A'Sughra	764	2-Mosques	7,909	7
25	No. 159 + 0	Khor A'Siyabi			Replaced	P- 10	No 159 + 200	Khor A'Siyabi	431	College	8,701	12
26	No. 169 + 900	Olah										
27	No. 166 + 908	Al Waqayhah										
28	No. 170 + 200	Sallan										
29	No. 174 + 200	Al Gushbah-1										
30	No. 175 + 400	Al Gushbah-2										
31	No. 176 + 900	Falaj Al Quhi										
32	No 183 + 316	Falaj Al Qabail										
33	No. 196 + 766	Liwa	11	●	Adjusted	P- 11	No. 195 + 800	Liwa	531	Municipal building, Bus shelter	4,681	11
34	No. 200 + 850	Liwa-1										
35	No. 201 + 750	Liwa-2										
36	No. 202 + 900	Liwa-3	12	●	Adjusted	P- 12	No. 202 + 500	Aarar Bani Sa'd	677	School, Bus shelter	4,214	10
37	No. 212 + 500	Al Haram										
38	No. 212 + 700	Sur Al Abri										
39	No. 213 + 800	Sur Bani Gizmah										
40	No 216 + 100	Tan Huuh										

2.4 Selection of Structural Type

- Grade separation

Throughout the periods of the feasibility and final design studies, attention has been paid to the issues of land use, land acquisition, the presence of monuments and/or their future plans as well as aesthetics in the vicinity of the roundabouts. For this study as well, detailed study has been carried out on these aspects, including the offices involved. Furthermore considering the aspects of construction and environment of the flyovers, the three alignment types and two shape types of form for the flyovers applied for this project are seen in Table 5, as follows.

Table 5 Flyover Alignment Types

	Type A	Type B	Special Type
F/O Alignment			
F/O Applied	Barka, Al Muladdah, Saham, Al Khaburah, Faraj Al Qabail	Sohar, A' Naseem Garden	Aqr
	Circular	Elliptical	Non-Modified
R/A Shape			
R/A Applied	Barka, Faraj Al Qabail, Saham, Al Khaburah	Sohar, Al Muladdah, A' Naseem Garden	Aqr

Selection of alignment type was conducted with high regard to economic feasibility, structural feasibility, and constructability in light of the situation in Oman. In addition, environmental and scenic considerations have been reviewed throughout the study, from the feasibility study to the final design stages.

Concerning the bridge length and span pitch of the flyovers; in consideration to economics, underground utilities, constructability, landscape and aesthetics; bridge length is to be 250 to 300 meters; span pitches are to be standardized at 26, 30, 32, and 35 meters in length.

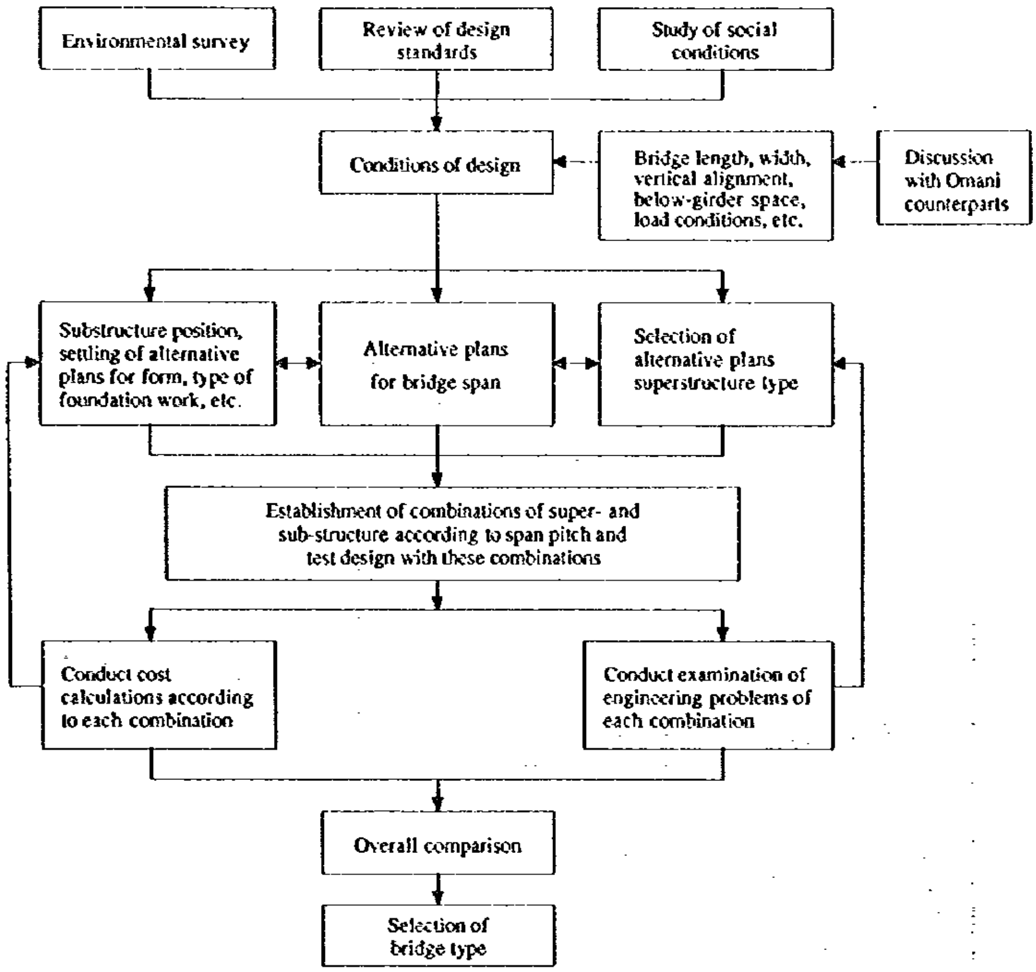


Figure 2 Review of Structure Type for This Project

<Factors for determining superstructure type>

- Economic feasibility (comparative), structural stability, constructability, aesthetics
- Specifications of materials and standardized girder distribution
- Standardization of span length (2 or 3 types of main girder standards)

===Applied type: prestressed concrete box-type girder

<Factors for determining substructure type>

- Specifications of superstructure, topographical/geological situation, structural stability, constructability
- Pier type is dependent upon scenic factors and landscape of the roundabout in question; must visually blend with its surroundings.

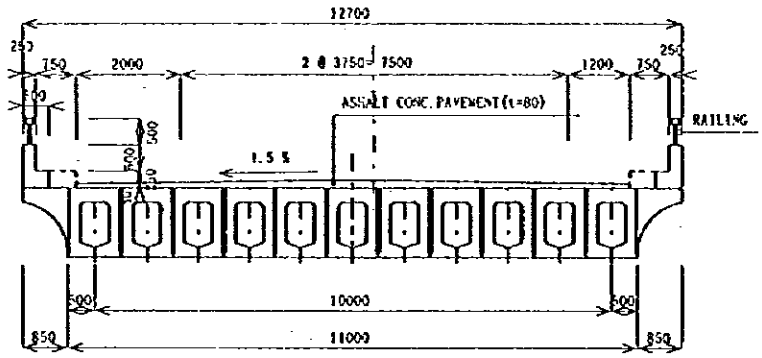
===Applied type: reinforced concrete reverse "T" type and two-column rigid frame type (slit structure)

<Factors for determining foundation structure type>

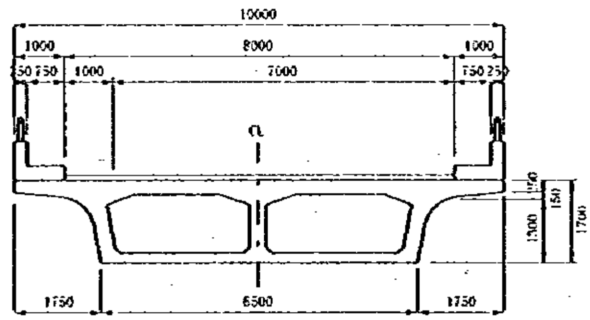
- Geological conditions and depth of bearing layer
- Size of superstructure and economic feasibility
- Constructability in terms of engineering achievements and the present situation in Oman

===Applied type: Spread foundation and cast-in-situ concrete pile foundation (Ø1.0 m, Ø0.6 m)

According to the above, super- and sub-structure types were selected as seen in Figures 3 and 4.



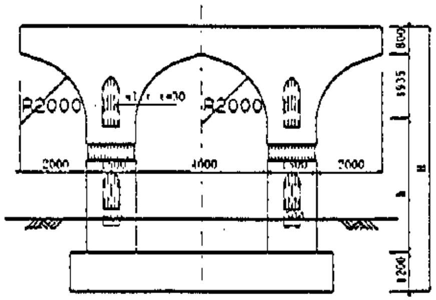
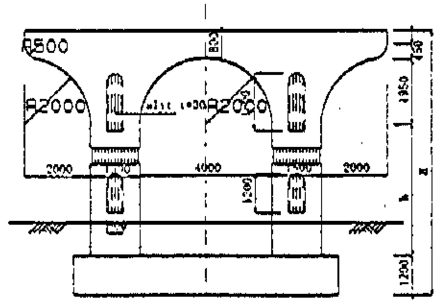
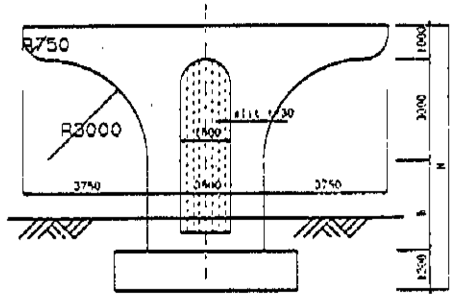
A' Nassem Garden, Barka, Sohar,Al Muladdah, Saham, Al Khaburah,Falej Al Qabail

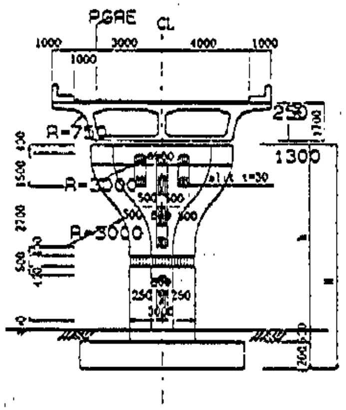
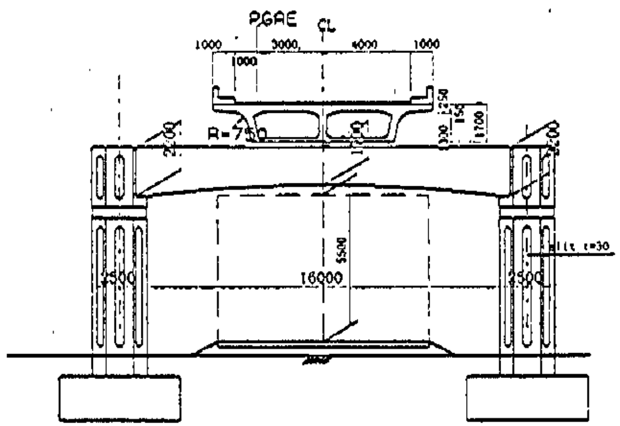


Aqr F/O

Figure 3 Superstructure Type

Figure 4 Substructure Type

	Type - 1	Type - 2	Type - 3
	Rigid Frame (Two Column)	Rigid Frame (Two Column)	T - Wall
Section of Sub-structure	 Recommended F/O : A'Naseem Garden. Sohar. Falaj Al Qabail.	 Recommended F/O : Barka. Al Muladdah. Al Khaburah.	 Recommended F/O : Saham. Combination with Type-2(for side span): Barka. Al Muladdah. Al Khaburah.

	Type - 4 (Special)	Type - 5 (Special)
	T - Wall	Rigid Frame (Two Column)
Section of Sub-structure	 Recommended F/O : Aqr	 Recommended F/O : Aqr

Pedestrian underpasses in Oman are standardized and have been constructed. Based on these standards, aesthetics, utilizability, and constructability are considered for the new applied design standards to be standardized at each new underpass location, as shown in Figure 5.

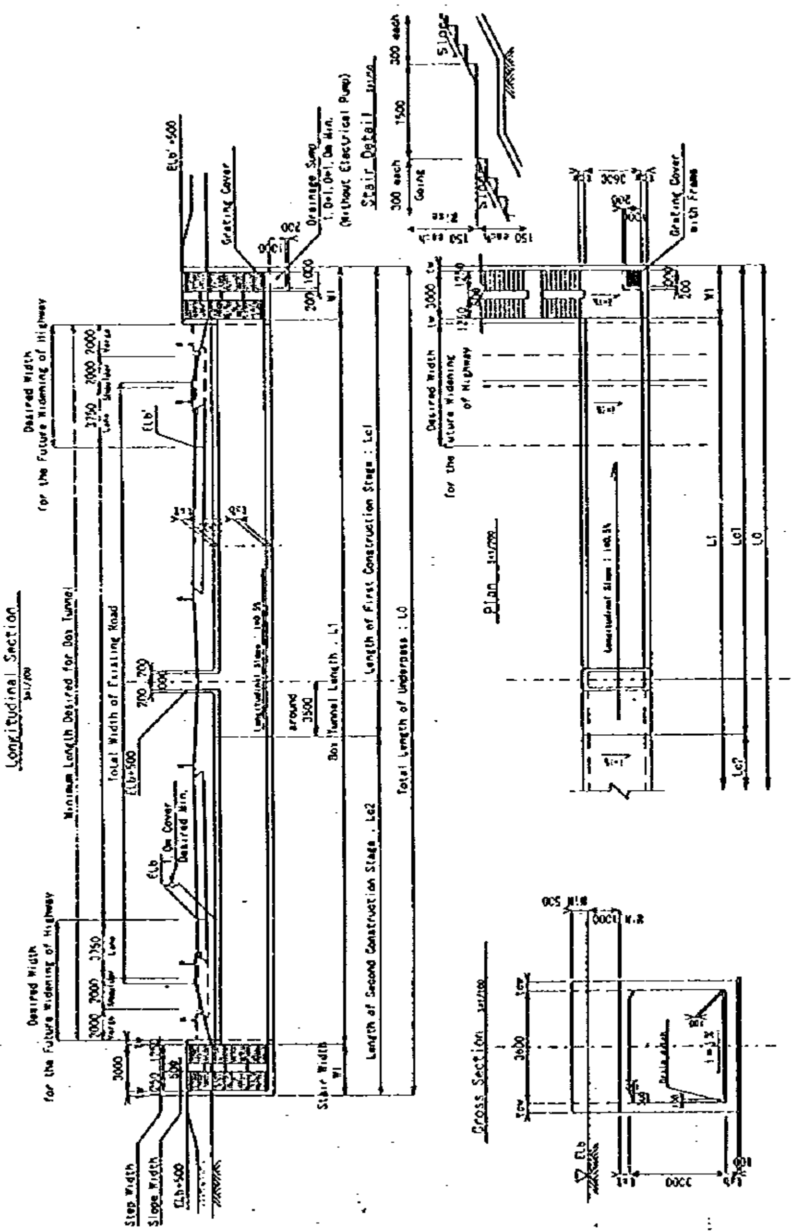


Figure 5 Standard-type of Pedestrian Underpass

3. Detailed Design of Flyovers and Pedestrian Underpasses

The Ministry of Communications Directorate General of Roads (DGR) newly issued the "Highway Design Manual" and "General Specification for Roads" in February 1994. Ample discussion was carried out with members of the DGR to reflect these standards in the road and structure designs. The design standards and specifications shown below have been applied in the Detailed Design of the project.

3.1 Design Standards and Applied Specifications

- Applied Standards for Detailed Design

[Sultanate of Oman]

- Highway Design Manual
  - Volume I (February, 1994)
  - Volume II (January, 1994)
- General Specifications for Roads (April, 1994)

[United States of America]

[American Association of State Highway and Transportation Officials] (AASHTO)

- A Policy on Geometric Design of Highways and Streets (1990)
- Standard Specifications for Highway Bridges (Fifteenth Edition 1992)
- Standard Specifications for Transportation Materials and Methods of Sampling and Testing
  - Part I
  - Part II

[American Society for Testing and Materials] (hereinafter referred to as "ASTM")

- Annual Book 1995
  - Section-1 Iron and Steel Products
  - Section-4 Construction

[American Concrete Institute] (hereinafter referred to as "ACI")

- Building Code Requirements for Reinforced Concrete (ACI318-83)

[Japan]

[Japan Road Association]

- Road Structure Ordinance
- Specifications for Highway Bridges (February, 1994)
- Design Guideline for Concrete Highway Bridges (February, 1994)
- Construction Guideline for Concrete Highway Bridges (February, 1994)
- Guideline for Road Design and Works
- Guideline for Reinforced Earth Method
- Guideline for Drainage Design of Roads

[Japan Highway Public Corporation]

- Design Standard for Highway and Bridges (February, 1994)

- Conditions of Road Design

• Road geometric design standard

Table 6 indicates the geometric design standards for expressway and rampway.

Design speed: main route, 120 kph; rampway 60 kph

Table 6 Road Geometric Design Criteria

Item	Unit	Design Speed (km/h)			
		120	80	60	40
TERRAIN		Level	Level	Level	Level
Sight Distance					
Min. Stopping Sight Distance	m	285	140	85	45
Min. Passing Sight Distance	m	790	510	380	240
HORIZONTAL ALIGNMENT					
Min. Radius of Curve	m	630	230	120	50
Min. Length of Curve	m	200	160	130	90
Min. Length of Transition Curve	m	100	80	65	45
Min. Radius without Transition Curve	m	1,400	900	600	300
VERTICAL ALIGNMENT					
Max. Gradient	%	3	5	6	6
Critical Length of Gradient	m	500	500	500	500
Min. K on Crest (VCL = KA)	m	100	49	11.5	4
Min. K on Sag (VCL = KA)	m	47	24	13	5.5

CROSSFALL					
Normal Crossfall	%	1.5	1.5	1.5	1.5
Max. Superrelevation	%	8 (6)	8 (6)	8 (6)	8 (4)
Min. Radius for Normal Crown Section	m	7,600	3,400	1,900	850
Max. Rate of Superelevation Run-off					
Divided Road with Dual Carriageway	m/m	1/200	1/150	1/125	-
Undivided Road with Single Carriageway	m/m	-	1/200	1/175	1/150
Rampway with 2-Lanes	m/m	-	1/150	1/125	1/100
Rampway with 1-Lane	m/m	-	1/200	1/150	1/100
Max. Combined Gradient	%	10	10	10	10

Note: The value in ( ) indicates the proposed ones

- Typical cross section of road

Figure 6 and 7 indicate the typical cross section of road

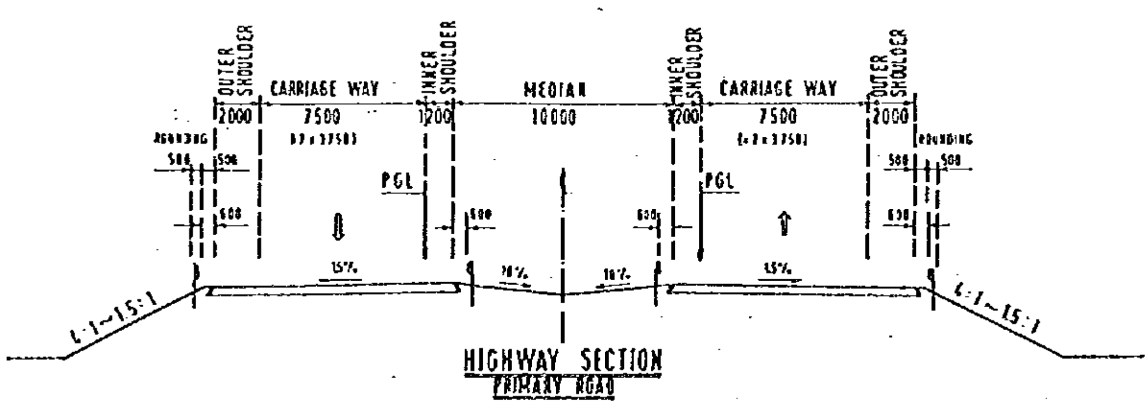


Figure 6 Typical Cross-Section of Highway

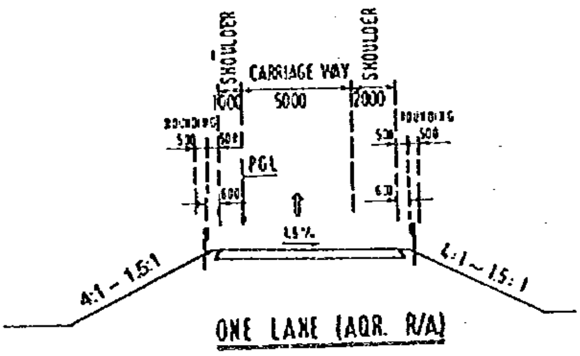


Figure 7 Cross-Section of Aqr R/A

• Road clearance

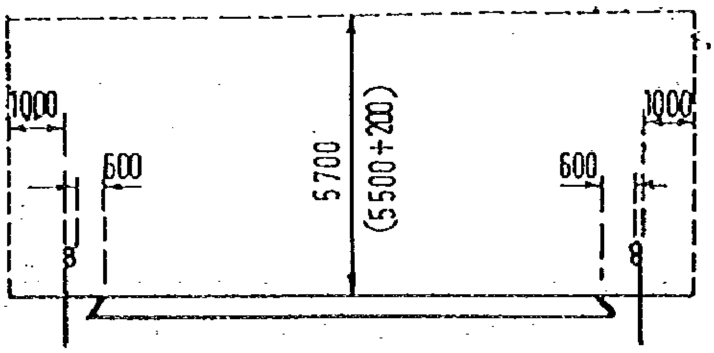


Figure 8 Clearances of Proposed Flyovers

- Design conditions for pavement and drainage structures design

Design of pavement and drainage structures is conducted based on the following standards:

Highway Design Manual Volume-1 (Pavement), 1994 Oman
Highway Design Manual Volume-1&2 (Drainage), 1994 Oman

Furthermore, pavement standards conform with the AASHTO Interim Guide for Pavement Structures, 1972.
Details of the standards related to this design are shown below.

<Pavement>

- Design CBR value is determined in consideration of the results of material test results from five quarries as part of this study. The design CBR value is adopted 25 % in the case that its value from the material test result exceeds 25 %.

- With an analysis period of 20 years, an accumulated 18 kip Equivalent Single Axle Load which is expected in this period is calculated from load equivalent conversion coefficient of each vehicle type and results from the traffic volume survey of this study. These coefficients are based on asphalt pavement, axle type, and the terminal serviceability index (Pt) 2.5.

- Regional factor of the Batinah Region is 0.8.

- Pavement thickness is determined by finding the design Structural Number (SN) by the nomograph in the specifications, using coefficient of relative strength from the material texture of each layer so as to satisfy this SN. The minimum thickness according to layer is as follows: wearing course = 50 mm, base course = 100 mm, subbase = 150 mm. Furthermore, if the CBR value exceeds 25%, it is permissible to do without the subbase.

<Drainage structures>

- Precipitation Probability Year is prescribed by road standards and types of drainage structures. On the primary/secondary street, culverts and Irish crossings are 50 years, open waterways are 10 years, and road surface drainage is 5 years.

- In the case that effluent water volume exceeds a contiguous water surface area of 10 square km the nomograph will be used in case it does not exceed 10 square km the rational method will be used. In the latter, precipitation intensity will be derived from the prescribed nomograph and concentration time from Kirpich formula. Precipitation intensity of road surface is 75 mm/hr.

- The potential water passing volume of open waterways, covered waterways (box or pipe), and side drains is derived from the Manning Method.

- Depth of stone paving at Irish crossings as a measure against scouring is a minimum of 1.5 meters; there is also a method of calculating by prescribed formula.

- Standard drawings for covered waterways are as in Volume 2.

- Bridge Design Condition
  - Design Live Load

    Truck load type : Special Truck Type A&B (Oman)
    AASHTO Standard HS20-44 Truck increased by 100% (U.S.A.)

    Distributed load type : AASHTO HS20-44 Loading increased by 100% (U.S.A.)

  - Typical Bridge Width

    For typical bridge width for bridge section, see Figure 9. for typical bridge width for Aqr, see Figure 10.

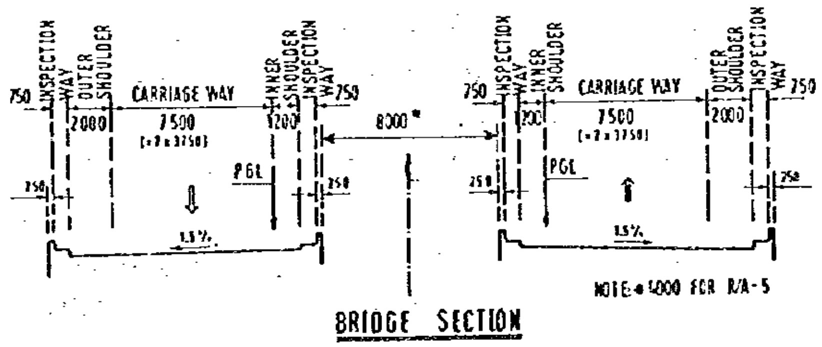


Figure 9 Typical Bridge Cross-Section for Bridge

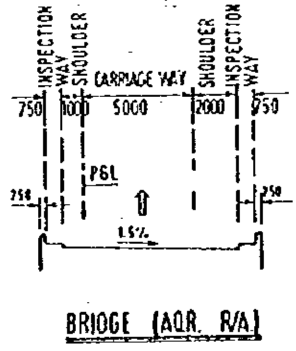


Figure 10 Typical Bridge Cross-Section for Aqr

• Structure Type

Superstructure:	Prestressed concrete box girder bridge (standard span, 26 m, 30 m, 32 m, 35 m)	
Substructure:	Abutment,	reinforced concrete reverse "T" type
	Pier,	reinforced concrete reverse "T" type reinforced concrete two-column type
Retaining wall:	reinforced concrete reverse "T" type unreinforced concrete gravitational type	
Foundation:	Spread foundations reinforced concrete cast-in-situ pile foundations (reverse circulation method) (Ø1.0 m, Ø0.6 m)	

- Design Conditions of Pedestrian Underpass

• Design load

Truck load type	: Special Truck Type A&B (Oman) AASHTO Standard HS20-44 Truck increased by 100% (U.S.A.)
Distributed load type	: AASHTO HS20-44 Loading increased by 100% (U.S.A.)

• Pedestrian underpass architectural limits: 3.0 meters high by 3.6 meters wide.
In the case of vehicle/pedestrian tunnel at Aqr: 4.5 meters high, 5.0 meters wide and 2 cells.

- Structure type

Pedestrian underpass	Reinforced concrete box culvert (underpass) Reinforced concrete (stairs, roof)
Aqr Box Culvert	Reinforced concrete box culvert

3.2 Design Methods and Analysis

- Design Methods of Structures

• (Superstructure) Structural analysis: Allowable stress method (all structures)
Load distribution Guyon - Massonet Theory

- Concrete strength

  Concrete standard strength (28 days)

Concrete σ_{28} Class	σ_{28} kg•f/cm^2	Cylinder N/mm^2	Cylinder kg•f/cm^2	Applications
16	160	16	163	Leveled concrete, masonry, concrete structure
24	240	24	245	Substructure, retaining wall, box culvert
32	320	32	326	Beam, horizontal girder, sidewalk and rail, cast-in-situ concrete pile
40	400	40	408	Prestressed concrete girder

- Reinforcing steel (AASHTO M31/M31M)

Tensile strength class	Tensile strength (kg•f/cm^2)	Yield point (kg•f/cm^2)
Grade 40	4,921	2,812
Grade 60	6,327	4,218

- Reinforcement diameter

(mm)

AASHTO No.	3	4	5	6	7	8	9	10
Official diameter	D9	D13	D16	D19	D22	D25	D28	D32

- PC steel

  (AASHTO M203, M204, M275 or BS5896, BS4486)

Class	Area of cross-section (mm^2)	Code no.	Tensile strength (kg•f/mm^2)	Strength yield point (kg•f/mm^2)
12T 15.2	1,664.40	SWPR 7B	190	160
10T 15.2	1,387.00	SWPR 7B	190	160
1T 15.2	138.70	SWPR 7B	190	160

- Allowable stress

Concrete (Prestressed Concrete) (kg•f/cm²)

	Class 32	Class 40
Allowable Compressive Strength		
Immediately after Prestressing	140	180
Primary Load	110	140
Allowable Tensile Strength		
Immediately after Prestressing	-12	-15
Primary Load (Dead Load)	0	0
Primary Load (Dead Load + Live Load)	-12	-15
Allowable Shear Stress		
Primary Load		5.5
Ultimate Load		53
Allowable Shear Stress		
Primary Load		-10

- Concrete (reinforced concrete) (kg•f/cm²)

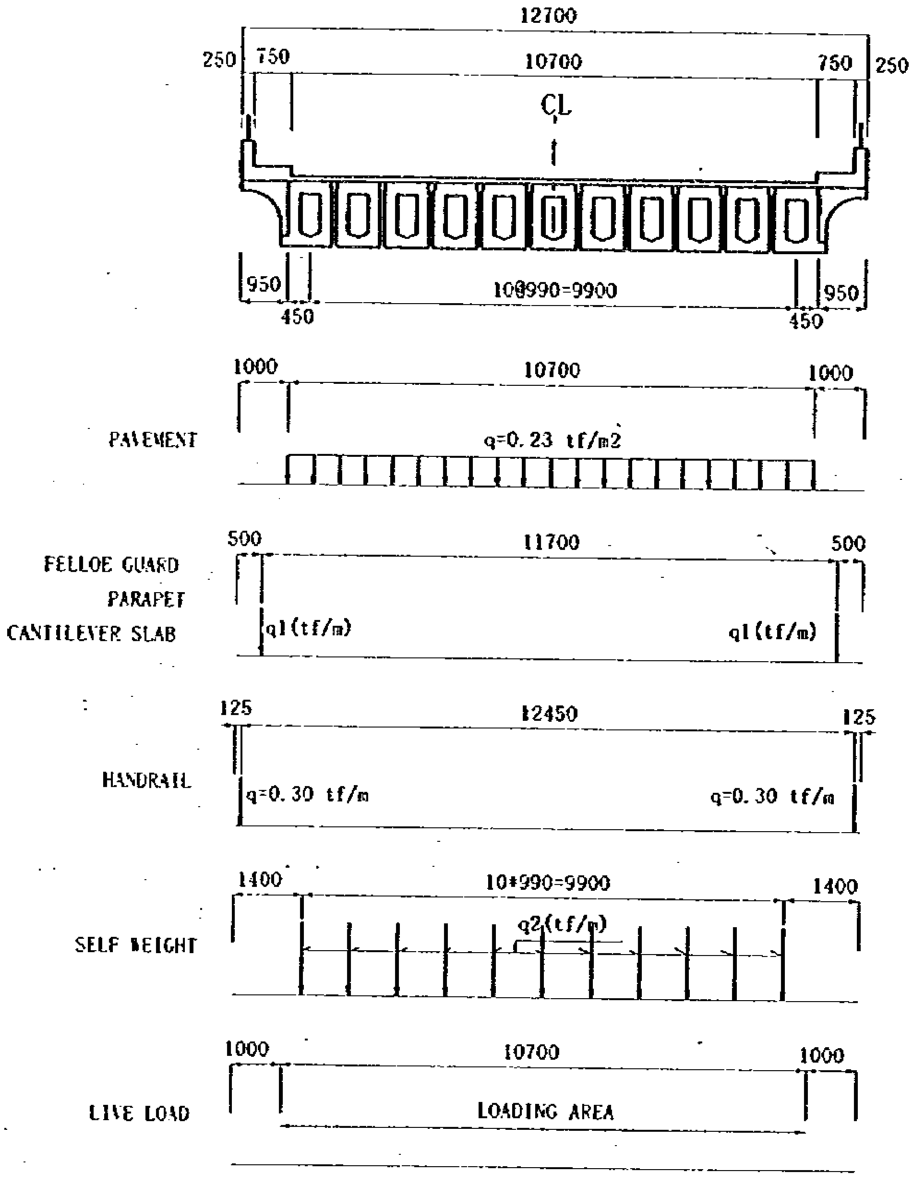
	Class 20	Class 24	Class 28	Class 32
Allowable Compressive Strength				
Flexure Stress	65	80	90	100
Axial Stress	50	65	75	85
Allowable Shear Stress				
Concrete	3.5	3.9	4.2	4.5
Diagonal Tensile Stress	15	17	18	19
Punching Shear Stress	8.0	9.0	9.5	10.0
Allowable Adhesive Strength				
Round Bar	7.0	8.0	8.5	9.0
Deformed Bar	14	16	17	18

* Cast-in-Situ Concrete Pile Class 32

- Reinforcement Bar

Allowable Tensile Strength	Grade 40	Grade 60
Ordinary members	1,400	1,800
Members underwater or below groundwater level	1,400	1,600

- **Loading Diagram for Structure**



Where:

	q1(tf/m)
L=25.1m	3.291
L=31.0m	3.441
L=34.0m	3.516

	q2(tf/m)
L=25.1m	2.188
L=31.0m	2.688
L=34.0m	2.938

Fig. 11 Loading Condition for Superstructure in Cross Section

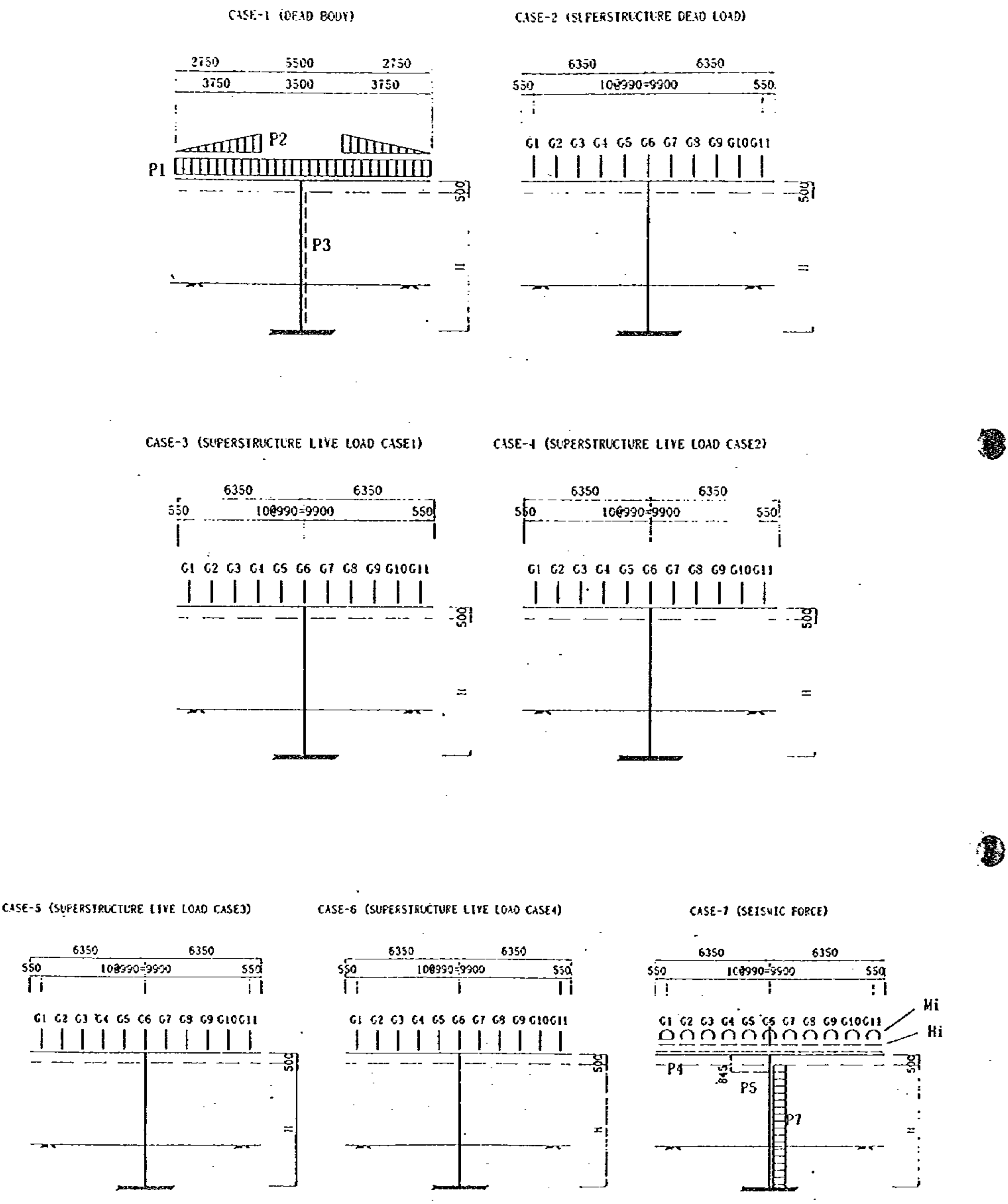
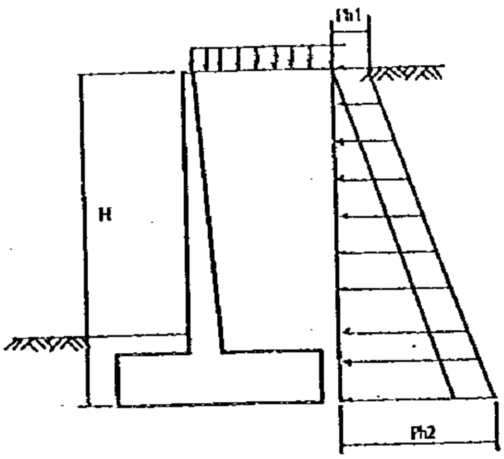
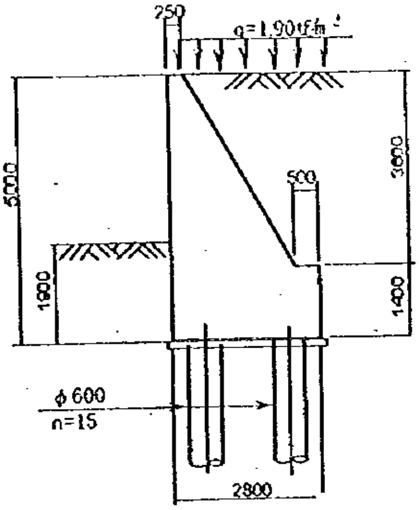


Fig. 12 Loading Condition for Substructure

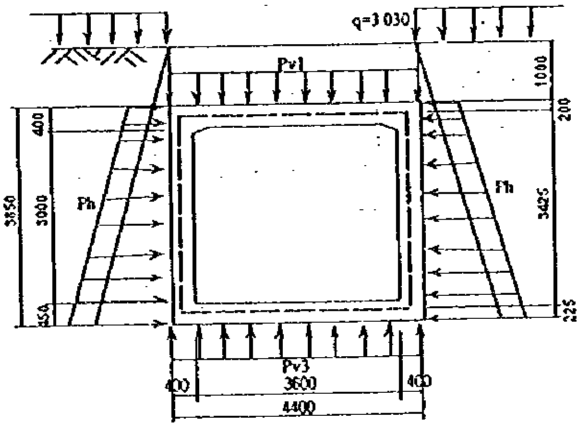


Inverted T-Type Wall

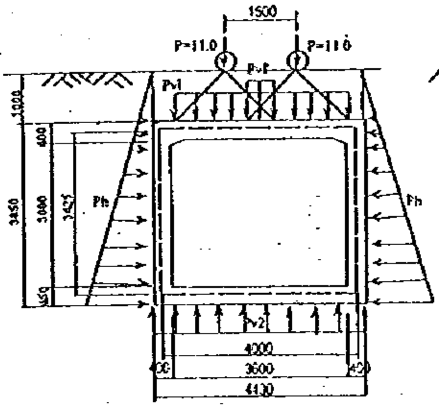


Graving Wall

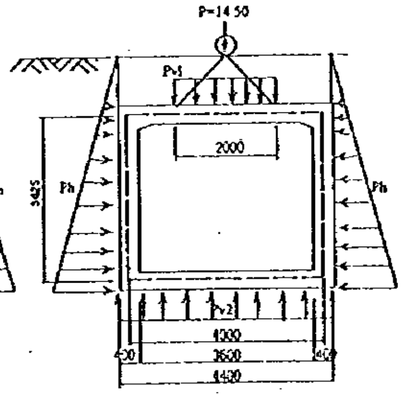
Fig. 13 Loading Diagram for Wall



Case 1: Uniform Load



Case 2: Special Truck Type A



Case 3: HS20-44 increased 100 %

Fig. 14 Loading Diagram for Box Culvert

- Design of Pavement and Drainage

• Pavement

Type of pavement of each future traffic volume (commulative ESAL) which was calculated according to design condition is as shown below.

Accumulative ESAL (x 1,000)	Type	Surface layer (asphalt concrete) (mm)	Base layer (asphalt concrete) (mm)	Upper level road bed (crushed rock) (mm)	SN
9,000 - 15,000	A	50	100	300	3.80
5,000 - 9,000	B	50	100	250	3.52
2,000 - 5,000	C	50	100	200	3.25
1,000 - 2,000	D	50	70	200	2.82
0 - 1,000	E	50	50	200	2.53
Service road		50	0	150	1.54

Note: = Period of analysis is the twenty year period between the years 2000 and 2020.
= The resulting figure from the CBR earthfill materials test is 50%; design CBR value of 25% is applied. Road bed thickness is 300 mm for all types.

Pavement type for each roundabout is shown in Table 7.

• Drainage

Drainage structures consist of the types indicated below, and drainage facility planning is conducted according to drainage conditions.

1) Cross culvert (box, pipe)

In order for the standard type to be used as design culverts, they will be divided into elongated types (added to existing ones) or newly-installed types, depending upon whether or not overburden can be obtained. In either case, box type will be 1.0m x 2.0m (B x D) x X (continuous number), pipe type will be ø 0.6m.

Table 7 Pavement Type of Each Flyovers

Design ESAL Unit: Thousands

No. of R/A	Name of R/A	Pavement	Highway			Roundabout	Rampway				Crossroad	
			At-grade		Retaining Wall Section		A-1	B-1	A-2	B-2	Inland	Coast
			Aqr	Muscat								
R/A-2	Naseem Garden	Design ESAL	4,503	4,647	4,245	510	592	458	796	813	1,005	847
		Pavement type	C	C	C	-	E	E	E	E	D *	E *
R/A-3	Barka	Design ESAL	3,865	4,997	2,755	3,493	2,067	2,376	2,239	2,346	1,807	1,883
		Pavement type	C	C	C	C	C	C	C	C	D	D
R/A-5	Al Muladdah	Design ESAL	3,264	4,596	2,571	2,021	1,237	1,524	4,036	4,041	2,571	0
		Pavement type	C	C	C	-	D	D	C	C	C *	- *
R/A-8	Khaburah	Design ESAL	3,383	3,228	2,620	2,433	2,342	1,802	2,342	1,505	1,971	2,933
		Pavement type	C	C	C	C	C	D	C	D	D	C
R/A-10	Saham	Design ESAL	6,288	6,797	4,554	7,991	3,352	3,576	4,369	4,576	6,097	6,249
		Pavement type	B	B	C	B	C	C	C	C	B	B
R/A-12	Sohar	Design ESAL	7,336	6,764	3,634	11,507	7,449	7,365	6,421	6,125	6,689	9,830
		Pavement type	B	B	C	A	B	B	B	B	B	A
R/A-14	Falaj Al Qabail	Design ESAL	4,222	4,913	3,073	2,286	2,288	2,288	3,653	3,698	3,928	2,273
		Pavement type	C	C	C	C	C	C	C	C	C	C
R/A-18	Aqr	Design ESAL	1,553	2,243	1,297	1,194	516	516	1,898	1,887	4,712	848
		Pavement type	D	C	D	-	E	E	D	D	C *	E *

Notes : (1) Rampway is classified as follows:

A-1 : merge lane towards Aqr . (for R/A-18, it denotes the merge lane towards Dubai.)
A-2 : diverge lane from Muscat side . (for R/A-18,it denotes the diverge lane from Muscat side.)
B-1 : diverge lane from Aqr side. (for R/A-18,it denotes the diverge lane from Dubai side)
B-2 : merge lane towards Muscat. (for R/A-18,it denotes the merge lane towards Muscat.)

(2) For R/A-18,Aqr and flyover are to be replaced by Dubai and At-grade respectively.

(3) * : Pavement design not included in this project.

2) Central divider drainage facilities

These drainage facilities will consist of side drains, water-collecting tank, and crosspipes, in that order, in the direction of the flow.

3) Abutment front side drainage facilities

The object of this facility is the drainage of the landscaped area surrounded by the roundabout ramp and abutment. Details of these drainage facilities are the same as the above.

4) Roundabout drainage facilities

These drainage facilities will consist of small-diameter pipes beneath the pedestrian walkway, side drains along the roundabout, and cross-ducts, in that order, in the direction of the flow.

5) Diverted waterway (large-scale open waterway)

6) Irish crossing

3.3 Construction Implementation Plan

The Batinah Highway, as National Route No. 1 which connects the Sultanate's capital Muscat with Dubai and Abu Dhabi in the United Arab Emirates, is one of the most vital routes in the country. Therefore, the planning of implementation of grade separation and pedestrian underpasses are important points in considering the improvement of traffic flow along this route. At the same time, it is necessary to maintain the characteristic identity of the Batinah Highway through design which accommodates aesthetics and landscape planning in addition to efficient construction.

In this light, points such as ease of construction, minimizing of construction period, and efficient detour planning are reflected within this final design. In addition, underground as well as overground utilities, and drainage facilities were carefully researched with the related authorities. Study was also conducted regarding these facilities' relation to project cost.

In basic consideration of Oman's rules and regulations concerning civil engineering construction as well as construction conditions such as climate, terrain, and geology; the implementation plan has been drawn up with consideration of planning of materials, construction machinery, construction equipment, construction methods, temporary works, roads for construction, temporary buildings according to construction phase as well.

Briefly,

(1) Conditions of construction pertaining to specific site (climate, terrain, geology, obstacles: e.g., construction in summer heat)

(2) Safe and sure construction, early completion

(3) Procurement of materials and equipment to each specific site

(4) Utilization of local materials, etc.

(5) Order of priority of facility construction (fifth and sixth Five-year Plans beginning in 1996)

(6) Observation of rules and regulations of the Sultanate

(7) Social environment of the specific site

(8) Principal construction facilities and equipment

- Planning of construction schedule

This project (the construction of eight flyovers and twelve pedestrian underpasses) will be carried out over a period of ten years which correspond to the Fifth (1996-2000) and Sixth (2001-2005) Five-year Plans. Therefore, in order to work out the planning of construction schedules for these projects, consideration of Oman's available construction equipment and labor situation must be made according to each construction item in terms of construction capability and time.

4. Environmental Impact Assessment

4.1 Survey Outline

- Environmental policy and environmental impact study

In 1986, the Sultanate of Oman put into effect the "Environmental Protection Law". Based on an understanding of this law, attention is paid to possible future degradation of the present environmental condition due to the project, and potential environmental improvements are also assessed. An Environmental Impact Statement for this project was submitted to the Ministry of Environmental by the DGR, upon which was based the Environmental Impact Assessment which was administered as stated below.

- Administration of Environmental Impact Assessment

The Environmental Impact Assessment was administered over a three-month period from May to August 1996. The area covered by the study was basically a 100-meter margin on both sides of the Batinah Highway (total 200 meters) in the vicinity of the eight roundabouts and twelve proposed underpasses.
In regards to the social environment, items covered included resettlement, socioeconomic activities, construction waste, historical buildings, cultural heritage, disaster risk, etc. Regarding the natural environment, assessment of trees, irrigation, and plant ecology was made. Concerning pollution, studies related to air pollution, noise pollution, and water/soil contamination were carried out. Measurements for atmospheric and noise pollution were made at five locations.

4.2 Predicted Environmental Impacts and Remedial Measures

- Social environment

Accompanying the construction of the flyovers and attached service roads, a number of commercial facilities (sundries, foodstuffs, repair shops) along the route are to be subject to relocation and compensation. Some amount of agricultural and/or open land will also need to be acquired. It has been found through an opinion survey that there are no negative feelings concerning the project on the part of the local residents, so it is assumed that acquisition and compensation will be carried out with little problem by the government's compensation committee.

Waste water and trash, etc., from the laborer's camp during construction will pose problems of water contamination and trash disposal. It will be necessary to obtain permits from the Environmental and local authorities for the laborer's camp, and water treatment methods, camp supervision, etc. must be carefully considered.

- Natural environment

During construction, it will be necessary to protect existing trees within the right-of-way. It will be necessary to transplant trees when possible. In case it is impossible to transplant a certain tree, it may be replaced with a younger one.

- Pollution

Atmospheric pollution by exhaust emissions will not pose a great problem with the amount of traffic volume forecasted for the year 2010. CO-2 and NOx densities are important factors in judging pollution, but the CO-2 density (μ g/m^3) for 2010 is forecast at 03 to 3.1, and NOx density (μ g/m^3) at 93~273 (308~909x0.3). Both of these figures are expected to be below WHO figures.

Areas which are presently barren ground will be planted with ground cover vegetation, thus bringing about certain environmental improvements.

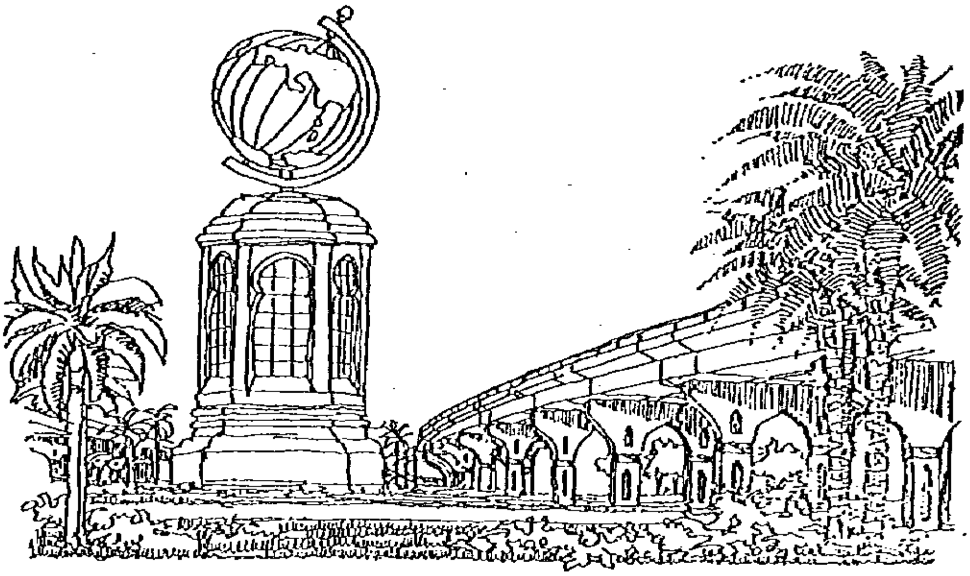
The predicted noise level for 2010 is Leq = 61.1~71.0dB(A). The level at Majaz A' Sughra is Leq = 71.0dB(A) as the present road project is used as a base. All other points are at a level of 66.0, which is below the standard level of 70; therefore will not pose a problem.

5. Aesthetics

Oman's urban and regional landscape policies have been highly fruitful over the last twenty years, with an overall integration of style and color which has also produced verdant public spaces which are among the most beautiful among the Gulf countries. The planting of trees and ground covers along main routes is proceeding with steady progress. There are also many flyovers which are comparatively well-designed in terms of aesthetics. Roundabouts along the Batinah Highway are all carefully landscaped and their monuments serve as community symbols; therefore design of flyovers in these situations requires careful attention and consideration of their presence.

5.1 Flyovers

Some roundabouts along the Batinah Highway are under the jurisdiction of the Ministry of Regional Municipality of Environment while others are under the jurisdiction of Sohar Development Office of the Muscat Municipality. Both of these authorities are striving to make the respective roundabouts as centers of community identity and easily recognized monuments at important intersections. This project is to construct flyovers at eight roundabouts, each at which the proposed structure possesses a larger scale in space than the existing monument itself, thereby holding potential to make the roundabout area a new local monument. Flyover design which respects the character of the existing monument will be of greatest importance. The alignment of the flyovers and pier style are the main factors of the overall landscape composition, dependent upon the presence (existing or planned) or absence of a monument which was the decisive factor in determination of flyover type. The proposed design for the flyovers takes into consideration traditional Islamic architecture, emphasizing arch design particularly for the piers. The area below the elevated section aims to be reminiscent of an arched corridor, creating a new sense of monumentalism while blending in with the existing scenery.

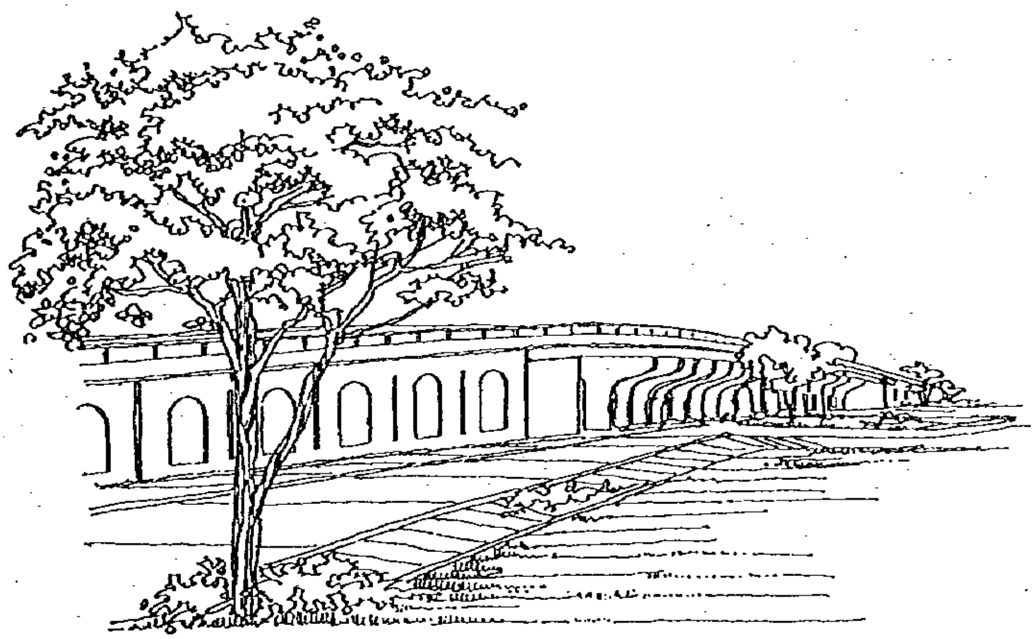


SOHAR Roundabout

5.2 Retaining walls

The retaining wall structure which retains the earthfill portion of the main route where it connects to the abutment of the flyover is a continuous length of 300m. As the retaining wall is a straight vertical type, continuous arch-style slits in relief on the wall surface will give it a sense of continuity with the design of the piers, preventing the overwhelming effect of a monotonous concrete wall by the addition of these light touches.

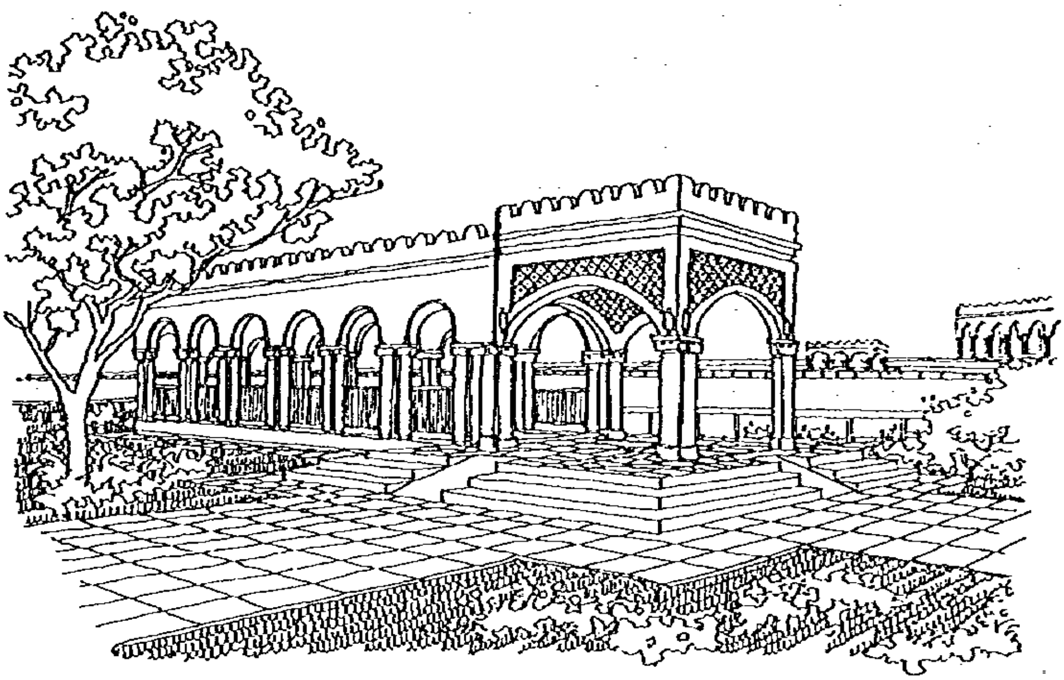
The central dividing zone of raised portion is in the form of a somewhat gentle slope, which will be covered chiefly with ground plants. The end of the inclined area is the point where it meets the abutment of the flyover, where it will be retained by a stone retaining wall, forming part of the outer edge of the roundabout.



RETAINING WALL

5.3 Pedestrian Underpasses

A total of twelve locations are planned along Batinah Highway for the construction of underpasses. These are chiefly locations which are major stops along the highway where a community has been divided by the highway and/or possess some important public facility on one side. At present, pedestrians have no choice but to make dangerous crossings as part of their daily lives. The design for the underpasses considered will invite use by its stylistic entrance with a combination of columns and arches in an elegant but familiar architectural style, being accompanied by a small plaza-type landing for easier access. The area directly below the central dividing zone of the highway will be a skylight, with an architectural style matching the entrances on both sides of the road.



PEDESTRIAN UNDERPASS

6. Project Cost

Estimates of project cost for the final design were calculated by figuring construction quantities for the eight flyovers and twelve pedestrian underpasses, including implementation planning. Calculations were conducted according to the government's own Standard Bill of Quantities (Ministry of Communications) as it is assumed that selected contractors of the Sultanate will be implementing the construction. It was by this bill that surveys on materials and machinery for procurement as well as construction equipment were carried out.

Table 8 Summary of Flyover Project Cost (In order of priority)

(Unit : R.O)

Roundabout	Construction cost	Land acquisition expenses	Construction supervision	Total
R/A-3 Barka	2,860,400	37,150	286,040	3,183,590
R/A-12 Sohar	4,083,781	3,900	408,378	4,496,059
R/A-2 A' Naseem Garden	2,875,251	45,210	287,525	3,207,986
R/A-5 Al Muladdah	2,919,043	79,120	291,904	3,290,067
R/A-10 Saham	3,640,548	15,318	364,055	4,019,921
R/A-8 Al Khaburah	3,035,078	23,920	303,508	3,362,506
R/A-14 Falaj Al Qabail	2,739,661	16,050	273,966	3,029,677
R/A-18 Aqr	2,944,251	254,989	294,425	3,493,665
Overall project cost	25,098,013	475,657	2,509,801	28,083,471

Table 9 Summary of Pedestrian Underpass Cost (In Order of Priority)

(Unit : R.O)

Pedestrian Underpass	Construction Cost	Construction Supervision	Total
P/U-1 Barka	97,895	9,790	107,685
P/U-3 A' Tareef	102,391	10,239	112,630
P/U-5 A' Thamad	103,978	10,398	114,376
P/U-6 A' Suweiq	99,270	9,927	109,197
P/U-2 Al Billah	95,013	9,501	104,514
P/U-7 Al Khadra	93,866	9,387	103,253
P/U-9 Majaz A' Sughra	93,799	9,380	103,179
P/U-8 Qarih	93,001	9,300	102,301
P/U-4 Al Qarat	93,129	9,313	102,442
P/U-12 Asrar Bani Sa'd	92,790	9,279	102,069
P/U-11 Liwa	94,832	9,483	104,315
P/U-10 Khor A' Siyabi	92,210	9,221	101,431
Overall project cost	1,152,174	115,217	1,267,391

Table 10 Summary of Total Project Cost

(Unit : R.O)

	Project Cost
Flyovers 8 Nos.	28,083,471
Pedestrian Underpass 12 Nos.	1,267,391
Total Project Cost	29,350,862

7. Project Implementation Programme

7.1 Project Implementation Planning

The implementation plan of this project is proposed over a ten-year period, spanning the Fifth (1996-2000) and Sixth (2001-2005) Five-year Plans.
Therefore, following the completion of the final design flyovers and underpasses will be constructed in order of priority ranking. The implementation program in Table 11 has been drawn up as a result of discussions with the Omani authorities regarding the timing of budget execution, time of order-placing, actual construction schedule, order of implementation, division of construction sectors, etc. of the Omani Government.

Table 11 Proposed Implementation Programme

			Fifth Five Year Plan					Sixth Five Year Plan				
			1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Final Engineering Design				12months								
(1) Flyover												
Preparation for documents				4		6	3	3 3	3		3	
Construction	Priority	Name of R/A										
	1	R/A-3 Barka				20						
	2	R/A-12 Sohar						24				
	3	R/A-2 A'Naseem Garden					20					
	4	R/A-5 Al Muladdah							20			
	5	R/A-10 Saham							20			
	6	R/A-8 Al Khaburah									20	
	7	R/A-14 Falaj Al Qabail									20	
	8	R/A-18 Aqr								24		
(2)Pedestrian Underpass												
Preparation for documents				2	2	2	2	4	4	4	4	
Construction	Priority	Name of P/U										
	1	P/U-1 Barka		8								
	2	P/U-3 A'Tareef				8						
	3	P/U-5 A'Tharmad					8					
	4	P/U-6 A'Suweiq						8				
	5	P/U-2 Al Billah							8			
	6	P/U-7 Al Khadra							8			
	7	P/U-9 Majaz A'Sughra								8		
	8	P/U-8 Qarih								8		
	9	P/U-4 Al Qarat									8	
	10	P/U-12 Asrar Bani Sa'd									8	
	11	P/U-11 Liwa										8
	12	P/U-10 Khor A'Siyabi										8

7.2 Tender/Contract Documents

- Basic Policy

Tender and contract forms which are presently used by the Ministry of Communications of the Sultanate of Oman form the base of the tender and contract documents prepared for the administration of this project. The types of documents shown in Table 12 are those generally used. Using these as a base, preparation of documents was conducted through discussion with the DGR to come up with a set of documents which meet the Oman standards.

Table 12 List of Items for Tender/Contract Documents

Document item	Items in common	Items by construction type
Pre Qualification	O	
Instruction to Tenderers	O	
Form of Tender Form of Agreement Form of Tender Bond Form of Performance Bond	O	
General Condition of Contract Special Condition of Contract	O O	
Bill of Quantity		O
General Specification Special Specification	O	 O
Drawings		O

- Pre-qualification

Pre-qualification is conducted in Oman in cases such as construction with no precedent, difficult construction, participation of foreign contractors, etc. It is necessary to wait for the Tender Board to decide whether or not this project corresponds to such criteria, but pre-qualification documents have been prepared by request of the DGR.

- Instruction to Tenderers and Form of Tender

The "Instruction to Tenderers" and "Form of Tender" are generally combined into "Prime Documents" in one volume; and for this project as well, they have been prepared separately for each site. This includes Invitation to Tender, Instruction to Tenderers, Form of Tender, Form of Tender Bond, et cetera.

- Conditions of Contract

Both General and Special Conditions of Contract are pre-made and available as "Standard Documents for Building and Civil Engineering Works"; therefore they have not been prepared specially for this project. These include Form of Agreement and Conditions. The Conditions are compiled according to the Conditions of Contract of the FIDIC (Federation International des Ingeniurs-Conseils), therefore should pose no problem.

- Bill of Quantities

A separate Bill of Quantities is prepared for each site based on the results of the project design.

- Specifications

The Specifications were modeled after the latest General Specification for Roads (April 1994), a document for road construction.
Special Specifications of each site which are not mentioned in the General Specifications documents are compiled separately.

- Drawings

Drawings have been compiled according to site and results of project design.

8. Conclusions and Recommendations

This final design study is part of a long term project, making steady progress, which is proposed to be conducted throughout the ten years of the Fifth and Sixth Five-year Plans (1996-2000, 2001-2005 respectively).

Road improvements at Al Muladdah Junction and a pedestrian underpass at Al Bidayah are already being constructed, and now it is expected that the construction of high-priority flyovers and pedestrian underpasses will be realized soon. The realization of this project is pertinent to national economic development and poses no problem to the Sultanate of Oman's engineering capabilities in terms of construction, equipment, and implementation.

In consideration of forecasts of future traffic conditions on the Batinah Highway as well as population increase resulting from growth in the regional economy, the grade separation of roundabouts will ameliorate traffic functions, alleviate congestion, and reduce traffic accidents. By the same token, the construction of pedestrian underpasses will strengthen sense of community of towns divided by the highway and reduce traffic accidents involving pedestrians. When the project is realized, areas along the Batinah Highway will enjoy the beautification and environmental improvement. The Highway will furthermore serve as foundation for economic development; encompassing not only the Sultanate but neighboring countries as well.

Regarding the transferal of skills to Oman, since the beginning of the feasibility study in 1994 through to the final design stages several meetings have been held with counterpart members of the Directorate General of Roads discussing technical aspects of the project. Furthermore, certain transferal of skills were carried out as training in Oman as well as in Japan. In addition to these, thorough and consistent skill transferal involving the entire process has been an effective form of transferal of skills.

When the construction phase of this project is reached, skill transferal involving the entire process from feasibility study to final design, supervision of construction, and operation; carried out thoroughly and consistently; will most likely benefit the future of civil engineering skills of the Sultanate of Oman.

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