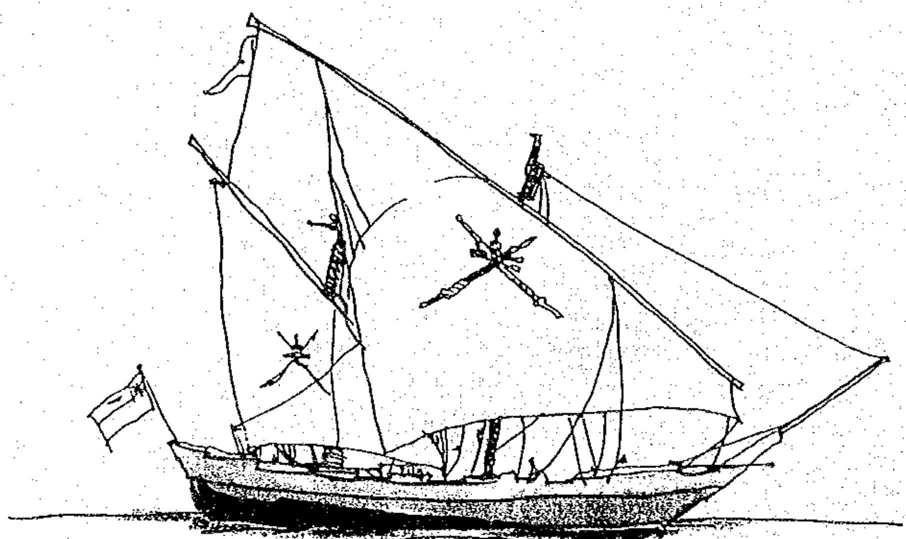
CHAPTER 4 PRESENT TRAFFIC PATTERN AND CHARACTERISTICS



CHAPTER 4

PRESENT TRAFFIC PATTERN AND CHARACTERISTICS

4.1 Traffic Survey

Three different traffic surveys were successfully carried out from 19th of March to 26th of March 1994. Axle Load Survey at 4 additional locations on Route 23, 21 and 7 were conducted from 23rd to 27th of April 1994. The location of the surveys are indicated in Fig. 4.1 and scope and type of these surveys are briefly described below:

(1) Roadside Interview Survey

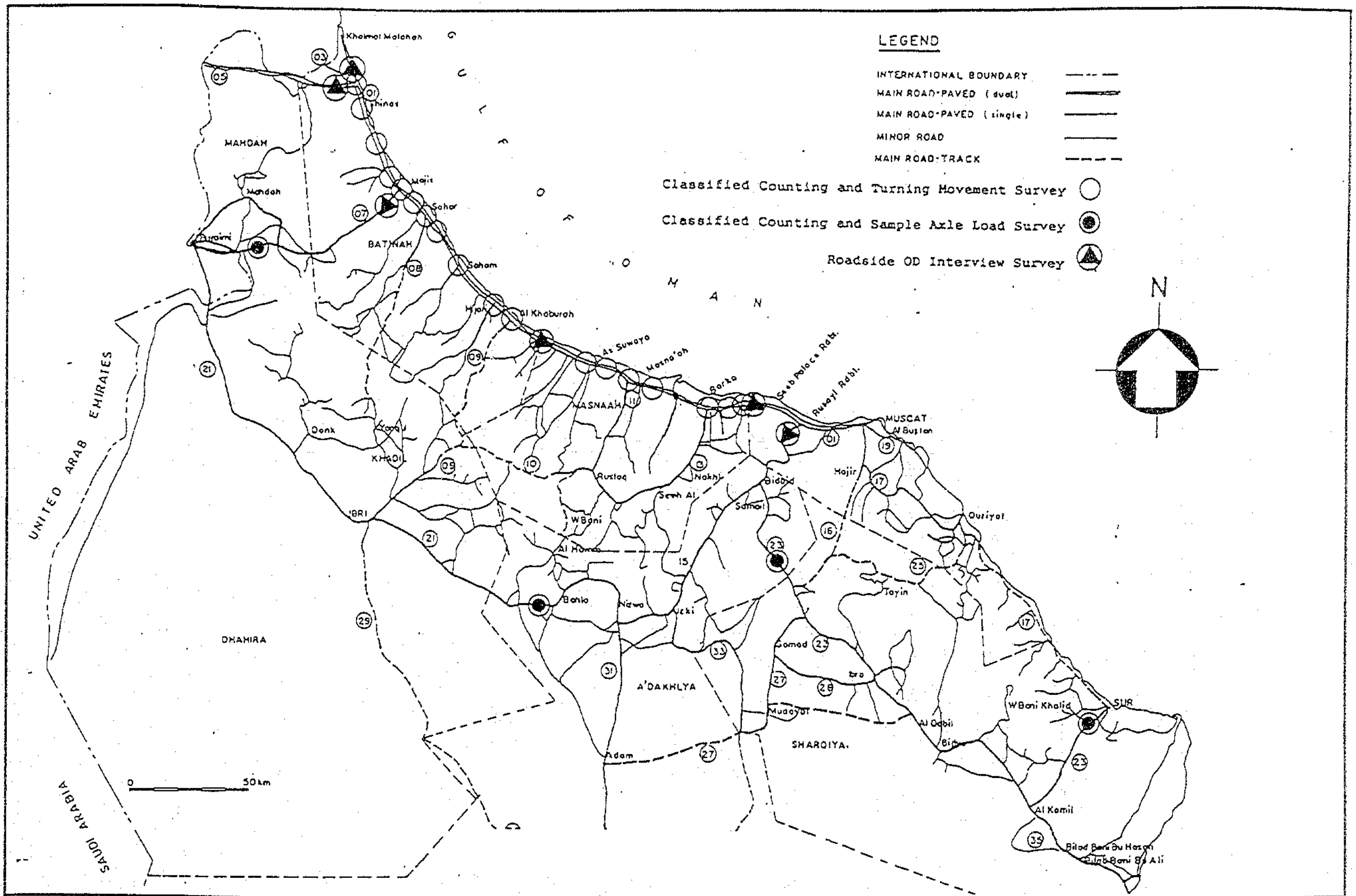
Roadside interview survey was planned to collect vehicular travel demand characteristics in the Batinah Highway as well as the major national routes so as to construct the present OD table. This survey was conducted at 6 locations and a total of 6,623 vehicles were stopped at these survey locations and interviewed.

(2) Traffic Volume and Turning Movement Survey

This survey is aimed at counting traffic volume by direction at the 18 study roundabouts and intersections. Twenty-four-hour classified traffic volume counting was also conducted at OD survey station of No. 6 on Route 15 towards Bidbid near Rusayl.

(3) Axle Load Survey

The sample axle load survey of trucks and the 24-hour traffic volume survey were conducted at four additional locations outside the Batinah Region near the bridges under study.



THE STUDY ON ROAD DEVELOPMENT PROJECT	JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 4.1 Location of Traffic Surveys

(4) Speed Survey

a. Travel Speed Survey

Travel speed survey along the Batinah Highway was conducted on the 26th of March 1994. This survey was aimed to measure the average travel speed of vehicle on Batinah Highway.

b. Spot Speed Survey

Spot speed survey was conducted at a selected road section between Naseem Garden R/A and Barka R/A. This survey is aimed at measuring the spot speed of various vehicle types.

c. Speed Variation Survey at Roundabout

Speed variations were measured at Barka Roundabout, as a sample roundabout, to know the delays at the Roundabout. Check points with known distances from the roundabout were designated and travel time was recorded at these points.

4.2 Results of Surveys

4.2.1 Traffic Volume

Daily Traffic Volume

Along the Batinah Highway, the highest traffic volume is counted at Bait Al Barakah R/A with 21,200 veh/day for both directions. It is observed that traffic volume generally decreases along the highway as the distance increases from Muscat. Fig. 4.2 shows the daily traffic volume along the Batinah Highway. Traffic volume after Al Khaburah tends to increase slightly towards Sohar at about 11,200 vehicles but decline again towards Aqr to about 5,500 vehicles a day.

This traffic demand pattern can be explained by the strong economic influence of Muscat region and Sohar region. Commuter traffic to Muscat for instance, comes from as far as the Al Khaburah area.

Present traffic demand on the national routes adjoining the Batinah Highway are also shown in Fig. 4.2. The highest demand of 7,280 veh/day is found on Route No.

13 from Barka R/A towards Nakhal and Rustaq. This is followed by 5,229 veh/day for Route No. 11 from Muladdah to Rustaq.

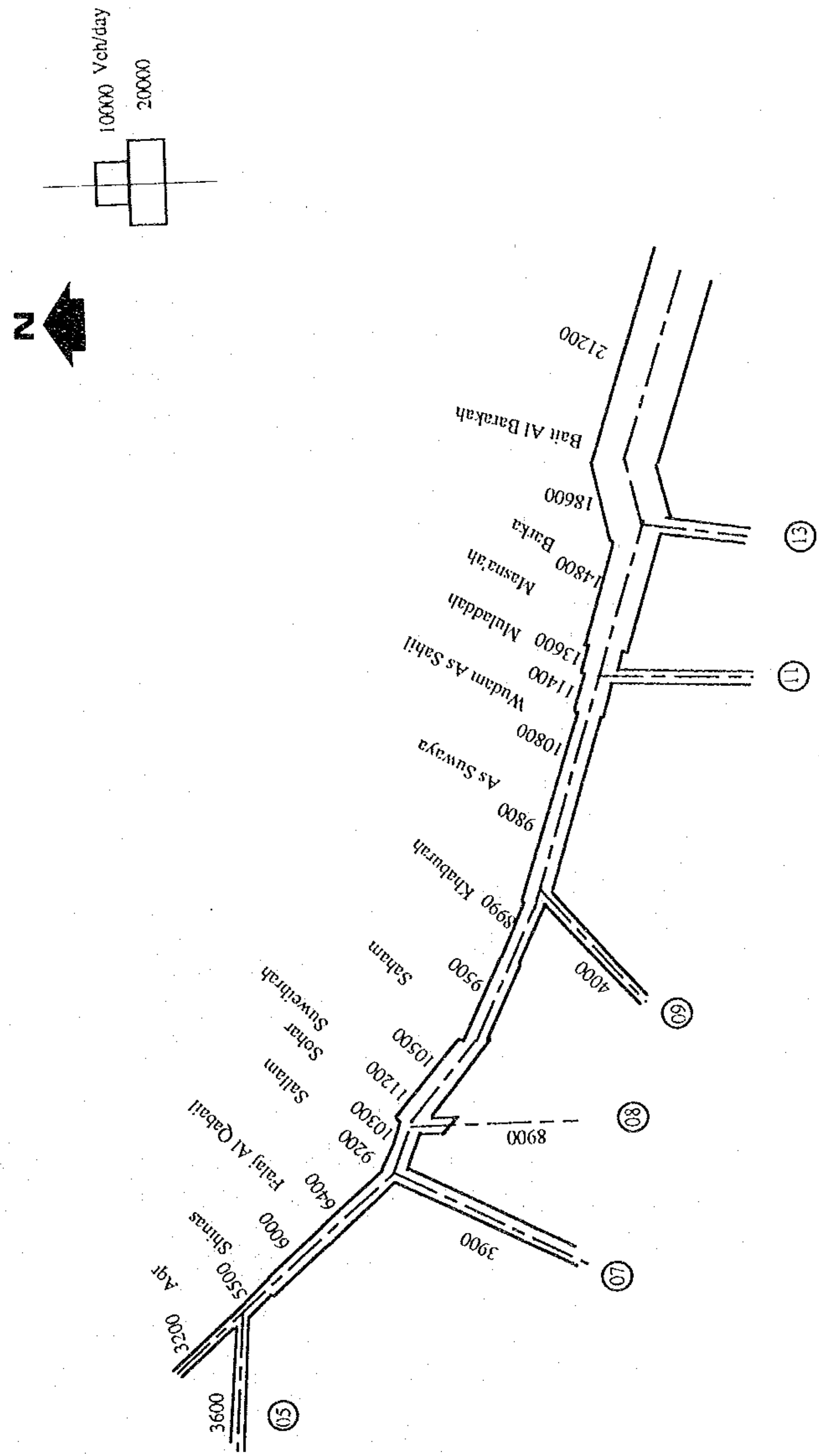
Traffic volume on other regional roads towards the inland area from Batinah Highway are also substantial at Saham R/A (9,042) towards Falaj Al Harth, As Suweiq R/A (3,460) towards Howqayn. Traffic volume at Sohar R/A in the inland direction at 8,893 reflects only traffic from the service roads fronting the highway to the roundabout which includes traffic on the unpaved regional road to Wadi Hibi.

Table 4.1 Summary of Traffic Volume

No.	Location	Daily Traffic Volume					
		Inbound	Peak (%)	Outbound	Peak (%)	To Coast	To Inland
TS-1*	Bait Al Barakah	9,009	9.32	12,191	11.01	887	969
TS-2	Naseem Garden	8,172		10,011		418	686
TS-3	Barka	7,609		9,665		9,824	7,280
TS-4	Masna'ah	5,662		8,037		2,114	559
TS-5*	Al Muladdah	5,575	7.29	5,227	8.02		5,229
TS-6	Wudan As Sahil	5,556		6,568		5,046	1,406
TS-7	As Suweiq	5,484		6,309		4,399	3,460
TS-8*	Al Khaburah	4,495	6.85	4,596	7.70	6,107	4,007
TS-9	Hijari	3,607		5,090			1,331
TS-10	Saham	5,374		5,297		9,247	9,042
TS-11		5,652		6,005		2,145	2,112
TS-12	Sohar	6,702		4,566		22,744	8,893
TS-13	Sallan	4,666		4,297		4,110	1,954
TS-14*	Falaj Al Qabail	4,074	7.63	4,099	5.95	1,937	3,874
TS-15	Majees	3,244		3,290		712	161
TS-16	Liwa	3,088		3,042		3,931	853
TS-17	Shinas	3,129		2,730		4,182	2,133
TS-18*	Aqr	2,725	7.41	2,651	5.92	551	3,551
TS-19*	Route 23 Brdge. No. 9	1,096	8.03	1,159	7.42		
TS-20*	Route 23 Brdge. No. 7	1,416	10.59	1,433	10.12		
TS-21*	Route 21 Brdge. No. 8	1,800	9.33	1,922	10.35		
TS-22*	Route 7 Brdge. No. 4	1,876	8.37	1,430	11.26		
OD-6*	Route 15 near Rusayl	6,582	8.13	7,346	7.79		

* 24 hours survey station, the rest are expanded 12 hours station

Fig. 4.2 Present Daily Traffic Volume on Batinah Highway, 1994



Traffic demand on roads towards the coastal areas and towns is also large especially for Sohar (22,744 veh/day), Barka (9,824 veh/day), Saham (9,276 veh/day), Al Khaburah (6,107 veh/day) and Wudam Al Sahil (5,046 veh/day).

The expansion factors - ratio of 12-hour count volume to 24-hour count volume - computed from results of the 24-hour survey stations ranged from 1.35 to 1.75 indicating a characteristic that traffic demand after 6 p.m. is substantial but is observed to decrease significantly after 10 p.m.

Vehicle Type Composition

Vehicle type composition along the Batinah Highway is found to vary only slightly throughout its entire length. There are generally more cars and vans at locations nearer to Muscat. On the other hand there are more pickups, light trucks and heavy trucks towards Aqr. As a whole, traffic on the Batinah Highway is generally made up of an average 67 % passenger cars (including taxis, vans) 28 % light trucks (mostly pickups) 1.2 % medium trucks 2.6 % heavy trucks and 0.4 % stage buses.

Hourly Traffic Distribution

Peak hour traffic features along the Batinah Highway vary by location. In general, for the roundabouts or junctions which are closer to Muscat and have larger proportion of commuting traffic, the hourly traffic demand pattern shows distinct morning and evening peaks. For other locations away from Muscat, traffic is more evenly distributed throughout the day.

Fig. 4.3 shows the hourly traffic distribution pattern for Bait Al Barakah R/A and Route 15 (OD station No. 6). Distinct morning and evening peaks can be seen for these two survey locations. At Bait al Barakah the morning peak at 7-8 a.m. is a lesser peak than the evening peak at 2-3 p.m. The peak hour traffic represents an average of 8 % of the daily total traffic volume.

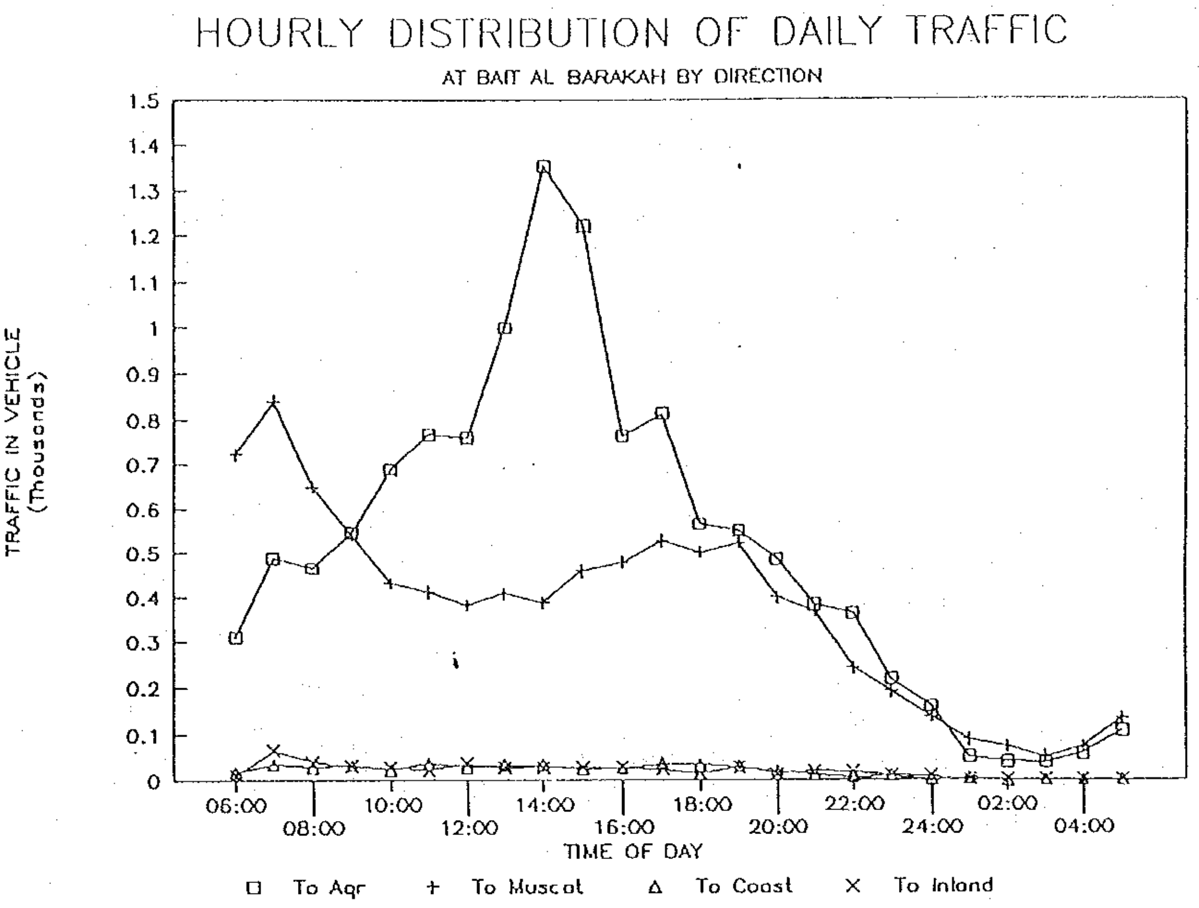
Compared to locations away from Muscat such as for Aqr R/A and Muladdah Junction in Fig. 4.4, traffic is found to distribute more evenly throughout the day with less distinct morning or evening peaks. In these locations, there is a high noon peak at 11-12 noon, in addition to the evening 2-3 p.m. peak.

Turning Patterns at R/A or Junctions

Turning patterns of vehicle traffic are plotted from the traffic volume survey. It is obvious that through-traffic holds the largest ratio of movement patterns at studied R/A or junctions. Fig. 4.6 (a) and (b) show the traffic flow pattern at Bait Al Barakah R/A and As Suweiq R/A. Large proportions of through-traffic are observed at these two locations.

On the other hand, traffic turning towards Rustaq and Nakhal from the highway to Route No. 11 at Muladdah Junction and at No. 13 Barka R/A are substantial, as clearly seen in Figs. 4.6 (c) and (d). About 30 % of the traffic turns inland toward Rustaq and Nakhal at Barka R/A.

At Sohar R/A, traffic to and from Sohar Town on the sea coast side is the main traffic stream at this location as shown in Fig. 4.7 (a). At Aqr R/A, traffic going towards Dubai in the U.A.E. from Batinah Highway constitutes the major traffic flow as shown in Fig. 4.7 (b).



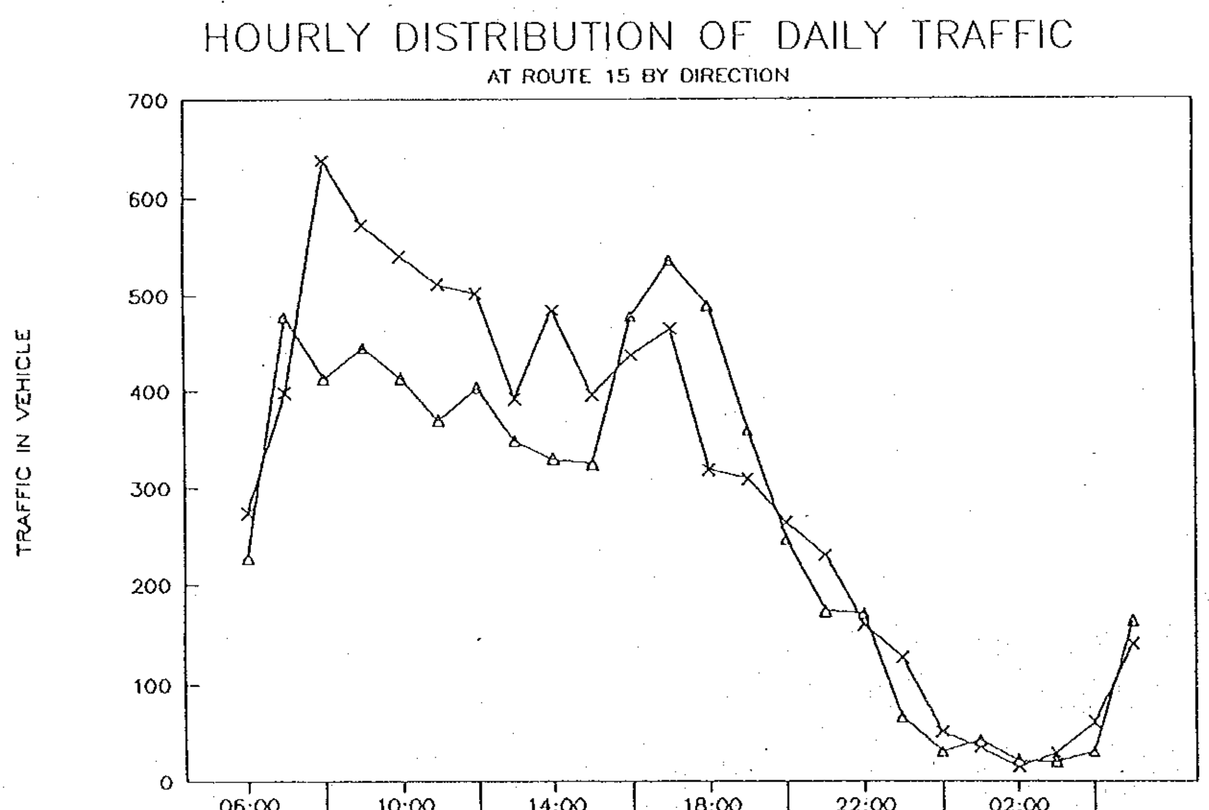
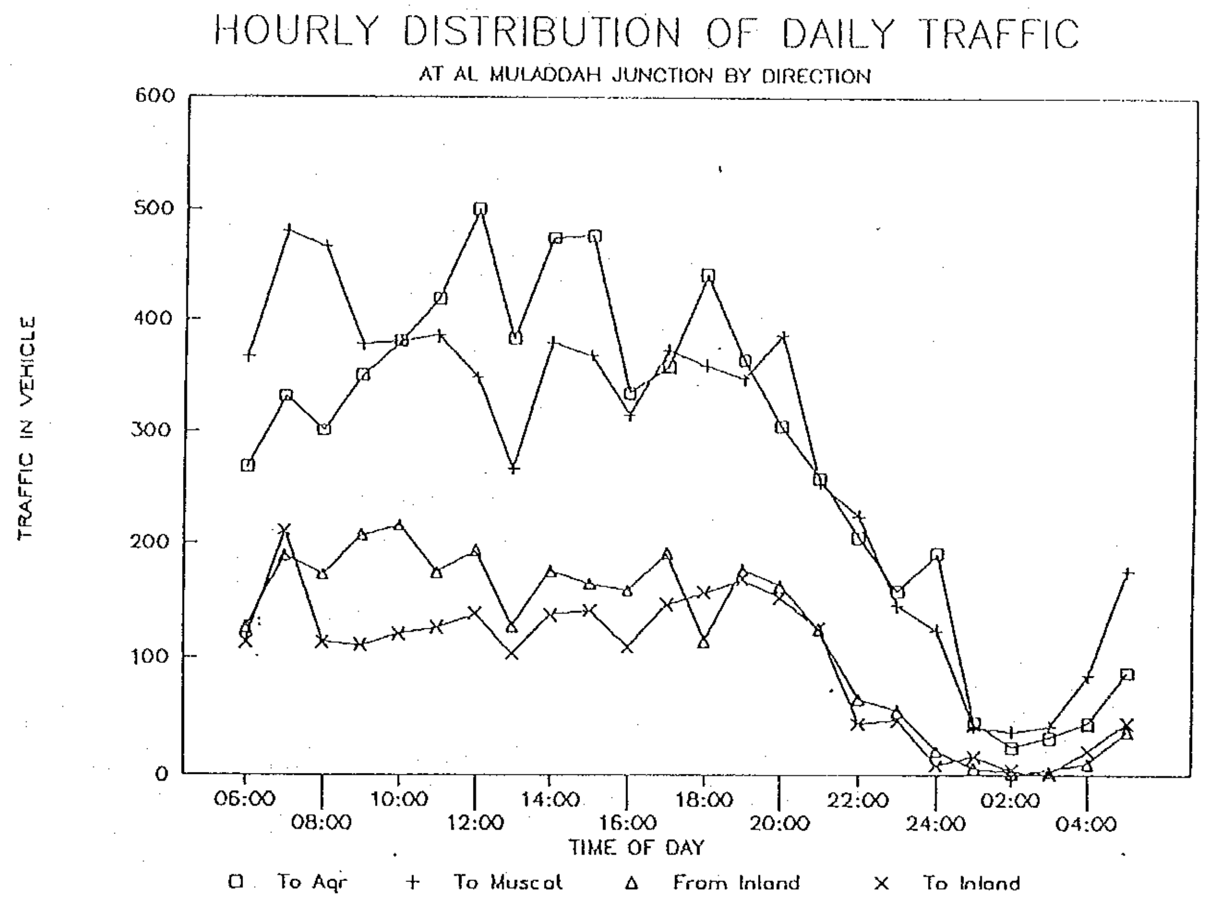
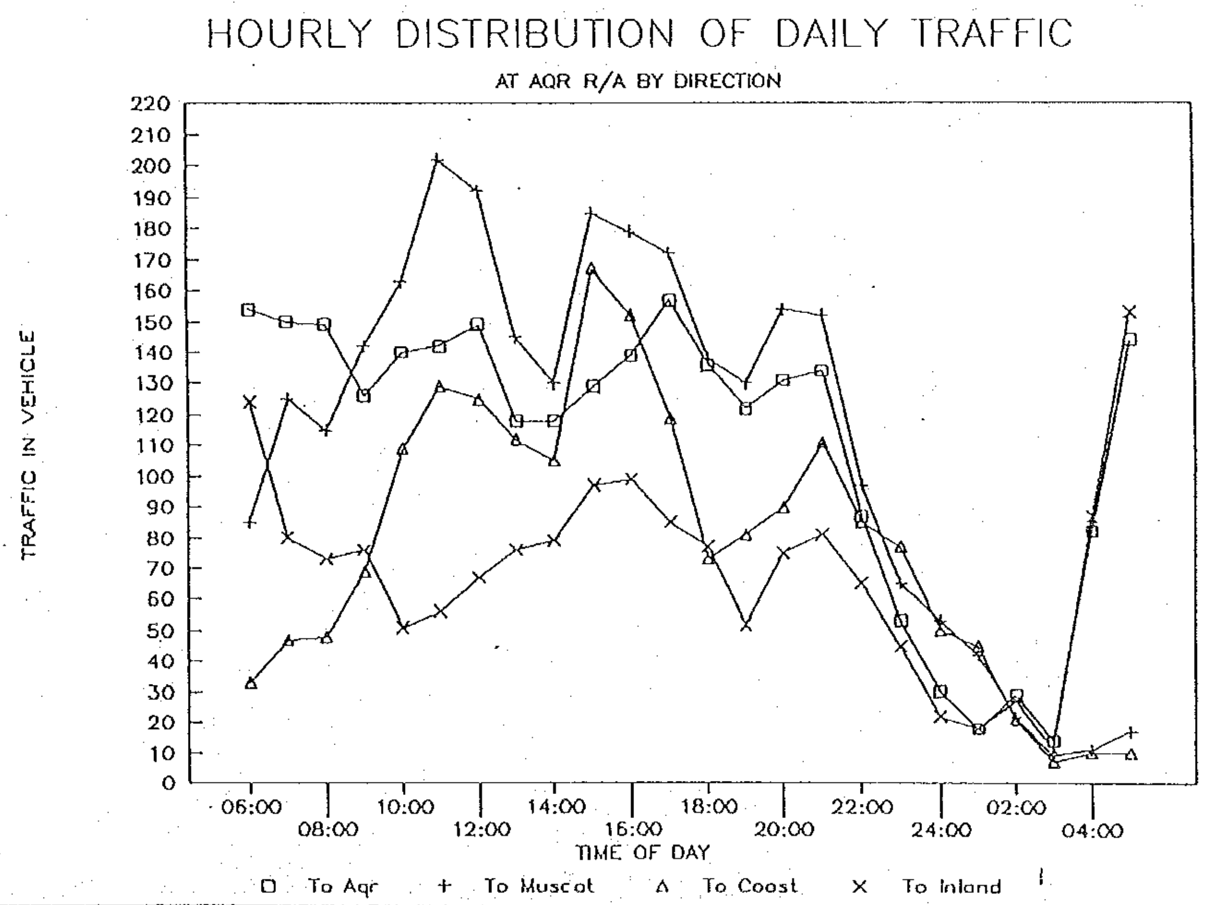


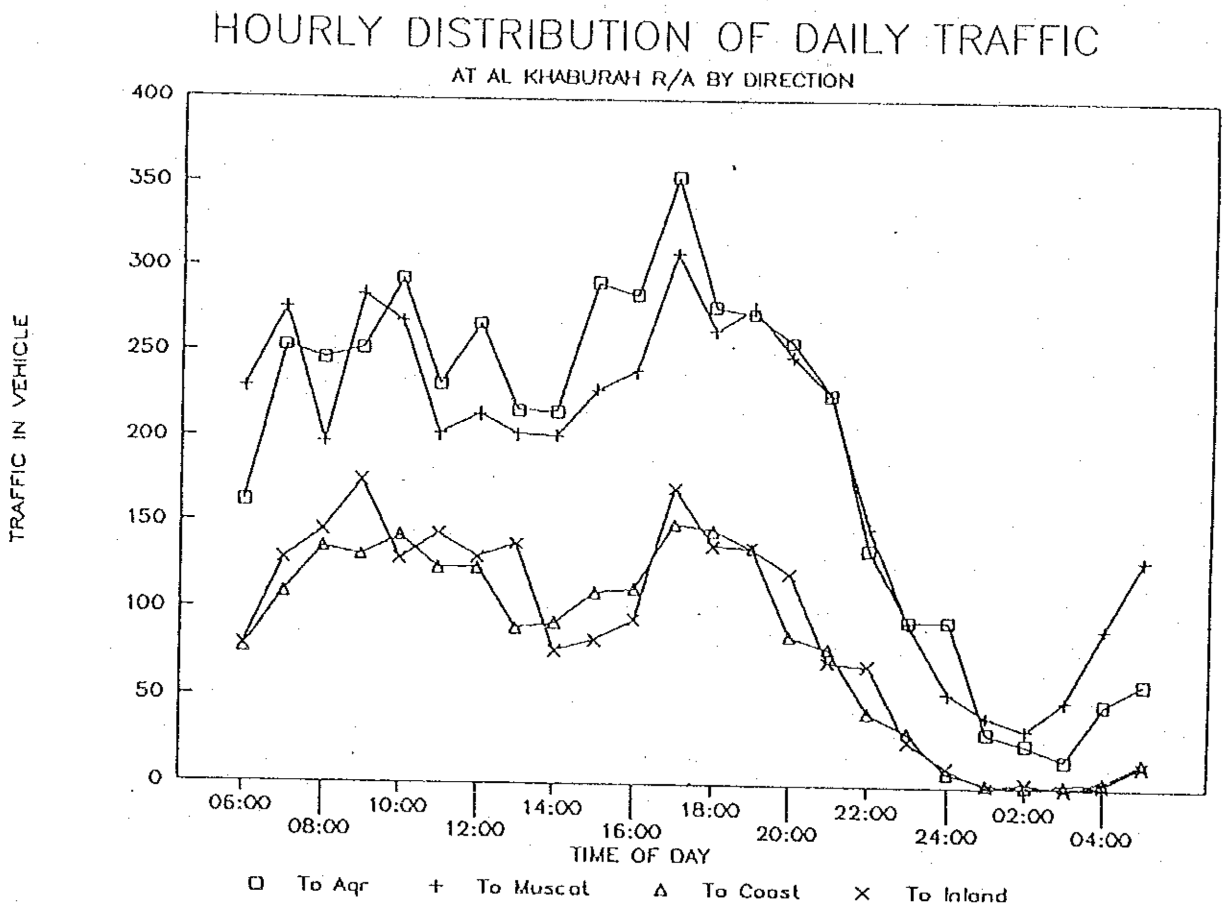
Fig 4.3

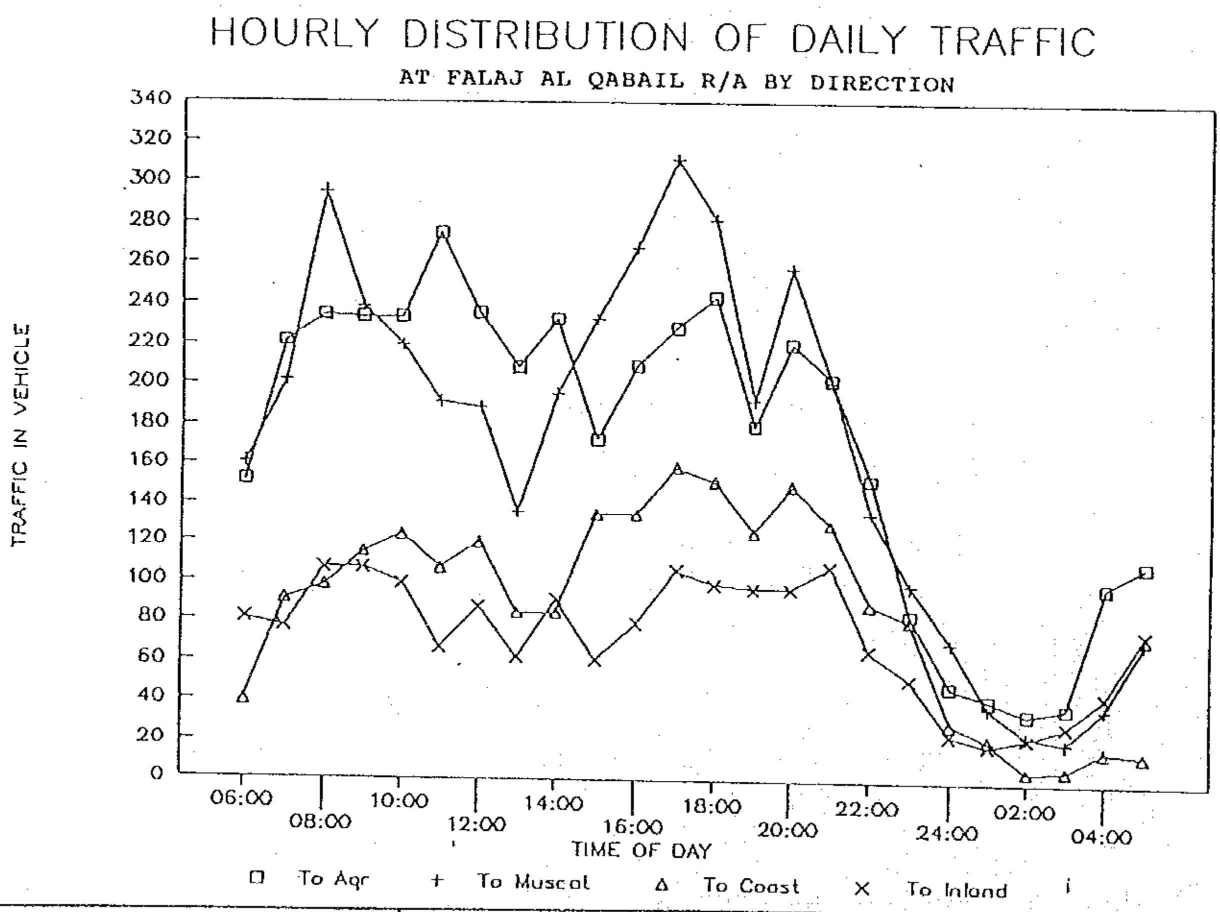
THE STUDY ON ROAD DEVELOPMENT PROJECT	JAPAN INTERNATIONAL COOPERATION AGENCY	Hourly Distribution of Daily Traffic at Bait Al Barakah and Route 15 (near Rusayl)



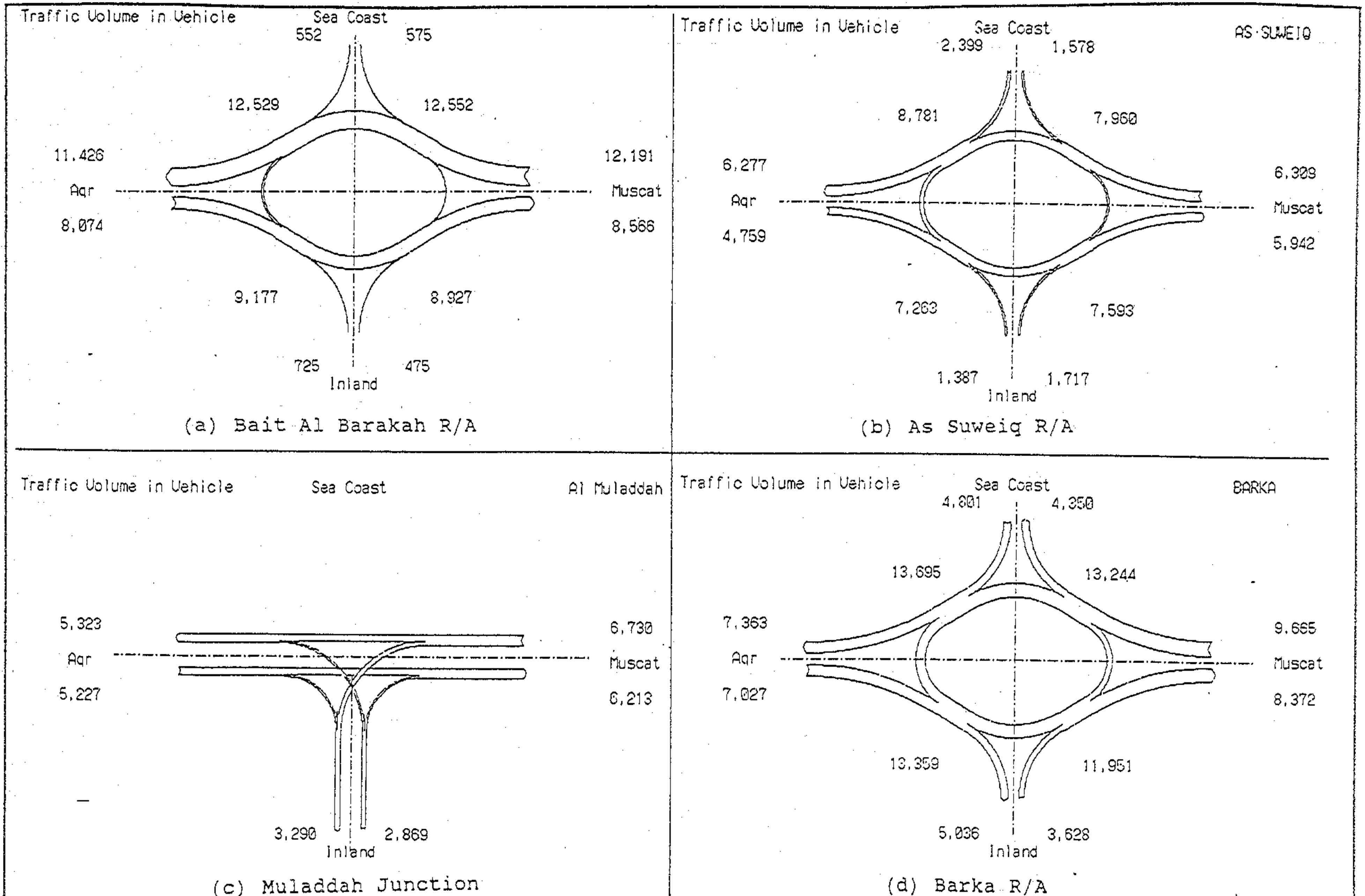


THE STUDY ON ROAD DEVELOPMENT PROJECT	JAPAN INTERNATIONAL COOPERATION AGENCY	Fig 4.4 Hourly Distribution of Daily Traffic at Al Muladdah and Aqr R/A

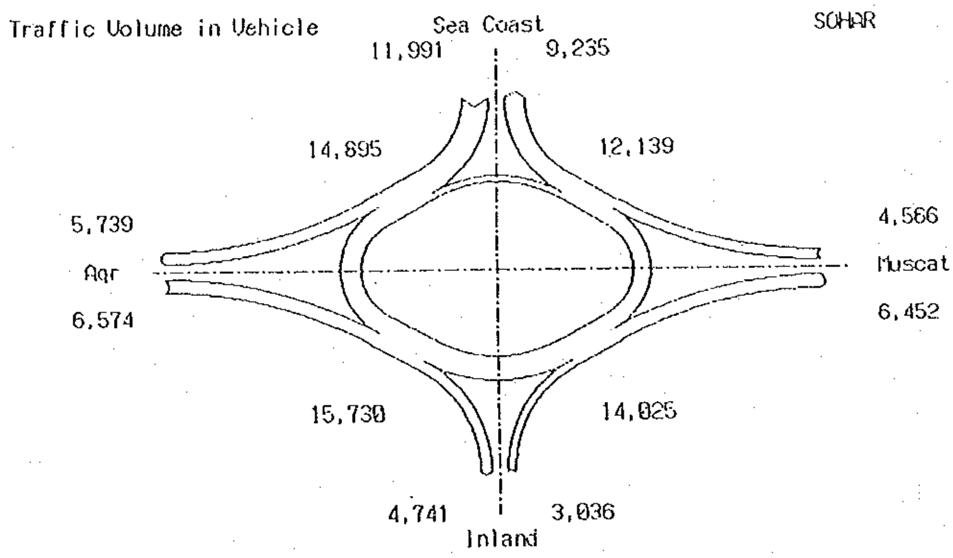




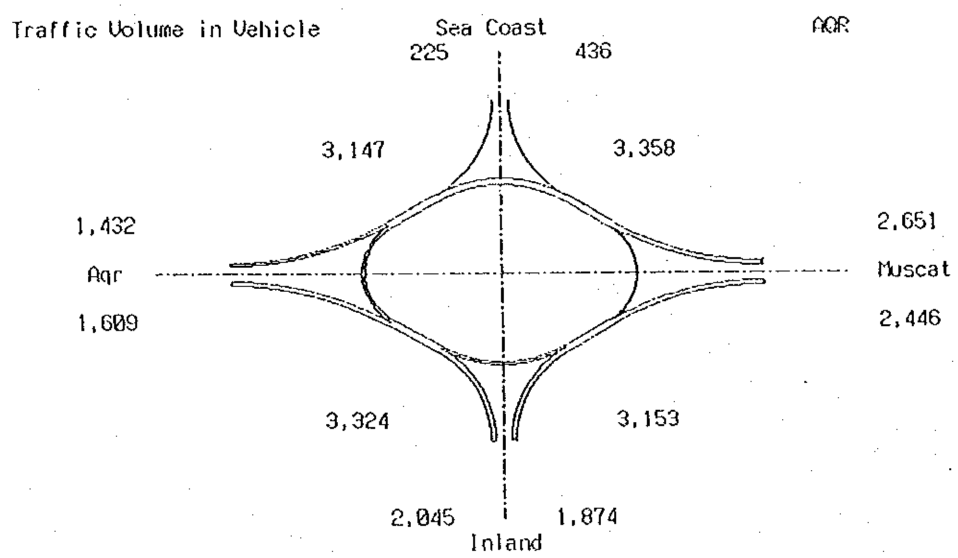
THE STUDY ON ROAD DEVELOPMENT PROJECT	JAPAN INTERNATIONAL COOPERATION AGENCY	Fig 4.5 Hourly Distribution of Daily Traffic at Al Khaburah and Falaj Al Qabail R/A



THE STUDY ON ROAD DEVELOPMENT PROJECT	JAPAN INTERNATIONAL COOPERATION AGENCY	Fig 4.6 Traffic Turning Movements at Bait Al Barakah As Suweiq R/A, Muladdah Junction and Barka R/A



(a) Sohar R/A



(b) Aqr R/A

Fig. 4.7

THE STUDY ON ROAD DEVELOPMENT PROJECT	JAPAN INTERNATIONAL COOPERATION AGENCY	Traffic Turning Movements at Sohar and Aqr R/A

4.2.2 Travel Speed

(1) Average Travel Speed

The average travel speed on the Batinah Highway was obtained by conducting the 'floating car' method travel speed survey. A 'test car' was used to run from one end to the other end a speed that enables it to 'float' with the traffic stream. The study R/A and junctions were designated as check points along the travel. Times when passing these check points were recorded and the average travel speed is computed.

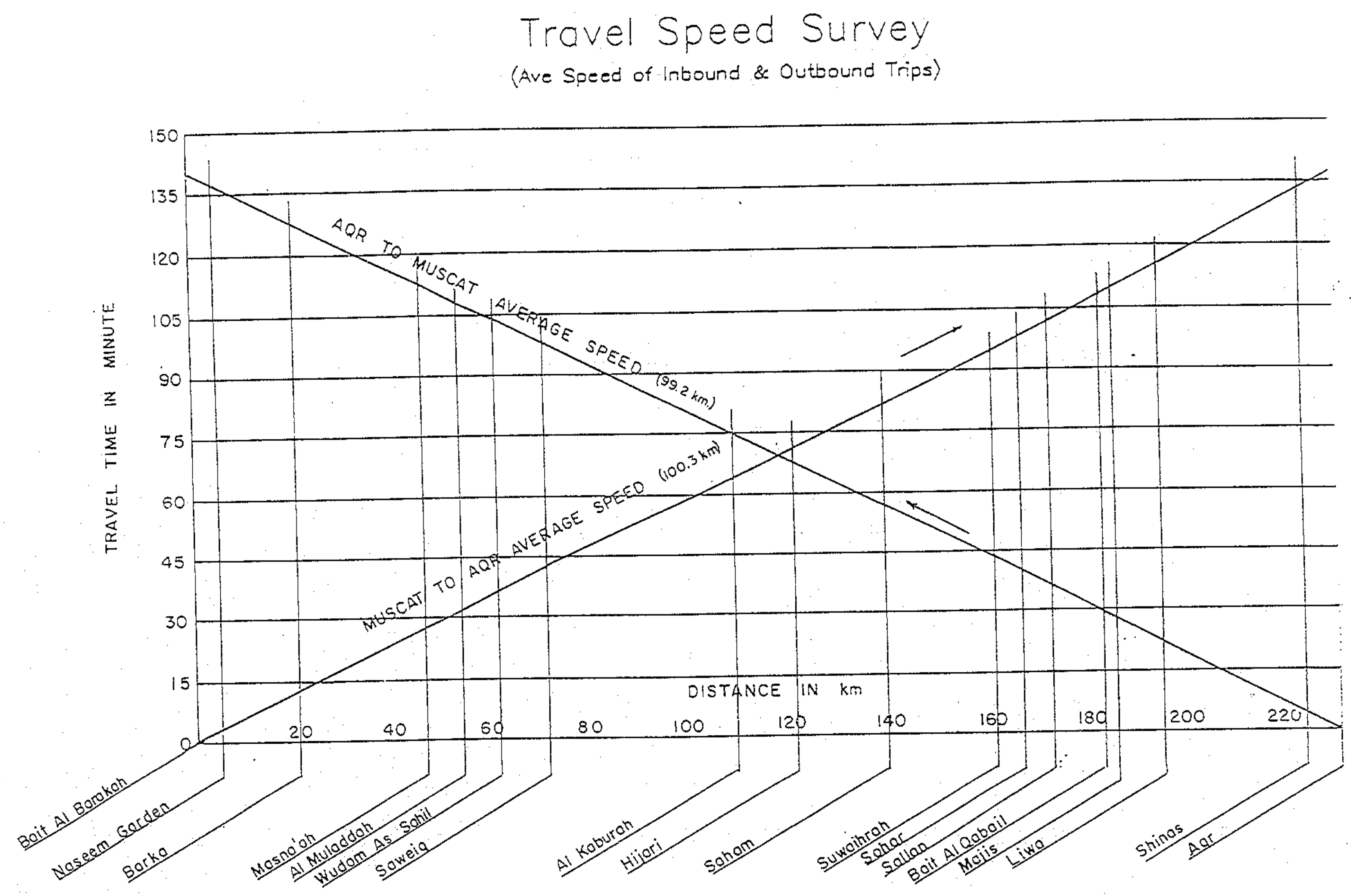
Four runs along the entire stretch of Batinah Highway were carried out.

From these surveys, the average inbound travel speed on the Batinah Highway is found to be 99.2 kph and for the outbound, is 100.3 kph. The overall average travel speed on the Batinah Highway is computed as 99.7 kph.

Fig. 4.8 is a time-space diagram showing the average inbound and outbound travel speed on Batinah Highway. Except for gradient changes of the graphs indicating slight variations in speed, there are no significant delays caused by stoppings at junctions or roundabouts. This indicates that traffic flow on the Batinah Highway is still free of any major congestion and is still operating at a good level of service.

(2) Spot Speed

Spot speeds of vehicles were measured by recording the elapse of times needed for the vehicles to run between two check points designated on a selected road section. The speed of the observed vehicle is then computed.



THE STUDY ON ROAD DEVELOPMENT PROJECT	JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 4.8 Average Inbound and Outbound Travel Speed Curves on Batinah Highway

The average spot speeds are found to be as following:

Vehicle Type	Average Spot Speeds
Passenger Cars	120.4 kph
Light Trucks	104.6 kph
Medium Trucks	83.7 kph
Heavy Trucks	82.7 kph
Buses	90.7 kph
All Vehicle Types	111.9 kph

The results of survey of a cumulative speed distribution pattern by vehicle types are shown in Fig. 4.9. (buses were excluded from this figure). From this figure, it is observed that 55% of the passenger cars obeyed the speed limit of 120 kph, while 45% exceeded the speed limit. Only 7% of light trucks and 3% of medium or heavy trucks exceeded this limit. The lower graph shows the cumulative speed distribution of all vehicles. At the 50 percentile, the speed is 108 kph and at the 75 percentile, the speed is about 122 kph. The speed limit of 120 kph is at the 70 percentile.

It can be said from the survey results that passenger cars are travelling at higher speed which is particularly dangerous to crossing pedestrians on the highway.

(3) Speed Variation at Roundabouts

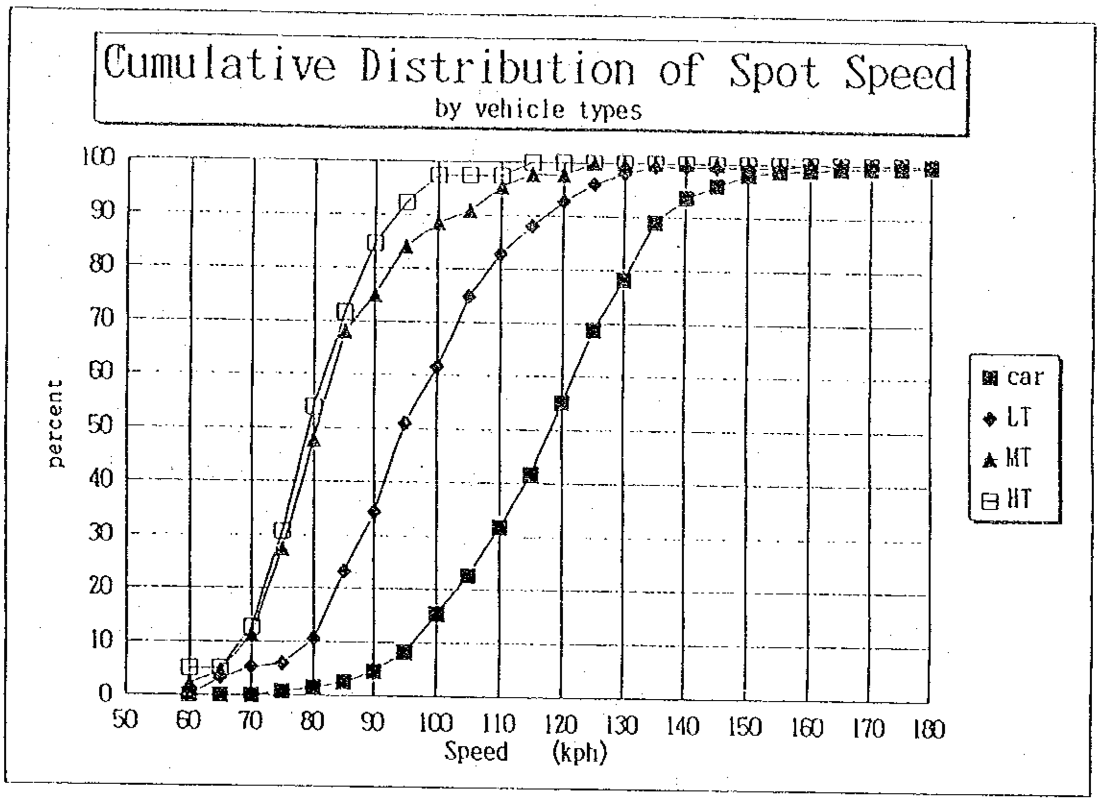
Vehicles invariably must slow down as they approach a roundabout. The speed variation of a vehicle at a roundabout depends on the visibility of the R/A as the driver approaches it and presence of any vehicle within the roundabout. To measure the delays caused by the speed variation changes in maneuvering through the roundabouts, check points were designated on both the approach and exit of Barka R/A, and the timings in crossing these points were recorded using a test car.

Twenty-four test runs were conducted, 12 in each direction. The observations were plotted in graphs. The results, however, indicated large variation in behavior.

Consequently, the observed results are grouped into three categories of A, B and C (see Fig. 4.10). Sample runs in Group A have to reduce speed within the R/A before can accelerating again after leaving the R/A. Group B samples show a constant speed within the R/A while Group C displays a feature where the test vehicle picked up speed after it entered the R/A.

The speed of vehicle as it approaches the R/A decreases to an average speed of about 90 kph as it crosses the first sign post and down to an average of about 58 kph at the entry point to the R/A. Within the roundabout, travel speed varies from 30 kph to 60 kph depending on the conditions, with an average of about 55 kph (the lowest recorded speed being 34 kph.)

The results of this survey, namely the average speed at approaches and within the roundabout, are used in designating future road conditions for future assignment of traffic on the highway.


Cumulative Distribution of Spot Speed
by vehicle types
100
90
80
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60
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40
30
20
10
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percent
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car
LT
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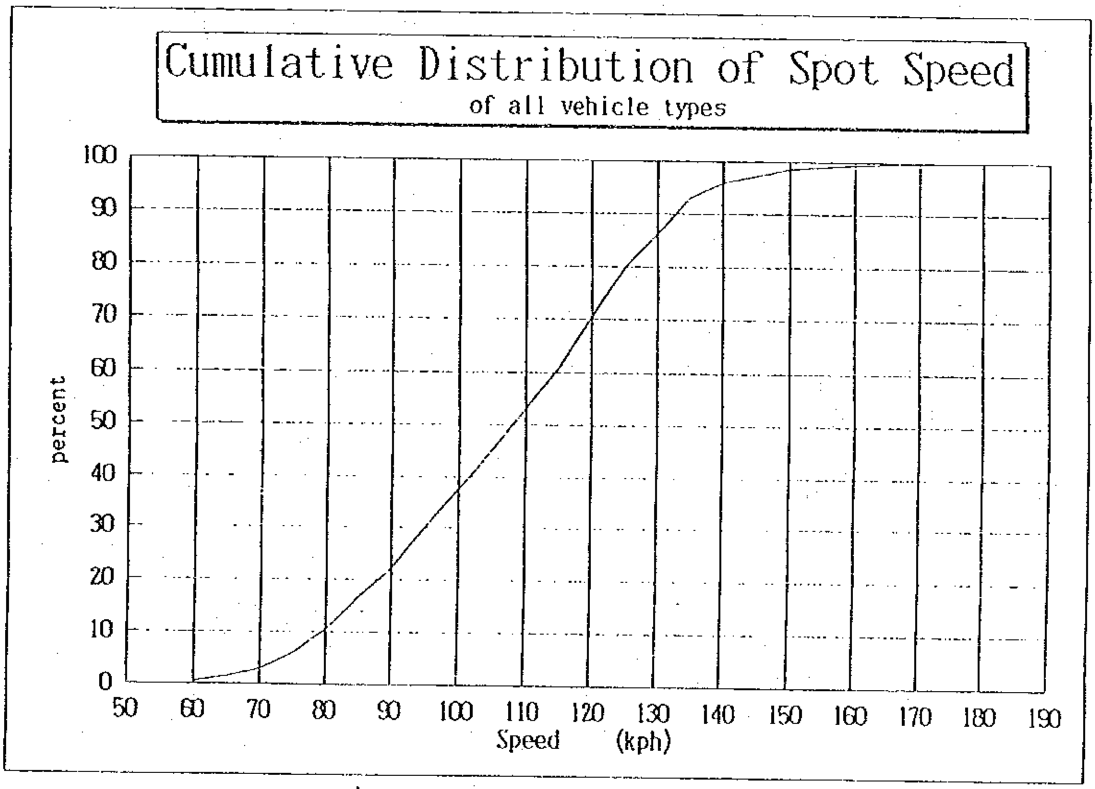
Cumulative Distribution of Spot Speed
of all vehicle types
100
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70
60
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40
30
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percent
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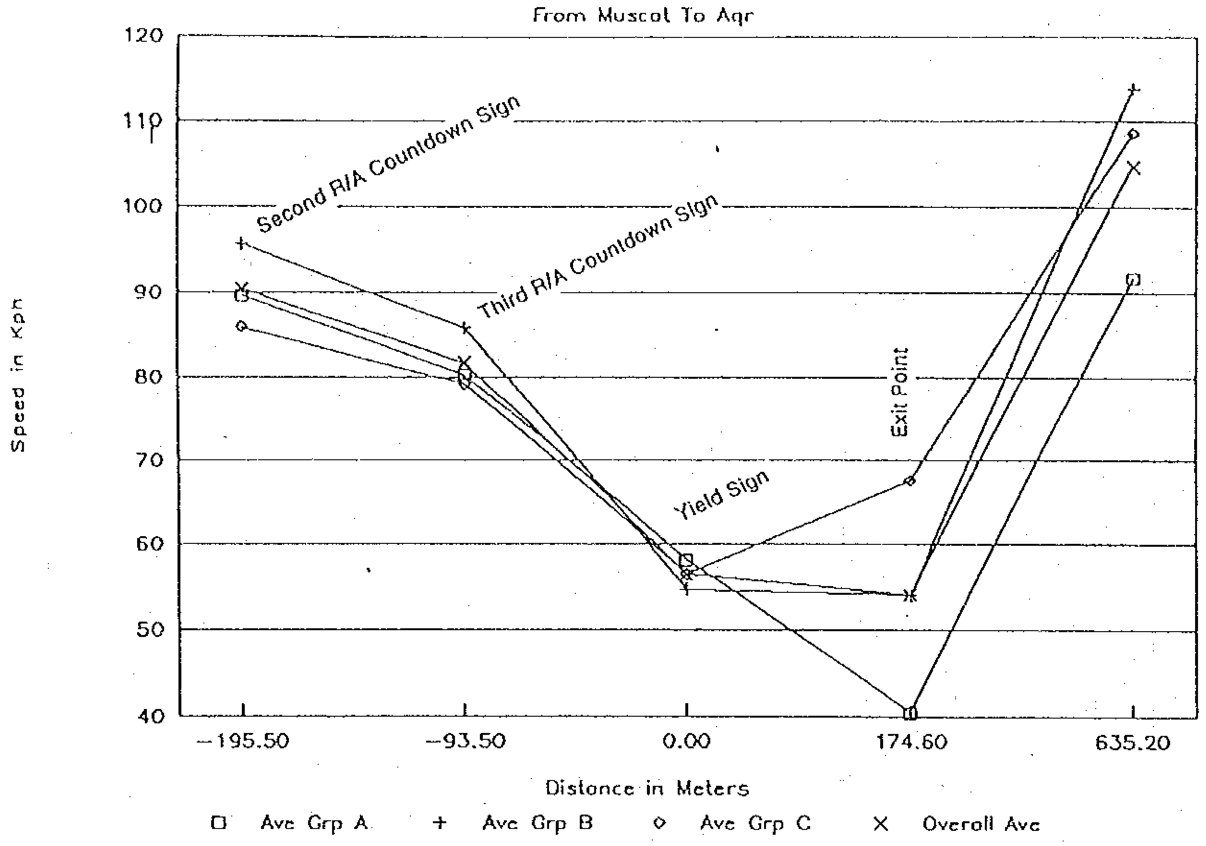
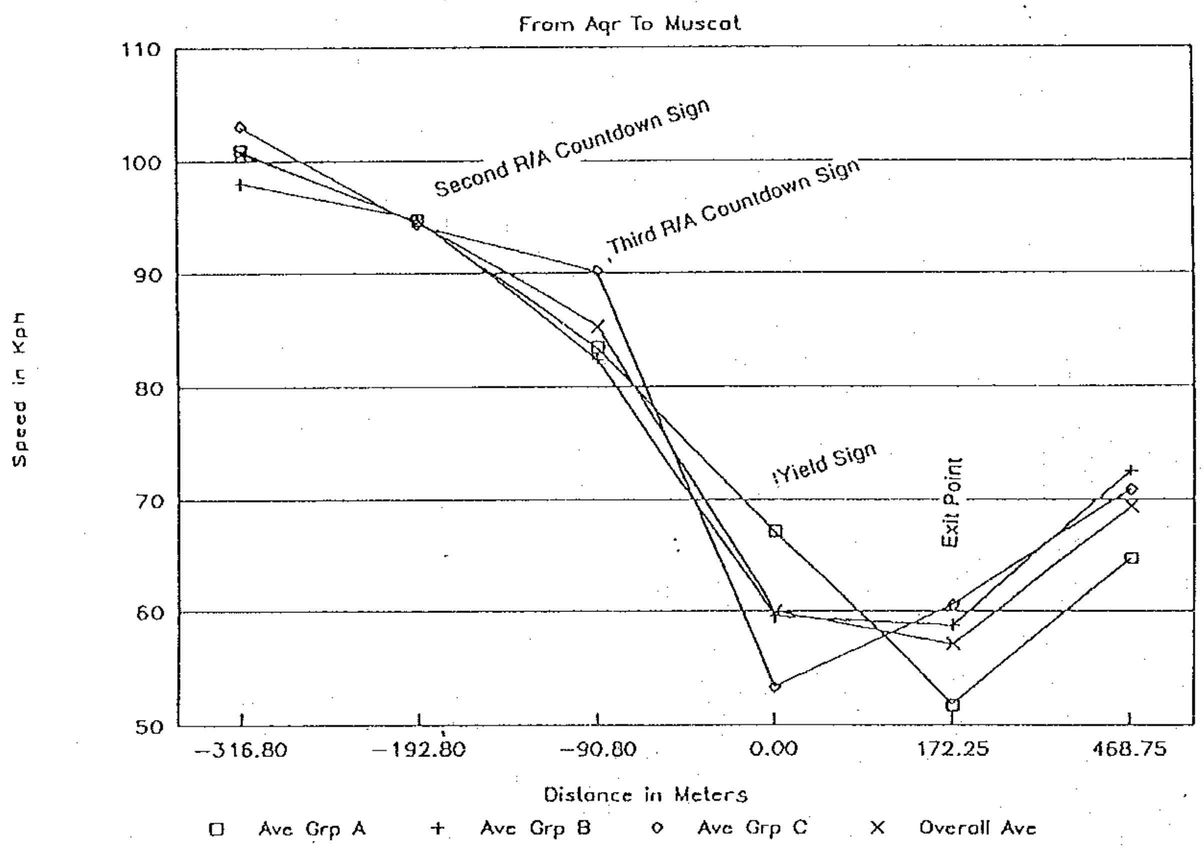
140
150
160
170
180
190
Speed (kph)





THE STUDY ON ROAD DEVELOPMENT PROJECT	JAPAN INTERNATIONAL COOPERATION AGENCY	Fig 4.10 Roundabout Delay Survey Results at Barka R/A

4.2.3 Origin Destination Survey

A roadside interview survey was conducted on the Batinah Highway for the preparation of the present OD table. The people in Oman were not accustomed to such surveys and hence some difficulties could not be avoided, but these difficulties would naturally be overcome in future as people become accustomed to similar surveys.

Total Trip

A total number of 6,623 vehicles were stopped as samples and inquired for the survey at 6 locations. The data of these samples were expanded to actual number by using the counted 24 hours traffic volume at the survey stations. Thus, the total vehicular trips using the Batinah Highway are estimated at 69,890 trips a day.

The vehicle registration in 1992 showed a total number of 33,272 vehicles registered in the Batinah Region. These vehicles are assumed to have been registered in the Batinah Region. Assuming these vehicles made 2.1 trips/vehicle a day, then a total of 69,870 trips would have been made in a day. Assuming that the trips made in the region using the Batinah Highway are the majority in terms of vehicle-kilometer, these daily trips are comparable with surveyed ones.

Trip Purpose

Of the total vehicular trips 45.5% were 'To Work' trips, 26.5% 'To Home' trips and 11.1% were 'Business' trips. Social trips made up 7.7% while shopping trips amounted to 5.1% of the total.

Average Trip Making Rate

It was found that 78.0% of the total surveyed vehicles made 2 trips a day whereas 13.0% made 1 trip a day. Only 2.0% of the surveyed vehicles made 3 trips a day while 6.8% of the surveyed vehicles made 4 trips or more a day. These data show relatively low trip-making rates of vehicles at the present, with overall average trip-making rate being 2.02 trips a day.

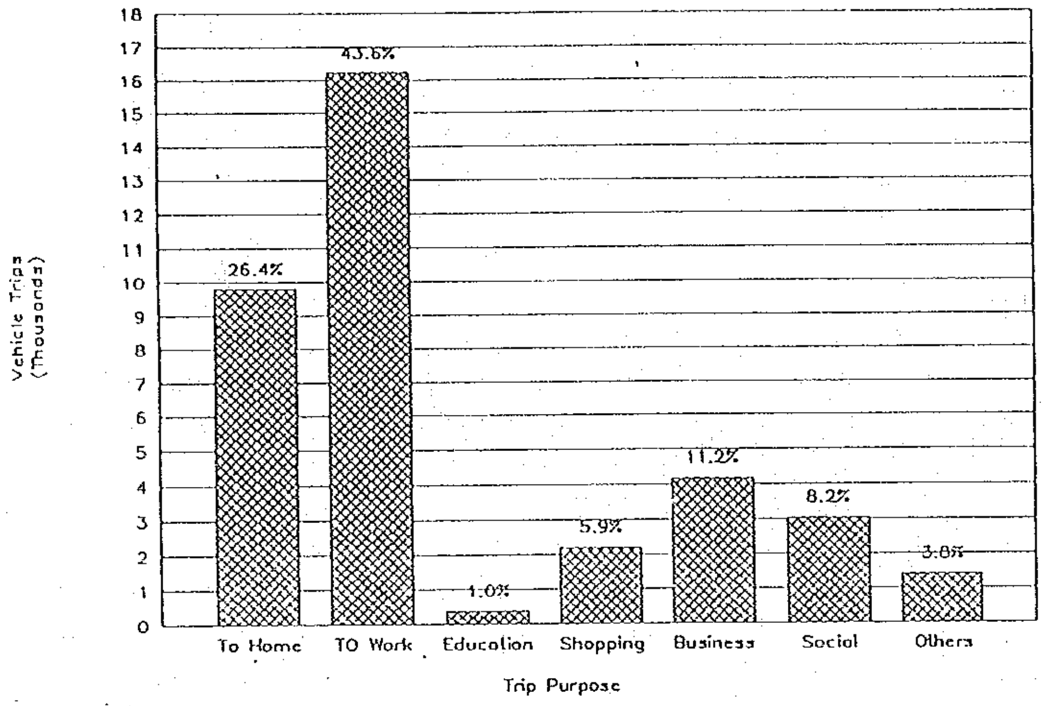


Fig. 4.11 Estimated Share of Vehicle Trips by Purpose in Batinah Region.

Occupancy Rate of Passenger Car

Of the total surveyed passenger cars (including vans that carry passengers for a fare), 41.7% are cars driven alone. However, 46.6% have 2-4 persons in the vehicle indicating a high proportion of ride sharing. Vehicles with 5 or more persons accounted for 11.7% and these represent the vans used for carrying passengers.

Type of Commodities Carried by Trucks

Among the commercial trucks surveyed, 40.7% are found to carry 'food and agricultural products', followed by 21.7% for 'construction materials'. Fig. 4.12 shows the share of various commodities carried by trucks.

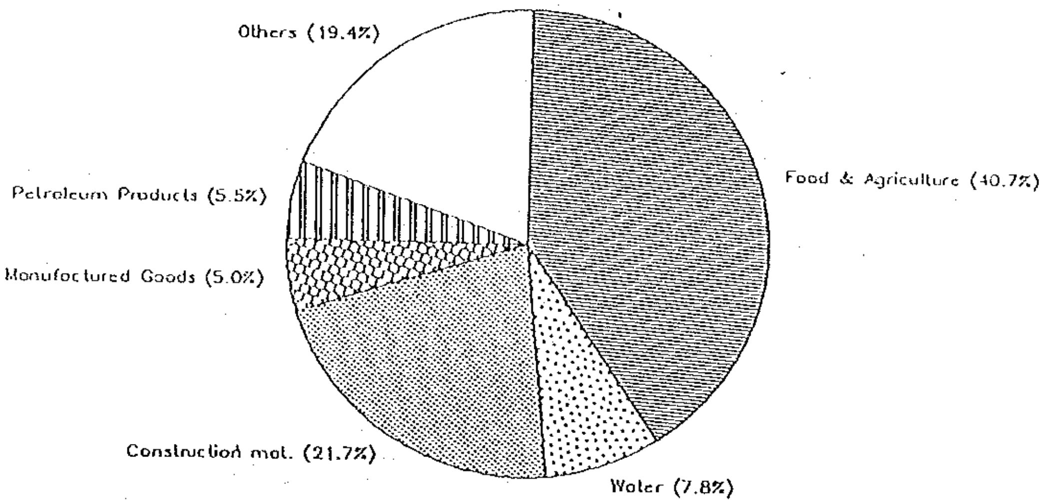


Fig. 4.12 Share of Commodities Carried by Trucks

Travel Demand between Batinah Region and Other Areas

From the OD survey, it is found that there were 41,600 internal trips within the Batinah Region. Fig. 4.14 shows the travel demand between Batinah Region and the surrounding areas or regions. Between Batinah Region and Muscat (including the other southern regions), total daily trips were estimated at 18,240 trips a day with 6,030 trips a day between the Batinah and U.A.E. (include Falaj Al Qabail).

Travel demand among areas within the Batinah Region is shown in Fig. 4.15. Travel demand between the Rustaq/Nakhal area and Barka/Suweiq/Masnaah were high. Travel demand between Sohar and Saham or Shinas were also substantial.

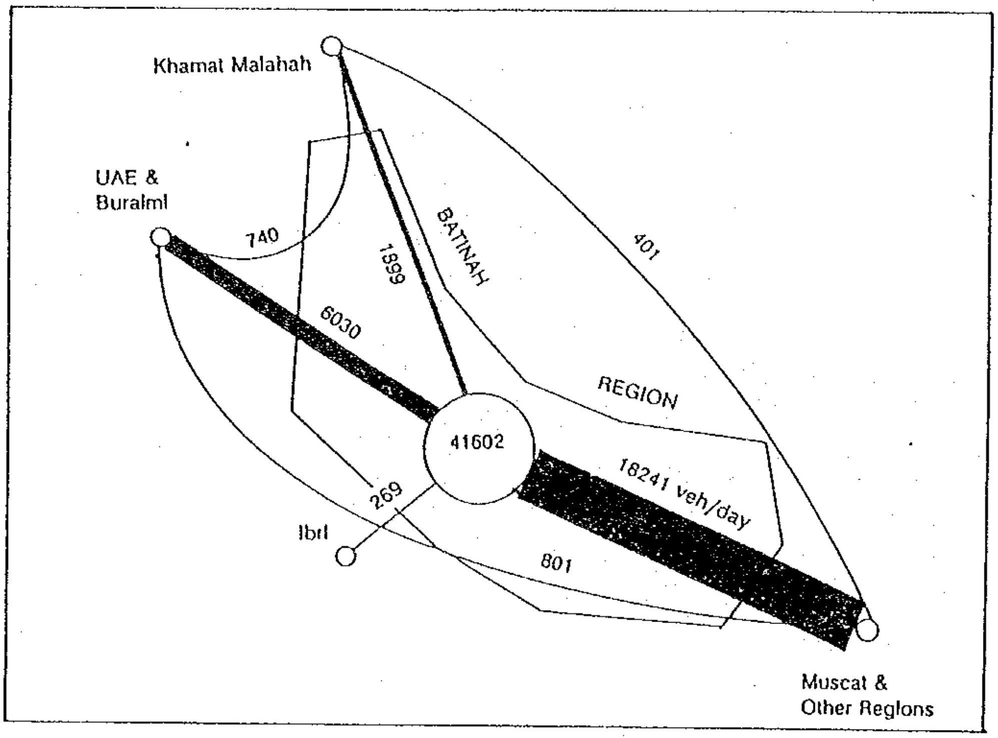


Fig. 4.14 Travel Demand Lines Among Batinah Region and Other Regions

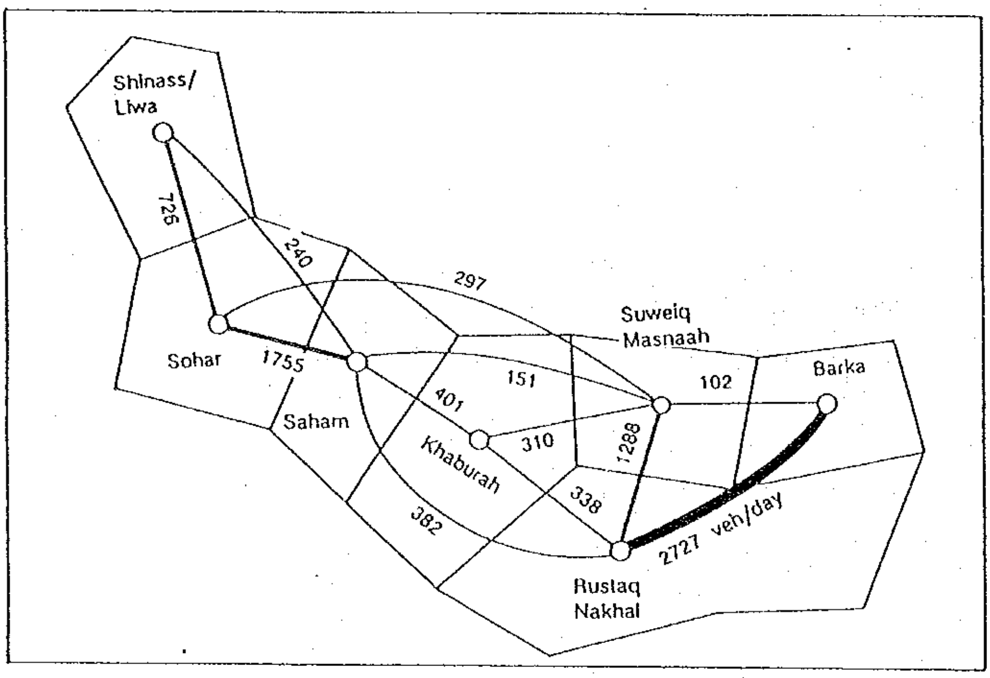


Fig. 4.15 Travel Demand Lines Among Areas Within Batinah Region

4.2.4 Axle Load Survey

A sample axle load survey and classified traffic counting surveys were carried out at four stations near the study bridges. These were:

(1) Bridge No. 4 - Route 7, section 2 near Falaj Al Qabail

(2) Bridge No. 7 - Route 23, section 1 near Samail

(3) Bridge No. 8 - Route 21, section 5 near Bahla

(4) Bridge No. 9 - Route 23, section 5 near Sur

Daily Traffic Volume

Classified traffic count was carried out for 24 hours and the results are given below:

Table 4.2 Daily Traffic by Direction at Axle Load Survey Locations in Vehicle/day

Location	Towards Muscat	From Muscat	Total Both Directions	Percent of MT and HT
Route No. 7/2 (Bridge No. 4)	1,876	1,430	3,306	2.6%
Route No. 23/1 (Bridge No. 7)	1,416	1,433	2,849	4.6%
Route No. 21/5 (Bridge No. 8)	1,800	1,922	3,722	2.4%
Route No. 23/5 (Bridge No. 9)	1,096	1,159	2,255	3.2%

MT = Medium truck (3 axle), HT = Heavy truck (4 axle and more, all trailers)

The daily traffic volume at these four locations was between 2,200 - 3,750 veh/day. The share of medium and heavy trucks is about 2.5 - 4.5 %.

Maximum Gross Truck Load and Axle Load

Trucks were randomly sampled and the axle load of all their axles were measured using a portable axle load gauge made available by the DGR.

The samples include heavy, medium, light trucks as well as stage buses. Results of the axle load survey are given in the table below:

Table 4.3 Results of Sample Axle Load Survey

Location	Maximum Gross Truck Load	Maximum Axle Load	Average Gross Load for HT*	Average Gross Load for MT*	Average Gross Load for LT*
Route No. 7/2 (Bridge No. 4)	58.13	17.60	40.84	33.60	15.24
Route No. 23/1 (Bridge No. 7)	49.89	12.00	38.10	18.69	7.23
Route No. 21/5 (Bridge No. 8)	48.36	12.15	32.74	17.26	9.40
Route No. 23/5 (Bridge No. 9)	58.30	16.00	49.70	23.90	13.07

Load in Tons
LT=Light Truck (2 axle), MT= Medium Truck (3 Axle),
HT=Heavy Truck (4 and more axles, all trailers)
*Average Gross Load computed from loaded truck samples only.

The maximum gross truck load on the study bridges is almost 60 tons on Bridges No. 4 and 9, while the maximum load at the other two bridges is close to 50 tons.

The type of commodity carried by the overloaded trucks is primarily construction materials such as asphalt mix, concrete mix, sand, aggregates and cement (in bags). Other materials are soft drinks in crates and liquid fuel.

4.3 Traffic Accident

4.3.1 Characteristics of Traffic Accidents in Oman

The trend of traffic accidents in general can be explained as following:

(1) Number of traffic accidents

Traffic accidents have increased rapidly with the increase of traffic demand and vehicle ownership. There was a ten fold increase in the annual number of traffic accidents in 2 years period from 1970 to 1972. The annual number of accidents continued to increase until 1985 except in 1983 and 1979, reaching the highest number of about 16,600 in 1985. However, the number of accidents has declined since 1986, excepting 1991 and 1992. The trend of traffic accidents is shown in Fig. 4.16.

The number of accidents in the year 1993 was 11,754 which is less by 13% than that of the previous year. This shows an accident rate of about 422 per 10,000 vehicles in 1993. The number of vehicles in 1993 as per vehicle registration record was 278,621 with an estimated annual growth rate of 9.3%.

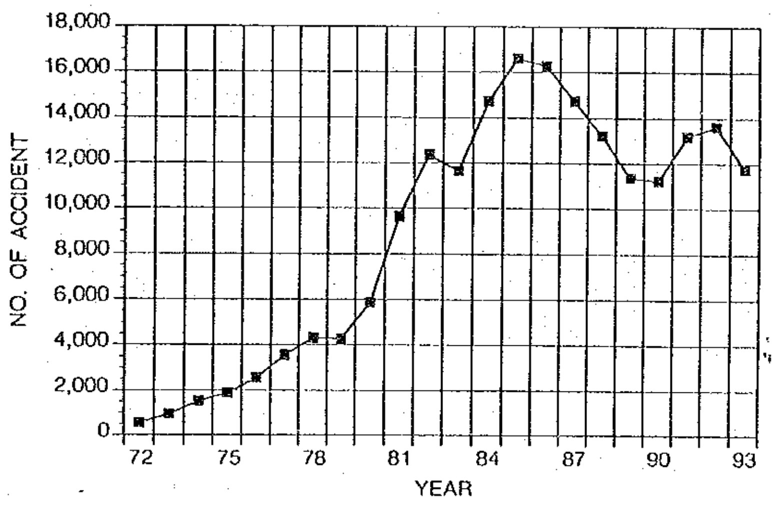


Fig. 4.16 The Trend of Traffic Accidents by Year in Oman

(2) Rate of Casualty

In 1993, the number of injuries out of 11,754 traffic accidents was 6,203 and number of fatalities was 461. This shows that one out of every two accidents involved a casualty which is a very high rate. Table 4.4 shows the number of casualties in traffic accidents.

Table 4.4 Number of Casualties in Traffic Accidents in Oman, 1993

Number of accidents	Fatalities	Injuries				Number of Casualies
		Serious	Major	Minor	Total	
11,754	461	351	2,324	3,528	6,203	6,664

(Source: Traffic Accident Statistics 1993, ROP)

(3) Causes of Traffic Accidents

The main factor attributing to traffic accidents is human error (97%) in 1993 as shown in Table 4.5. Negligence and speeding together caused about 70% of the total accidents whereas 6% were due to intoxication.

However, the factors categorized under human error would be mostly affected indirectly by the highway condition or the factors related to it.

Table 4.5 Traffic Accident by Causes in Oman, 1993

Cause of Accident	No. of Accident	Share	
Poor Highway Condition	100		0.8 %
Poor Vehicle Condition	156		1.3 %
Negligence	4,932	42.0 %	97.9 %
Speeding	3,576	30.4 %	
Fatigue	73	0.6 %	
Bad Driving	1,988	17.0 %	
Psychological Condition	165	1.4 %	
Alcohol	764	6.5 %	
Total	11,754		100 %

(Source: Traffic Accident Statistics 1993, ROP)

(4) Types of Collision

More than half of the total accidents in 1993 were reported as vehicle-to-vehicle collision. 6,584 (56 %) of the total accidents were of this type. The types of collision are shown in the Table 4.6.

Table 4.6 Traffic Accidents by Type of Collision in Oman, 1993

Type of Collision	Number	Share
Vehicle-to-vehicle collision	6,584	56.0%
Collision with pedestrian	1,440	12.3%
Vehicle Turnover	1,519	12.9%
Collision with objects	2,211	18.8%
Total	11,754	100%

(Source: Traffic Accident Statistics 1993, ROP)

(5) Pedestrian Fatality

The number of pedestrian fatalities in traffic accidents was 153 in 1993, out of which 30% was found to be children under 10 years. This shows children in higher proportion of involvement in traffic accident fatalities. The number of fatalities of children was about 5 times higher than that of Japan. Table 4.7 shows pedestrian fatalities in the year 1993.

Table 4.7 Pedestrian fatality by age group in Oman, 1993

Age Group	Up to 10 years	11 to 20	21 to 30	31 to 40	41 to 50	51 to 60	61 to 70	Over 71	Total
Fatalities	48	10	26	18	20	13	16	2	153
Share	31.4%	6.5%	17.0%	11.7%	13.1%	8.5%	10.5%	1.3%	100%

(Source: Traffic Accident Statistics 1993, ROP)

4.3.2 Characteristics of Traffic Accident in Batinah Region

A higher number of traffic accidents occurred in the Batinah Region, which includes the Batinah Highway (the study highway), than any other region. The exact location of traffic accidents can not be pinpointed since there are no kilometer markers in any roads in the Sultanate.

(1) Fatality Rate

The highest number of fatalities was recorded in the Batinah Region in 1993. The number by region for the years 1992 and 1993 are shown in the Table 4.8. Fatalities in Batinah Region increased by 33% from 102 in 1992, to 136 in 1993. Fatalities in the Batinah Region accounted for almost 30% of the total number in the Sultanate for 1993. Thus fatalities in the Batinah Region increased at a high rate although the total number of fatalities decreased in this period.

Table 4.8 Number of Fatality by Region

Region	Fatalities in 1992	Share in 1992	Fatalities in 1993	Share in 1993	Fluctuation in Number
Batinah	102	21.8 %	136	29.5 %	+34
Dakhaliya	89	19.0 %	81	17.6 %	-8
Muscat	93	19.9 %	74	16.1 %	-19
Dakhira	68	14.5 %	60	13.0 %	-8
Sharqiya	50	10.7 %	51	11.1 %	+1
Dhofar	46	9.8 %	41	8.9 %	-5
Wustan	12	2.6 %	14	3.0 %	+2
Musandam	8	1.7 %	4	0.8 %	-4
Total	468	100 %	461	100 %	-7

(2) Number of Injuries

The Batinah Region had the highest number of traffic accident injuries in 1993, with 26.7 % of the total accident injuries recorded in the whole country. There was an increase of 227 cases of injuries in the Batinah Region between 1992 and 1993 which is about 70 % of the total increase of injuries in the entire Sultanate. Table 4.9 shows the number of injuries by region.

Table 4.9 Number of Injury by Region

Region	Injuries in 1992	Share	Injuries in 1993	Share	Fluctuation
Batinah	1,432	24.6 %	1,659	26.7 %	+277
Muscat	1,459	25.0 %	1,428	23.0 %	-31
Dakhaliya	1,009	17.3 %	1,085	17.5 %	+76
Sharqiya	708	12.2 %	769	12.4 %	+61
Dakhira	573	9.8 %	640	10.3 %	+67
Dhofar	475	8.2 %	476	7.7 %	+1
Wustan	102	1.7 %	90	1.5 %	-12
Musandam	68	1.2 %	56	0.9 %	-12
Total	5,826	100 %	6,203	100 %	+377

(Source: Traffic Accident Statistics 1993, ROP)

(3) Causes of Traffic Accidents

Table 4.10 shows the major causes of traffic accidents in the Batinah Region in 1993. High speed, negligence and poor driving habits were the three most prominent causes of traffic accidents in the region. The Batinah Region had the highest proportion of speeding offenses in the country, accounting for 23.4%, and also topped the list for poor driving with 34.3% of the national records.

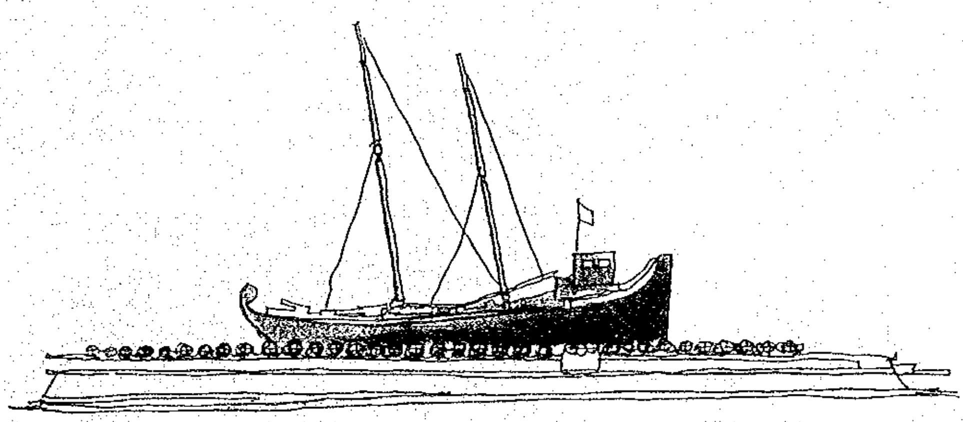
Table 4.10 Traffic Accident by Causes in Batinah Region and Oman, 1993

Causes of Accidents	Batinah Region	Share	Oman	Share
High Speed	837	31.4 %	3,576	30.4 %
Negligence	726	27.2 %	4,932	42.0 %
Bad Driving	680	25.5 %	1,988	16.9 %
Alcohol	306	11.5 %	764	6.5 %
Fatigue	42	1.6 %	73	0.6 %
Poor Road Condition	31	1.2 %	100	0.9 %
Psychological Condition	25	0.9 %	165	1.4 %
Poor Vehicle Condition	18	0.7 %	156	1.3 %
Total	2,665	100 %	11,754	100 %

(Source: Traffic Accident Statistics 1993, ROP)

The other important characteristic of traffic accidents in the Batinah Region is the large number of accidents involving pedestrians. The number of accidents involving pedestrians in this Region was 322, which is 22.4 % of the total number of such accidents of the whole country in 1993.

CHAPTER 5 FUTURE TRAFFIC DEMAND ESTIMATION



CHAPTER 5

FUTURE TRAFFIC DEMAND ESTIMATION

5.1 Input For Future Traffic Demand Estimation

The four-step future traffic demand forecasting procedure; namely, forecast of future generation and attraction, distribution, modal split and assignment; which is widely used in transportation study, requires substantial information such as future zonal socioeconomic indicators (population, employment or land use pattern, vehicle ownership, income level, etc.) in order to calibrate models in estimating future demand and distribution.

The forecast of future traffic demand on the Batinah Highway could be carried out using the above mentioned four-step method if sufficient detailed information can be acquired. In view of the lack of such information, a simpler method can also be used to predict the future demand on such a simple road network with acceptable accuracy if some measures are taken to gather sufficient traffic volume data to reflect on the present traffic flow and demand pattern.

The major data input required for the estimation of future traffic demand on Batinah Highway is as follows:

(1) Traffic demand data/pattern from traffic survey, both OD pattern and traffic volume by direction.
(2) Present and future population trends by wilayat in the study area,
(3) General annual traffic demand growth trend nationwide, and that for the Batinah Highway,
(4) Vehicle ownership growth trend,
(5) Committed or ongoing road development/improvement projects,
(6) Observable development trends at particular areas along the study highway,
(7) Future regional development plan for the study area and GDP growth trend.

The major input is further elaborated below:

Future Population

The average annual growth rate of population in Oman is estimated at 3.5% a year in the 1992 Statistical Yearbook published by the Government of Oman. This statistical resource also provided the present population sizes by wilayat along the Batinah Region.

In the 'Batinah Regional Plan" conducted by the Ministry of Housing, 1991, the population of Batinah Region was projected to grow at 3.3% per year by the year 2010. The report provided the total projected 2010 population of 808,100 for the region with breakdown by wilayat. Such strategies are reflected in the projected future population distribution along the Batinah Region with some districts having higher growth rates than the others.

The projected future population in 2010 is not applied directly to the estimation of future traffic demand on the Batinah Highway as trip making data with population base are not available. The above population projection is more important as a basis for trip distribution in future as the present population distribution pattern by wilayat would be significantly different in future. The total traffic demand estimated for 2010 is then distributed in proportion to the future population by wilayat and then traffic zones.

Future Road Network Development

The "Batinah Regional Plan' has recommended the Government to consider the construction of the second Batinah Highway to further accelerate growth in this important region in the country. Although the plan realizes such a project has not been ruled out, rationality clearly dictates that it will not be within the year 2010, considering the current underutilization of the Highway and priorities in road development projects in other parts of the country.

Road widening on Route No. 11 has started from Rustaq towards Muladdah Junction. Construction of paved roads from Ibri to Al Khaburah and to Rustaq have been committed and will be completed within the year 2010. These are two important road development projects in the Batinah Region.

These road projects are taken into account in the future road traffic assignment and demand projection. The Report on "Feasibility Studies of Road Projects" in 1992 has estimated a volume of 5,000 vehicles a day from Ibri to the Batinah Region via these two routes in future.

Development along the Highway

Developments of industrial estates are in progress at a number of locations along the Batinah Highway, notably at Majees and the opposite side of Naseem Garden. These developments are taken into account in estimating future trip generation from these two areas.

Traffic Demand Growth Trend

The 'Feasibility Studies of Road Projects' conducted by Gibb Petermuller for MOC in 1992 has reported annual traffic demand growth trend along various national routes in the country. The rates varied from a low of 2.5% to a high of 14%. For the Batinah Highway, data gathered from DGR indicated an annual growth trend of about 4.66 % between 1989 to 1993.

Vehicle Ownership Growth Trend

Vehicle ownership trend is an important factor which affects future traffic demand. The vehicle ownership increase by wilayat along the Batinah Region can not be ascertained due to the manner the data on vehicle registration is kept at present. Nevertheless, the recent (1990-1992) vehicle registration growth trend for the country can be computed from data in the Statistical Yearbook of 1992 to be about 7.9% a year. It is obvious that some regions may experience higher growth rates than others. Muscat Region for instance will definitely experience a higher growth rate than Dhofar Region. Next to Muscat Region, Batinah Region has the second highest vehicle registration in 1992.

5.2 Future Traffic Demand Estimation Method

The future traffic demand estimation procedure for this study is illustrated in Figure 5.1. The upper portion of the figure is the verification of the present OD table constructed using results of the OD survey supplemented by using gravity model and the distribution of present population among the wilayats. The present OD table is assigned to the present highway network of the study area and the results are compared with actual observed traffic volume on various section of the highway.

The lower portion of the figure illustrates the preparation of the future OD table, using the OD pattern from the present OD table, future total trip generation by zones are estimated using forecasted future population, vehicle registration and traffic growth trends. The future OD table is then assigned to the future highway network which is assumed to include future committed highway projects and other regional development projects in the study area.

5.2.1 Preparation and Verification of Present OD Table

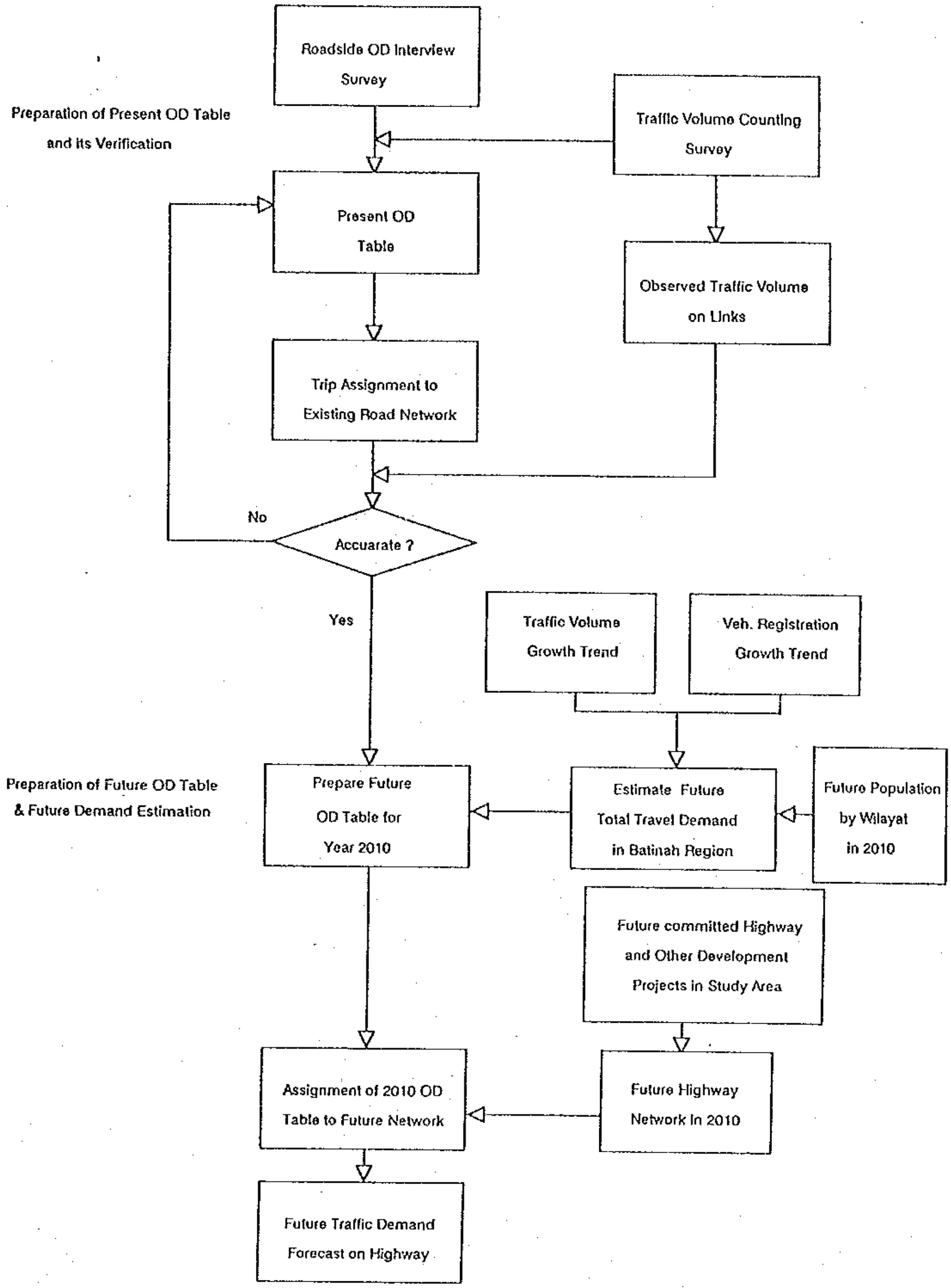
The present OD table is constructed from results of the OD survey duly expanded using traffic counting survey data. As the OD survey locations are limited, the results must be supplemented using gravity model with present population sizes of wilayat in estimating traffic between OD pairs that are not enumerated by the survey to obtain a more realistic OD table.

The present OD table must be verified before it can be applied to the preparation of future OD table essential for estimating future traffic volume on the Batinah Highway. The verification is carried out by simulating traffic volume on the highway using a computer model and then comparing the simulated traffic volume results with actual survey data collected on site. Several iterations are necessary and each time adjustments are made to the simulation conditions or OD table until the simulation results matched with the actual observed traffic data. Figure 5.2 shows the results of the actual traffic volume survey compared with results from the computer simulation model.

Once this is achieved, the OD table is ready to be applied to estimate future OD distribution table, given the future total generated and attracted trips to each zone and assuming the OD distribution pattern still holds for the target year of 2010.

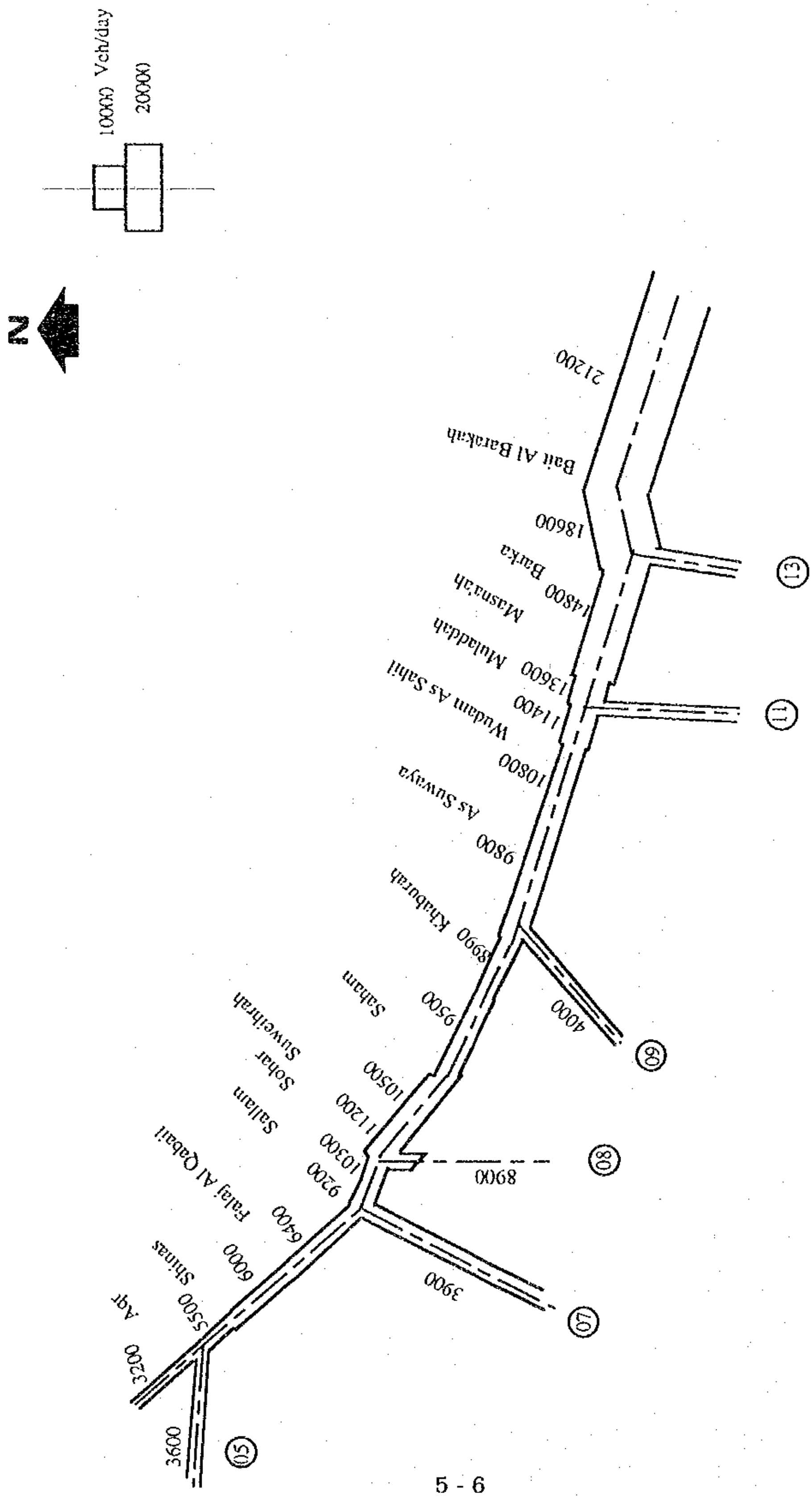
5.2.2 Future Traffic Demand Estimation

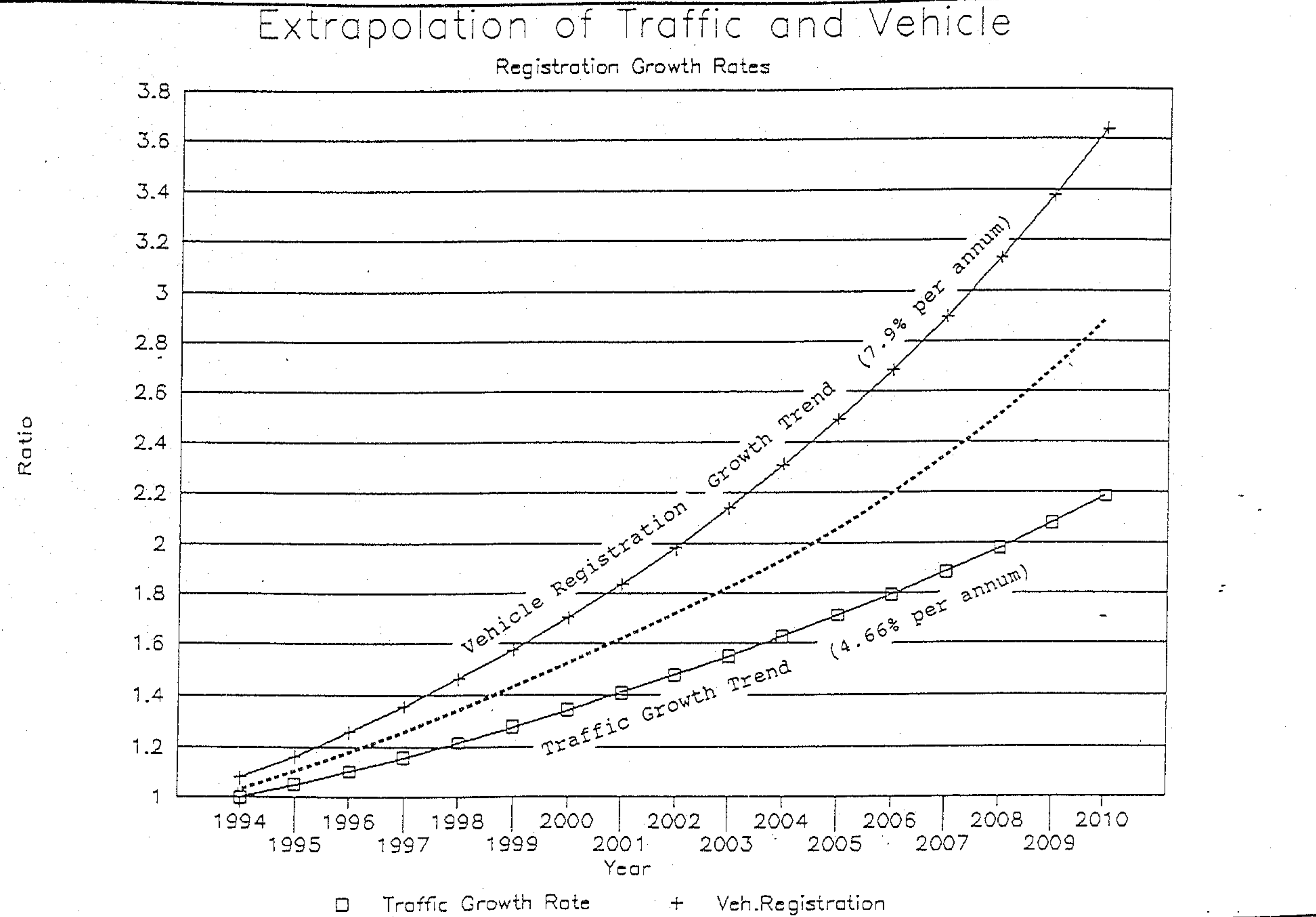
The frame of future traffic demand on Batinah Highway in 2010, which is estimated based on past traffic growth trend on the highway and vehicle registration growth rate, is distributed using the forecasted future population by wilayat in 2010. Traffic demand increase on the Batinah Highway from 1989-1993 and past vehicle registration growth rate are extrapolated to the year 2010. Growth of vehicle ownership and traffic in most of the developed countries experienced a rapid growth before eventually stabilizing and the growth trend 'flattened' to form an 'S' curve. For the Sultanate of Oman, traffic and vehicles ownership are likely to increase gradually up to 2000 but at faster rates after 2000 and up to 2010 before stabilizing to a certain level. With this assumption, the extrapolation curves are assumed to follow the patterns given in Fig. 5.3.



THE STUDY ON ROAD DEVELOPMENT PROJECT	JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 5.1 Future Traffic Demand Estimation Procedure

Figure 5.2 Present Traffic Assignment Results Compared with Observed Traffic Data, 1994





THE STUDY ON ROAD DEVELOPMENT PROJECT	JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 5.3 Extrapolation of Traffic Volume and Vehicle Registration to Year 2010

Based on these extrapolation graphs, vehicle registration is expected to increase by about 3.6 times to a total of about 975,000 vehicle by the year 2010 from the current level of 270,680 vehicles in 1993. The ownership rate of 1 vehicle to every 7.8 persons at present is expected to rise to 1 vehicle to every 3.5 persons. This rate seems to be reasonable and comparable to the rates achieved in many developed countries where average of about 1 vehicle to every 3 persons. (The rates for Japan in 1988 was 1 vehicle to every 2.3 persons while for Kuwait in 1987 was 1 to every 3.4 persons).

Traffic growth trend on the Batinah Highway, if extrapolated based on past annual traffic growth rate of 4.66 % alone would put the future demand at about 2.2 times the estimated present level. However, in view of the likely increase in trip making rate per vehicle expected in future and increased mobility of people as observed in many developed countries, this estimate of future traffic demand should be somehow adjusted by the higher vehicle registration growth trend.

For these reasons, the future traffic demand on Batinah Highway in 2010 is taken to be between the two curves in Fig. 5.3. It is therefore estimated to increase by 2.9 times the present level of 69,892 vehicle trips a day to 202,686 vehicle trips a day. These trips are assumed to generate in proportion to the future zonal population, namely the projected wilayat 2010 population.

Next, the development of traffic due to completion of two road projects from Ibri to Khaburah and Rustaq can be estimated at about 5,000 vehicle trips a day. Out of these, 60% are assumed to travel from Ibri to Rustaq and 40 % to Khaburah. Considering also traffic generation from industrial estates at Majees and near Naseem Garden, the total future traffic demand of 2010 is consequently estimated to be about 210,170 vehicle trips a day.

5.3 Traffic Assignment

The traffic assignment model used in this study is 'The Highway Emulator' model developed by CTP (Central Transportation Planning) of Boston, USA. This model is chosen for this study because of its simple operation requirements and appropriateness for estimating future traffic volume on a simple road network like the Batinah Highway and its adjoining roads.

Fig. 5.2 shows the assigned traffic volumes on the highway comparing with observed data. The results show that the model together with the prepared network and traffic operation data for the assignment is able to simulate traffic demand on the highway to an acceptable degree of accuracy.

The estimated future traffic demand in 2010 in the form of an OD table is assigned to the future highway network shown in Fig. 5.4. The network includes the following committed routes that connect to the Batinah Highway:

(1) Linkage between Ibri and Al Khaburah,
(2) Linkage between Ibri and Rustaq.

The results of the traffic assignment are shown in Fig. 5.5. The future traffic volume on the Highway is estimated at about 59,900 veh/day near Bait Al Barakah R/A to 43,900 veh/day at Muladdah Junction and 28,800 at Al Khaburah R/A. And it increases again to about 35,900 veh/day at Sohar R/A before decreasing to about 15,900 at Aqr R/A.

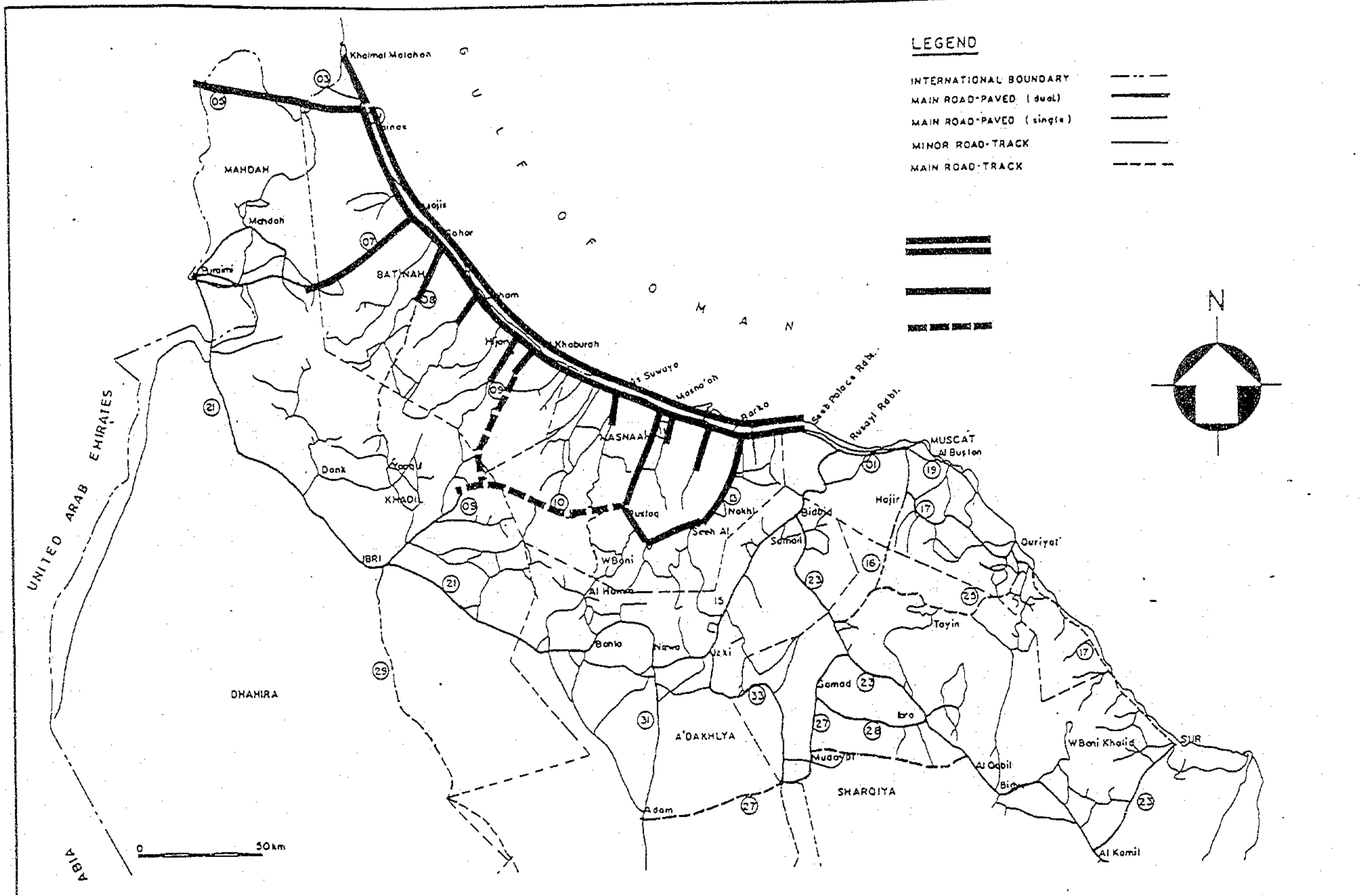
On the national routes adjoining the highway, the highest traffic volume is expected on route No. 11 between Rustaq and Muladdah Junction at 25,690 veh/day, followed by route No. 13 between Rustaq and Barka R/A at 21,050 veh/day. Traffic volume on route No. 5,7 and 9 would be above 10,000 veh/day.

Traffic on the adjoining coastal roads are estimated to be about 31,500 veh/day at Sohar, 10,700 veh/day at Saham and 9,880 veh/day at Barka.

In terms of traffic at the roundabouts, the results of future traffic assignment indicates that considerable traffic congestion is foreseeable at some of the roundabouts if no improvement to the existing road condition is carried out. In terms of traffic volume within the roundabout, Barka R/A is expected to handle up to 36,770 veh/day, 30,860 veh/day at Naseem Garden R/A, 30,550 veh/day at Bait AL Barakah R/A, and 24,900 veh/day at Muladdah Junction.

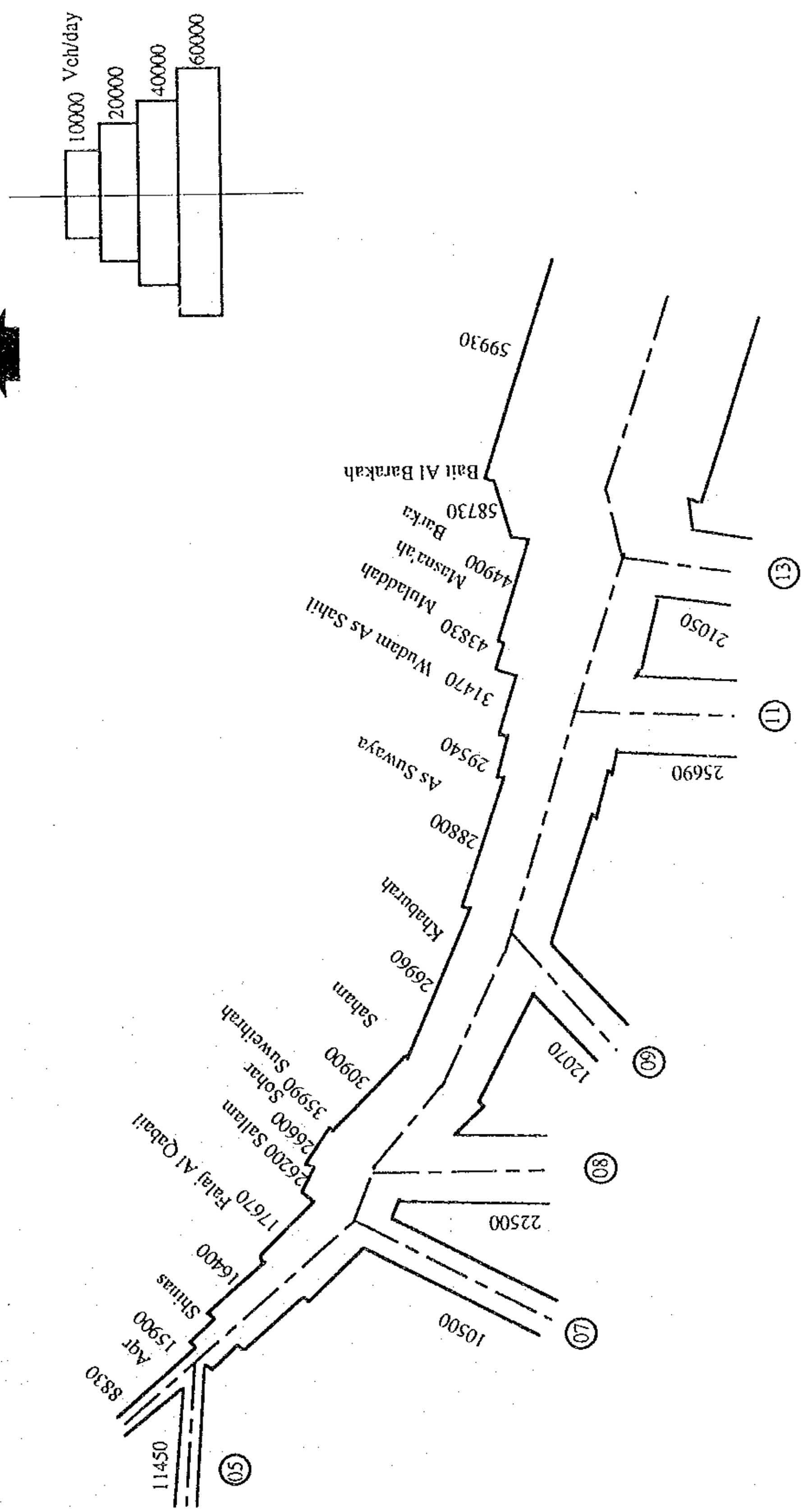
Figs. 5.6 and 5.7 show the traffic demand and pattern at selected roundabouts by year 2010.

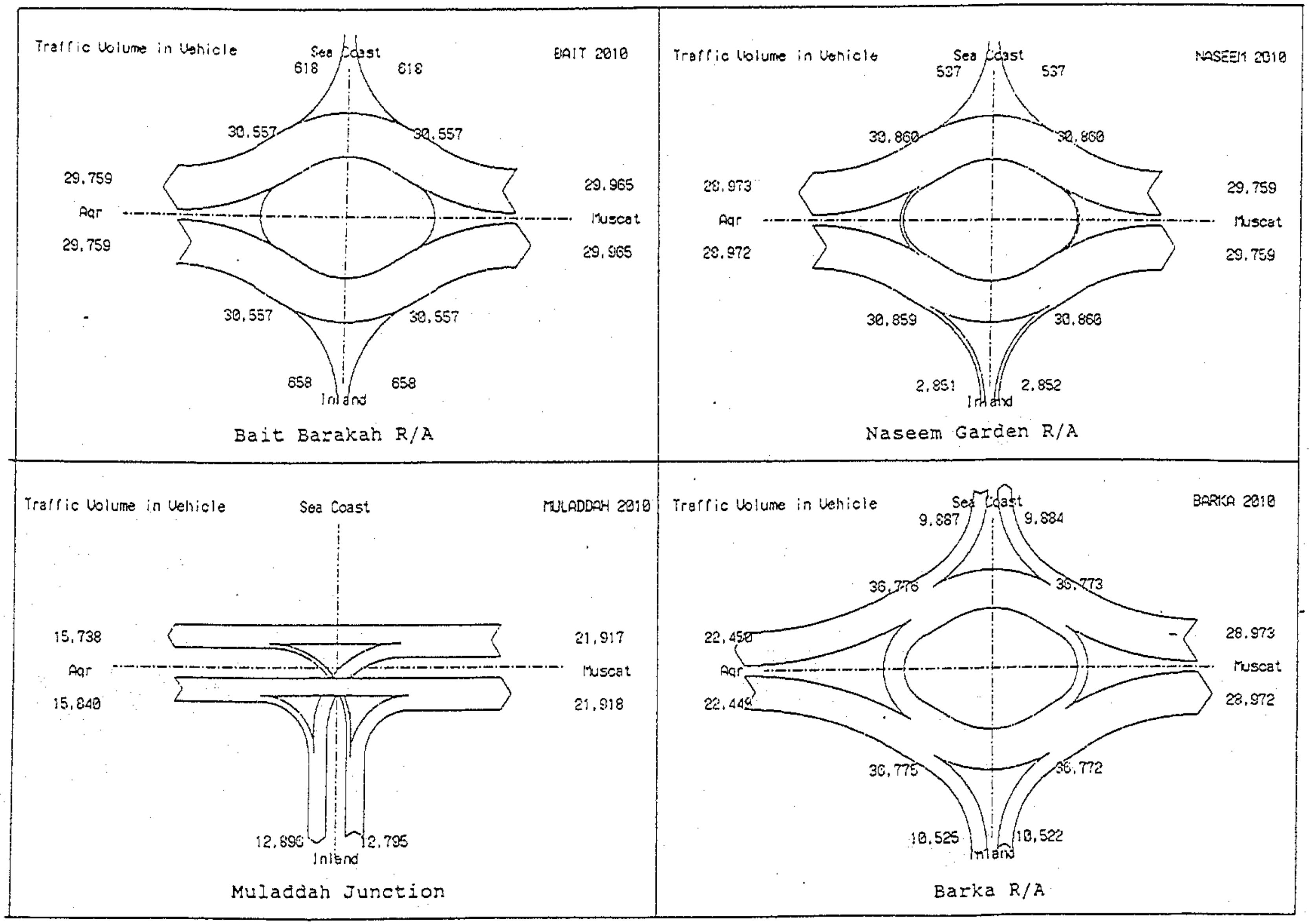
The traffic demand in 2010 at Sohar R/A is estimated at 34,700 veh/day and at Saham R/A, it will be about 25,800 vehicle/day. Traffic demand is also large at Masnaah R/A at 23,550 veh/day while at Khaburah R/A the traffic will be less than the above roundabouts, at 19,600 veh/day.



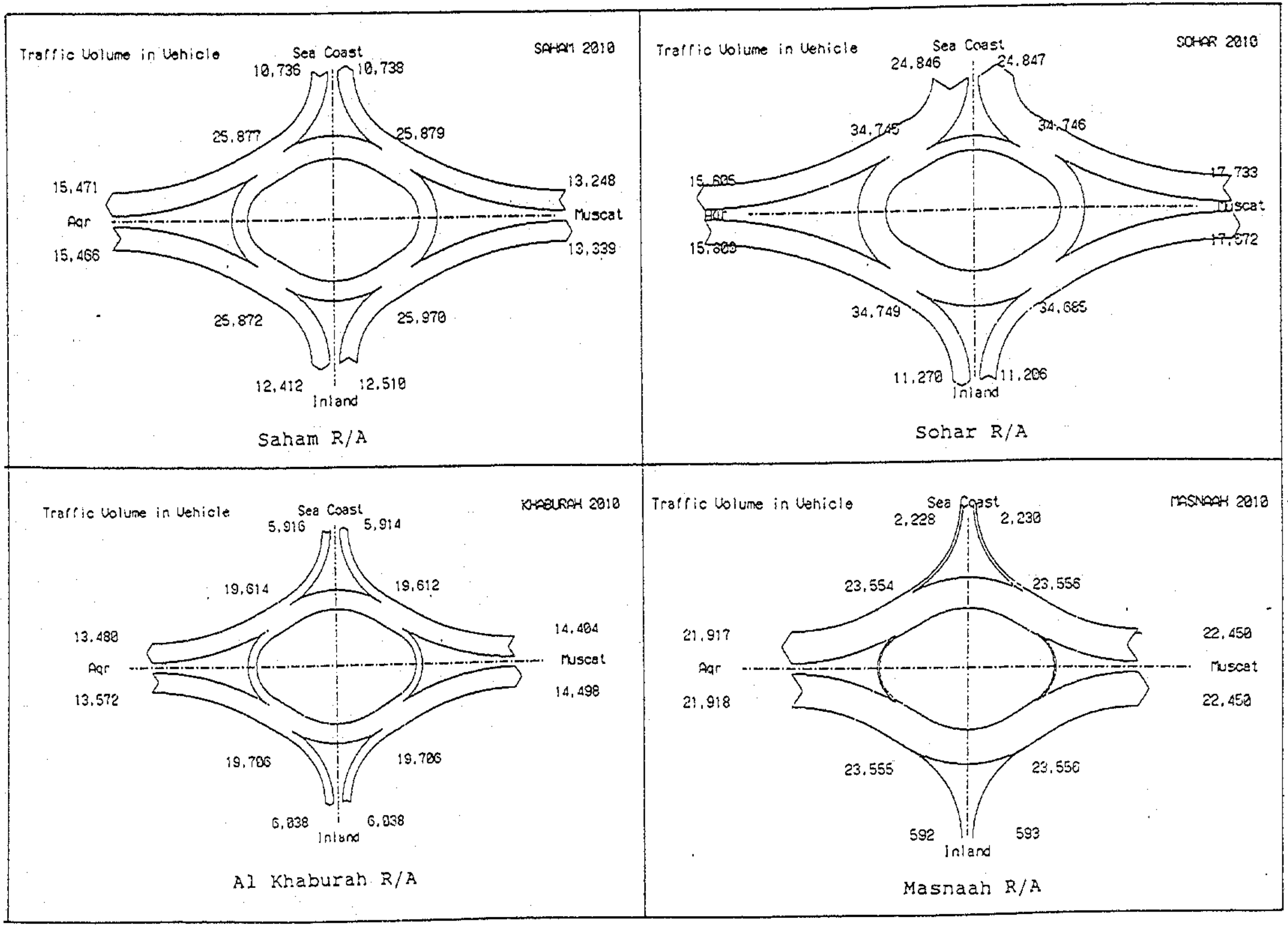
THE STUDY ON ROAD DEVELOPMENT PROJECT	JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 5.4 Future Highway Network For Assignment of Future Traffic in 2010

Figure 5.5 Forecasted Future Traffic Demand on the Batinah Highway, 2010



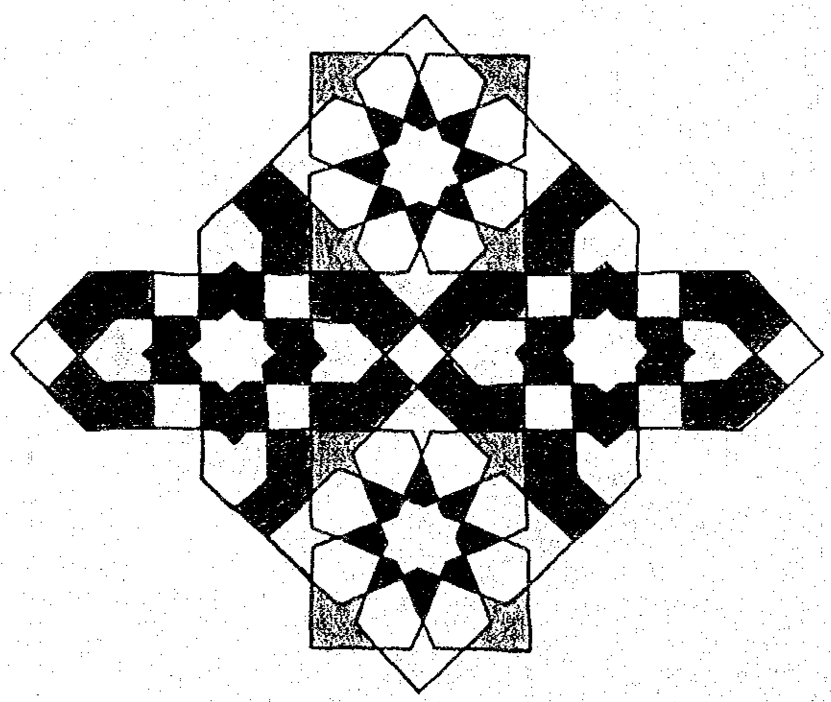


THE STUDY ON ROAD DEVELOPMENT PROJECT	JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure 5.6 Forecasted Traffic Demand at Barka, Bait Barakah, Naseem R/A and Muladdah Junction by 2010**



THE STUDY ON ROAD DEVELOPMENT PROJECT	JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure 5.7 Forecasted Traffic Demand at Sohar, Saham, Masnaah and Khaburah R/A by 2010**

CHAPTER 6 DESIGN CRITERIA



CHAPTER 6

DESIGN CRITERIA

This section discusses the design standards to be applied for the design of the grade separation of the Batinah Highway.

The design standards are divided into the following three sections:

- Geometric design standard
- Design Live Load
- Traffic Capacity of the Batinah Highway.

6.1 Geometric Design Standard

There exists the following Government's standard related to the design of the Batinah Highway.

- Highway Design Standards, Volume 1, General - 1986

The Government's standards are used to the maximum extent when applicable. The American and Japanese standards are referred to for items not covered in the Government's standards.

The recommended geometric design standard for the grade separation of the Batinah Highway is shown in Table 6.1. The major points are briefly discussed in the following:

(1) Design Speed

a. Main Highway

The Batinah Highway has its starting point at the capital city Muscat and runs along the Batinah coastal plain along the Gulf of Oman and connects with the United Arab Emirates. Its total length is approximately 274 km (to Khatmat), and is a high-speed highway (Design Speed 120 km/hr) with a large capacity.

For its entire length, the Batinah Highway was designed for 120 km/hr speeds. However, where there are residential areas or at roundabout intersections there is a speed limit of 80 km/hr. It has become necessary to change the at-grade roundabout crossings to a separation of grades for through-movement ensuring driving safety and increasing the capacity of the highway.

Based on the above, a 120 km/hr design speed for the grade separation of the Batinah Highway is recommended.

Table 6.1 Geometric Design Standard

Item	Unit	Batinah Highway	Rampway
Terrain		flat	flat
Design Speed	km/hr	120	80
Stopping Sight Distance	m	200	115
Lane Width	m	3.75	3.50
Number of Lanes	Lanes	4	1 or 2
Median Width	m	12.40	-
Inner Shoulder	m	1.20	0.75
Outer Shoulder	m	2.00	2.00
Minimum Radius	m	585	230
Minimum Radius not Requiring Transition Curve	m	1,000	1,000
Maximum Gradient	%	3 (5)	5 (7)
Minimum Vertical Curve Length	m	Fig. 6.3	Fig. 6.3
Superelevation	%	8	8
Vertical Clearance	m	5.50	5.50

Note: ( ) shows absolute minimum values.

b. Interchange Ramps

The AASHTO manuals recommend the following speeds for the design of interchange ramps:

- High Standard: 85 % speed of main road (120 km/hr x 0.85 = 102 km/hr)

- Middle Standard: 70 % speed of main road (120 km/hr x 0.70 = 84 km/hr)

- Low Standard: 50 % speed of main road (120 km/hr x 0.50 = 60 km/hr)

Based on the above, in consideration of the speeds (40 ~ 60 km/hr) at roundabouts, the type of ramps, the design speed for ramps are recommended to be 80 km/hr.

(2) Road Width Composition

a. Main Highway

i) Carriageway

The width of the grade-separation for the road carriageway proper, not including shoulder widths, is recommended to be the same width as main highway road.

ii) Shoulders

The width of the shoulders of the main road carriageway on the existing bridge is: right side, w = 0.75 m, left side, w = 0.75 m. However, the grade separation portion is approximately 1.0 km, so it is recommended to make the right shoulder width w = 2.00 m for emergency parking purposes.

b. Interchange Ramp

The road width composition for the Interchange Ramp will be determined as follows in accordance with the Omani Highway Design Standards, General - 1986, and the composition of the existing Batinah Highway as follows:

Lane Width:	3.50 m
Shoulder Width:	2.00 m (outer shoulder)
	0.75 m (inner shoulder)

Typical cross-sections of highway and ramp are shown in Fig. 6.1.

(3) Clearance Limits

The limits of horizontal and vertical clearance of the highway and other roads are illustrated in Fig. 6.2.

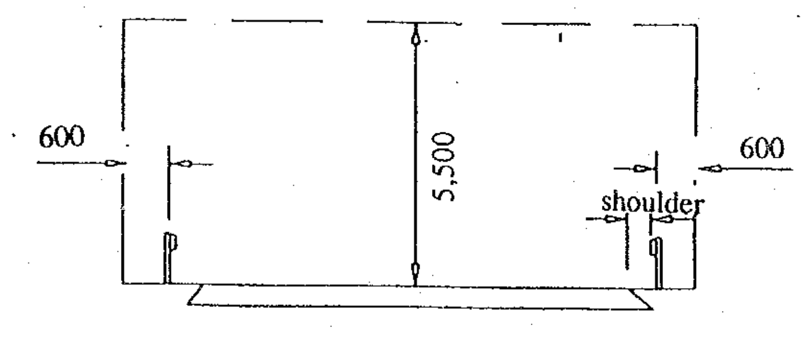
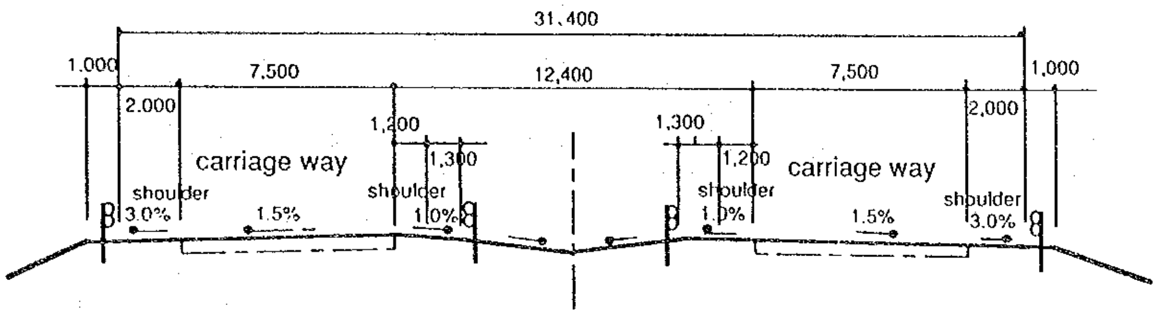
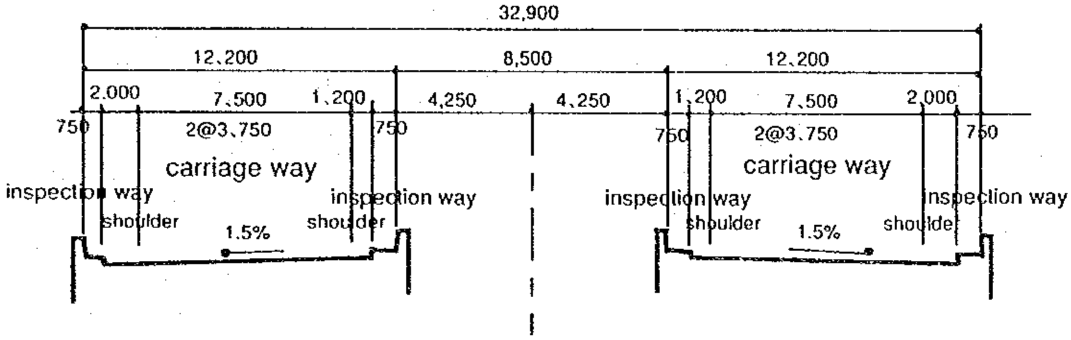


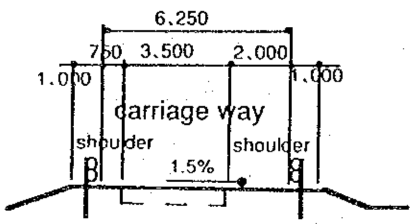
Figure 6.1 Clearance Limits



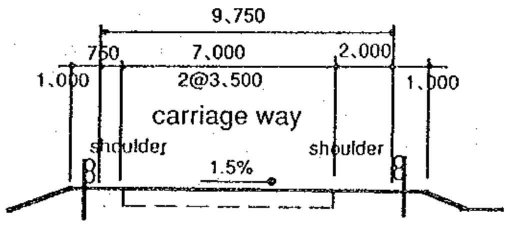
HIGHWAY SECTION



BRIDGE SECTION



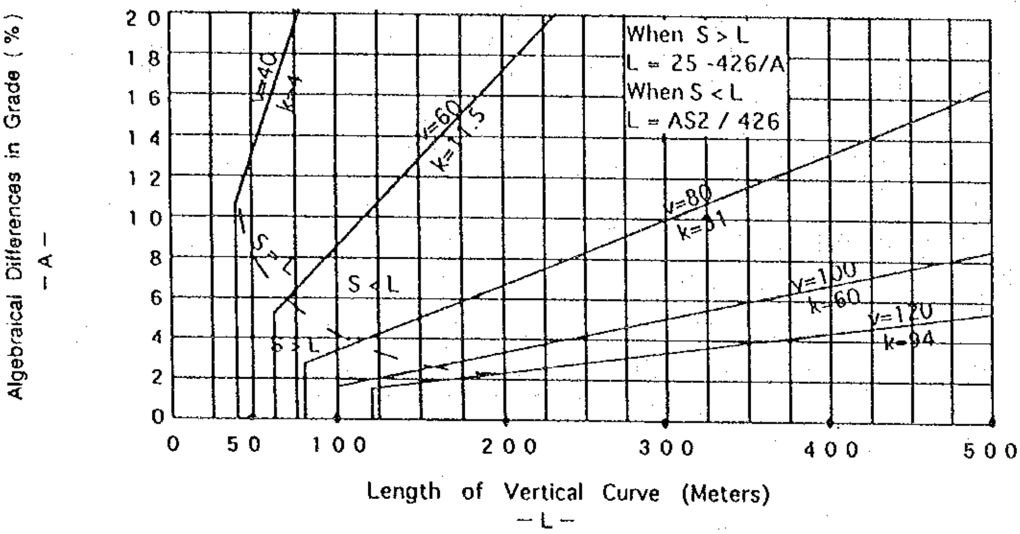
ONE LANE



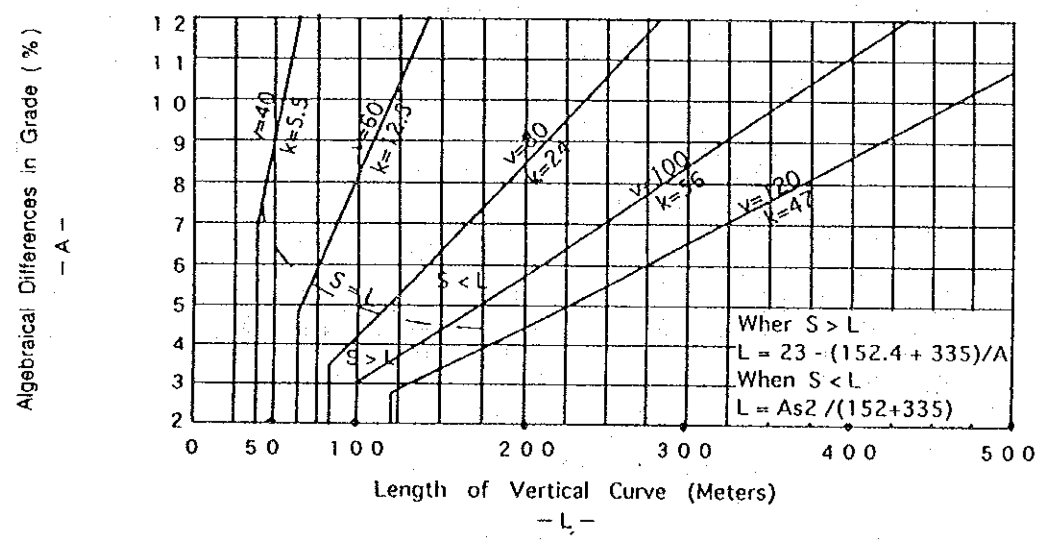
TWO LANES

RAMP WAY SECTION

THE STUDY ON ROAD DEVELOPMENT PROJECT	JAPAN INTERNATIONAL COOPERATION AGENCY	Fig 6.2 TYPICAL CROSS SECTION



Length of Vertical Curve for Crest Vertical Curves



Length of Vertical Curve for Sag Vertical Curves

THE STUDY ON ROAD DEVELOPMENT PROJECT	JAPAN INTERNATIONAL COOPERATION AGENCY	Fig 6.3 Minimum Vertical Curve Length

6.2 Design Live Load

In proportion to the development of the road system, many bridges have been constructed since 1970. In the beginning of the development, design standards for live load applied in various countries were used, such as AASHTO: HS (20), BS: 45 HB, FS: BC30, etc. Therefore, existing bridges have various loading capacities. Recently, the traffic volume of heavy vehicles has increased along with the development of the road systems.

Under above mentioned circumstances, the MOC determined the design standards for the road structures in 1992. Furthermore, the standards are under revision to meet the current conditions of the increase of heavy road traffic.

This study is intended to supply relevant information for the revision of the design live load in Oman.

6.2.1 Application of Loading in the 1992 Revision

(a) General

The highway live loadings on the roadways or bridges or incidental structures will consist of standard trucks or of lane loads which are equivalent to truck trains.

(b) Classes of Loading

Three different types of loading are provided:-

1) 40-ton truck
2) Lane loading
3) 60-ton truck

These loadings are illustrated in Fig. 6.4, Fig. 6.5 and Fig. 6.6.

The variable axle spacing has been introduced in order that the spacing of the tractors may approximate more closely to the tractors now in use. The variable spacing also provides a more satisfactory loading for continuous spans. In that, heavy axle loads may be so placed on adjoining spans so as to produce the maximum negative moment.

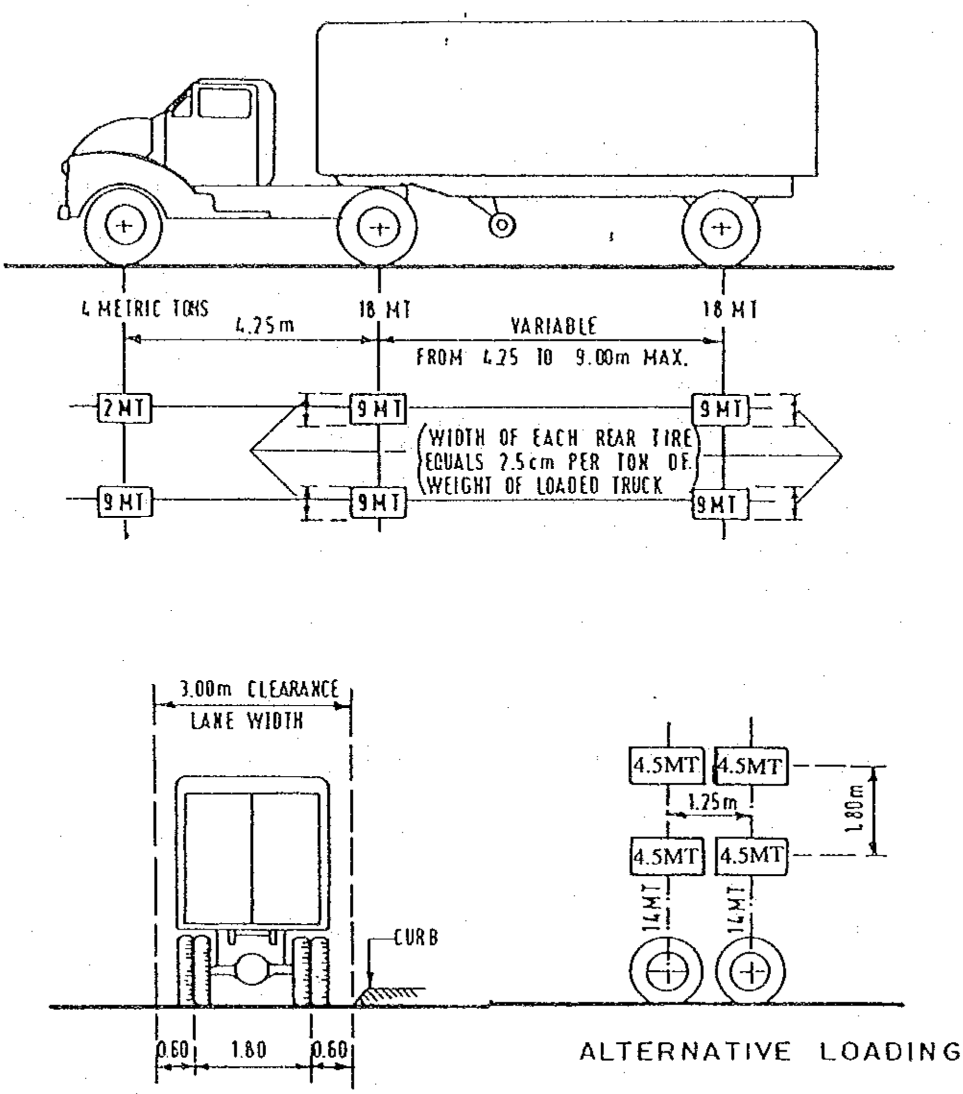


Fig. 6.4 40 T TRUCK

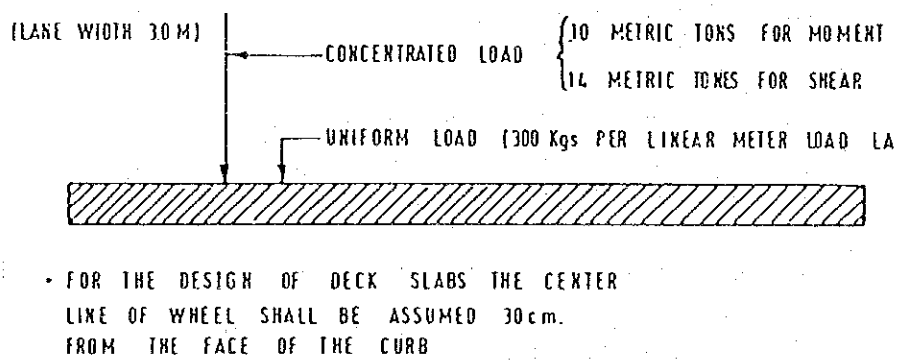
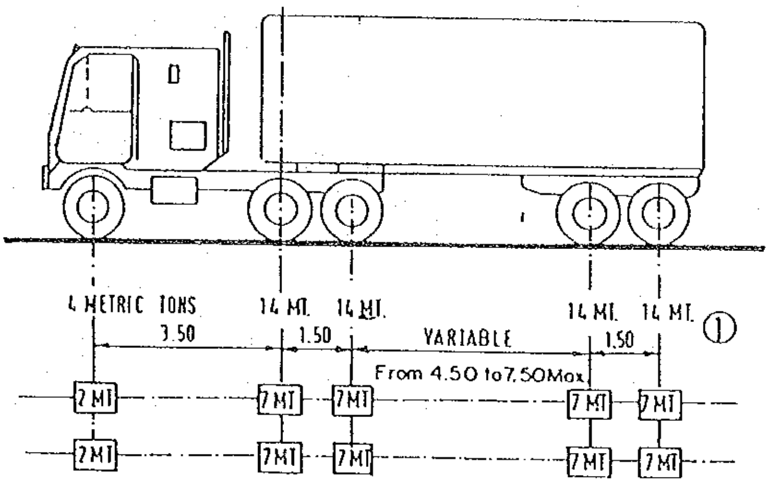
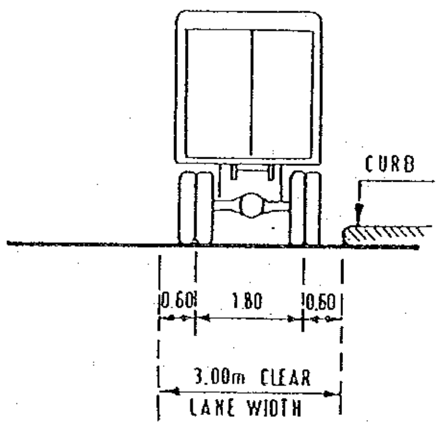


Fig. 6.5 LANE LOADING





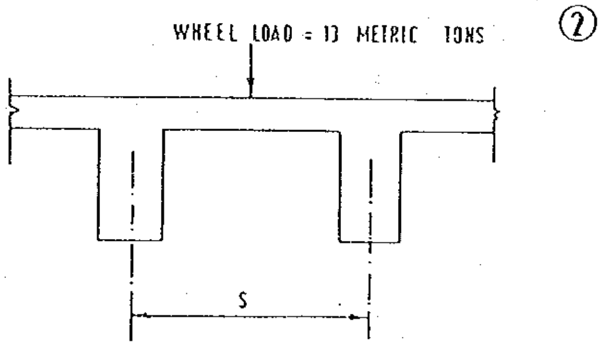


Fig. 6.6 60 T TRUCK

(c) Traffic Lanes

The lane loading of standard truck shall be assumed to occupy a width of 3.0 meters.

Number of traffic lanes (N) shall be as shown in the following table.

	N
6 - 9.0 meters	2
9 - 12.0 meters	3
12 - 15.0 meters	4

The lane loading of trucks shall be assumed to occupy any position within their individual design traffic lane, which will produce the maximum stress.

(d) Standard Truck and Lane Loads

The wheel spacing, weight distribution and clearance of the standard truck loads shall be as shown in Figs. 6.4 and 6.6, and corresponding lane loads shall be as shown in Fig. 6.5. Each lane loading shall consist of a uniform load per linear meter of traffic lane combined with a single concentrated load. The concentrated load and uniform load shall be considered as uniformly distributed over a 3.0 meter width on a line normal to the centre line of the lane.

For the computation of moments and shears, different concentrated loads shall be used as indicated in Fig. 6.5. The lighter concentrated loads will be used when the stresses are primarily bending stresses, and the heavier concentrated loads will be used when the stresses are primarily shearing stresses.

(e) Standard Truck and Lane Loads

- Traffic Lane Units

In computing stresses, each 3.0 meter lane loading of single standard truck shall be considered as a unit, and fractional load width of fractional trucks shall not be used.

- Number and Position, Traffic Lane Units

The number and position of the lane loads shall be as specified in (c) and, whether lane loading or truck loading, shall be such as to produce the maximum stress, subject to the loading combinations given below.

2 Lane	-		(a)	2 - 60-ton trucks
		or	(b)	2 Lane Loads
3 Lane	-		(a)	2 - 60-ton trucks and 1 - 40-ton truck
		or	(b)	2 - 60-ton truck and 1-one-lane load
		or	(c)	3 Lane Loads
4 Lane	-		(a)	2 - 60-ton trucks and 2 - 40-ton trucks
		or	(b)	2 - 60-ton trucks and 2-two-lane loads
		or	(c)	4 Lane Loads

- Loading for Maximum Stress

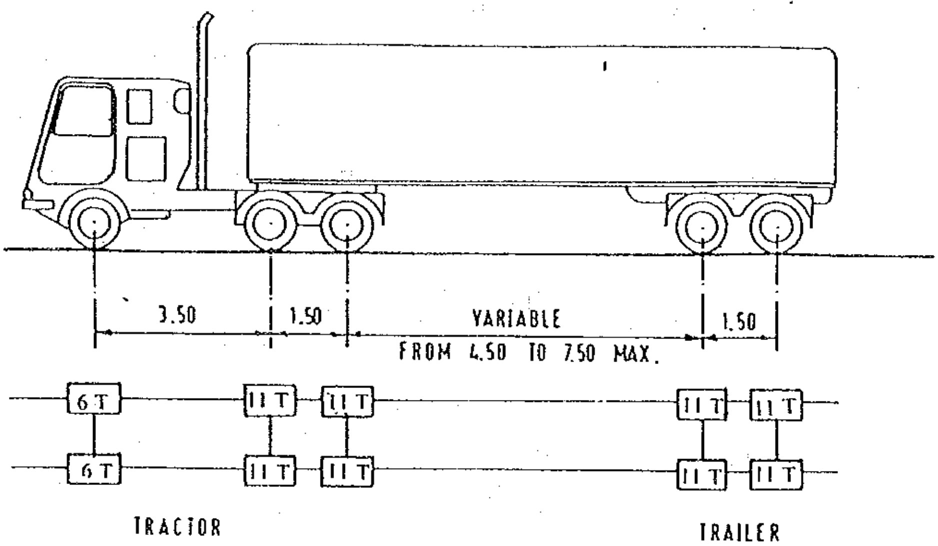
The type of loading to be used shall be loading which produces the maximum stress. The axle spacing for trucks shall be varied between the specified limits to produce maximum stresses.

6.2.2 The Consideration of the Revision in February 1994

Bridges of highways shall be designed for truck and lane loadings as specified below.

- Truck and lane loading shall be AASHTO HS-20 increased by 100 %. Bridges shall be checked for special trucks Type A as shown in Fig. 6.7.

- The design of bridges on primary roads and streets shall also be checked for special trucks Type B as shown in Fig. 6.8. Other roads may also require these loads to be applied (e.g. access to power stations, chemical plants, etc.) where agreed with the client.



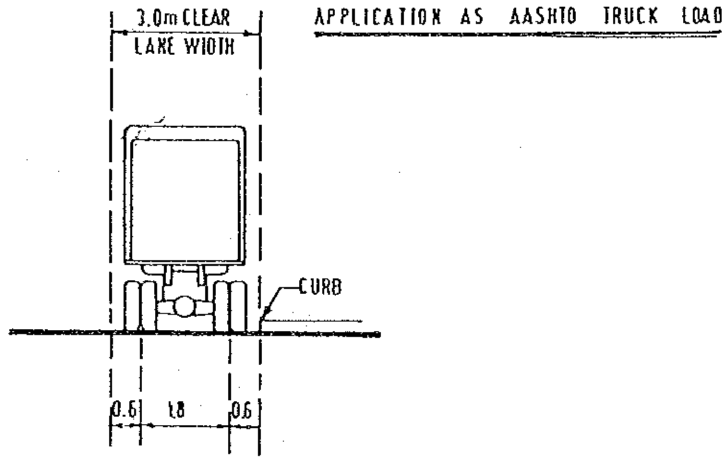
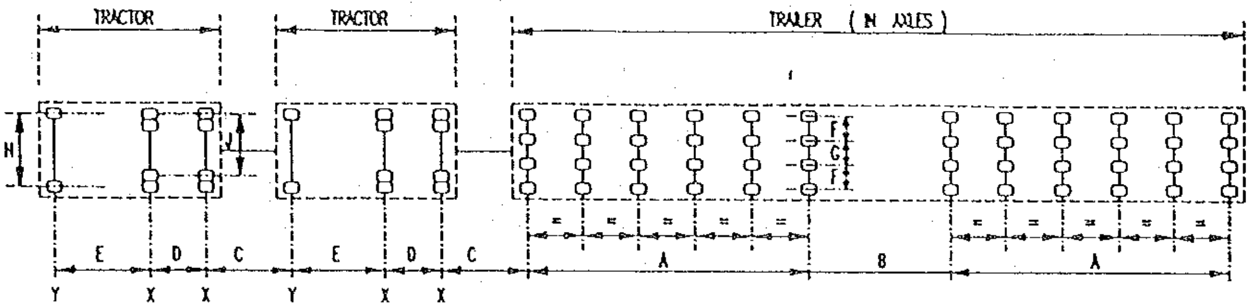


Fig. 6.7 SPECIAL TRUCK TYPE A (100 T)



VEHICLE TYPE	DIMENSIONS (mm)									TRAILER			TRACTOR		
	A	B	C	D	E	F	G	H		NO. OF AXLES (N)	SELF WEIGHT (Tonne)	PAYLOAD (Tonne)	AXLE LOAD X	AXLE LOAD Y	TOTAL WEIGHT (Tonne)
B 1	8000	13650	5500	1600	4400	1020	900	2700	1850	12	90	310	18.3	10.0	46.6
B 2	10570	0	4775	1500	6250	1020	900	2700	1850	15	50	210	9	6	24.0

APPLICATION:
MAY BE PLACED ANYWHERE WITHIN TWO LANES, NO OTHER TRAFFIC SHALL OCCUPY THE TWO LANES FOR THE LENGTH OF THE TRUCK PLUS 20m AHEAD AND 20m BEHIND.
TRACTORS MAY BOTH PULL (AS SHOWN) OR ONE PULL AND ONE PUSH

Fig. 6.8 SPECIAL TRUCK TYPE B

- Only one special truck shall be applied to a bridge at one time.

- Thermal effects should be considered for a maximum shade air temperature of 52 °C and for a minimum shade air temperature of 0 °C.

- The acceleration coefficient for seismic loads shall be taken as 0 in Dhofar Region, 0.2 g in Musandam, and 0.1 g elsewhere.

6.2.3 Bending Moment and Shear Force due to the Design Live Load Application from the Codes of Various Countries

As mentioned previously in section 6.2 the revision of the design live load is now in process.

A comparison study was made for the revision of the design live load in Oman in order to establish the code in the world codes.

The bending moments and shear forces due to the design live load intended to be adopted as the new design standard are calculated regarding the representative spans (simple beam) in Oman as follows.

L = 15 m, 20 m, 25 m, 30 m and 35 m

The loading conditions are

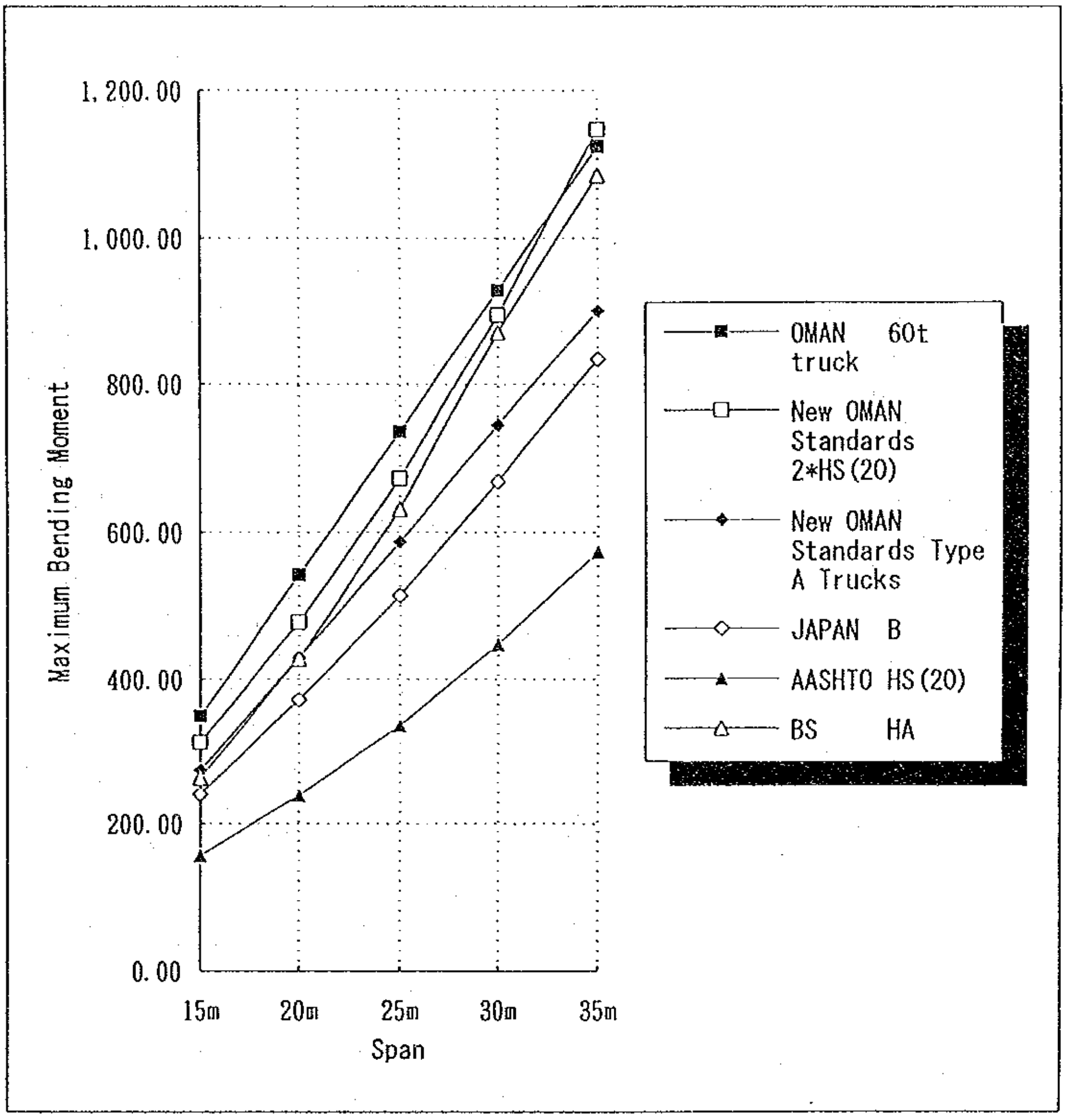
a. Lane load
b. 60 ton truck
c. As new design live load .... AASHTO HS-20
2 times loading

Regarding above mentioned spans, the bending moments and shear forces due to the design live loads of

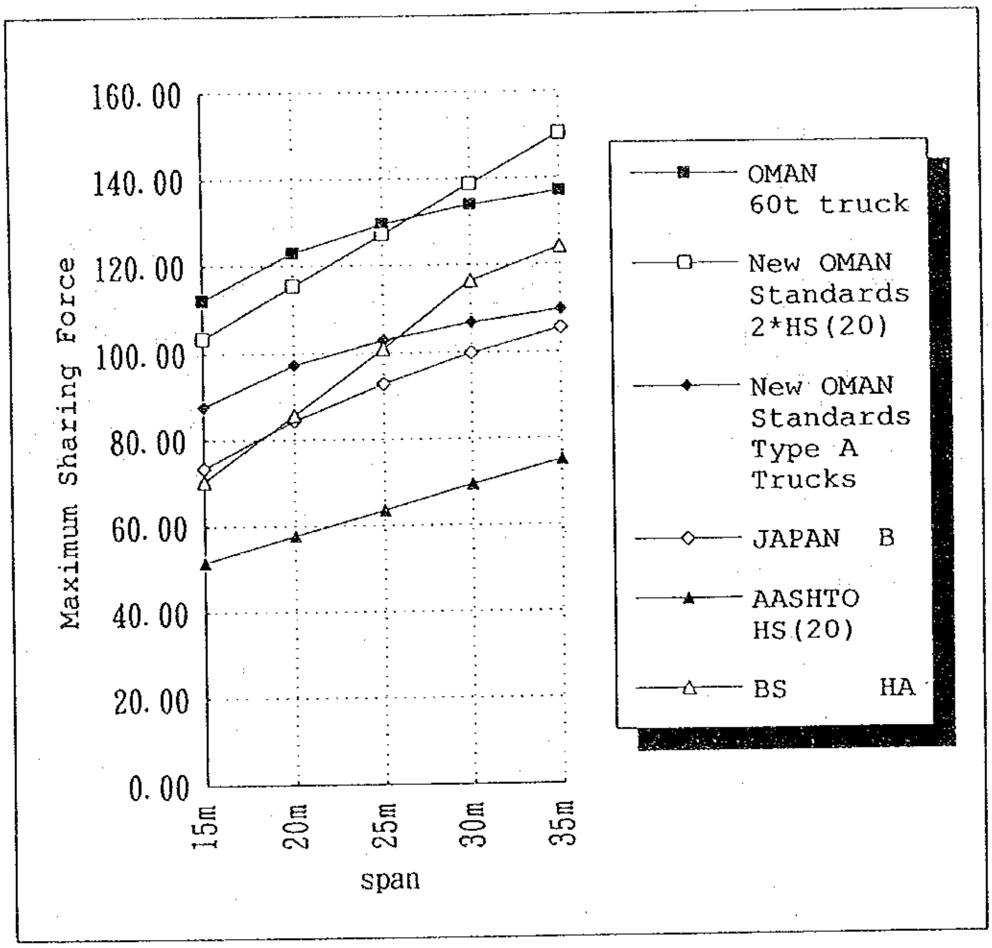
a.	AASHTO	HS-20
b.	BS	HA
c.	Japanese	TL-25 (B)

are calculated and compared with the results from Omani Standards.

The results of the comparison due to the above mentioned method, are shown in Fig. 6.9 and Fig. 6.10 as follows.



THE STUDY ON ROAD DEVELOPMENT PROJECT	JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 6.9 Comparison of Bending Moment According to the Codes of Various Countries



160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Maximum Sharing Force
15m
20m
25m
30m
35m
span
OMAN
60t truck
New OMAN
Standards
2*HS(20)
New OMAN
Standards
Type A
Trucks
JAPAN B
AASHTO
HS(20)
BS HA

The loading by Omani 60 t truck gives the maximum bending moment for the 15 m, 20 m, 25 m and 30 m spans. The loading by the new Omani design live loading gives the loading for the 35 m span only.

The loading by the Omani lane load gives a bigger bending moment than the loading by AASHTO HS-20, but less than the loading by BS-HA and the Japanese TL-25 (B).

The loading by Omani special truck Type A gives a bending moment of almost the same values as the Japanese TL-25 (B).

In summary, the loading by Oman 60 t truck is slightly heavier than BS - HA standard. The Omani live loading system will be one of the heaviest loading systems in the world.

6.2.4 The JICA Study Team's opinion: According to the comparative study of the above mentioned methods,

The JICA Study Team considers as follows:

(1) The live loading system intended to be adopted as the design criteria, AASHTO HS-20 2 times loading and 60 t truck loading are among of the heaviest loads in the world. Furthermore, considering the development of the economy and the resulting increase of heavy trucks, it is recommended that the new Omani live loading system be adopted for the proposed bridges.

(2) The existing bridges, which were constructed of reinforced concrete approximately 20 years ago, are already deteriorating and need to be rehabilitated in order to increase bridge capacity. Such methods are established and recommended in Chapter 9 of Volume III.

It is not economically feasible to bring the load capacities of existing bridges up to satisfy the new Omani live loading standards.

Thus, different methods are recommended in regards to reinforcing existing bridges.

(3) It is recommended that traffic controls be established especially for heavily loaded vehicles.

6.3 Traffic Capacity of the Batinah Highway

6.3.1 Main Highway and Ramps

The traffic capacity on the main highway and ramps was calculated from Table 6.2.

Table 6.2 Analysis of Design Road Capacity

Description		Batinah Highway	Interchange Ramp
Design Speed (km/h)		120	80
Terrain of Grade		Flat	Flat
Capacity Under Ideal Conditions (PCU/Hour/Lane)		2,000	2,000
Design Level of Service		B	C
Coefficient of Service Level		0.80	0.80
Maximum Service Flow Rate (PCU/Hour/Lane)		1,600	1,600
Width of Lane (m)		3.75	3.50
Lateral Clearance (m)	Roadside	2.00	2.00
	Median	0.75	0.75
Heavy Vehicles	Rate of H.V. %	10	10
	Composite Passenger Car Equivalency	1.7	1.7
Coefficient	Width of Lane	1.0	1.0
	Lateral Clearance	1.0	1.0
	Heavy Vehicle	0.91	0.91
	Driver Population	1.00	1.00
	Total	0.91	0.91
Service Flow Rate (Veh/Hr/Lane)		1,500	1,500
Design Hourly Volume Ratio (%)		8 %	10 %
Directional Distribution Ratio (%)		60 %	60 %
Design Daily Capacity (Veh/Day/Lane)		15,000	12,000

6.3.2 The Traffic Capacity of Roundabouts

For calculation of capacity at roundabout in Oman, there is a Standard based on the British Transport and Road Research Laboratories materials.

(1) The Formula for Calculating Capacities of Roundabouts

$$Qe = k\,(F - fc \times Qc)$$

Where:

Qe	:	inflow traffic volume
Qc	:	traffic volume already in roundabout
k	:	$1 - 0.00347\,(\text{Ø} - 30) - 0.978\,(1/r) - 0.05$
F	:	$303X$
fc	:	$0.210td\,(1 + 0.2X)$
td	:	$1 + 0.5\,(1 + M)$
M	:	$\exp\,((D - 60)/10)$
X	:	$v + (e - v)/5$

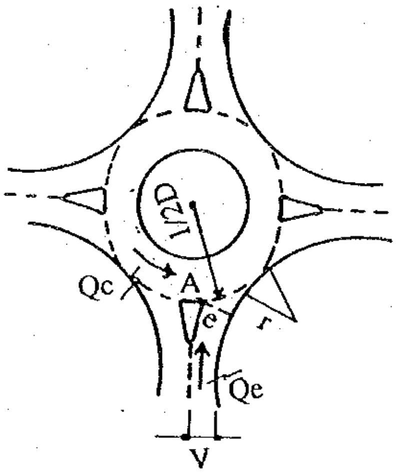


Fig. (A)

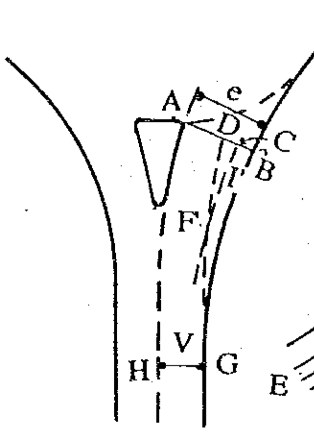


Fig. (B)

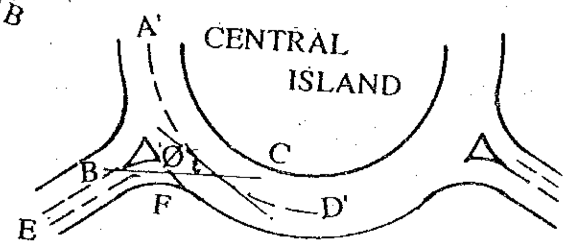


Fig. (C)

Geometric Parameter	Definition
Entry Width (e)	The width of the entry arm into the junction measured from Point A along the normal to the nearside ωRB.
Approach Half-Width (V)	The width of the entry arm upstream of the flare measured from the median line to the nearside curb along a normal. See Fig. A.
Average Length of Flare (I')	In Fig. B, I' is defined by I' = CF' where the line of CF' is parallel to BG and distance (e - Y)/2 from it. Usually CF' is curved and its length measured along the curve to get I'.
Sharpness of Flare (s)	A measure of the rate at which extra width is developed in the entry flare it is defined by the relationship S = 1.6 (e - V)/I'.
Entry Radius (r)	Measured as the minimum radius of curvature of the nearside curbline at entry. See Fig. A.
Entry Angle (Ø)	The angle between the circulating traffic and that entering the junction. Fig. C shows Ø for well defined conventional Roundabouts. For other types, see DOT TA 23/81 (1981).
Inscribed (D)	The diameter of the largest circle that can be inserted within the junction outline. Where the outline is asymmetric, the local value in the region of entry is used. See Fig. A.

This formula indicates that the approach traffic capacity is defined by the width of the approach, and is deducted by the traffic volume already in roundabout. It is a similar type of formula as calculating capacity of merging, and the "offside priority" rule currently practiced in Oman.

"k" is a constant decided by the geometry of roundabout and almost equals to for high grade facility. The value for "F" is maximum capacity at approach end calculated by "X" which is width of approach end considering widening. "fc" is a constant decided by the geometrical structure such as inscribed radius D.

(2) The Applied Formula

The formula to determine the traffic capacity at roundabouts on the Batinah Highway will be as follows assuming "D" equals 80 and "V" equals 7.3.

$$Qe = 2{,}200 - 0.52 \times Qc$$

By this formula, however, the influence of a vehicle already in a roundabout (coefficient of Qc) is 0.52. But, the traffic practice at roundabouts in Oman does not seem to coincide with this formula.

In Oman, at roundabout approach with two lanes, a vehicle wanting to turn right should use right lane then enter outer lane of roundabout, and when wanting to go straight should use left lane then enter inner lane of roundabout. This requires longer waiting time for sufficient gap in traffic on roundabout.

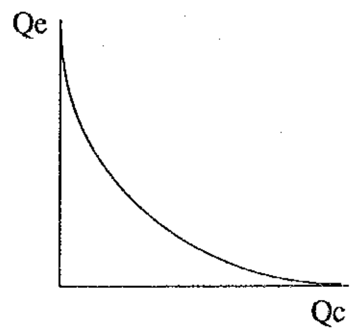
Considering this rule the influence of the vehicle already in the roundabout is considerably large, possibly larger than 1.0. The inter-relationship of Qc and Qe would be downward convex as shown below. But, in our study such a precise traffic study to determine exact value of the coefficient was not undertaken.

But, for the limited purpose to calculate v/c ratio as one of the indices to give priority for flyover, but not precise traffic analysis, it seems to be less problem to assume the coefficient to be 1.5. Then we obtain the following formula to calculate v/c ratio.

$Qe = 2{,}200 - 1.5 \times Qc$ (PCU/hour)

$Qe = 2{,}000 - 1.5 \times Qc$ (Vehicle/hour)

The result is shown in Table 6.3.



(3) Volume/Capacity Ratio (V/C)

The traffic capacity can be obtained from the above formula and the traffic volume is obtained on referring to Chapter 5. Traffic Volume/Traffic Capacity Ratio (V/C) will be as shown in Table 6.3.

Table 6.3 Traffic Capacity in the Roundabout

Location		To Aqr		To Muscat		V/C Ratio (Q_3)		
		Batinah (Q_1)	R/A (Q_2)	Batinah (Q_1)	R/A (Q_2)	to Aqr	to Muscat	Average
Bait Al Barakah	(R/A 1)	29,965	591	29,759	797	1.126	1.131	1.129
Naseem Garden	(R/A 2)	29,759	1,101	28,972	1,887	1.151	1.174	1.163
Barka	(R/A 3)	29,373	7,400	22,449	14,326	1.791	3.735	2.763
Masua'ah	(R/A 4)	22,450	1,106	21,918	1,637	0.869	0.875	0.872
Al Muladdah	(JCT 5)	21,917	2,994	15,840	9,173	0.953	1.153	1.053
Wudam As Sahil	(R/A 6)	15,738	778	14,871	1,745	0.598	0.598	0.598
Suweiq	(R/A 7)	14,770	2,113	14,498	2,486	0.607	0.610	0.608
Khaburah	(R/A 8)	14,404	5,208	13,572	6,134	0.732	0.742	0.737
Al Hijari Junction	(R/A 9)	13,480	707	13,339	939	0.510	0.511	0.511
Saham	(R/A 10)	13,248	12,831	15,466	10,406	1.605	1.301	1.453
Suwayhrah	(R/A 11)	15,471	3,150	14,319	4,296	0.679	0.680	0.680
Sohar	(R/A 12)	14,370	12,469	12,070	14,732	1.634	2.234	1.934
Sallan	(R/A 13)	11,863	4,319	13,340	3,049	0.564	0.582	0.573
Falaj Al Qabail	(R/A 14)	13,336	1,623	8,837	6,126	0.532	0.483	0.507
Majis	(R/A 15)	8,834	356	8,456	737	0.328	0.320	0.324
Liwa	(R/A 16)	8,457	928	8,202	1,184	0.324	0.319	0.321
Shinas	(R/A 17)	8,201	1,039	7,957	1,284	0.316	0.311	0.314
Aqr	(R/A 18)	7,959	1,627	5,725	3,859	0.318	0.264	0.291

Notes : Batinah show inflow traffic volume of the Batinah Highway.

: R/A show traffic inflow intersection with traffic in roundabout.

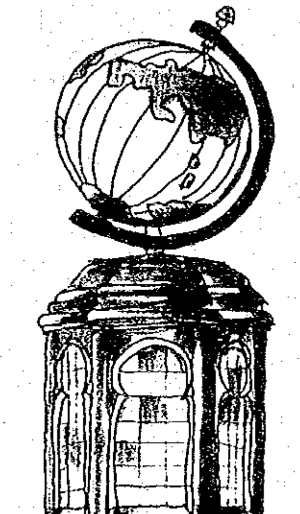
: V/C ratio is calculated from following formula

$Q3 = Q1 \times 8\%/(2{,}000 - 1.5 \times Q2 \times 8\%)$

where : Q3 : V/C ratio

8% : Peak ratio

CHAPTER 7 SELECTION OF THE GRADE SEPARATION STRUCTURES AND THE ORDER OF PRIORITY



CHAPTER 7

SELECTION OF THE GRADE SEPARATION STRUCTURES AND THE ORDER OF PRIORITY

This chapter will consider the design standards for the grade separation structures to be adopted in this project, together with the configuration of structures that can be constructed in the roundabout, and the conditions that will be applicable to adapt the structure. The order of construction will require the decision for the basic configuration of the grade separation structure and its ability to accommodate cross and turning movements at intersected highways.

7.1 Existing Condition of Roundabouts in Study

The following observations were gathered from the initial reconnaissance survey along Batinah Highway from Bait Al Barakah R/A to Aqr R/A covering all the 18 study roundabouts and junctions. Table 7.1 is a summary of the general reconnaissance survey notations.

(1) Physical Features of Roundabouts

All the existing 16 roundabouts were designed in an oblong shape in the direction of the highway, thus giving weaving priority to through-traffic. Such a design concept is probably aimed at maintaining a fairly reasonable speed for the through traffic when passing through the roundabout.

When traffic approaching from the side becomes substantial, then difficulty in weaving by minor traffic may occur creating long queues and conflicts.

(2) Conditions of the Highway and Roundabouts

Severe rutting and cracking of highway pavement were observed at several locations between Bait Al Barakah R/A up to Al Khaburah R/A. The section of the Batinah Highway beyond Al Khaburah is in fairly good condition, based on visual observations. All the roundabouts are well maintained and in excellent condition.

(3) Median Openings

There are many median openings for accesses to neighboring villages. Although safety measures such as weaving lane, channels and islands are provided at some locations, the slow speed of turning traffic at these openings are potential accident hazards in view of the high speed of through-traffic.

(4) Service Roads

The old coastal road has become the service road for villages and buildings fronting the highway. Traffic on these service roads are collectively discharged at the roundabouts or major junctions in some locations. However, there are still many small direct accesses to the service roads or single buildings or plots along the highway. Traffic accessing the highway via such side-openings are potential accident hazards.

(5) Irish Crossings

There are many Irish crossing along the highway. They are identified by the red and white water level measuring rods on both sides of the carriageway. There is evidence of scouring of curbs by rocks occasionally carried down by floodwaters along the wadis.

(6) Beautification Efforts by Local Municipality

Local municipal authorities along the Batinah Highway have made great efforts in various beautification schemes at the roundabouts and major junctions. Impressive monuments for example are erected at 5 locations, namely Bait Al Barakah, Sohar, Sallan, Suwayhrah and Wudam As Sahil Roundabouts. At the other 9 roundabouts, beautification efforts include generous planting of flowering shrubs, installation of rock gardens, water fountains and life-size animal statues as shown in Fig. 7.1.

(7) New Development at Roundabout and Junction

The improved accessibility at roundabouts and junctions have obviously attracted new development. New buildings of 2 or 3 story high and those under construction can be observed at Masna'ah R/A, Al Muladdah Junction, Saham and Khaburah Roundabouts.

Except for the new roundabouts at Majis, Naseem Garden and Bait Al Barakah R/A, there is a general conglomeration of shops, restaurants and other services such as vehicle workshops, gas stations at the roundabouts and major junctions. Denser conglomerations were observed at Barka, Khaburah, Saham, Sohar, Falaj Al Qabail, Shinas and Aqr Roundabouts; and at Muladdah, Jumma and Al Bidayah Junctions.

(8) Pedestrian Crossings

The amount of pedestrians crossing the highway is directly correlated to the density and type of shops, services and public facilities found fronting the highway. The denser the conglomeration of such facilities, the higher the number of pedestrians crossing the highway was observed.

Significant numbers of pedestrians crossing the highway were observed at Barka, Wudam As Sahil, Khaburah, Saham, Sohar, Liwa, Shinas and Aqr Roundabouts, and at Muladdah, Jumma and Al Bidayah Junctions.

(9) Public Buildings

The presence of public buildings such as schools, mosques, clinics and markets near and at the roundabout or junctions are obviously major generators of pedestrian traffic crossing the highway. School children were observed crossing the highway after disembarking from school buses on their way from school. Shoppers and worshippers are also forced to cross the highway to get to the market or mosque.

(10) Roadside Vendors

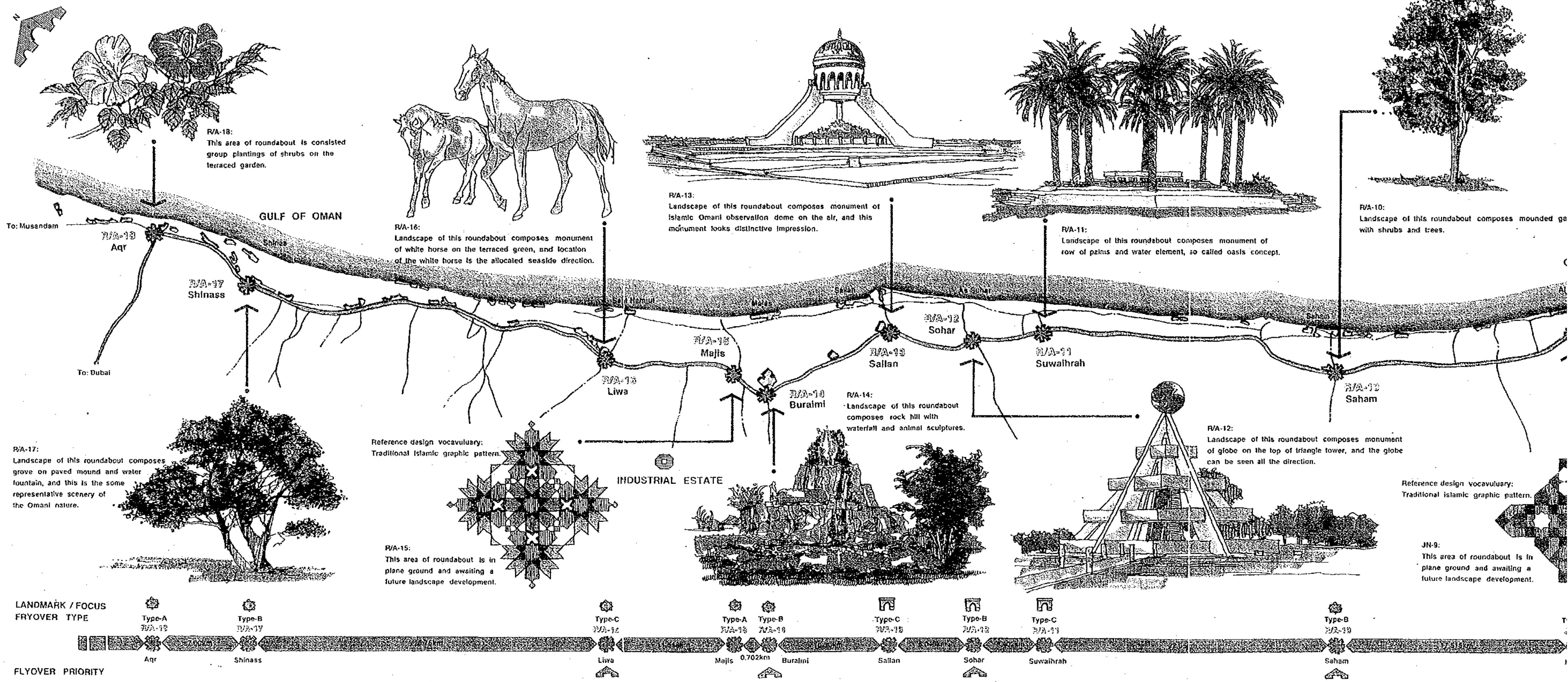
There were also vegetable vendors hawking farm produce from nearby vegetable gardens observed along the Batinah Highway. The vendors and vehicles stopping to partronize these informal stalls are potential traffic hazards.

Table 7.1 Summary of Results of Site Reconnaissance Survey

No.	Name of R/A or Junction	Type of Structure in R/A	Landuse in the Vicinity	National Route	Access to Towns or Development Areas	Public Building	Pedestrian Volume	Service Road to Highway	Alignment	Others/Remarks
1.	Bait Al Barakah R/A	Religious Monument	Palace Ground and Military School		Private access road to Palace and Military		Nil	Paved service road	Good	Need to preserve aesthetic of R/A
2.	Naseem Garden R/A		Agriculture and public park		Access to Naseem Garden Park	Public park	Nil		Good	New R/A to development area
3.	Barka R/A	Water fountain and shrubs	Commercial and agriculture	Route No. 13	Access to Barka coastal town and inland to Rustaq		Significant	Paved & unpaved service roads	Good	Major junction to Rustaq from the east (Muscat)
4.	Masna'ah R/A	Rock garden	Agriculture, some new commercial development		New road to coastal town		Sizeable	Unpaved service roads	Good	
5.	Al Muladdah Junction	(T-Junction)	Commercial and residential, informal bus terminal for Rustaq, presence of new development	Route No. 11	Access to Rustaq		Significant	Paved service road	Good	Major junction to Rustaq from traffic from the west (Sohar and Aqr)
6.	Wudam As Sahil R/A	Cultural Monument (Bat-tail Ship)	Established commercial and residential areas		Access to coastal town	Mosque, fort	Significant	Unpaved	Good	Preserve monument
7.	Suweiq R/A	(Shrubs)	Public institution, residential		New access roads to coastal town and public institution	ROP station	Small	Unpaved service roads	Good	
8.	Khaburah R/A	(Lawn)	Established commercial and residential areas	Route No. 9	Access to Rustaq and to coastal town	Mosque, clinic	Significant	Paved & unpaved	Good	
9.	Al Hijari Junction	(T-Junction)	Established commercial and residential areas, agriculture		Access to Hijari town and to coastal area		Sizeable	Unpaved	Good	
10.	Saham R/A	(Shrubs)	Estalbished commercial areas, evidence of new development		Access to coastal town and to interior Rawdah	Mosque, clinic	Significant	Unpaved	Good	
11.	Suwayhrah R/A	Cultural monument (date palms & fountain)	Residential and agriculture		Access to Sohar	Mosque	Small	Paved & unpaved	Good	Preserve monument
12.	Sohar R/A	Cultural monument	Established commercial areas, agriculture	Route No. 8	Main access to Sohar and to interior Wadi Hibi		Significant	Paved & unpaved	Curve	Preserve monument
13.	Sallan R/A	Religious monument	Residential areas, agriculture		Access to Sohar		Small	Unpaved	Curve	Preserve monument
14.	Falaj Al Qabail R/A	Rock Garden	Established commercial and residential areas	Route No. 7	To Buraimi and to coastal town	Mosque	Significant	Paved & unpaved	Curve	Major junction to Buraimi and U.A.E.
15.	Majis R/A		Agriculture and new industrial estate		Access to new industrial estate		Nil	Unpaved	Good	Access to industrial estate
16.	Liwa R/A	(Shrubs)	Commercial on one side and agriculture		Access to coastal town		Significant	Unpaved	Good	
17.	Shinas R/A	(Shrubs and rock garden)	Established commercial and residential areas				Significant	Unpaved	Curve	
18.	Aqr R/A	(Shrubs)	Established commercial areas and residential	Route No. 5	Access to coastal Aqr town and to U.A.E.	Mosque	Significant	Paved & unpaved	Good	Major access point to U.A.E.

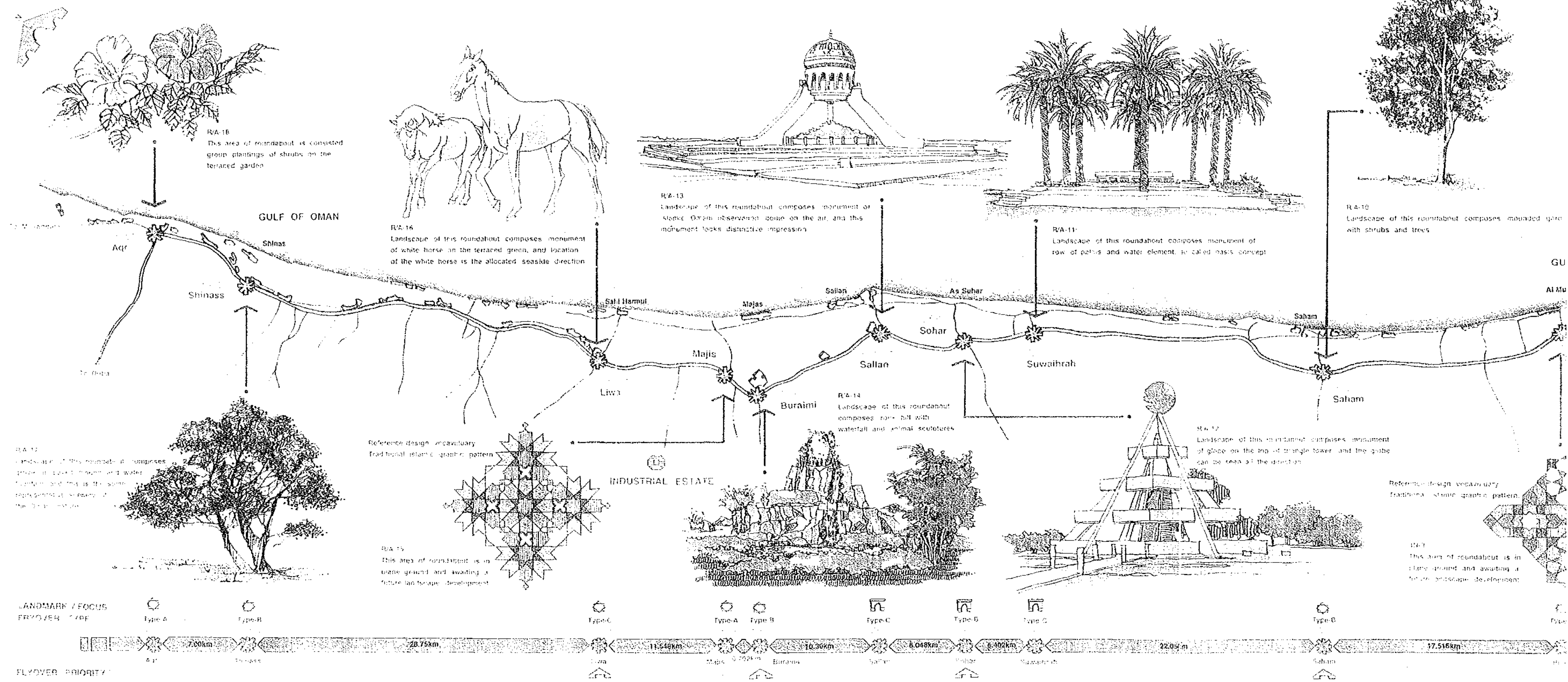
THE STUDY ON ROAD DEVELOPMENT PROJECT

LANDSCAPE SEQUENTIAL SCENARIO THROUGH BATINAH HIGHWAY

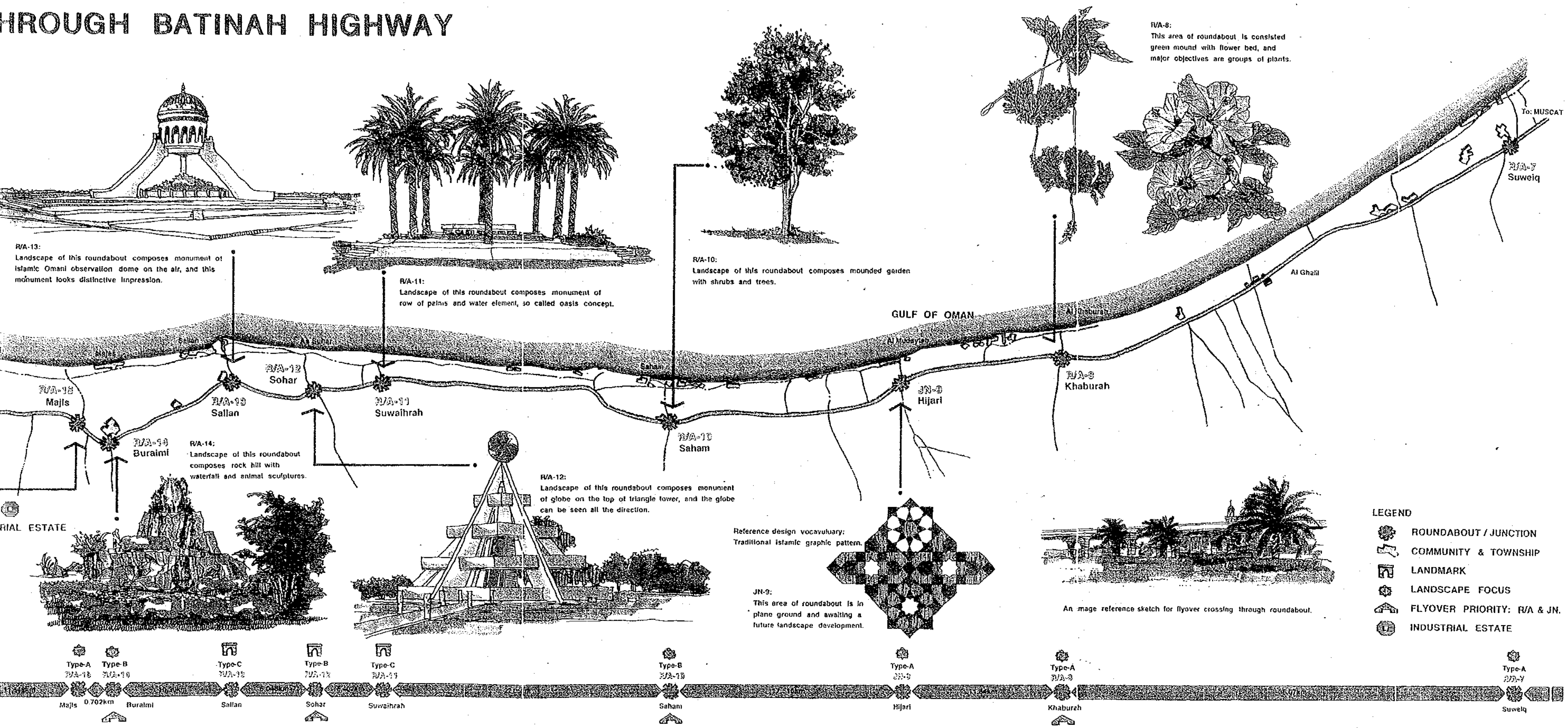


THE STUDY ON ROAD DEVELOPMENT PROJECT

LANDSCAPE SEQUENTIAL SCENARIO THROUGH BATINAH HIGHWAY

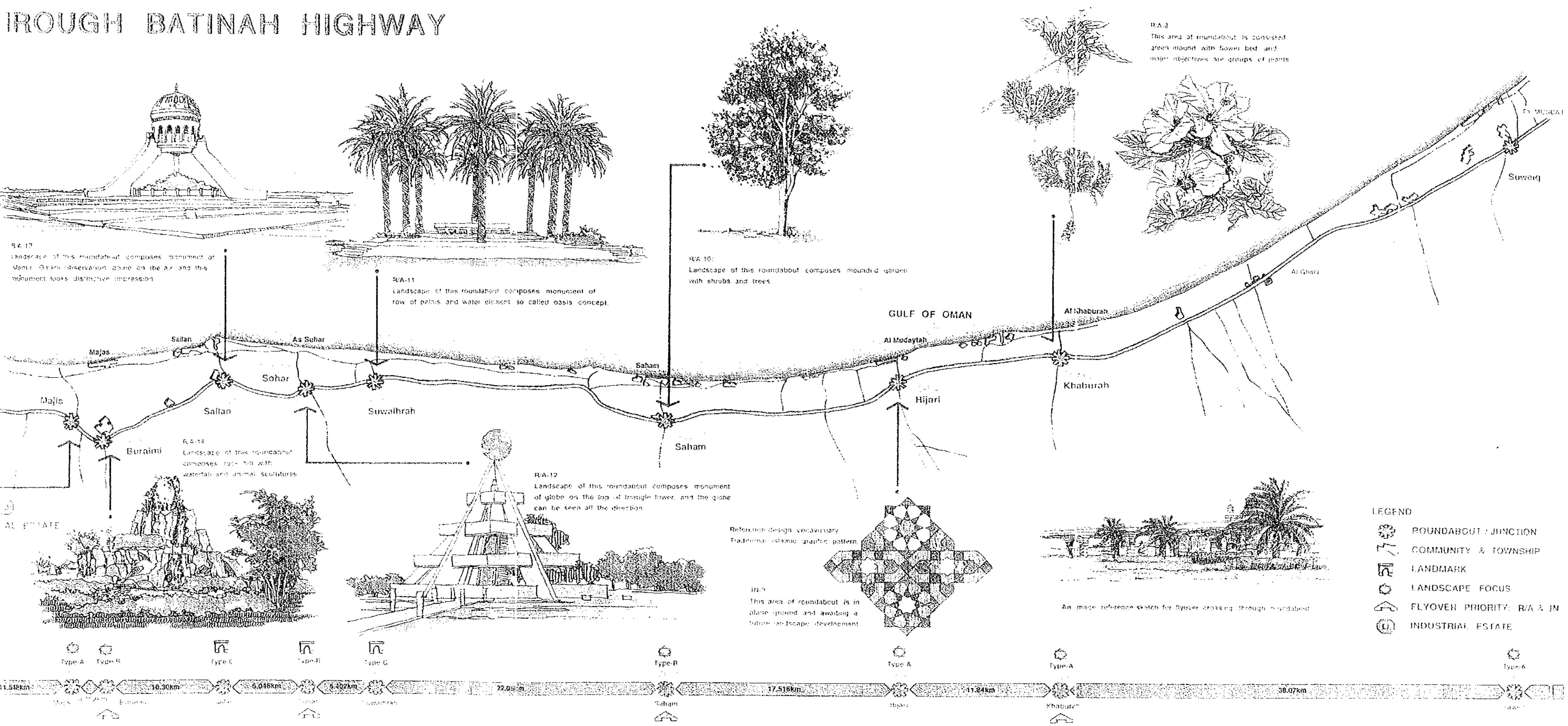


...MENT PROJECT
...HROUGH BATINAH HIGHWAY



THE STUDY ON ROAD DEVELOPMENT PROJECT	
ROUTE	BATINAH HIGHWAY
TITLE	LANDSCAPE SEQUENTIAL SCENALIO THROUGH BATINAH HIGHWAY (Aqr - Suweiq)
SHEET NO.	1 / 2

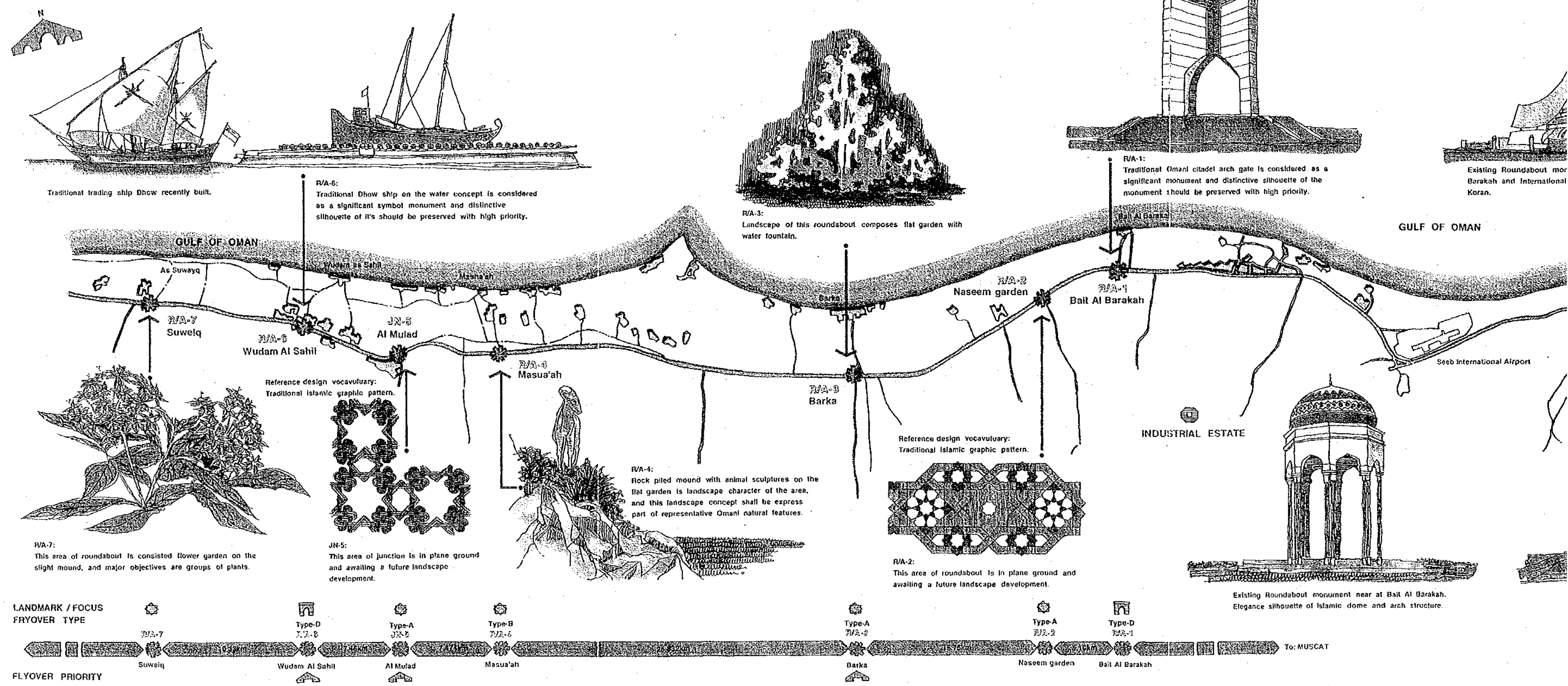
MENT PROJECT
IROUGH BATINAH HIGHWAY



THE STUDY ON ROAD DEVELOPMENT PROJECT	
ROUTE	BATINAH HIGHWAY
TITLE	LANDSCAPE SEQUENTIAL SCENALIO THROUGH BATINAH HIGHWAY (Aqr - Suweiq)
SHEET NO.	1 / 2

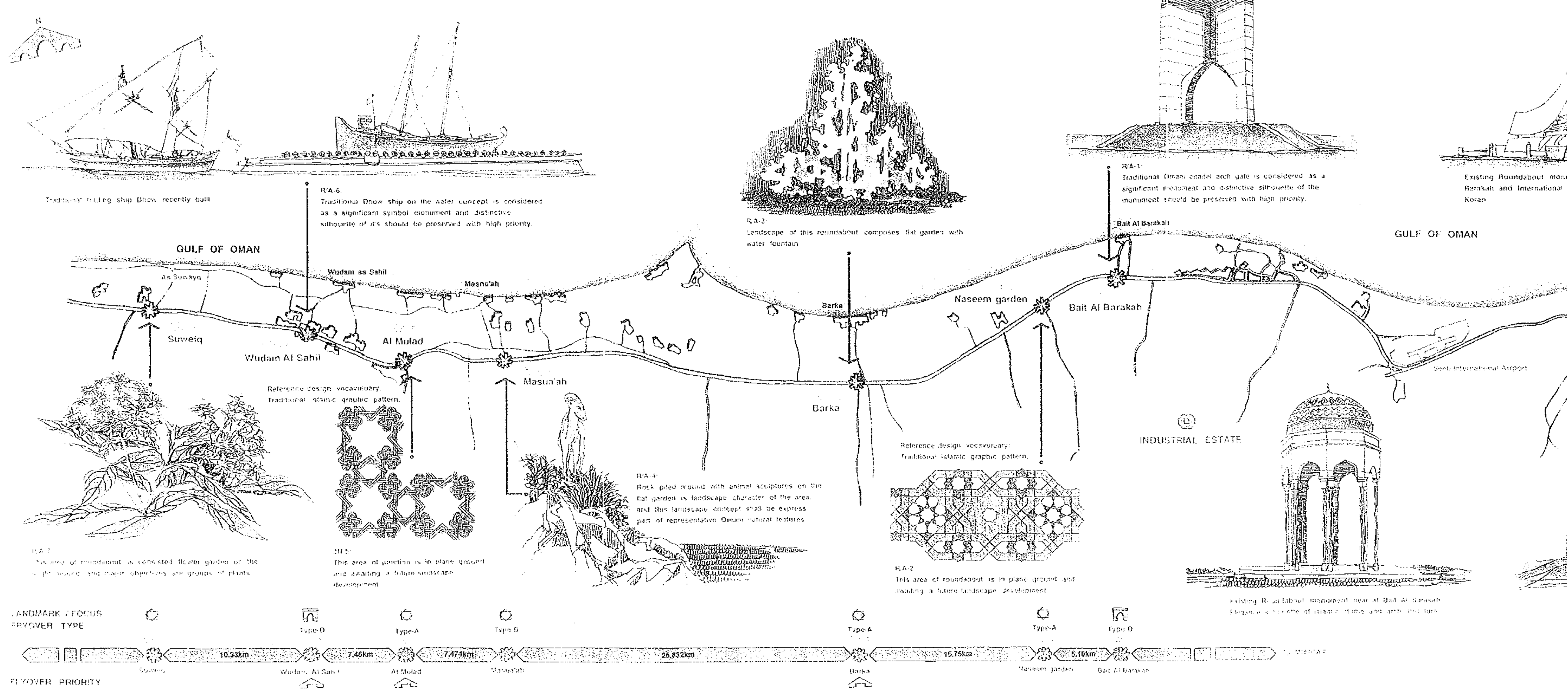
THE STUDY ON ROAD DEVELOPMENT PROJECT

LANDSCAPE SEQUENTIAL SCENARIO THROUGH BATINAH HIGHWAY



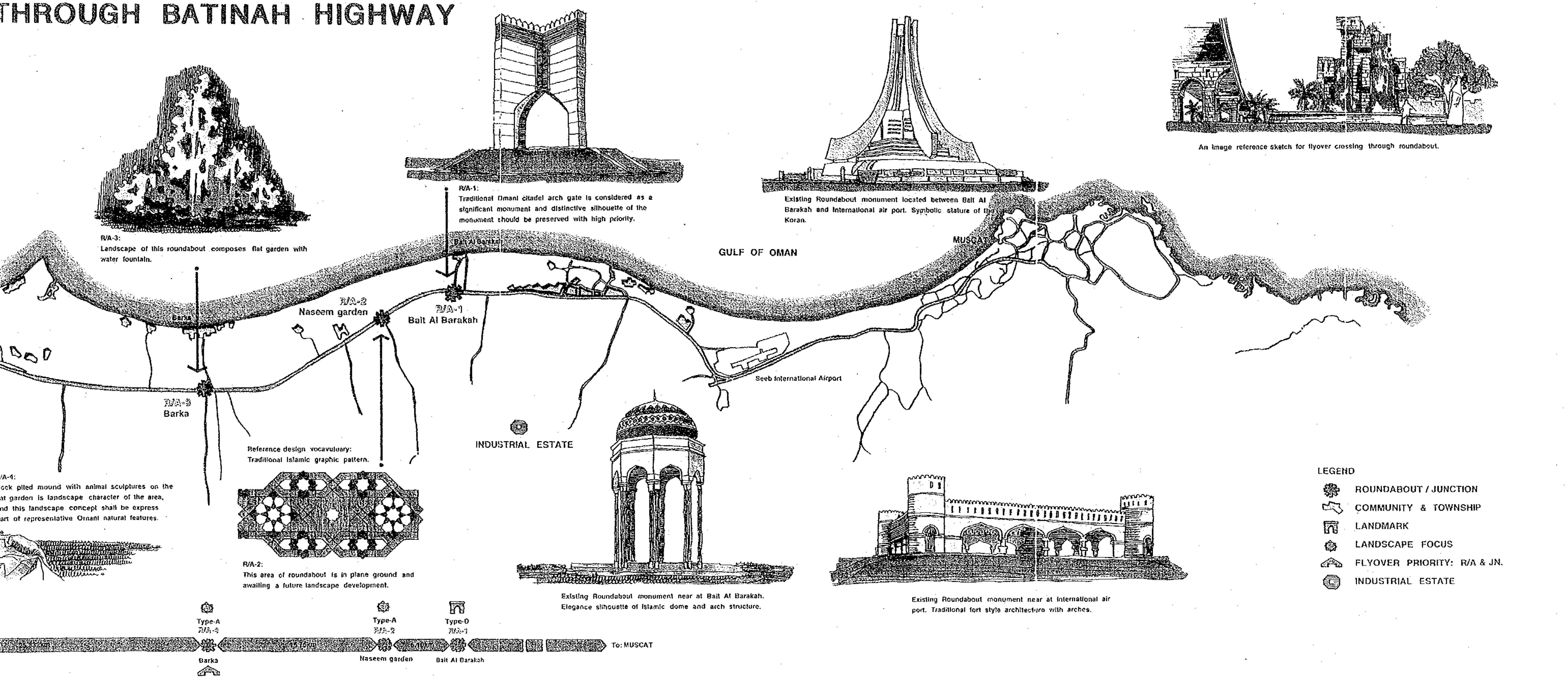
THE STUDY ON ROAD DEVELOPMENT PROJECT

LANDSCAPE SEQUENTIAL SCENARIO THROUGH BATINAH HIGHWAY



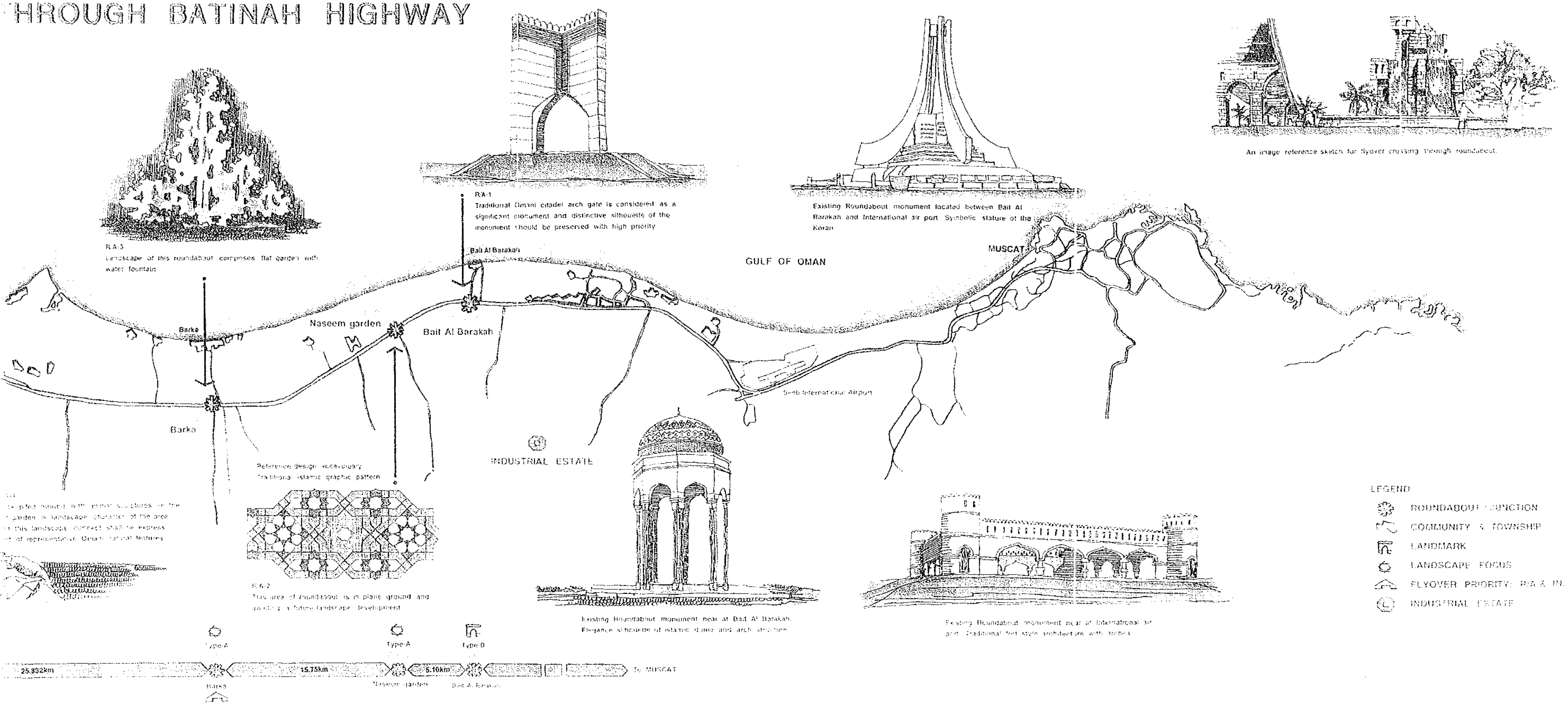
PMENT PROJECT

THROUGH BATINAH HIGHWAY



THE STUDY ON ROAD DEVELOPMENT PROJECT	
ROUTE	BATINAH HIGHWAY
TITLE	LANDSCAPE SEQUENTIAL SCENALIO THROUGH BATINAH HIGHWAY (Suweiq - Muscat)
SHEET NO.	2 / 2

PMENT PROJECT
THROUGH BATINAH HIGHWAY



THE STUDY ON ROAD DEVELOPMENT PROJECT	
ROUTE	BATINAH HIGHWAY
TITLE	LANDSCAPE SEQUENTIAL SCENALIO THROUGH BATINAH HIGHWAY (Suweiq - Muscat)
SHEET NO.	2 / 2

7.2 Design Policy for Grade Separation Facilities

Grade separation for facilitation of through-traffic flow where the main highway and a local road intersect, is an issue which requires study to find the most effective solution.

Then, in this section we have studied the basic configuration, type of structure and comparative studies of the recommended type base on the Barka Roundabout. The Barka Roundabout is selected as a typical case to examine the type of flyover, because the 16 study roundabouts have almost the same alignment of ellipse with diameters of 140 meters and 80 meters.

7.2.1 Basic Type of the Grade Separation

The following three basic types of flyover roundabout intersections were considered:

i) To grade-separate through-traffic of the Batinah Highway by flyover or underpass.

ii) to grade-separate crossing road.

iii) to change roundabout type intersection into another type of interchange such as cloverleaf or diamond interchange.

Of the several types of interchanges, type (i) is recommended as the most preferred type for the following reasons:

① This configuration (Type i) above) allows the passage of the most traffic volume and will be the most effective.

② Grade separation type ii) is deemed inappropriate for developed or settled areas near roundabouts, as the residents would neither benefit from it, nor would it relieve traffic congestion significantly.

③ This type iii) of grade separation can be met by the trumpet, or the direct Y-type, and will require the grade separation by raising lanes for the main through-traffic in order to evade other traffic. On the Batinah Highway, the roundabouts have the role of evading other traffic, and after the grade separation, traffic into the roundabout will fall off, causing the land value to rise. It is for this reason that type iii) was not selected.

Recommended Basic Types of Grade Separation Facilities

Three alternative flyover alignments and one type of underpass to segregate through-traffic on the Batinah Highway were selected as follows; shown in Table 7.2.

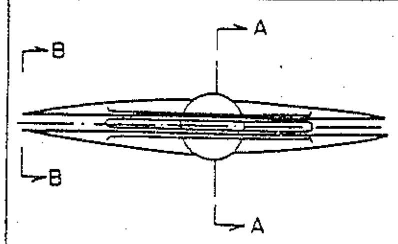
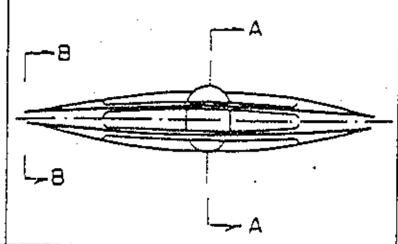
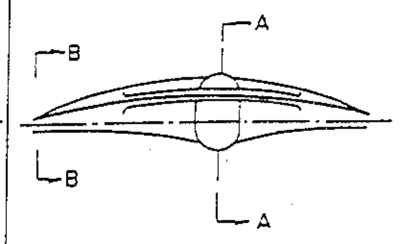
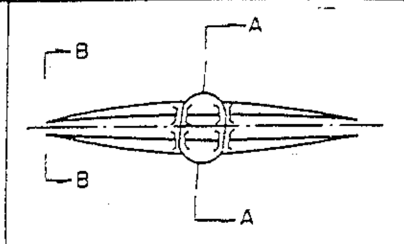
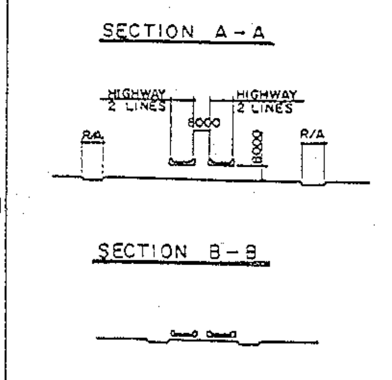
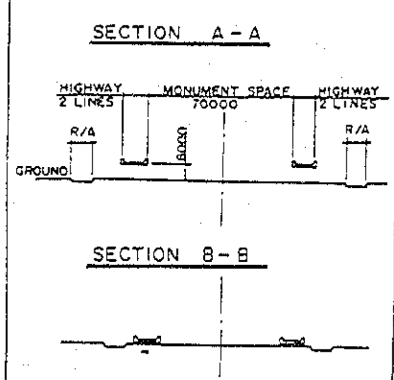
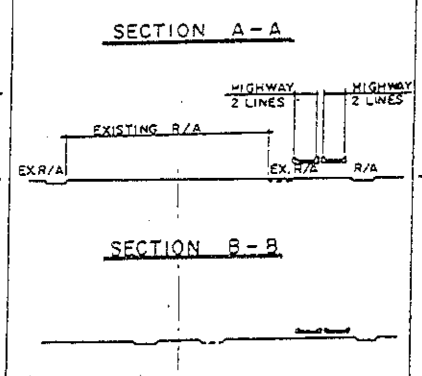
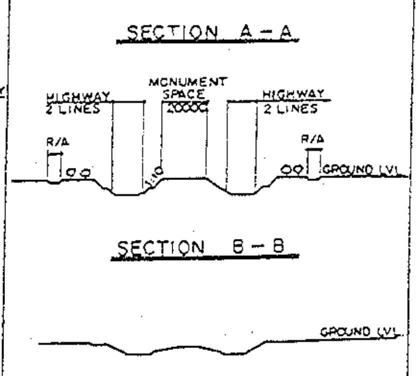
Type A: Straight direct connection of through-traffic lanes requiring removal of monuments at the central island of the roundabout.

Type B: The flyover structures are shifted to the edges of the roundabout to preserve the monuments.

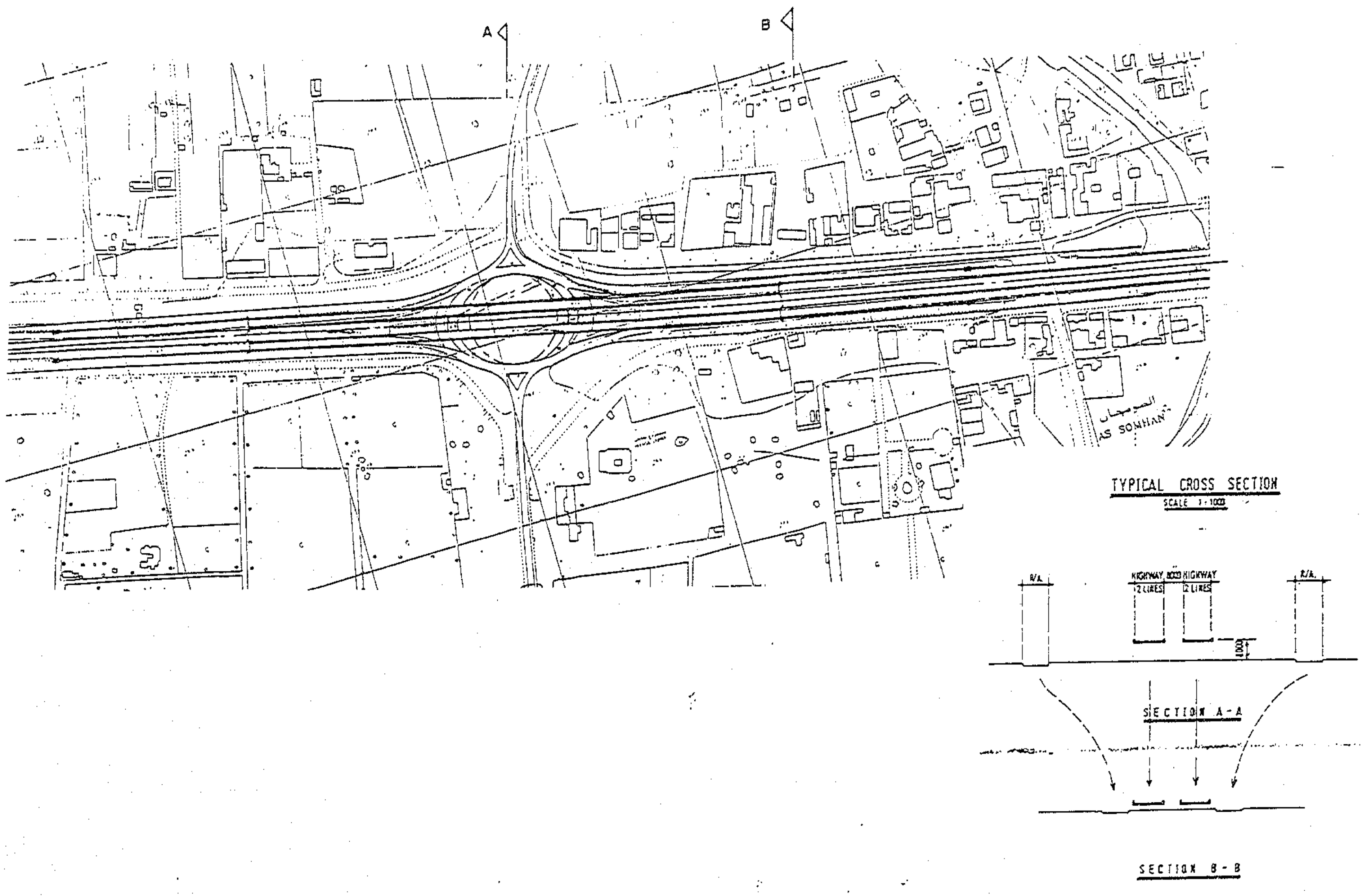
Type C: The flyover structures are shifted to one side of the roundabout to preserve the monuments.

Type D: Alignment is almost same as Type B, but approach is depressed type, and roadway of roundabout cross through traffic lanes by four bridges.

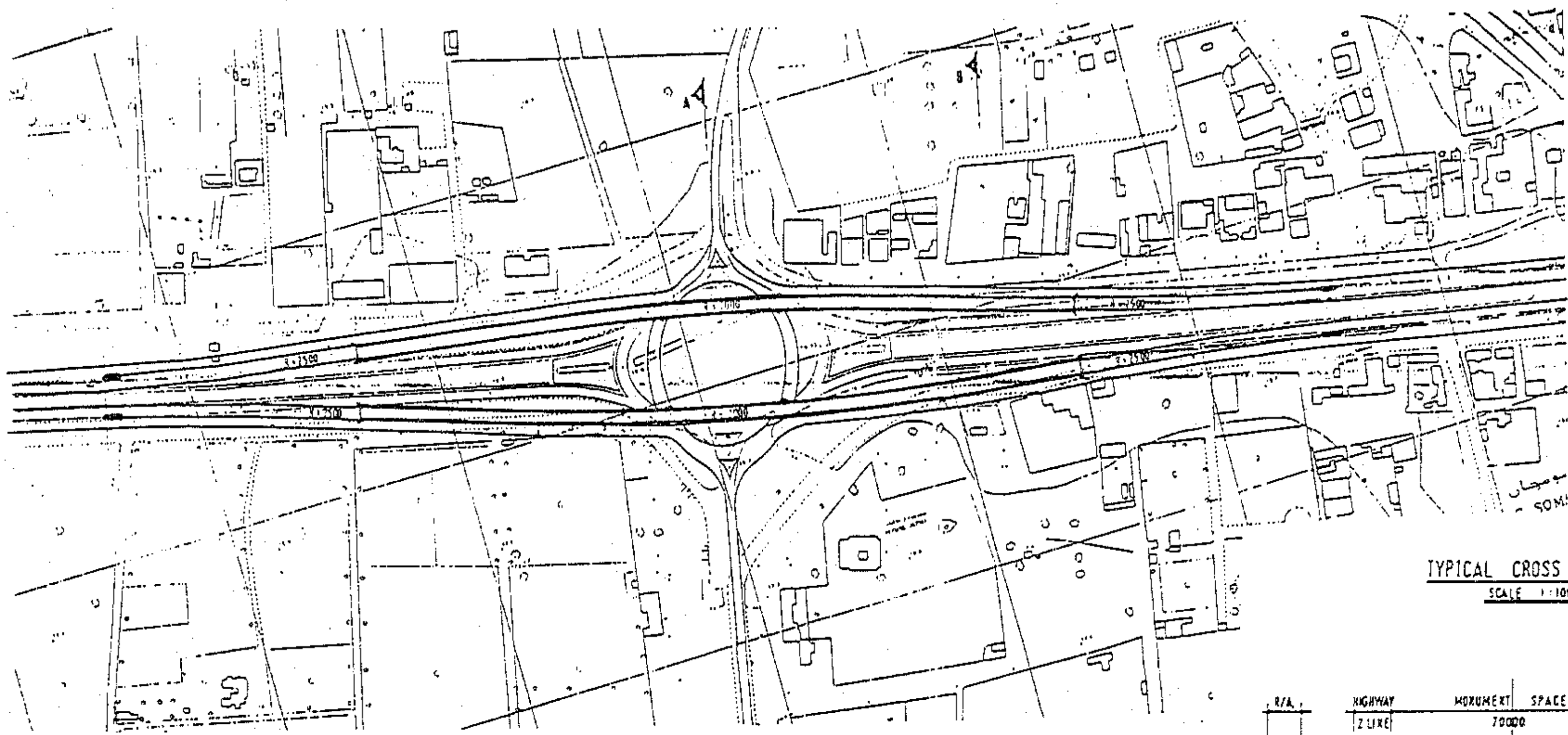
The above four types of alignments are shown in Figs. 7.2 to 7.6.

	TYPE A	TYPE B	TYPE C	TYPE D
SKETCH				
TYPICAL CROSS SECTION				
DESCRIPTION OF TYPE	Directly Connecting Through Roadway. Passing Center of R/A.	Flyover Shifted to Both Side of Edge of Existing R/A.	Flyover Shifted to One Side of Edge of R/A.	Alignment Same as Type B but Through Roadway to be Depressed.
RELATIONSHIP TO MONUMENT	Monument not Preserved.	Almost All Monument Preserved.	Flyover; Shifted to Preserve Monument.	Same as Type B

THE STUDY ON ROAD DEVELOPMENT PROJECT	JAPAN INTERNATIONAL COOPERATION AGENCY	Table 7.2 Comparison of Basic Types of Flyovers

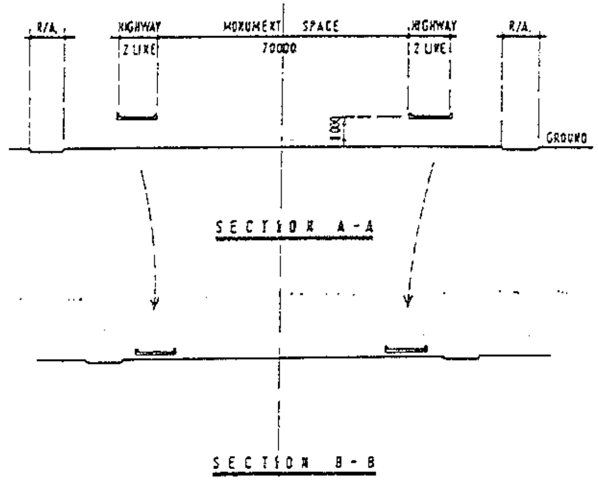


THE STUDY ON ROAD DEVELOPMENT PROJECT	JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 7.2 Type: A

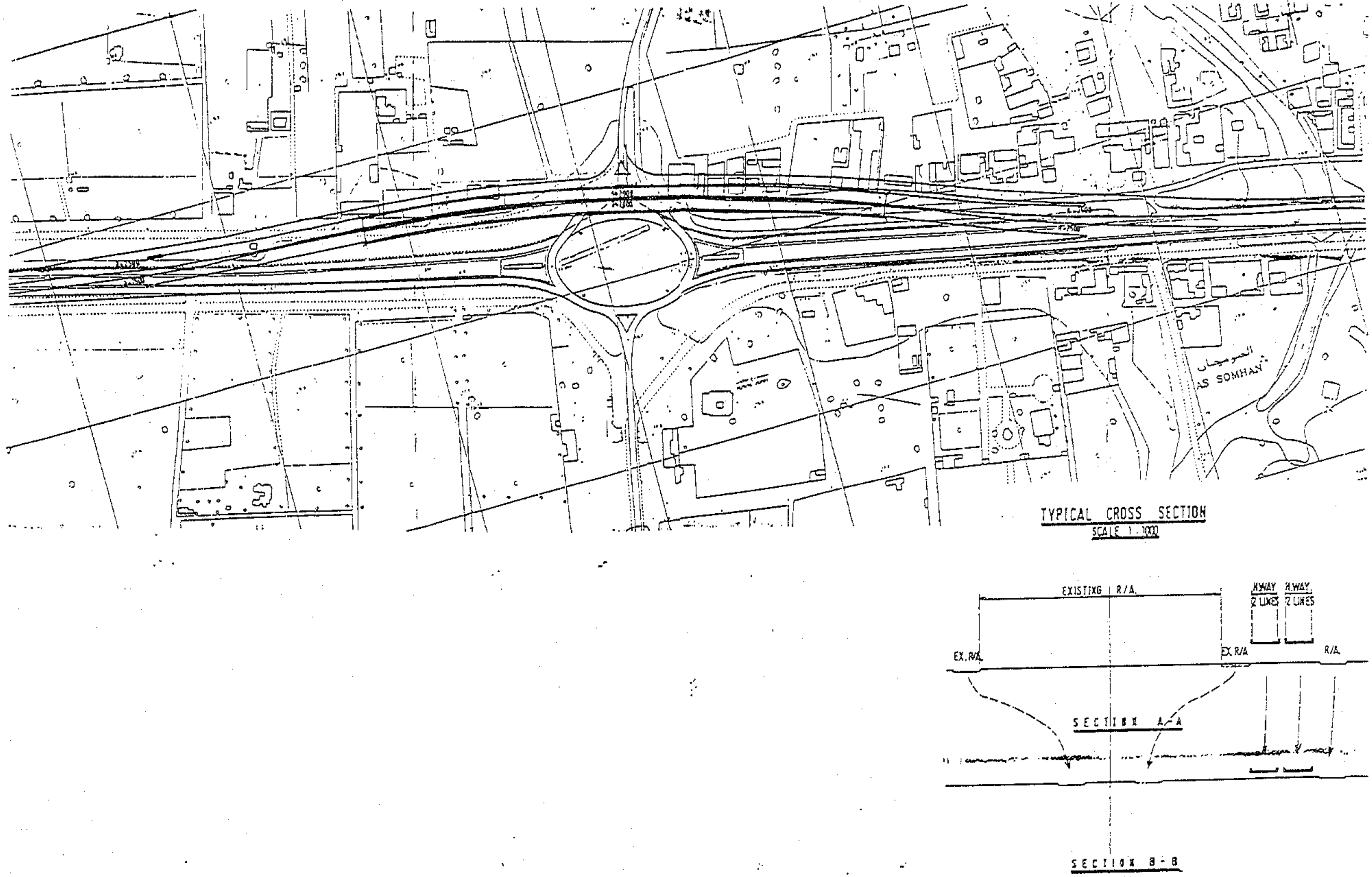


TYPICAL CROSS SECTION

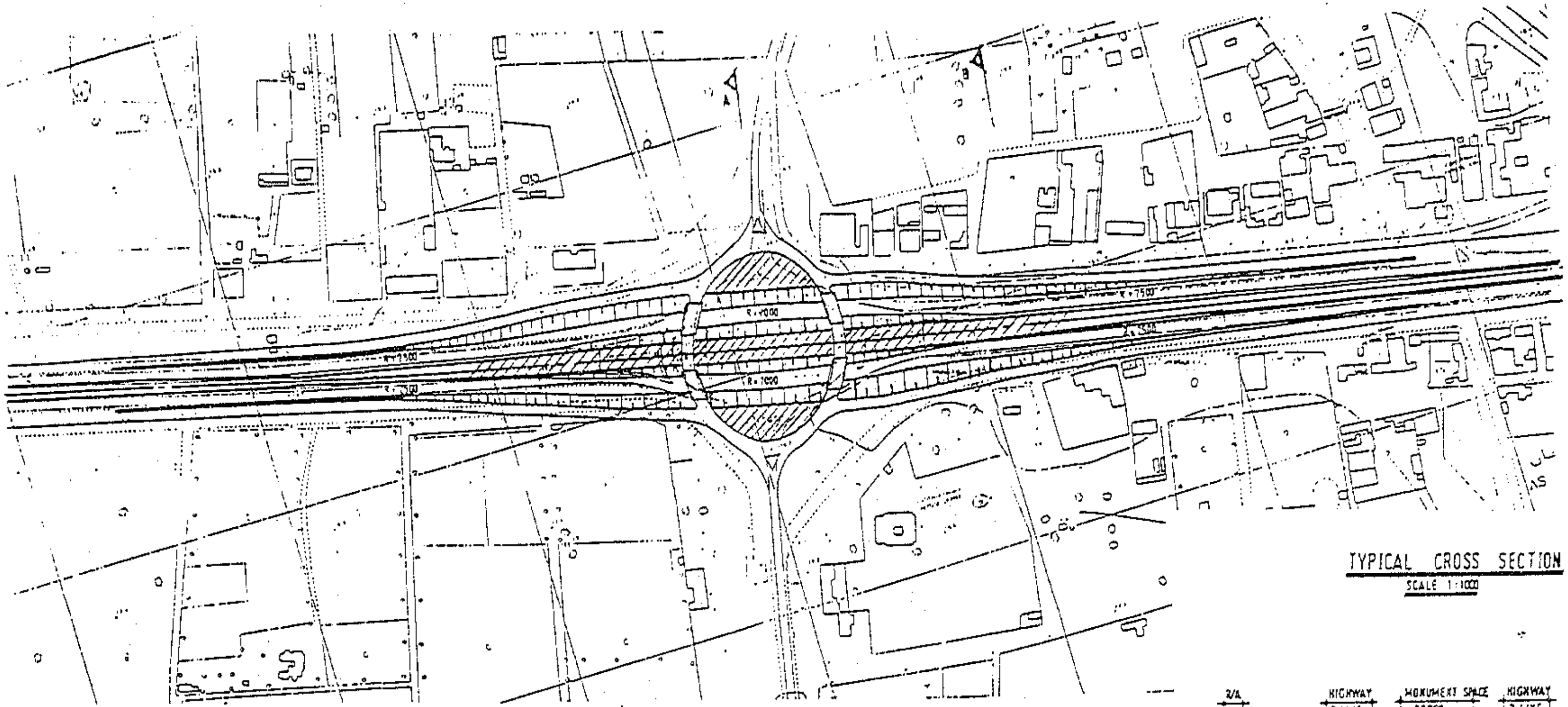
SCALE 1:1000

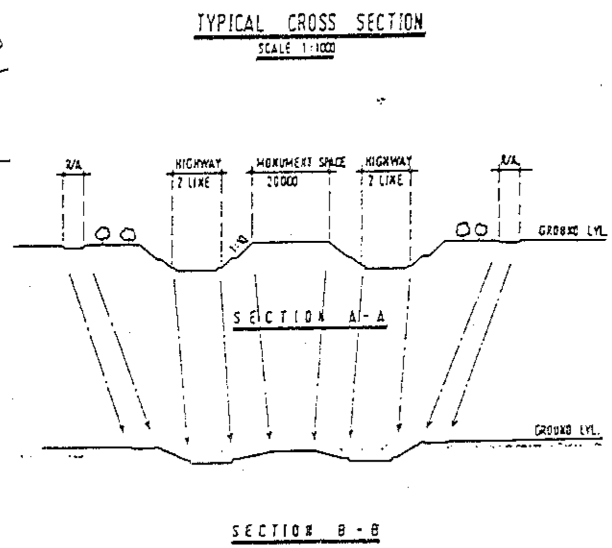


THE STUDY ON ROAD DEVELOPMENT PROJECT	JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 7.3 Type: B

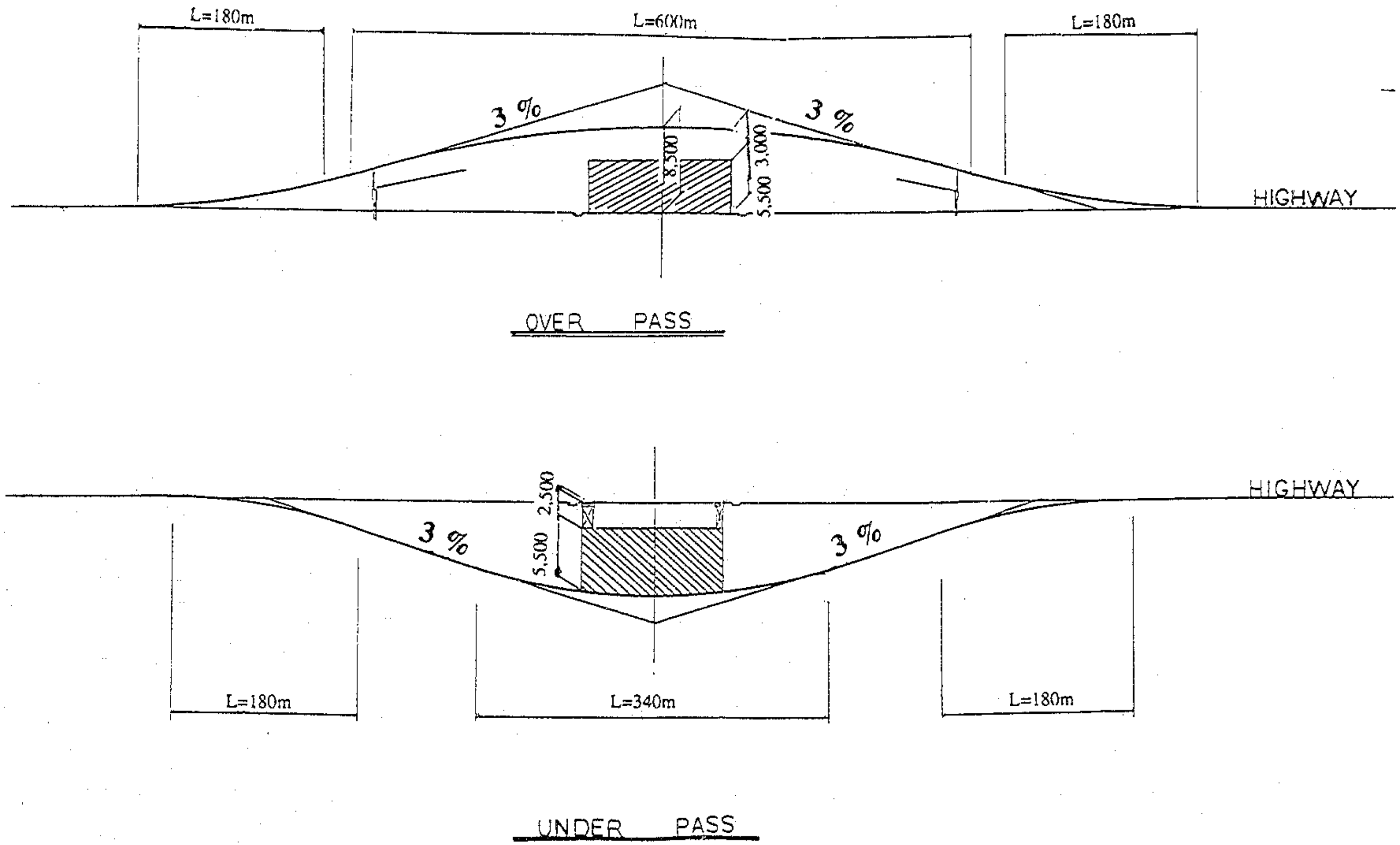


THE STUDY ON ROAD DEVELOPMENT PROJECT	JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 7.4 Type: C





THE STUDY ON ROAD DEVELOPMENT PROJECT	JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 7.5 Type: D



THE STUDY ON ROAD DEVELOPMENT PROJECT	JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 7.6 Vertical Alignment

7.2.2 Evaluation of Existing Monument Characteristics in Relation with Flyover

(1) Spatial Occupational Requirement for the Flyover at Roundabout and Junction

Proposed alignment of the flyover is aimed to pass over the area of roundabout and junction for facilitating through-traffic on the highway. The structural dimension of the flyover is 13.0 meters in width for each single carriage way, and in the case of parallel carriage type (Type-A and Type-C) of flyover, there is 8 meters interval distance between both sides of the carriageway in general. Therefore, 34 meters of width for the flyover structure will be required for either roundabout or junction area.

Besides width required for the flyover, space for the work road for flyover construction will definitely be necessary (10 meters width at both sides of the flyover carriage way) in the implementation period. Under such considerations, 54 meters of total width of aerial zone through the roundabout may be directly affected, and most of monument and landscaped objects in the roundabout would be physically affected during construction period.

On the other hand, flyover aligned around both sides of roundabout (Type-B) requires more space during the implementation period. That would be 10 meters additional space on both sides along each carriageway, therefore 33 meters width will be required. Therefore, for both carriageways, a total of at least 66 meters of width is required during construction from edge to edge.

(2) Scenic Disturbance Problems to the Roundabout Monument Affected by Flyover

Regarding scenic disturbance issues for the roundabout monument by the construction of flyover, proposed flyover structure has approximately a range of between 8 to 10 meters at the highest point above ground level. The major symbolic monuments are situated approximately in the range of 10 to 12 meters in height at center of the roundabout.

Under these circumstances, most of the symbolic monuments may be scenically affected by the flyover structure in similar height range. In most cases, flyover structure may give scenic blocking to the monument silhouette from the view point of observing on the vicinity ground level. Since each monument has been designed for local identity both to the vicinity area and for highway drivers, each monument has specific features performing as a landmark of the area.

Thinking in terms of landscaping, there are different design features between symbolic monument and flyover structure, therefore design continuity and harmony may be some what quite difficult features to be solved, unless some of monument familiar design elements may be involved to the flyover structure design.

Meanwhile, landscape objects of lower height, particularly plantings, will be in scenic competition with the flyover structure.

7.2.3 Basic Landscape Consideration and Criteria on the Monument of the Roundabout.

There are 18 roundabouts and junctions existing throughout Batinah highway and some of the areas have characteristic features with monuments. Some roundabout areas are awaiting future landscape development.

Concerning the evaluation on the monument and surrounding landscape condition through these 18 of roundabouts and junctions, 5 major classified categories may be proposed for the monuments on the roundabouts and junctions.

(1) Maximum Preservation of Existing Monument and Roundabout Landscape

Those monuments which have quite significant features with large solid structure and have aesthetically very important role to the surrounding landscape as vicinity landmarks, shall be considered as high priority for preservation.

Most of this type of monuments are located at areas where large townships or significant facilities are situated nearby the roundabout. These monuments themselves perform as landmarks and symbols of the vicinity identification. The view to the monument from each direction is quite important to the vicinity as well as to drivers.

Existing aesthetic conditions of these monuments at the roundabout should not to be disturbed with any structural obstacles, and whole scenic condition of the monument on the roundabout should be kept as it is now. So, flyover structure will not be exposed on the ground with any scenically disturbing object.

On the other hand, some monuments are large enough and the flyover is not so competitive proportionally to the monument in the visual sense. Flyover design should be considered harmoniously and uniform with the monument.

(2) Relocation and Layout Rearrangement of the Existing Small Monument

There are small-scale monument compositions and landscaping existing on some roundabouts. In certain areas, major monument components are positioned under the course of the proposed flyover structure. In such cases, these major monument components may need to be relocated from original place to another place without giving large functional impacts to the flyover structure.

The original location of these major monument components shall be shifted to another location within the roundabout, making a good adjustment on the basis of the original layout of the roundabout landscaping.

(3) Morphological Layout Adjustment on the Basis of the Existing Condition

Some roundabout areas have landscape composition with small size monumental elements and plantings. Under such a situation in a roundabout, the required space for the proposed flyover structure shall be obliged to disintegrate the original layout of the landscaping of the roundabout area.

In these cases, original layout shall be morphologically adjusted and original roundabout landscape design components shall be somewhat retained in order to maintain original design impression of the area.

(4) Reconstruction of the Roundabout Landscaping

For another case of landscaping composition on the roundabout with natural elements and plantings, the proposed flyover structure and adjustment of roundabout alignment shall require new configuration so that the existing area will have scenic continuity of the original landscaped form.

In these cases, whole landscape original layouts shall be reconsidered, and new landscape development layout designs shall be proposed. The new