ENGINEERING STUDY

CHAPTER 6 TECHNICAL SURVEY AND ANALYSIS

6.1 Present Condition of Roads and Utilities in Irbid

6.1.1 Existing Road Network in Irbid

The existing road network in Irbid is shown in Figure 6.1.

According to the Municipality of Irbid, the total length of roads in the municipality was approximately 130 km as of March 1981, and about 15% of the total road network is unpaved gravel road. Most arterial roads in the City which are part of the national road network are radial roads passing through the centre of Irbid.

These national roads are Route 11 and Route 16 (primary roads) and Route 23 (secondary road) as presented in Figure 6.1.

- Route 11 is linked with Route 15 at about 17.4 km southwest of Irbid and consists of two lanes with a small section in Irbid City consisting of four lanes. Route 11, between Zarqa and Route 15, classified as a rural collector road, is newly under construction.

- Route 16, an east-west road, connects Irbid City with the Jordan Valley in the west and Mafraq in the east towards Baghdad. It consists of two lanes, with a small four lane section in Irbid City.

- Route 23 is the main road from Irbid to the northwest. It connects the City with the Yarmouk River to the north and Ajlun to the south and consists of two lanes. However, 2 km of this road in the City is used as a one-way road, because of its narrow width.

- Hashimi Street is Irbid City's broadest street and passes through the centre of the City in an east-west direction, dividing the City into northern and southern parts. More than half the street consists of four lanes and an extension of 300 m on its eastern part is now under construction.

- Radial Roads : one is Bishra Road, 6 m in width, in the east towards Bishra and is about 50 m south of Hashimi Street (to which it runs parallel) and the other road is in the northwest towards Tugbul.

- Inner Ring Road : the Inner Ring Road is located at about 1.0 to 1.5 km from the City centre.

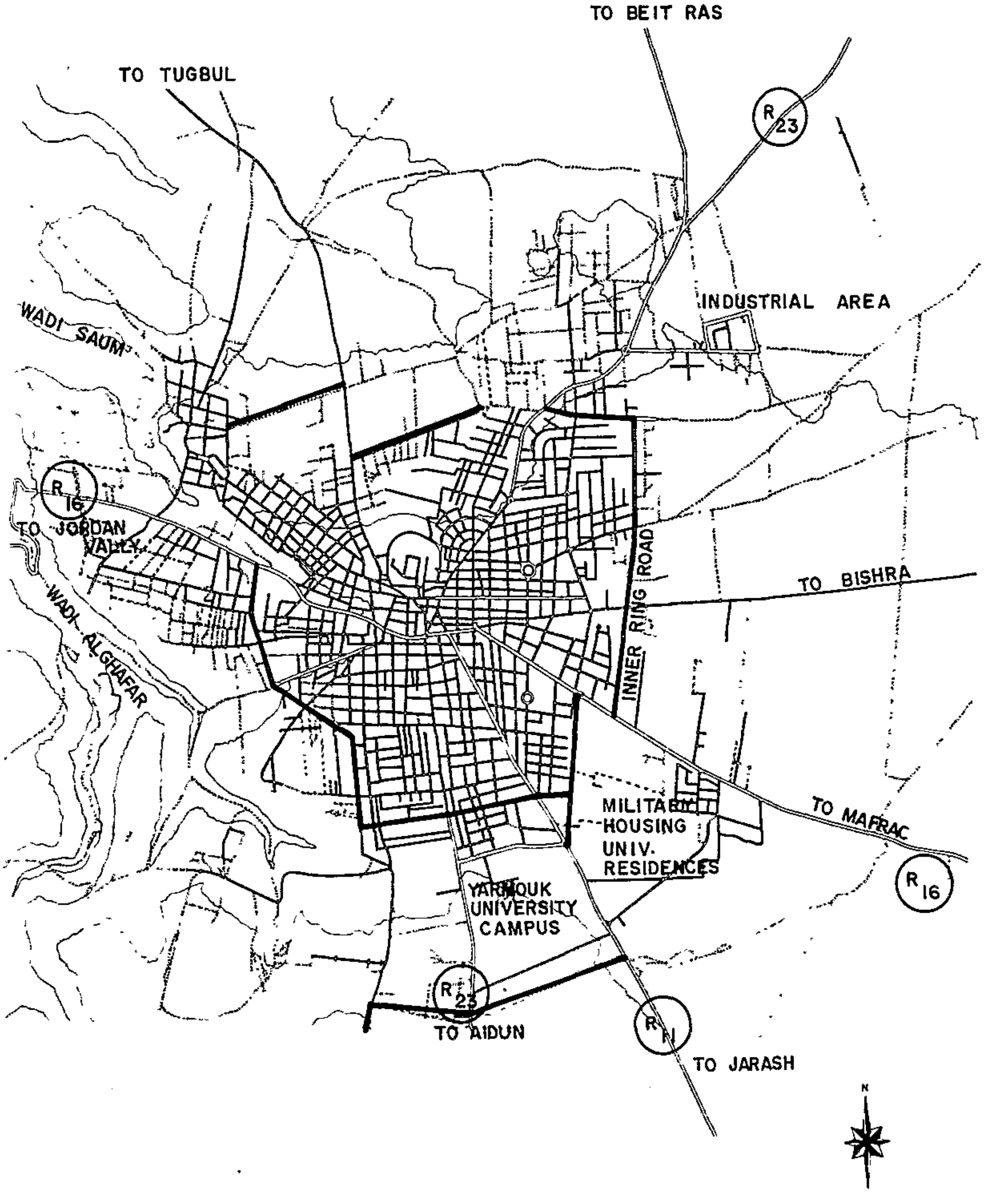
  The total length of the Inner Ring Road is about 8 kms, of which 4.3 km of the south-west section and southern section is open to traffic; 2.5 km of the eastern section is now under construction. The right-of-way of the eastern section will be 30 m in width and will be used as a dual carriageway.

- The Inner Ring of the eastern section, planned by the Municipality, does not smoothly link up with Mafraq at the intersection of Route 16. At present, the Inner Ring Road is not joined at its north-west section, and construction has been stopped, due to it being an established residential area. Consequently, a large amount of compensation must be paid to residents in order to obtain a right-of-way and to resume construction. About 400 m. in the northern section between Route 23 and the road to the north of the refugees area has been planned to be constructed by Irbid Municipality.

- Just a small part of the Boundary Ring Road (500 m. in the southern part and 200 m. crossing Wadi Saum in the eastern part) are now under construction.

- Traffic signals are installed at two intersections of the main road in the CBD. Most of the intersections in Irbid City are rotary system intersection type.

Fig. 6.1 ROAD NETWORK IRBID, 1980



0 1 2 KM

6.1.2 Planned Road by Irbid Municipality

Irbid City is developing towards the south, east, north and northwest directions where re-adjustment of agricultural lands to be assigned as residential areas has been planned since 1970 by Irbid Municipality. According to the Irbid Municipality, the arrangements have been settled with the land owners.

Development is physically limited in the west and southwest by steep wadis which drain eventually into the Jordan River. The City is located in the rolling countryside, in and near Wadi Zabada, Wadi El-Ghafar, Wadi Tariq Saum, and Wadi el-Hamam.

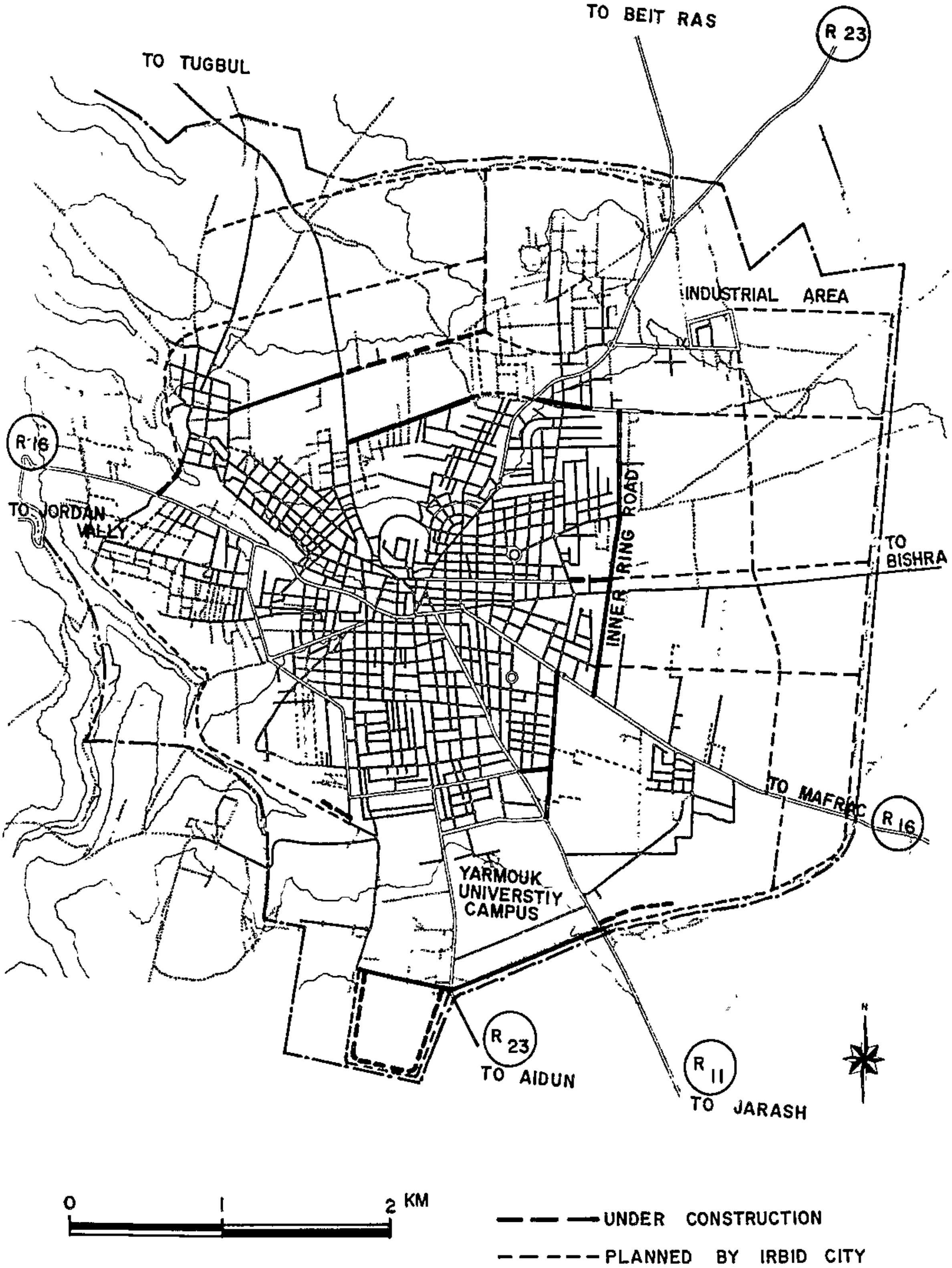
Ring Roads have been under study since 1970 by the Municipality of Irbid, as a part of the City planning activities.

All main roads have a right-of-way width of about 20 - 30 m., and their interesections are rotary system type, especially the main intersections.

- Small Ring Roads around the Central Business District (C.B.D.) of 1.0 km diameter, were planned in 1972 by Irbid Municipality; however, it was abandoned since it requires large compensation for the removal of people now residing on the right-of-way.
- All roads have been planned inside the boundary of Irbid City. Taking future expansion towards the northeast and southeast of the city and traffic requirements into consideration, it is recommended that a road network should be planned there.
- Planned Boundary Ring Roads in the eastern part do not smoothly link up with the intersection of Route 16 and with the part from the existing industrial area to Route 23.

  In order to have smoother a road network, it is recommended that route alignment should be revised, and the intersection of the Boundary Ring Road with the Hashimi Street should be planned as a channelized intersection.
- Hashimi Street is a wide road having four lanes; it has been planned as a connecting road for three ring roads and is planned to be further extended to Ramtha via Bishra in accordance with the city expansion.

Fig. 6.2 PLANNED ROAD NETWORK



SOURCE : MUNICIPALITY OF IRBID

6.1.3 Potable Water, Sewerage and Stormwater Drainage System

(1) Potable Water Distribution

Presently, the Municipality of Irbid purchases most of its water from the Water Supply Corporation (WSC). WSC obtains the water from wells and springs in the Azraq, Dhuleil, and Sammaya areas which are approximately 60 to 100 km west and south of Irbid.

The Municipality of Irbid maintains pumping stations at two springs as water supply sources. These springs are located at Rahoub and Khreiba, 10 km northwest and 12 km north of Irbid, respectively.

(2) Sewerage

Existing sanitary sewers in the City of Irbid consist of 500-mm diameter pipe having a total length of approximately 600 m. The sewers presently discharge into the box culvert that has been constructed as part of the storm drainage system in the Wadi Tariq Saum drainage area. Waste water from these sewers flows untreated into the stormwater culvert, and then into the Wadi Tariq Saum.

All other domestic and commercial sewage is collected and disposed of in cesspools or septic tanks. Cesspools provide a rudimentary level of treatment. They collect most of the heavier colloids, and allow the liquid portion of the waste water to flow into the ground. This liquid waste water either eventually reaches the groundwater, or returns to the surface.

(3) Storm Water Drainage

There are two hydrologic basins with storm water drainage networks serving the Municipality of Irbid. Both are in the upper water-sheds of the Wadis el Hamam and Tariq Saum. The existing network in Wadi Tariq Saum flows east to west, and is located along and just south of the Palestine Road.

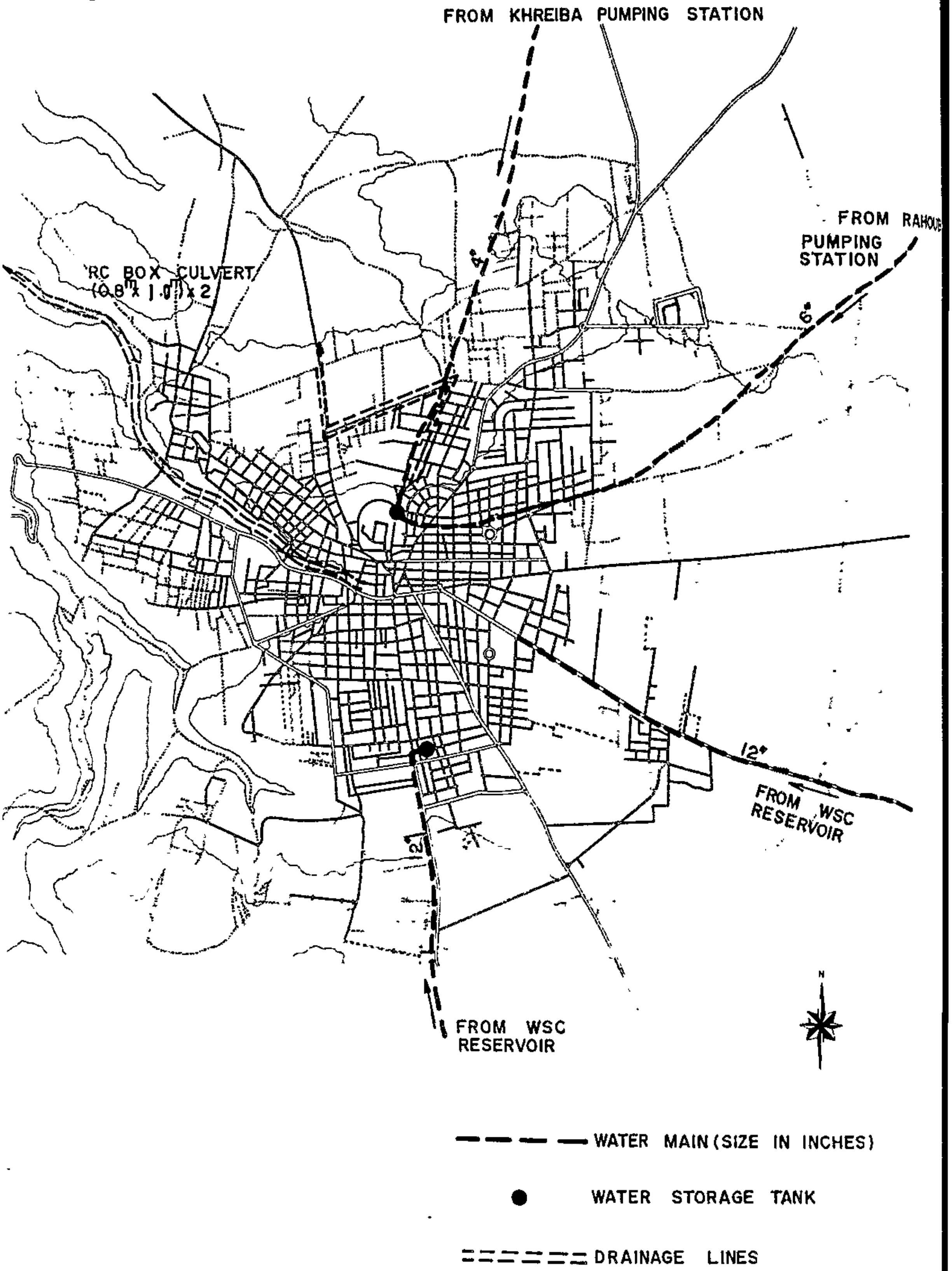
Recent expansion of the municipal storm water collection system has included a major extention of the Wadi Tariq Saum network to the downstream City boundary, and a consolidation of the lower network in Wadi-el Hamam. Large parts of these networks receive sanitary waste water flows.

In the Wadi Tariq Saum basin, (0.8 m x 1.0 m) x 2 reinforced concrete box culvert is located.

Jerusalem Street is a new road (under construction) that crosses Wadi Tariq Saum, and is on the western boundary of the planning area. Two reinforced concrete box culverts (3 m x 3 m) are located under this road which crosses Wadi Tariq Saum.

Existing potable water, sewerage and storm water drainage systems are shown in Fig. 6-3.

Fig. 6.3 WATER SUPPLY AND DRAINAGE LINES



6.1.4 Common Ducts

Common ducts enclose the distribution lines of public utilities systems such as electricity, water, and telecommunication that are installed in a single box culvert laid underground along streets.

In Irbid district, electricity, water and telecommunication systems are the responsibility of the Jordan Electric Authority (JEA), Water Supply Corporation (WSC) and Jordan Telecommunication Corporation (JTC), respectively.

At the present time, the concerned agencies have no idea to construct the common ducts.

Conditions or criteria for the construction of common ducts generally are as follows:

- All concerned agencies should hold a conference to olan a mutually agreeable location for each distribution line.
- It is often more efficient if all distribution lines be installed at the same time.
- Box culverts (2.0 m height x 1.5 m width) should be constructed one meter below the surface.

  Construction cost will be approximately JD.180/m.
- Usually, the construction cost is shared with the concerned agencies.

Since there is enough land space for public utilities along streets due to the 30 m of right-of-way and construction costs of box culverts is high, it is recommended that public utilities in this project be installed individually.

6.2 Material Survey

6.2.1 Aggregates

A large quantity of aggregate is prepared by the crushing method, from the approximate 275 quarries in Jordan from which crushed aggregate is produced. The aggregate is used in concrete, asphalt mixes and road bases.

In addition, there are 16 sand sites and 72 rock sites, from which building stones can be obtained.

The aggregate quarries are distributed all over Jordan as follows:

Amman 155, Balqa 14, Irbid 56, Zarqa 19, Karak 5, Mafraq 8, Madaba 4, Aqaba, Taflla and Ma'an 14.

About 6×10^6 m^3/year of crushed aggregates are produced from these quarries. The amount of crushed aggregate meets the demand in Jordan.

(1) Various Kinds of Aggregates in Jordan

a) Valley Aggregate:

This was formed by the sweeping away of rocks from the mountains, follwed by sedimentation in the valleys or low regions.

This is found in the Al Ghour valley region, Ma'an, Modawwara and Zarqa valleys.

This kind of aggregate has the following characteristics: good gradation, high specific gravity, low water absorption and good resistance to wear either by attrition or abrasion.

b) Granite Aggregate:

This kind of aggregate, which has several colours, is found in Algatam Valley, Aqaba and south of Ma'an. It has these characteristics : good resistance to wear either by attrition or abrasion.

c) Volcanic Stone:

It is found in Mafraq and Wadi Dulail. It has the characteristics of low resistance to abrasion and attrition and low specific gravity. Therefore, it is used for light weight concrete.

d) Hard Basalt Aggregate:

This kind of aggregate, which is dark in colour, is found in Mafraq and the Jordanian/Iraqi border. It is characterised by a high specific gravity and low water absorption.

e) Limestone Aggregate (Calcium Rock):

This kind of aggregate is found in various regions and is widely used in Jordan, but its characteristics differ according to the quarries; some is good and others are bad.

f) Fine Aggregate:

There are two kinds of fine aggregate in Jordan, one is obtained from the mountains, the desert and the river bed. This is used for concrete and asphalt concrete. The other is from the crushing plants.

(2) Quarries in Irbid Region

The kind of aggregate in Irbid Region is a limestone aggregate. There are 56 quarries in this region, with a production capacity of 14,350 m^3/day. That supplies all usage in Irbid, Jerash, Ajlun and Ramtha, according to the investigations of the Building Materials Research Center of the Royal Scientific Society.

These quarries are shown as follows :

Name of Quarries	No. of Quarries	Production Capacity (m^3/day)
Husn	30	8,850
Wadi Alghafar	13	2,200
Al Sammouh	5	1,100
Zabda-Farkouh	4	0,900
Jerash Region	4	1,300
Total	56	14,350

Source : Royal Scientific Society.

6.2.2 Steel Bars

Steel bars are manufactured in Jordan from ingot which are imported from West Germany, Spain and other countries. Manufactured steel bars in Jordan amounted to 86,000 tons in 1980, but this quantity does not meet all the demand. About 20,000 tons of steel bars has to be imported from India, Spain, Italy and other countries.

The production of steel bars in Jordan is shown as follows:

	1976	1977	1978	1979	1980
Tons	62,379	63,819	65,289	80,961	86,173

Source : Department of Statistics.

Two factories are now manufacturing steel bars in Jordan: one is the Jordan Steel Industry, which produced 53,000 tons per year, the other is the Arab Steel Company, which produced 33,000 tons per year.

It is expected that the National Steel Company will be in operation at the end of this year.

Steel bars have 13 kinds of diameter sizes ranging from 8 m/m to 32 m/m, in 2 m/m intervals except the 28 m/m size and they are classified as round bars (8 m/m to 10 m/m) and deformed bars (10 m/m to 32 m/m).

The yield tensile strength is 3,700 Kg/cm^2, therefore, an allowable tensile strength of 1,200 Kg/cm^2 is used in the design. Usually, round bars are only used for stirrups in Jordan.

6.2.3 Asphalt

The Jordan Petroleum Refinery Company is now producting 500 tons of asphalt per day (maximum production capacity of asphalt is 650 tons per day) from crude oil imported from Saudi Arabia. Domestic demand in 1980 was 400 tons per day in summer (April - November) and 250 tons per day in winter (December - March).

About 20,000 tons of asphalt per year is exported to Iraq.

The various kinds of asphalt are asphalt cement of 60/70 and 80/100 penetration grade, and cut-back asphalt MC-70, RC-250 and RC-800.

The two contractors with asphalt mixing plants with a maximum capacity of 250 tons per hour each, are operating in Husan, 11 km to the south of Irbid City.

6.2.4 Cement

Cement is produced in Jordan by the Jordan Cement Company in Fuheis. A quantity of 912,700 tons of both white and Portland cement were produced by this Company in 1980. However, an amount of 200,000 tons of cement was imported from Greece, Korea, Lebanon and Cyprus during the same year to meet the domestic demand.

Production of cement in Jordan is shown as follows:

	1976	1977	1978	1979	1980
1,000 tons	582.4	537.6	553.0	623.2	912.7

Source : Department of Statistics.

6.2.5 Cost Index of Construction Materials

The cost index of construction materials, fuels and living index are shown as follows:

	1975	1976	1977	1978	1979	1980
Construction Materials	100.0	124.4	131.1	141.3	154.5	189.0
Fuels	100.0	109.9	115.2	121.1	161.1	299.6
Cost of Living	100.0	111.5	127.7	136.6	156.0	173.3

Source : Department of Statistics.

The highest cost increase compared with other items was the increase in fuels and construction materials. These items went up by about 86 and 22.3 percent respectively during 1980, compared to only 33 and 10 percent in 1979.

The cost of construction materials is described in Chaper 9, 'Construction Cost Estimate'.

According to the Royal Scientific Society's report on Jordan's economy (September 8th, 1981), a reasonable inflation rate would be 11 to 14 percent, judging from three indices used this year by the Department of Statistics as follows:

1) Cost of living index 11.1%

2) Ministry of Supply's retail price index of principal consumer goods 12.5%

3) Central Bank wholesale price index 14.1%

6.3 Soils and Aggregate Investigation

6.3.1 Summary

Irbid is located on a plateau which inclines from southeast to northwest. Along the western ridge of city, facing wadi-cut valleys, the topography is steep.

The bedrock is Cretaceous limestone covered with Alluvium a few meters thick. The eastern part of the Ring Road are in a thick topsoil area; western part is in rock area.

The characteristics of soil of test pit sample is shown in table 6.1. All the soils are clayey. According to AASHTO specification, all soils are classified as A-7-5 with Group Index 14-47. Therefore it use as subgrade is not so good. CBR values of half of the soils are less than 3%. From compaction testing, the natural water content was found to be approximately equivalent to optimum water content or within 10% towards the wet side of optimum water content. Hence, it seems to be possible to compact soil materials to about optimum water content by means of drying during road construction.

Table 6.1 Characteristics of Soil Pit Soils

Passing percent of #200 SIEVE		(%)	58 - 96
Liquid limit	LL	(%)	65 - 81.5
Plasticity index	PI		26.5 - 38.1
Classification			A-7-5
Group index	GI		14 - 47
Specific gravity	Gs		2.601 - 2.804
Natural water content	Wn	(%)	20.2 - 34.7
Wet density	γt	(g/cm^3)	1.522 - 1.671
Void ratio	e		0.975 - 1.283
Degree of saturation	Sr	(%)	55.0 - 78.0
Maximum dry density	γdmax	(g/cm^3)	1.470 - 1.652
Optimum water content	Wopt	(%)	18.6 - 26.7
CBR		(%)	1.89 - 4.19

At the bridge abutment, support rock appears - 7m below ground level at MB - 1 and appears within - 1m at MB - 2. Both are stable rock.

The western part of the Road is in a rocky area. Therefore it will be necessary to use blasting or rock breakers. However, there are many cases where the routes is near houses, so it is expected that blasting will be restricted. It is possible to cut rather steep rock slopes along these routes. To guard against falling rocks it will be necessary to install some revetment depending on exfoliation ofthe surface.

The proposed quarry sites for coarse aggregates are Wadi El Chafar on the western margin of Irbid and Husn, 9km South from Irbid. Husn will be the main quarry site because it seems that El Ghafar may have production difficulties for large quantities in the future.

There is no quarry site for fine aggregate near Irbid. If such are required, fine aggregate must be carried from a site near Amman. For the fine aggregate of earthworks, it is advantageous to use crushed rock which is control graded at quarry sites.

6.3.2 Introduction

This report contains the results of geological investigations along the planned routes and studies on the properties of aggregates.

Excavating of test pits, testing for density in-place and sampling for laboratory tests were conducted along planned routes. At bridge sites, machine boring and standard penetration test were performed.

In the laboratory testing of soils which were sampled at the planned routes, and testing of aggregates which were sampled at quarry sites near Irbid were conducted.

The details of sampling are shown in table 6.2.

Table 6.2 Details of Sampling

Bore Hole (Mechanical boring = 12m)

	Samples taken
Standard penetration test	4
Test Pit	
Field density Sampling	4 10

Laboratory Test

		Samples taken
Soil	specific gravity	10
	moisture content	10
	particle size analysis	10
	liquid limit	10
	plastic limit	10
	compaction	10
	CBR	10
Aggregate	specific gravity and absorption	2
	sieve analysis	2
	soundness	2
	resistance to abrasion	2
	flaky and elongated pieces	2

6.3.3 Method of Investigation

Almost tests conformed to AASHTO TESTING METHOD except for visual observation at the test pits.

Specifications consulted are as follows:

- Test for density of soil in-place — AASHTO T 191
- Penetration test and sprit-barrel sampling of soils — AASHTO T 206
- Specific gravity of soils — AASHTO T 100
- Moisture content of soils — ASTM 2216
- Particle size analysis of soils — AASHTO 88
- Determining the liquid limit of soils — AASHTO 89
- Determing the plastic limit of soils — AASHTO 90
- The California bearing ratio — AASHTO 193
- Specific gravity and absorption of coarse aggregate — BS 812
- Sieve analysis of fine and coarse aggregates — ASTM C 136

• Soundness of aggregate by use of sodium sulfate	ASTM	C 88
• Resistance to abraision of small size coarse aggregate by use of the Los Angeles machine	AASHTO	T 96
• Percentage of flacky and Elongated pieces in coarse aggregate	BS	812

6.3.4 Outline of Topography and Geology

(1) Topography

Irbid is located on a plateau which inclines from southeast to northwest. Wadi Beit Ras, Wadi Soum, Wadi Zabdah and Wadi El Ghafar are located from the northern border to western and east boarders where mountains are steepest. A flat area which is slightly rolling spreads over the central and eastern parts of the City.

Therefore the Outer Ring Road and eastern part of the Boundary Ring Road pass through flat areas. The western part of Boundary Ring Road passes through the shoulder of a mountain slope located on the western edge of city.

(2) Geology

In Irbid the basement is Cretaceous limestone covered with Alluvium which is a few meters thick. Moreover, in some areas, chalk of Tertiary and basalt of Quaternary exist.

Limestone is found plentifully along Wadi Zabdah located at the western foundary of the City. In many cases, the limestone is silicified and accompanied by chert and marl.

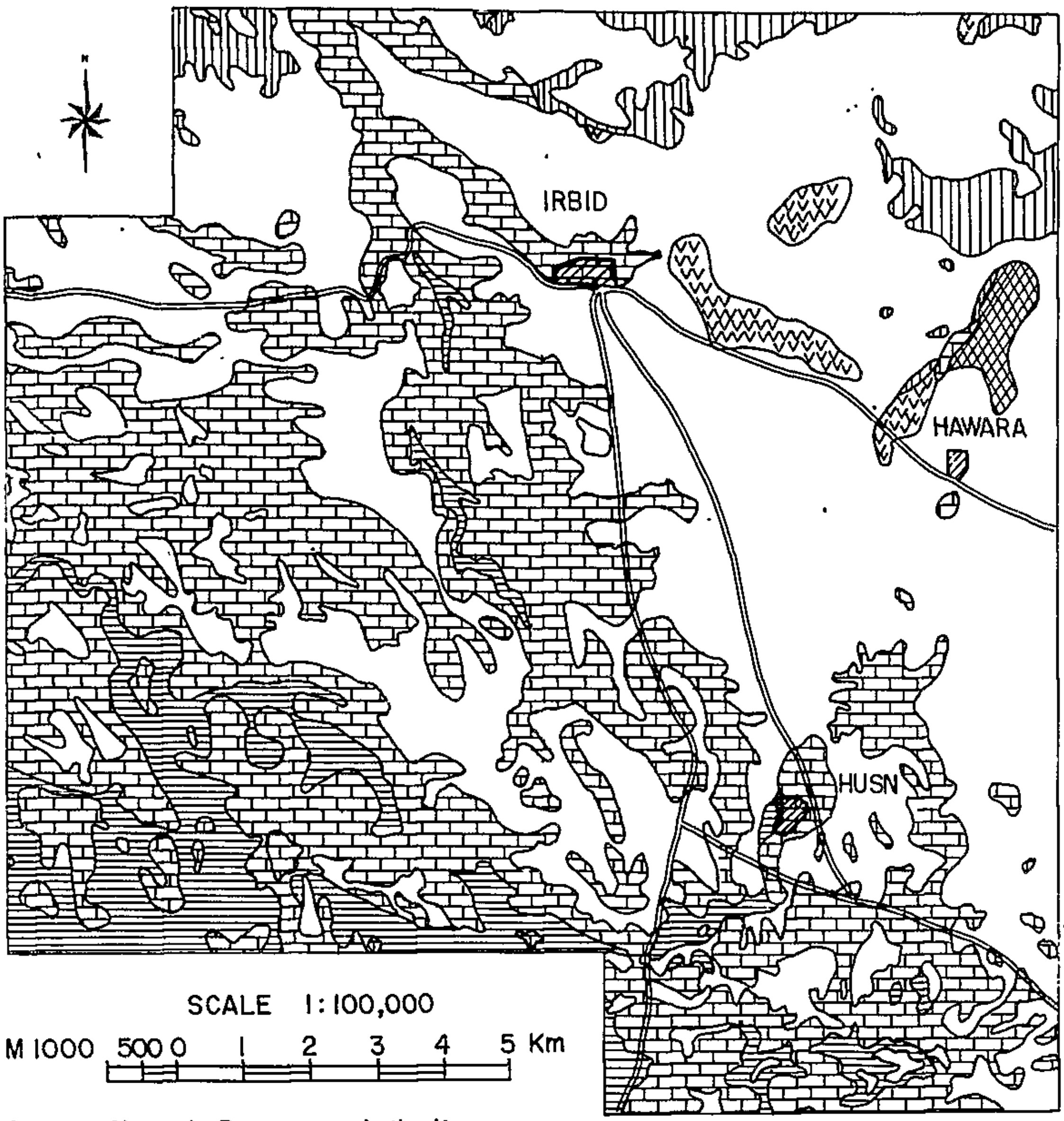
Chert, which is light grey and a little soft, is distributed on a small scale at the northern border of the City.

Basalt is distributed at the eastern edge of the City and under the plateau surface although there is no outcrop.

Limestone is also distributed in Husn where a quarry site is located.

Alluvium, covering the above-mentioned rocks, is reddish brown or dark brown clayey soil accompanied by gravels. There are numerous cracks

FIG. 6.4 GEOLOGICAL MAP



SCALE 1:100,000

M 1000 500 0 1 2 3 4 5 Km

Source : Natural Resouces Authority

Age	Group	Formation
PLEISTOCENE – RECENT		Soils and Alluvia
		Basalt
	Plateau Gravel	Undifferentiated
PALEOCENE – EOCENE	Belge	Lower Chalk
UPPER CRETACEOUS		Lower Silicified Limestones
	Ajlun	Upper Limestones

caused by drying shrinkage on the surface of the ground.

The whole distribution of geological formalious is shown in figure

6.3.5 Investigation along Planned Routes

(1) Geology

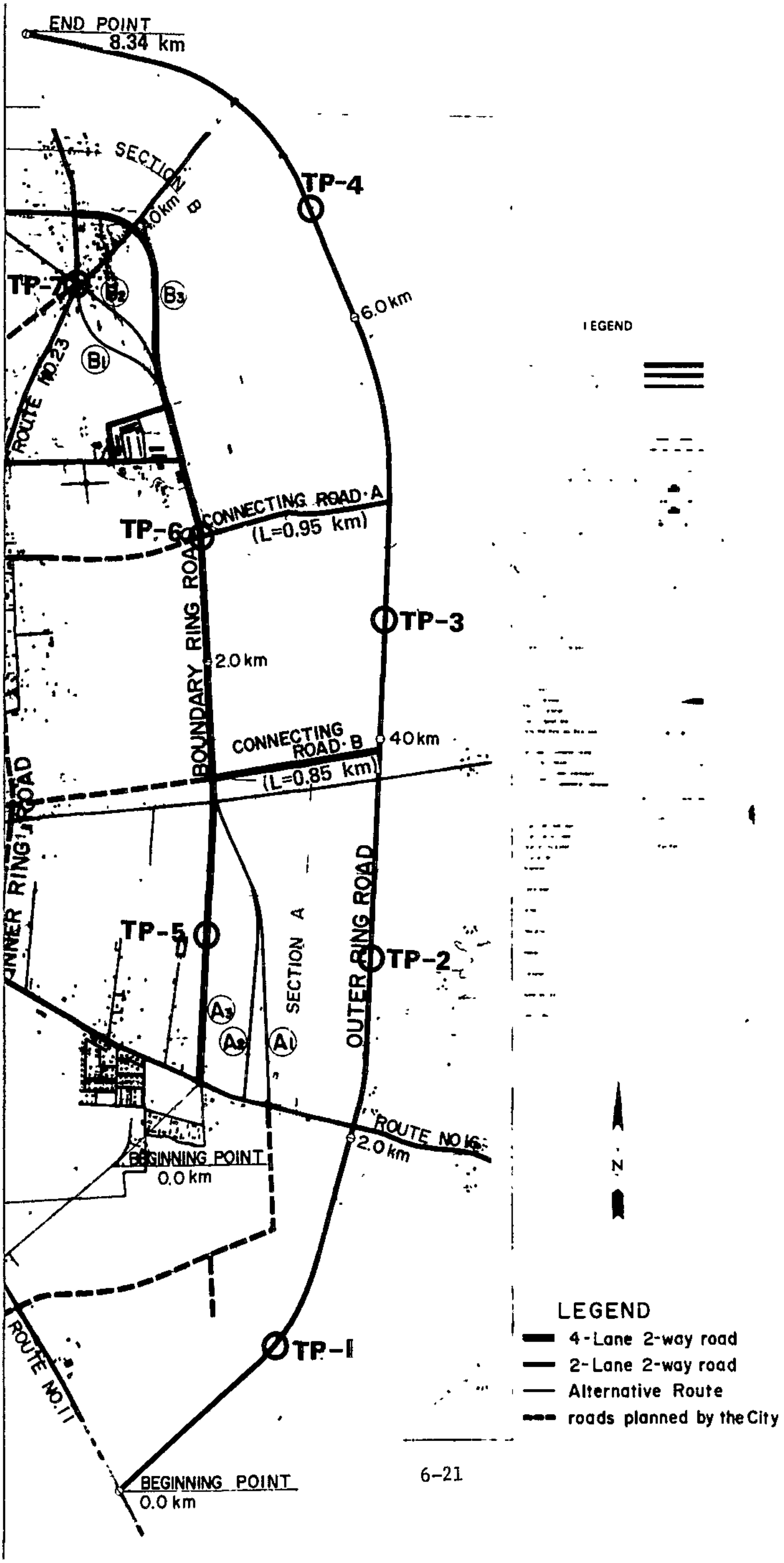
The study along planned routes consisted of subgrade investigation at earthworks part and foundation investigation at bridge site. The study sites are shown in figure 6.5.

As mentioned before the clayey soil covers the bedrock in the eastern part of the routes on the plateau but in the western part, facing wadi-cut valleys, the rock areas along the route are frequently exposed.

Cleyey soil is reddish brown or dark brown and accompanied by gravels 10 - 50 mm in diameter. The soil near surface is solid to drying. However, the deeper soil more than 0.1 - 0.2 m retains moisture and is plastic. Many cracks, 0.5 - 4 cm in width, caused by drying shrinkage are observed on the surface to about 1 m depth.

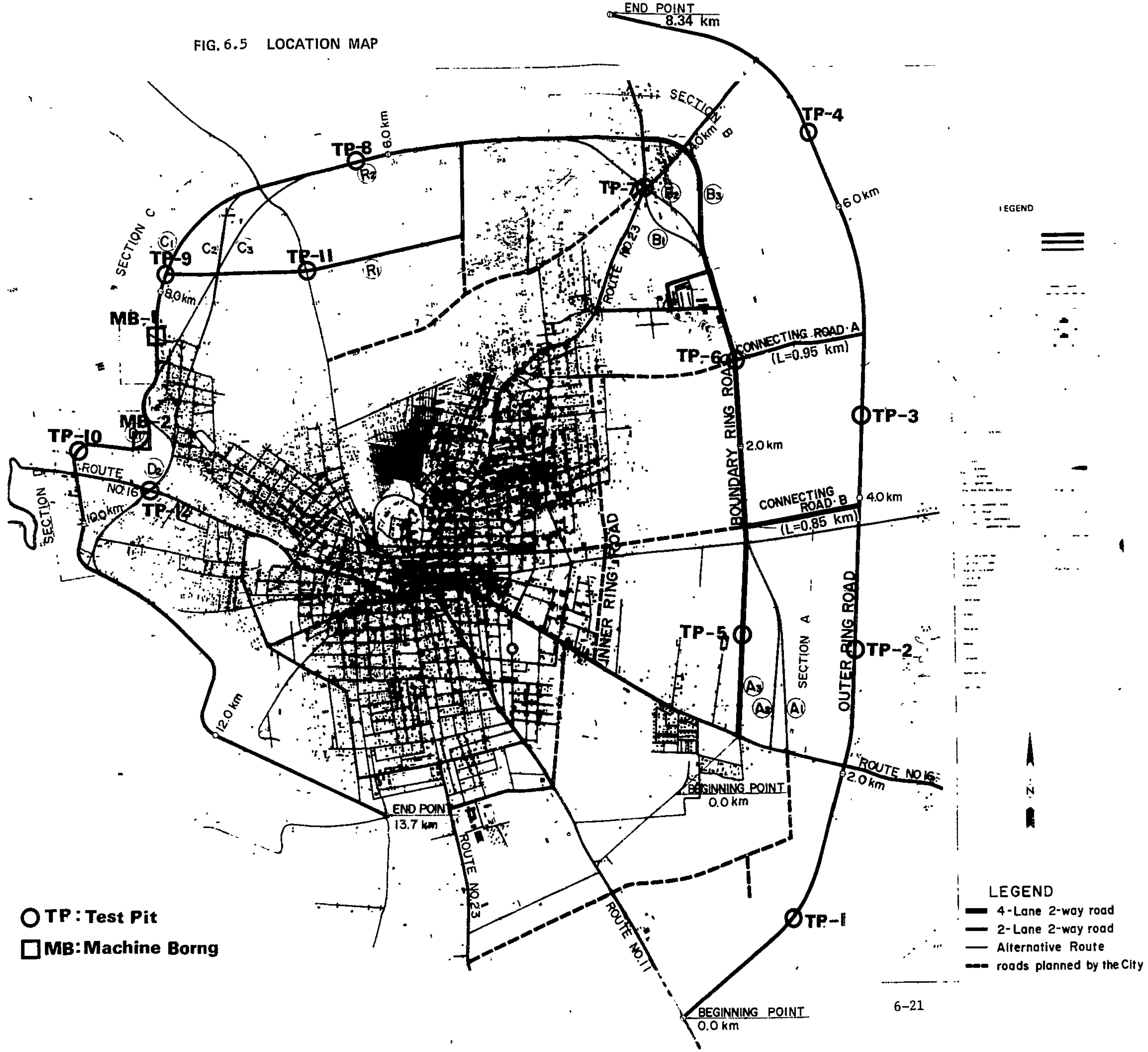
The kinds of rocks are limestone, silicified limestone, chert and marl. Ordinarily their bedding plane is clear. The strikes of strata are northeast-southeast or north-south. The dips of strata are 5 - 20 degrees declining to the northeast or east. There are hardly any faults and continuity is fine; however, there are many slight folds, so dip is a little different at each point.

Surface conditions are shown in figure 6.6. as test pit logs.



END POINT
8.34 km
TP-4
SECTION B
6.0 km
TP-7
B2
B3
B1
ROUTE NO.23
CONNECTING ROAD A
(L=0.95 km)
TP-6
BOUNDARY RING ROAD
TP-3
2.0 km
CONNECTING ROAD B
(L=0.85 km)
40 km
INNER RING ROAD
OUTER RING ROAD
TP-5
SECTION A
TP-2
A3
A2
A1
ROUTE NO.16
2.0 km
BEGINNING POINT
0.0 km
TP-1
ROUTE NO.11
BEGINNING POINT
0.0 km
N
LEGEND
4-Lane 2-way road
2-Lane 2-way road
Alternative Route
roads planned by the City

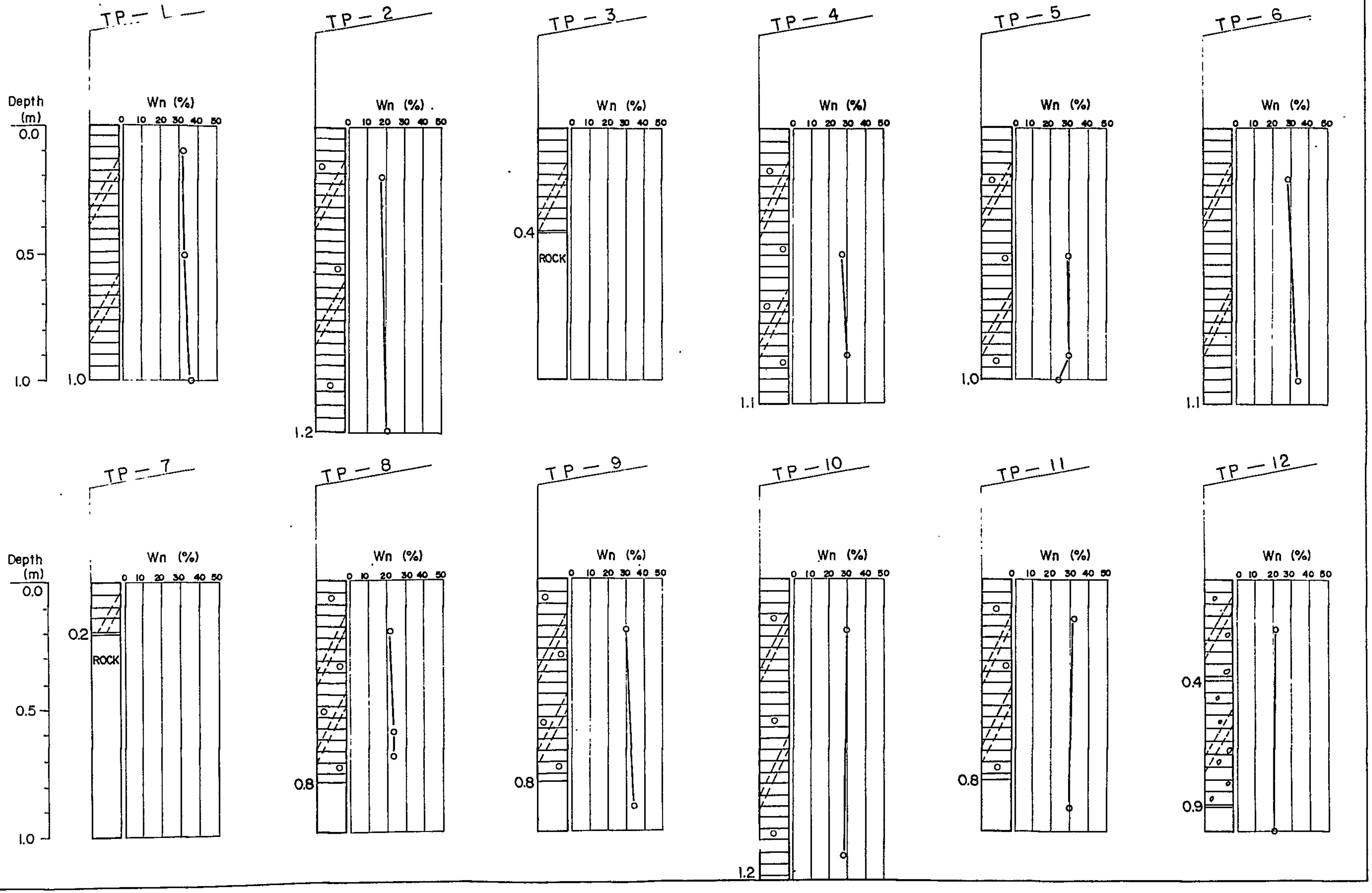
FIG. 6.5 LOCATION MAP



○ TP : Test Pit

□ MB : Machine Borng

FIG. 6.6 TEST PIT LOGS



(2) Field Density

The natural state density at each test pit location is shown in table 6.3.

Table 6.3 Result of Field Density Tests

	Dry Density g/cm3	Wet Density g/cm3	Water Content %
TP - 1	1.24	1.67	34.72
TP - 4	1.20	1.59	32.80
TP - 5	1.23	1.52	23.76
TP - 8	1.32	1.61	22.27

The values of TP - 1, 4 and 5 are ordinary for clayey soil, but for TP - 8, the dry density is a little high and natural water content is a little low. The reason for this is that a lot of sand is contained in the soil.

(3) Soil Characteristics

The soil characteristics of each test pit are shown in table 6.4

The result of grain size analysis indicate that in all samples the percentage of fine materials that consist of clay and silt surpasses the percentage of coarse materials that consist of gravel and sand. Therefore topsoil can be said to consist of fine materials. According to AASHTO classification which uses consistency limit and grain size, all samples are classified as A-7-5. The Group Index which indicates the general grade as subgrade are almost all larger than 20, and they show that the aptitude is not so good.

Specific gravity centers between 2.6 to 2.8 which are general values.

Natural water content is 20 to 35%, indicating that the soil depth under the surface retains moisture fairly well even though the surface is dry.

The compaction test indicates maximum dry density 1.47 to 1.65 g/cm^3 and optimum water content 19 to 27%. Since the natural content is 20 to 35%, the natural water content is approximately equivalent to optimum water content towards the wet side of optimum water content. (See figure 6.7).

CBR values, being reflected by clayey soil, are 1.9 to 4.6% and half of the samples are less than 3%.

	TP-7	TP-8	TP-9	TP-10	TP-11	TP-12
	0.2	0.8	0.8	1.2	0.8	0.9
	Rock	32	22	18	7	32
		10	5	3	3	7
		58	73	79	90	61
		68	78	82	93	68
		61	75	79	91	62
		58	73	79	90	61
		62	67.5	69.5	67	65
		26.8	32.5	30.5	32.7	32.1
		A-7-5 (14)	A-7-5 (26)	A-7-5 (29)	A-7-5 (36)	A-7-5 (19)
		2.607	2.70	2.804	2.75	2.719
		22.3	33.6	28.9	28.6	20.2
		1.614				
		0.975				
		59.6				
		21.2		18.6	21.8	20.8
		1.630		1.652	1.578	1.560
		4.63		2.33	3.23	4.19

GRADATION CURVES

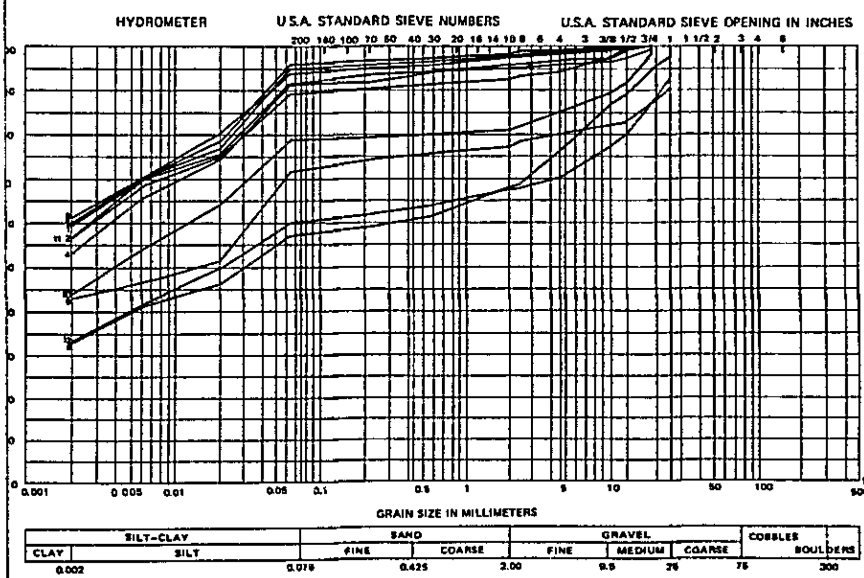


Table 6–4 SUMMARY OF LABORATORY TEST OF SOILS

				TP-1	TP-2	TP-3	TP-4	TP-5	TP-6	TP-7	TP-8	TP-9	TP-10	TP-11	TP-12
Sampling Location				TP-1	TP-2	TP-3	TP-4	TP-5	TP-6	TP-7	TP-8	TP-9	TP-10	TP-11	TP-12
Sample No.															
Sampling Depth (m)				1.0	1.2	0.4	1.1	1.0	1.1	0.2	0.8	0.8	1.2	0.8	0.9
Gradation	Gravel		(%)	4	2	Rock	5	2	2	Rock	32	22	18	7	32
	Sand		(%)	5	7		5	4	2		10	5	3	3	7
	Silt-Clay		(%)	91	91		90	94	96		58	73	79	90	61
	Classified Grading Pass	No. 10 (2.00mm)	(%)	96	98		95	98	98		68	78	82	93	68
		No. 40 (0.425mm)	(%)	92	97		91	95	96		61	75	79	91	62
		No. 200 (0.075mm)	(%)	91	91		90	94	96		58	73	79	90	61
Liquid Limit		LL	(%)	70	69		69.5	65	81.5		62	67.5	69.5	67	65
Plasticity Index		PI		29.9	29		31.5	26.5	38.1		26.8	32.5	30.5	32.7	32.1
Classification (Group Index)		GI		A-7-5 (35)	A-7-5 (34)		A-7-5 (35)	A-7-5 (33)	A-7-5 (47)		A-7-5 (14)	A-7-5 (26)	A-7-5 (29)	A-7-5 (36)	A-7-5 (19)
Specific Gravity		Gs		2.77	2.75		2.74	2.63	2.71		2.607	2.70	2.804	2.75	2.719
Natural State	Water Content	ωn	(%)	34.7	20.2		32.8	23.8	33.4		22.3	33.6	28.9	28.6	20.2
	Wet Density	γt	(g/cm³)	1.671			1.594	1.522			1.614				
	Void Ratio	e		1.233			1.283	1.139			0.975				
	Degree of Saturation	Sr	(%)	78.0			70.0	55.0			59.6				
Compaction CBR	Optimum Water Content	ωopt.	(%)	21.7	25.9		26.4	21.1	26.7		21.2		18.6	21.8	20.8
	Maximum Dry Density	γ dmax.	(g/cm³)	1.536	1.470		1.560	1.574	1.520		1.630		1.652	1.578	1.560
	C B R		(%)	1.89	3.34		2.10	2.20	2.35		4.63		2.33	3.23	4.19

Classification of Soils and Soil-Aggregate Mixtures (AASHTO M145)

General Classification	Granular Materials (35% or less passing 0.075 mm)							Silt-Clay Materials (More than 35% passing 0.075 mm)			
	A-1		A-3	A-2				A-4	A-5	A-6	A-7
Group Classification	A-1-a	A-1-b	A-3	A-2-4	A-2-5	A-2-6	A-2-7	A-4	A-5	A-6	A-7-5, A-7-6
Sieve Analysis, Percent passing: 2.00 mm (No. 10) 0.425 mm (No. 40) 0.075 mm (No. 200)	50 max. 30 max. 15 max.	.... 50 max. 25 max.	.... 51 min. 10 max.	.... 35 max.	.... 35 max.	.... 35 max.	.... 35 max.	.... 36 min.	.... 36 min.	.... 36 min.	.... 36 min.
Characteristics of Fraction passing 0.425 mm (No. 40) Liquid limit Plasticity index	.... 6 max.		.... N.P.	40 max. 10 max.	41 min. 10 max.	40 max. 11 min.	41 min. 11 min.	40 max. 10 max.	41 min. 10 max.	40 max. 11 min.	41 min. 11 min.*
Usual Types of Significant Constituent Materials	Stone Fragments, Gravel and Sand		Fine Sand	Silty or Clayey Gravel and Sand				Silty Soils		Clayey Soils	
General Rating as Subgrade	Excellent to Good							Fair to Poor			

* Plasticity index of A-7-5 subgroup is equal to or less than LL minus 30. Plasticity index of A-7-6 subgroup is greater than LL minus 30 (see Figure 2).

Group Index (GI) = (F−35)[0.2 + 0.005(LL−40)] + 0.01(F−15)(PI−10)

where F = % Passing 0.075 mm sieve, LL = Liquid Limit, and PI = Plasticity Index

GRADATION CURVES

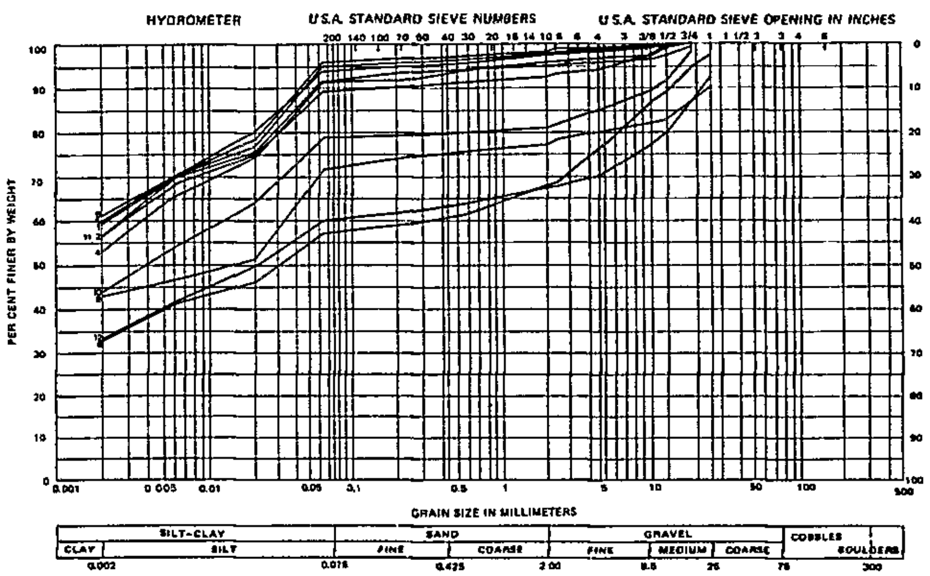
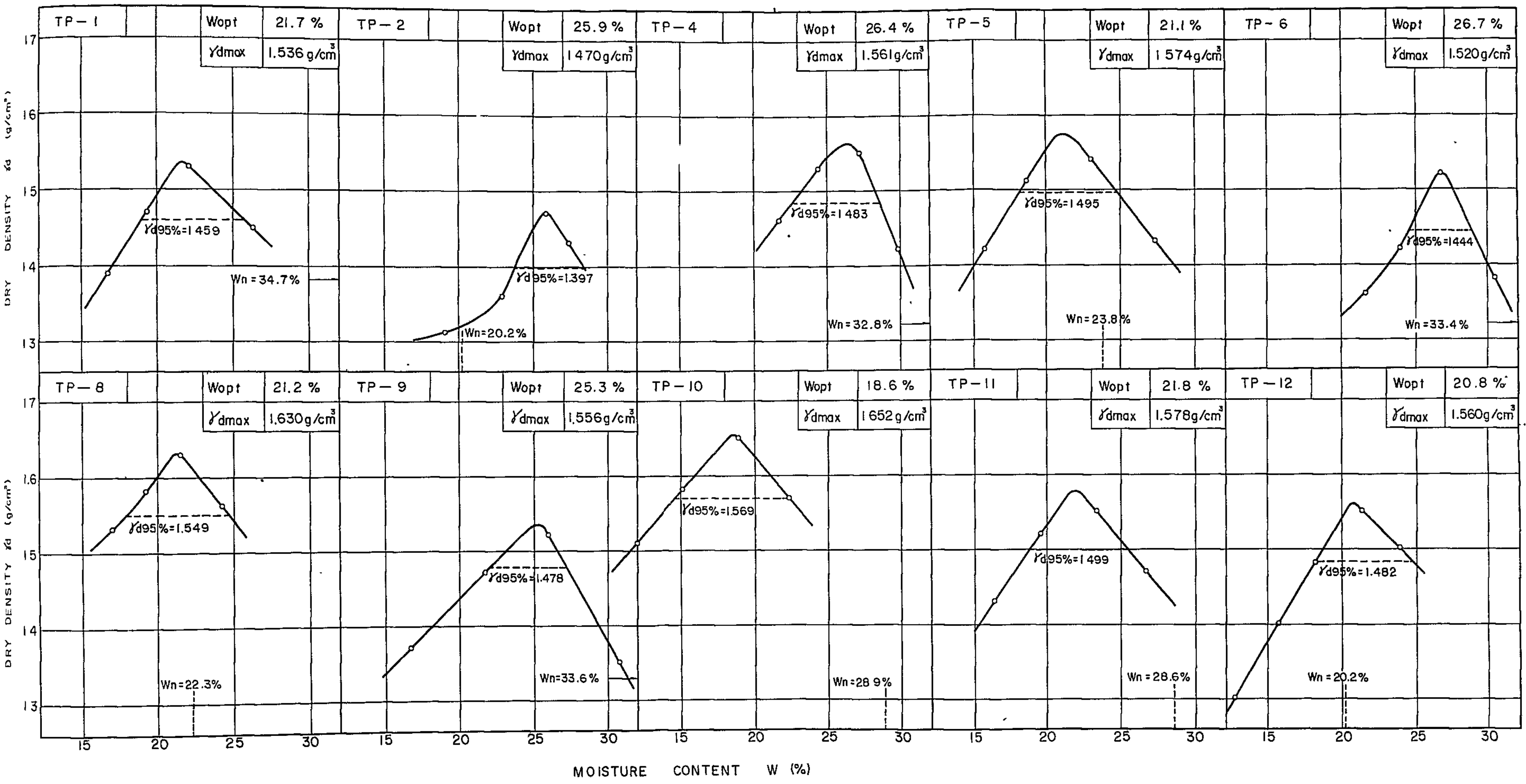


Fig 6.7 COMPACTION CURVE

Wopt : OPTIMUM MOISTURE CONTENT
γdmax. MAXIMUM DRY DENSITY
Wn : NATURAL MOISTURE CONTENT
γd95%. 95% VALUE AGAINST MAXIMUM DRY DENSITY



(4) <u>Bridge Foundation</u>

MB-1 and MB-2 are located in Wadi Soum that is a rocky area. Boring points were abutment points for each bridge where bedrock is covered with topsoil.

The geological characteristics each point are as follows;

MB-1

0 - 2.0m	fill materials, clayey soil with gravel and organic materials
2.0 - 2.5m	former natural top soil, clayey soil with gravel, N - value = 38
2.5 - 6.7m	clayey soil with gravel, N - value = 58 - 60
6.7 - 7.0m	bedrock, marly limestone
7.0 - 10.0m	limestone and chert

MB-2

0 - 0.3m	topsoil, clayey soil with gravel
0.3 - 2.0m	bedrock, chalky limestone

FIG. 6.8 BORING LOG MB-1

C.R	Number Blows	R.Q.D. %	Depth (m)	Sample	Log	Soil Description	Lab. Results: kg/cm² Qu	% Mc	g/cm³ γd	% S
0.0	35	0.0	0.0, 1.0, 2.0			Top Soil Fill materials;light brown,dry, loose silty clay with limestone gravel and organic materials.		9.6		
5	38	00	2.0, 2.5			Brown, to pale yellow wet, weak marly silty clay with limestone gravel.		12.96		
66	58 60	00	3.0, 4.0, 5.0			Dark brown to red, wet, firm to stiff silty clay with gravel and pebble of limestone and marly limestone (gravel decreases with depth till it disappears at 4.0m depth.		10.2 20.9		
80		25	6.0, 6.7			Light brown, wet, firm, silty clay with limestone gravels.(6.0-6.30) red, wet, stiff to very stiff silty clay.				
20	0.0		7.0			Light brown, weak marly limestone gravels				
0.0	0.0		8.0, 9.0, 10.0			Percussion Light brown, dry, silty clay with grey gravels and boulders of chert. ROCK				

C.R.: Core recovery the percentage of solid core recovered in a given unit

R.Q.D: Rock quality designation

The percentage of solid core recovered than 4" in length

FIG. 6.9 BORING LOG MB-2

C.R.	Number Blows	R.Q.D. %	Depth (m)	Sample	Log	Soil Description	Lab. Results kg/cm² Qu	% Mc	g/cm³ γd	% S
			0.0			Top Soil, Dark grey, wet, loose silty clay with limestone gravel.				
			0.3							
			0.5			White to pale yellow, dry, moderately weak, chalky limestone				
0.0		0.0	1.0							
			1.5							
			2.0							

C.R.: Core recovery the percentage of solid core recovered in a given unit

R.Q.D: Rock quality designation

The percentage of solid core recovered than 4" in length

6.3.6 Aggregates Investigation

(1) Quarry Sites

Since Wadi El Ghajar and Husn were chosen as proposed quarry sites near Irbid, investigation was made with the results indicated below.

Wadi El Ghajar is located in the valley at the edge of the City. Boundary Ring Road passes above the limestone quarry site and transportation conditions are favorable. However, since the quarry site is located near houses, some tunnelling is being done; hence it may be difficult to blast and mass-produce after this.

Husn is located 10 km south of Irbid. The rock quarried there is also limestone. The area of quarry site is extensive and there is no problem regarding quantity. There are producers of various scales in this area and one of them furnishes asphalt plants.

(2) Characteristics of Aggregates

The Characteristics of aggregates are shown in table 6.6.

Absorption of Husn aggregate is 2.5% with the sample of Irbid showing a slightly larger value of 3.6%.

Abrasion values of both are similar and of sufficient quality since Husn is 30% and Irbid is 28%.

The percentage soundness of Husn is 2.2% and of Irbid is 6.3%; hence both are of good quality.

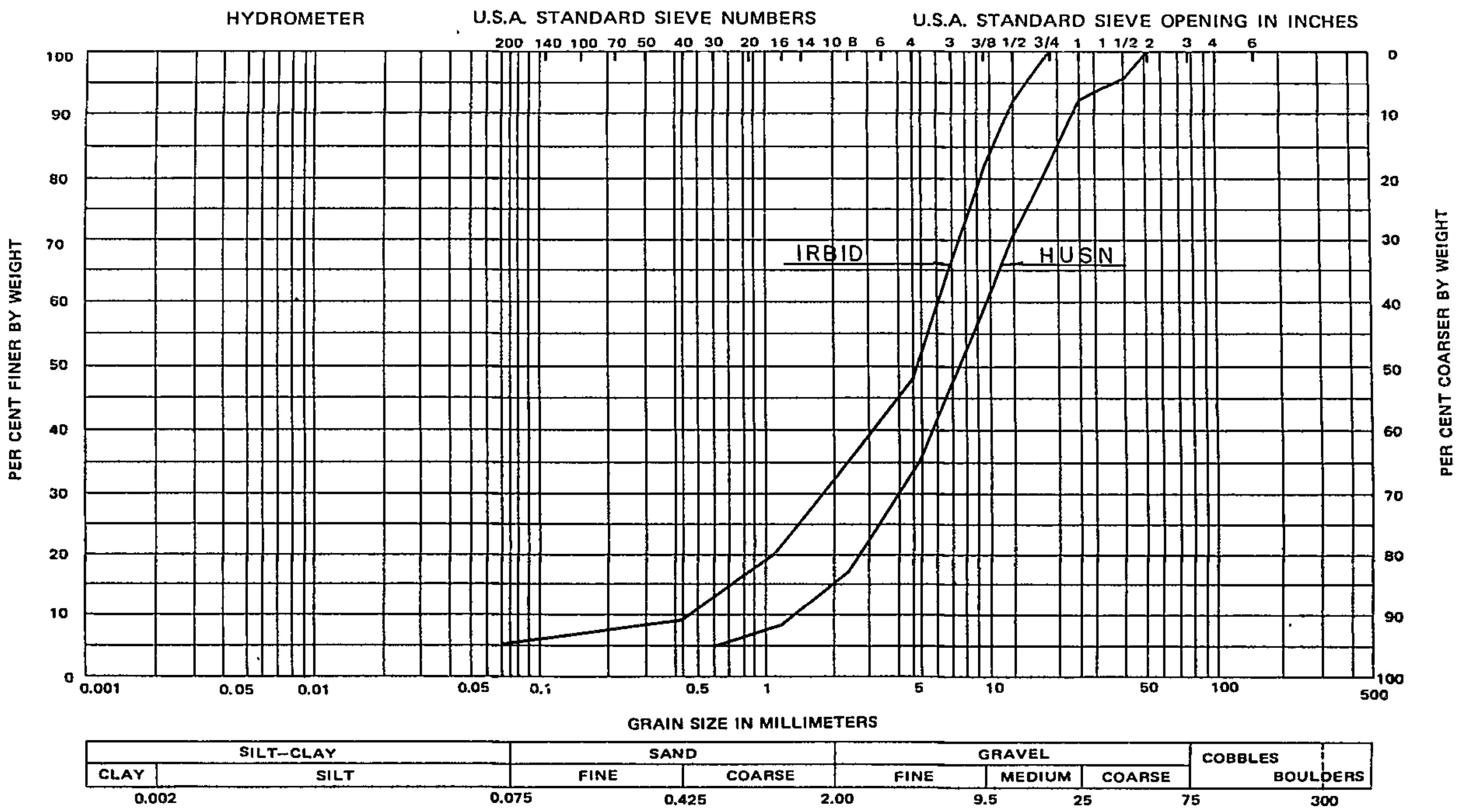
For the degree of flakiness and elongation, the values of Husn are 15.7% and 18.7% while those of Irbid are 8.1% and 12.8%; these values seem slightly high.

The size gradation is summarized in figure 6.10.

Table 6.5 TEST DATA SUMMARY OF AGGREGATES

Description		Sieve Opening (mm)	Sieve Opening (in)	HUSN	IRBID
Specific Gravity	A. Saturated Surface-dry Condition				
Specific Gravity	B. Bulk Specific Gravity			2.51	2.43
Specific Gravity	C. Apparent Specific Gravity				
Absorption (%)				2.54	3.63
Abration of Aggregate (%)				30.00	28.40
Soundness of Aggregate (%)				2.23	6.27
Flakiness (%)				15.72	8.12
Elongation (%)				18.68	12.76
Sieve Analysis Total Passing Percent (%)		101.1	4		
		76.2	3		
		63.5	2½		
		50.8		100	
		38.1		96	
		31.7			
		25.4	1	93	
		19.1	3/4	83	100
		15.9			
		12.7	1/2	72	93
		9.52	3/8	59	82
		4.76	4	34	48
		2.38	8	17	
		1.19	16	8	21
		0.59	30	5	
		0.425	40		9
		0.297	50		
		0.149	100		
		0.075	200		5

FIG. 6.10 GRADATION CURVES



6.3.7 Designation and Construction

(1) Earthwork

In Irbid, topsoil a few meters thick covers the bedrock. The topsoil is thin in the hilly area and thicker in low ground. Hence, most of the hills consist of rock and there is no large borrow pit near Irbid. Therefore road embankments will consist of topsoil along the route or gravelly material from quarry sites.

Topsoil is clayey soil with characteristics as shown in Section 6.4.5. Natural water content is within 10% of the optimum water content or towards the wet side of optimum water content. Thus, it should be easy to compact soil materials to about optimum water content by means of drying during construction.

(2) CBR

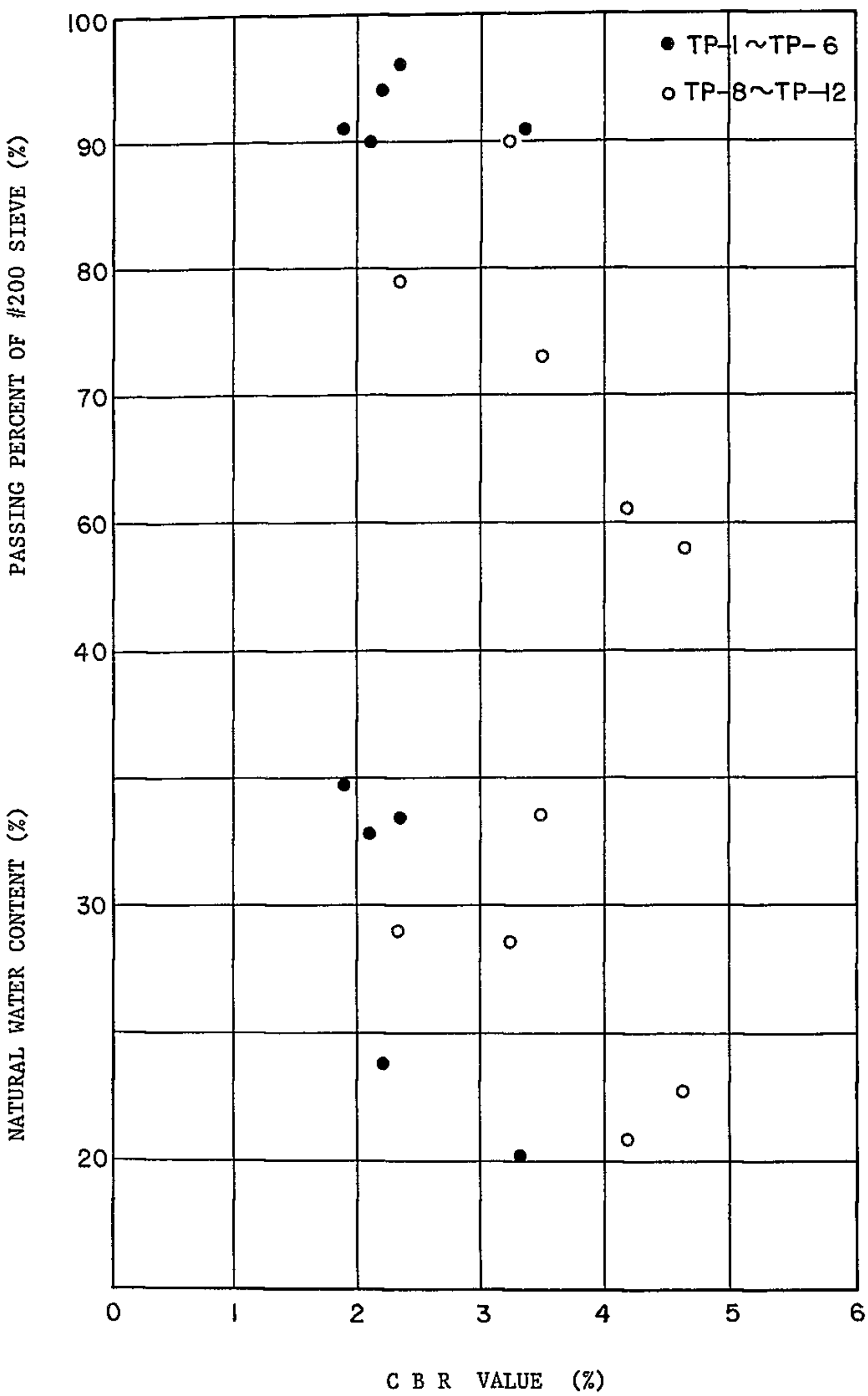
Figure 6-10 shows the relation between CBR value and percent passing #200 sieve with natural water content. There is a rather clear correlation between grading and CBR: CBR increases with decrease in fine materials. Especially the samples where fine materials are less than 75%, CBR larger than 3%. In the other figure, samples with a natural water content less than 25% seem to have large CBR values.

Moreover Figure 2.7.1 shows that the samples from the eastern part of Ring Road (TP-1 to TP-6) have much finer materials and have a tendency to have low CBR values.

(3) Bridge Foundation

At MB-1, the depth of clayey soil with gravel continues to -7m below fill materials which are 2m thick and the deeper part is rock. The N-value of clayey soil with gravel is about 60. However, it is likely that this N-value was influenced by gravel. Therefore it is necessary to locate the bridge substructure in rock deeper than -7m. The bedrock consists of alternation of marl, silicified limestone, chert and sandstone. Each rock is good support because the dip of layers are horizontal and hence the rocks are firm and stable.

FIG. 6.11 RELATION BETWEEN CBR VALUE AND FINE MATERIAL, NATURAL WATER CONTENT



At MB-2, topsoil is thin and rock appears within -1m depth. The bedrock at this point consist of silicified limestone, marl and chert. It makes good support rock.

(4) Rock Excavation

of excavation. Since the rock consist of silicified limestone, marl and chert, oil feed rippers are not suitable for ripping. It will be necessary to use blasting or rock breakers, but since in many cases the routes are near houses, it is expected that blasting will be restricted. The cutting planes of the existing road and of quarry sites near Irbid are almost vertical and stable since there are few landslides. The declination of layers are at right-angles to the axis of valley or toward the hills even though the dip is 5 - 20 degrees. There is no possibility of land-slide of rock along the bedding plane; therefore it is possible to cut a rather steep in the rock along these routes. To guard against falling rocks it will be necessary to employ some revetment works depending on the exfoliation of the surface.

(5) Aggregates

Proposed quarry sites of coarse aggregates are Wadi Al Kafar at the western edge of Irbid, and Husn, 9 km south of Irbid city. Husn will be the main quarrry site because tunnel mining has progressed at Wadi Ghafar.

At present, some fine aggregate is being mined at a wadi around Irbid and fragments after crushing are being utilized. Excellent sand is carried into Irbid from Swailih which is located in the suburbs of Amman; however, it is difficult to use the sand in large quantities as earthwork materials. For fine aggregate in the earthwork, it is advantageous to use crushed rock which is control graded.

In Irbid, there is a factory of ready-mixed concrete which can be used for ordinary concrete structures.

6.4 Hydrology

6.4.1 General

Study was carried out to furnish basic data and to form a hydrological and engineering point of view for the design of drainage structures. In this chapter, the feasibility report of "IRBID MUNICIPAL WATER DISTRIBUTION, SEWERAGE, STORM DRAINAGE AND SOLID WASTE DISPOSAL PROJECT" March 1980, has been used as reference material.

6.4.2 Site Investigation

The investigation aimed at determining the extent of the catchment area and the coefficient of run-off for the waterway, and, at fixing the size of drainage structures.

To learn more about the existing hydrological data, the study team also carried out several site investigations including a land survey. The characteristics of the affected area were investigated carefully.

(1) Rainfall

The climate of Irbid is very dry since rainfall averages only 400 - 500 mm per year. Rainfall is normally limited to the winter months, November until April. The other months are usually dry, with the exception of May and October which sometimes receive rain. There are no perennial streams in the area.

There are two rainfall monitoring stations in Irbid. The first was established at the secondary school and has recorded extending over 42 years from 1937 to 1979. The second station, established at the Agricultural Experiemental Station, has records extending over 25 years from 1954 to 1979. A continuous recording station was established at the school in the late 1960's and it has records for the past 8-years.

The Natural Resources Authority maintains the records at these and all rainfall monitoring stations in Jordan.

Table 6.6 Rainfall in Irbid Nursery (mm)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Years Analyzed
Monthly Average	110.9	88.0	83.9	29.0	6.6	0.1	00	00	0.9	13.5	44.6	85.6	1941-1975
Max Monthly	301.5	191.5	216.5	192.6	40.4	1.0	00	00	23.1	126.0	173.4	276.0	1941-1975
Max in 24 Hours	71.0	58.3	63.3	54.8	16.4	0.9	00	00	12.5	29.2	56.0	69.0	1955-1980

Source : Meteorological Directorate, Statistics Division

There are no published rainfall intensity/duration/frequency curves that are based on actual recorded rainfall intensities. The only available curves are those developed in an unpublished document entitled "Rainfall Intensities in Jordan for Use in Engineering Design", technical paper No. 2 by M. Ibbitt of the Natural Resources Authority in 1969. This paper is based on the correlation of annual with daily rainfall, and hourly with shorter duration rainfall. In pursuing this analysis, he used some factors from the United States and Australia.

Ibbitt's curves indicate a higher intensity than the curves in the feasibility report of "IRBID MUNICIPAL WATER DISTRIBUTION, SEWERAGE, STORM DRAINAGE AND SOLID WASTE DISPOSAL PROJECT" March 1980.

This fact necessitates plotting other curves for the recorded rainfall intensity in various stations in Jordan.

In this project, rainfall intensity/duration/frequency curves by the feasibility report (above-mentioned) based on 24 hour duration data over 42 years of Irbid City, is adopted for use in the design of drainage structures for the Ring Road.

(2) <u>Return Periods</u>

The lack of specific flood damage information for the Irbid area precludes undertaking even a simple cost-benefit analysis. Therefore, there must be recourse to sound engineering judgement, in regard to the technical and financial feasibility of providing an acceptable level of protection. It was concluded that a 10-year design storm for run-off analysis and sizing of new storm water collectors would be appropriate. For major culverts, the 25-year design storm is used.

(3) <u>Run-off Estimation Method</u>

The rational formula was used in the calculation of flood discharges for the following reasons:-

1) Catchment areas to be handled are not too large

2) Peak discharges are used in preliminary designs

3) If the other methods are used, verification of the results is difficult

4) The formula is widely used and easy to calculate.

The rational formula is expressed as follows:-

$$Q = \frac{1}{3.6} \cdot F \cdot R \cdot A$$

where Q = Peak discharge in cubic meters per second

F = Coefficient of run-off

R = Rainfall intensity in millmeters

A = Drainage area in square Kilometers

6.4.3 Hydraulic Design Principles

(1) General (Hydraulic Design of Culvert)

The purpose of hydraulic design is to determine the type and size of culvert taht will most economically deal with excessive water and flooding. In almost all cases, the primary control is the permissible head of water at the upstream side of the structure.

In some cases a higher head of water may cause serious damage and must be prevented. For example, a higher head of water may result in flooding of valuable property in settled areas, and roads with relatively low embankments in the vicinity may also be flooded, interrupting traffic and causing serious damage to pavements and embankments. Sometimes high velocities through the culvert may produce erosion problems at the downstream side or thereaten to damage the culvert of its appurtenances.

(2) Discharge Capacity

Because of its wide use, Manning's formula is used to calculate the mean velocity and discharge capacity of each water flow.

Manning's formula is expressed as follows:-

$$Q = V.A = \frac{1}{M} \cdot A \cdot R \frac{2}{3} \cdot 1 \frac{1}{2}$$

where: Q = Discharge, in cubic meters per second

A = Area of cross-sectional flow in square meters

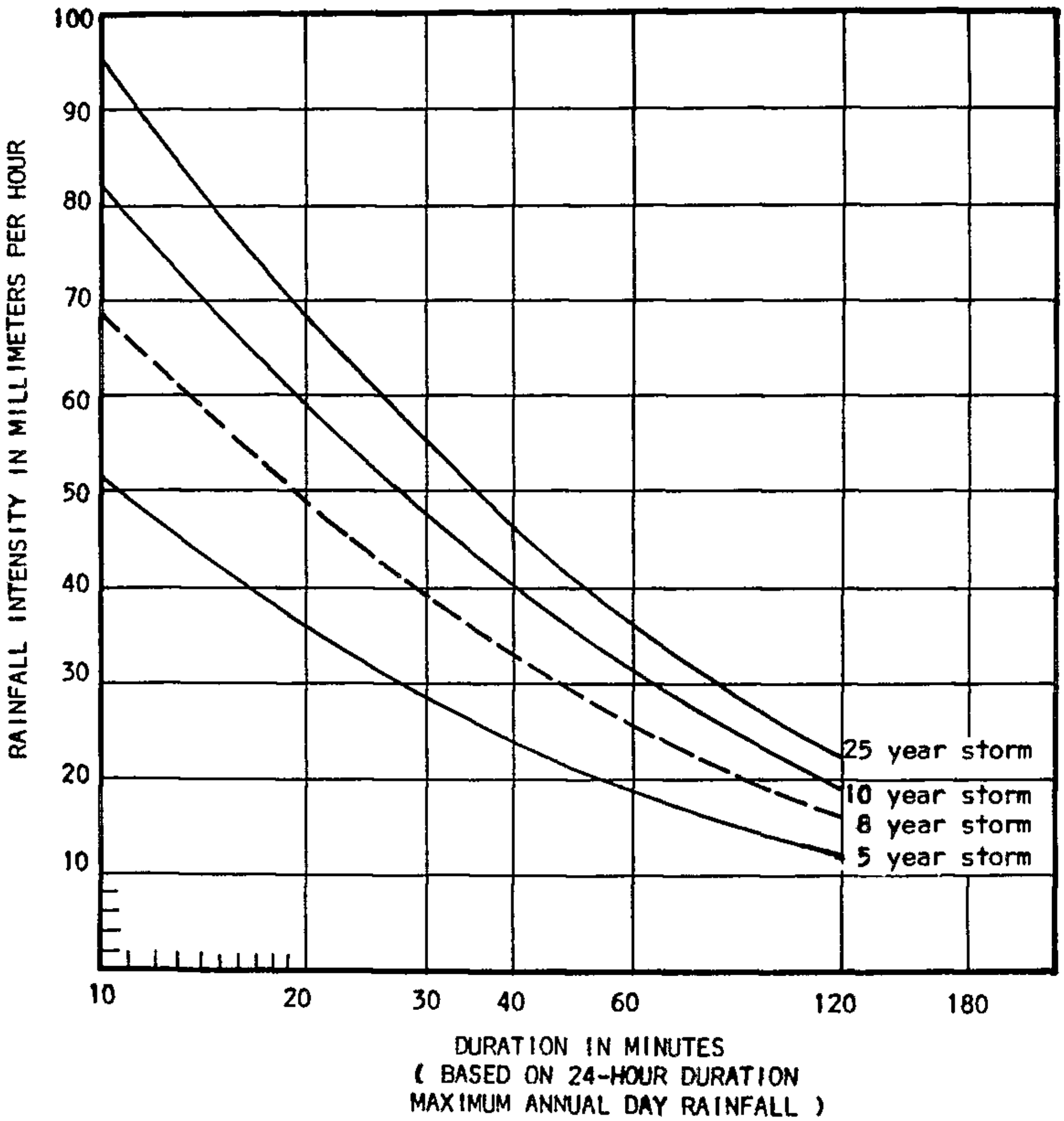
R = Hydraulic mean depth in meters

V = Mean velocity in meters per second

M = Manning's roughness coefficient; typical values which are adopted for this study are shown in Table 6.6

Table 6.7 Values of Manning's Roughness Coefficient

Type of lining	Values of N
Earth Ditches	0.025
Concrete pipe culvert	0.013
Cast-in-place concrete	0.019



6.5 Local Contractors and Labour Force

6.5.1 Constructors

Contractors in Jordan are certified to construct various types of works, and are graded by classes.

General contractors handle projects such as roads, bridges, airports, harbors, irrigation systems, railroads, buildings, water supplies, sewerage, electrical, mechanical works, etc.

There are two grades of General Contractors (1st Class and 2nd Class) and four grades Highway Contractors (1st Class to 4th Class). Eleven first-class General Contractors and the fourteen first-class Highway Contractors were registered at the Ministry of Public Works in 1981.

Some of the first-class "General Contractors" have a capital of JD 1 million and have experience and capability in the construction of airports, highways, bridges, buildings, water supply systems and drainage/sewerage systems.

This kind of contractor has several hundred technical personnel (engineers and technical staff), a respectable amount of equipment - crushing and screening plants, concrete plant, paving equipment, cranes and other kinds of equipment.

6.5.2 Labour Force

Due to the emigration of Jordanians to other Arab countries, especially to the Gulf States, there is a scarcity of skilled labour since most of the emigrants are technical skilled workers.

Consequently, the number of foreign skilled and non-skilled workers have increased, especially in recent years to fill the labour demand of Jordan's industries. A cheaper labour force is sought. The number of foreign workers registered at the Ministry of Labour was 26,450 in 1979 with about 70 percent of this figure coming from Arab countries (mostly from Egypt) and 25 percent from Asian countries.

The education system and technical courses in Jordan are shown in Table 6.8.

In addition, there is a mechanical training school under the management of the Ministry of Public Works, Equipment and Maintenance Department.

Table 6.8 Education System in Jordan

Type of School	No. of Schools	Graduates per year	Term of Education
1. University (Engineer)	2		4 years after high school
2. Polytechnic (Technician)	2	400	2 years after high school
3. Industrial/Secondary (ISS) (Craftsman)	6	800	3 years after junior high school
4. Trade Training Center (TTC) (Skilled Worker and Semi-Skilled Workers)	21	1,000	2 years after junior high school

Courses at TTC and ISS

Electricity

Radio and T.V.

Communications

Mechanical

Welding

General Mechanics

Wood Workers

Food Workers

Tilers, Plasterers

Polytechnic Courses

Electricity

Electronics

Mechanics

Civil Engineering

Chemistry

(Source: Ministry of Education)

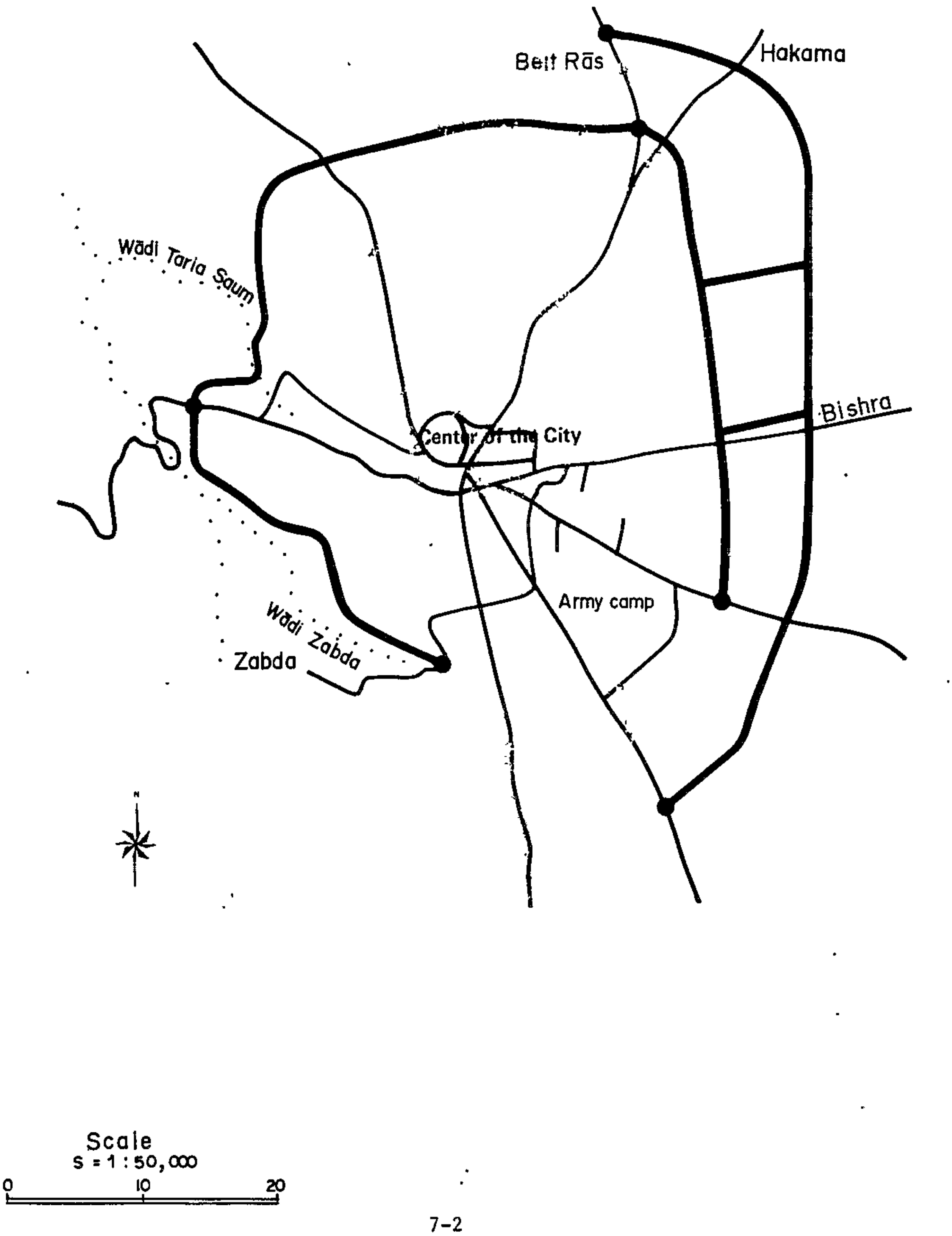
CHAPTER 7 DESIGN STANDARDS AND ALTERNATIVE ROUTE STUDY

7.1 General

The Ring Road project for the City of Irbid, as shown in the land use planning in Chapter 3, is part of a program of infrastructure improvement for the purpose of promoting development of various urban functions. The Boundary Ring Road (BRR) has an average radius of about 2.5 km and the Outer Ring Road (ORR) of about 3.5 km.from the urban center, and extends for a distance of about 24 km (including Connecting Roads of some 2 km) and connects the various existing radial Roads at the periphery of the City of Irbid. The Ring Roads will form the backbone of the future of the City of Irbid, and strive as an arterial street and by-pass for through traffic.

In this chapter, a comparative analysis from different angles is made for the Ring Roads and the intersections, which are planned with respect to the existing roads, from the point of view of road maintenance, traffic characteristics and forecasted traffic demand in order to obtain a suitable solution so that a policy may be established for the project roads economically and technically and that an effective and feasible alternative may be determined.

Fig. 7.1 **MAP OF PROJECT AREA**



7.2 Design Standards

7.2.1 General

Generally, in regard to the Design of Urban Highways and Arterial Streets, the standards by AASHTO (A Policy on Design of Urban Highways and Arterial Streets) have been referred to.

However, the Ring Roads in the City of Irbid are planned in 'flat' 'Rolling' and "Mountainous' areas; therefore, the standards by AASHTO are unsuitable in some parts for this project.

In this project, the standards by AASHTO, the Highway Design Manual by MPW in Jordan and the Japan Road Design standards have been compared and studied with due consideration for natural conditions, economics, traffic characteristics and maintenance.

Following is a brief description of the design standards adopted for this study.

7.2.2 Design standards

(1) Design Speed

Factors relevant to determing the design speed for the proposed roads are as follows:

1) Site conditions

a) BRR (To the north and east of the city)

In the future, these areas will be developed and become an integral part of the city. The surrounding area is flat and rolling land.

b) BRR (To the west of the city)

Beyond the sparcely developed residential area to the west, there is a mountaineous area running along the Wadi Zabda.

c) ORR (To the east of the city)

Stretching 3.5 km from the center of the city in a southeast direction and extending northeast is an area that is being developed for residential use. At the moment, it is used for cultivation.

d) CR (Connecting Road between BRR and ORR)

The land in this arae to the east of the city is similarly used for cultivation.

2) Speed Limits of Existing Roads

The speed limits of existing roads at the places where proposed road junctions are to be, is 60 - 80 km/h on the eastern and northern sides of the city, and is 40 - 60 km/h on the western side.

Based on the character and function of roads, the design speeds have been fixed as follows:

Road	Speed (km/h)	Area Description
BRR (BP-70 km)	80	Flat & Rolling (F/R)
BRR (7.0 - EP)	60	Mountainous
ORR	80	F/R
CR	80	F/R

In determining these speeds the opinions of the users have been taken into consideration as far as was possible.

(2) Right-of-Way

The Rights-of-way required for the proposed roads have been based on the Highway Design Manual by MPW in principle but the Right-of-way for the roads planned by the City of Irbid has been adopted for the Ring Roads in re-adjustment areas for agricultural lands.

The Rights-of-Way for this project have been determined as follows:

Road	Number of Lanes	Right-of-Way(m)
BRR (BP-4.0 km)	2 x 2	30
BRR (4.0-10.0 km)	2 x 1	20 (MIN)
BRR (10.0 km-EP)	2 x 1	20 (MIN)
ORR	2 x 1	30
CRA	2 x 1	30
CRB	2 x 1	30

(3) Lane Width

From MPW standards and based on those of AASHTO, a lane width of 3.60 m is recommended.

(4) Shoulder Width

As the roads pass through a residential area in the Flat/Rolling sections it is proposed that the right shoulder should be used as a parking lane. Based on AASHTO and MPW standards, a right shoulder width of 3.0 m is recommended as a parking lane.

(5) Median Width

In order to allow traffic to filter into adjoining areas, auxiliary lanes for left turns are to be provided. Also, in order to allow U-turns, a minimum median width, including side strips, of 3.0 m is proposed.

(6) Cross Slopes

For the purposes of surface drainage, a standard gradient of cross fall 2.0% is recommended.

(7) Maximum Superelevation

With respect to the center line of the roads, the outer and inner edges will be elevated and lowered respectively, to give the required slopes on road curves.

With respect to arterial roads, the presence of adjacent buildings and the frequency of road junctions often limit slope gradients. In view of this, a maximum superlevation of 6.0% in flat/rolling areas and 8.0% in mountainous areas is recommended.

(8) Minimum Horizontal radius of Curvature

As far as possible and with due regard for the limitations imposed by the terrain, a large radius of curvature will be adopted.

In Table 7.4, the respective geometric design values for the roads are shown. These are derived from the figures recommended by AASHTO, MPW and the Japan Road Design Standard.

7.2.3 Summary of Road Design Standards

The values indicated in Table 7.1 are minimum and/or maximum based on the AASHTO, MPW and Japan Road Design Standard. However, for safety reasons, it is desirable that these figures be increased/decreased somewhat.

Moreover, this design standard should be adopted for a part of Boundary Ring Road which the Irbid Municipality will plan.
And in addition, the future traffic volume and vehicle composition in the study should be used as a reference.

Table 7.1 Comparison of Roadway Geometric Design Standards

Item		Unit	Recommended Design Standard in this study		Jordan MPW Design Standard		AASHTO Design Standard	Japan Road Design Standard
Classification			Flat/Rolling	Mountainous	Rolling	Mountainous	Urban	Urban
Design Speed		Km/h	80	60	80	60	80	60
Minimum R.O.W. Width		m	30 (4-Lane) 20 (2-Lane)	-	-	-	-	-
Lane Width		m	3.6	3.6	3.6	3.6	3.65	3.25
Shoulder Width		m	3.0	3.0	3.0	3.0	3.1	2.5 - 3.25
Median Width		m	2.5	-	-	-	3.0	0.5
Crossfall of Pavement		%	2.0	2.0	2.0	2.0	2.0	2.0
Crossfall of Shoulder		%	4.0	4.0	4.0	4.0	4.0	2.0
Type of Pavement		-	Asphaltic concrete --------- hotmix					
Maximum Superelevation		%	6.0	8.0	8.0	8.0	6.0	6.0
Minimum Radius		m	255	120	230	120	255	150
Maximum Gradient		%	5.0	8.0	5.0	8.0	4.0	*7.0 5.0
Stopping Sight Distance		m	110	80	105	80	110	75
Minimum Vertical Curve Length*	Crest	m	K = 26	K = 14	K = 26	K = 14	Refer to Fig. 7.5, 6	50
	Sag	m	K = 23	K = 15	K = 23	K = 15		
Minimum Radius for Curve not Requiring Transition Curve		m	1,000 (2,000)	500 (1,000)	1,000	1,000		500 (1,000)
Minimum Radius for Curve not Requiring Super-elevation		m	3,500	2,000	-	-	1,800	2,000
Value of Superelevation			Refer to Fig. 7.7					

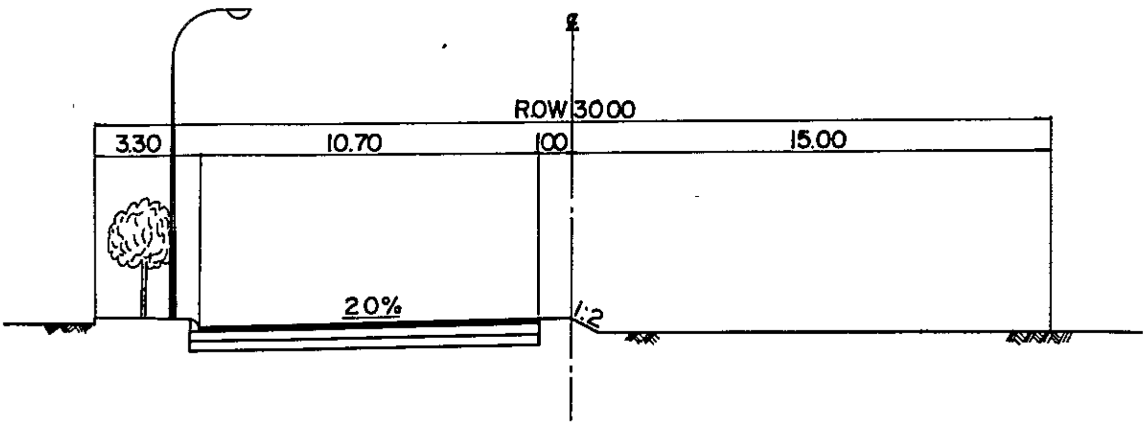
Notes: 1. The items with asterisks indicate absolute maximum values.

2. L = K x A where A = Algebraic Difference in Grade-Parcent.

FIG. 7.2 TYPICAL CROSS SECTION OF RING ROAD IN IRBID CITY

BOUNDARY RING ROAD SECTION I
(BAGHDAD STREET TO BEIT RAS STREET)

STAGE - I



BOUNDARY RING ROAD SECTION I
STAGE - 2 AND

CONNECTING ROAD - B

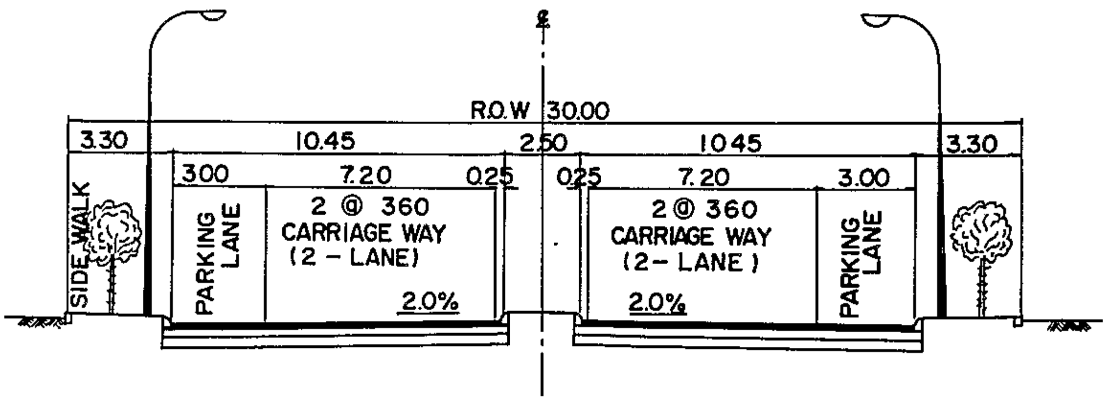
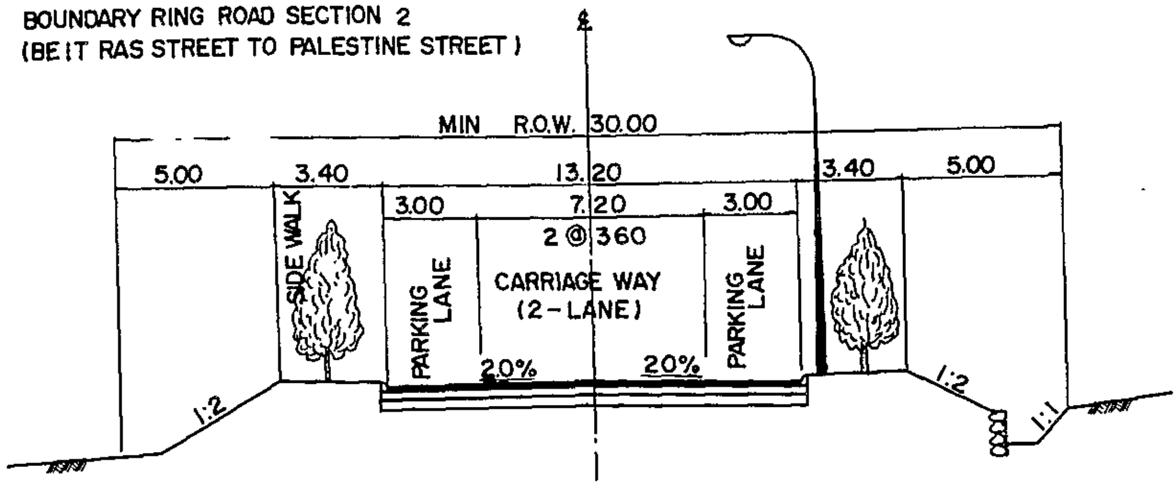
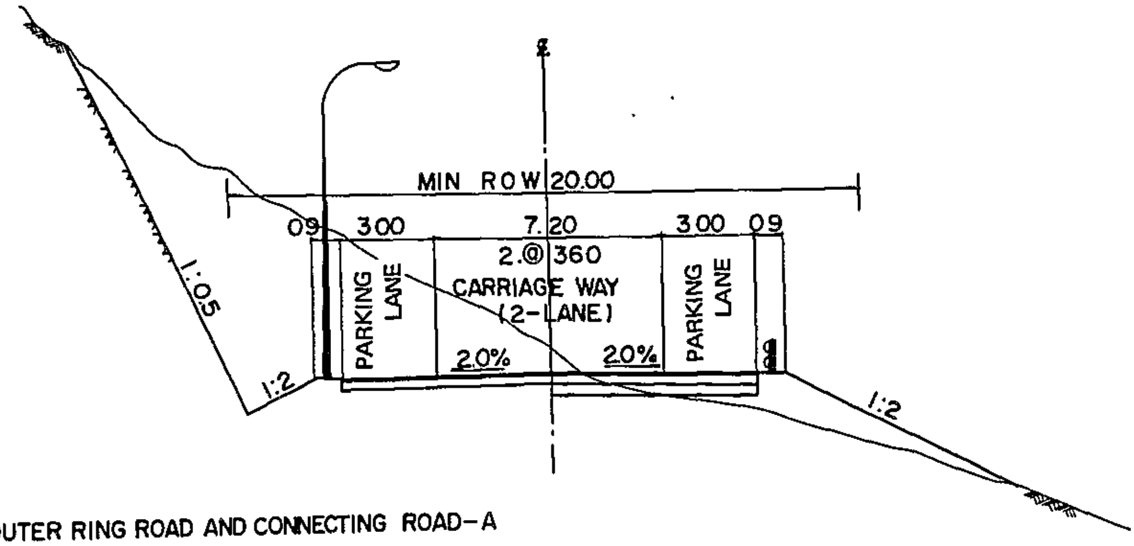


FIG. 7.2 CONTINUE

BOUNDARY RING ROAD SECTION 2
(BEIT RAS STREET TO PALESTINE STREET)



BOUNDARY RING ROAD SECTION 3
(PALESTINE STREET TO BAB AL-WADD STREET)



OUTER RING ROAD AND CONNECTING ROAD-A

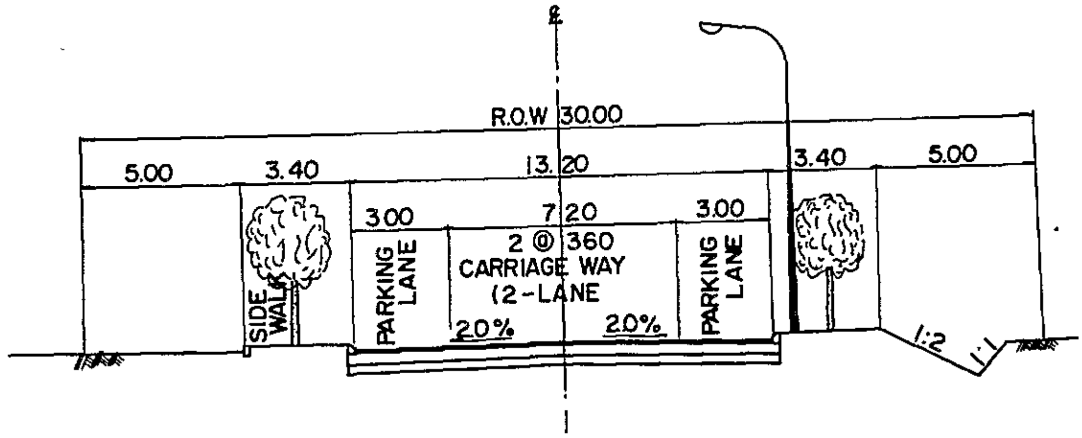


Fig. 7.3 LENGTH OF VERTICAL CURVE (CRESTS)

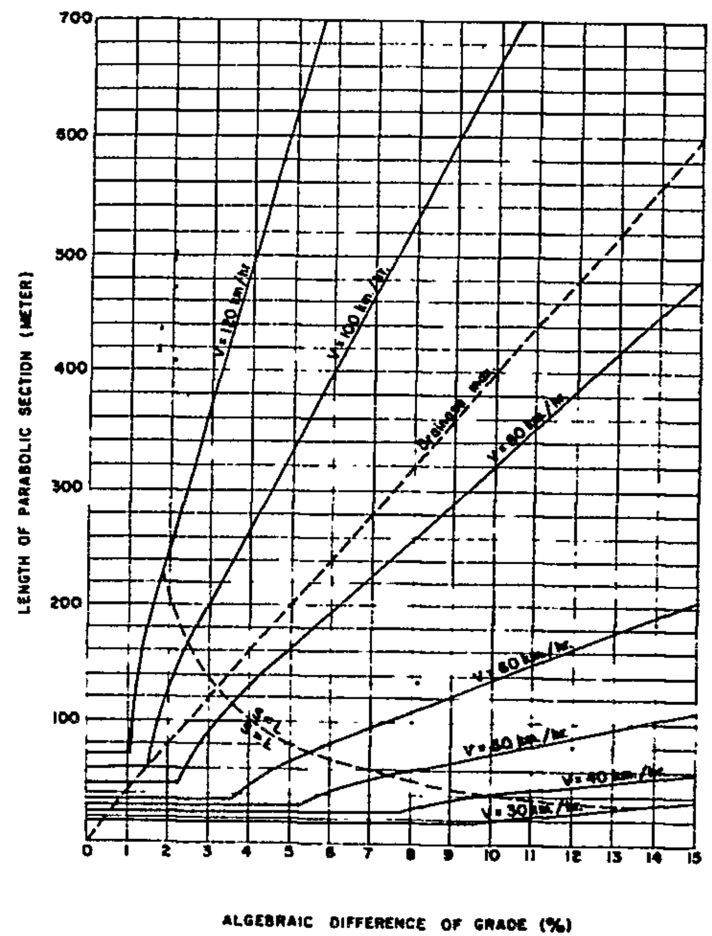
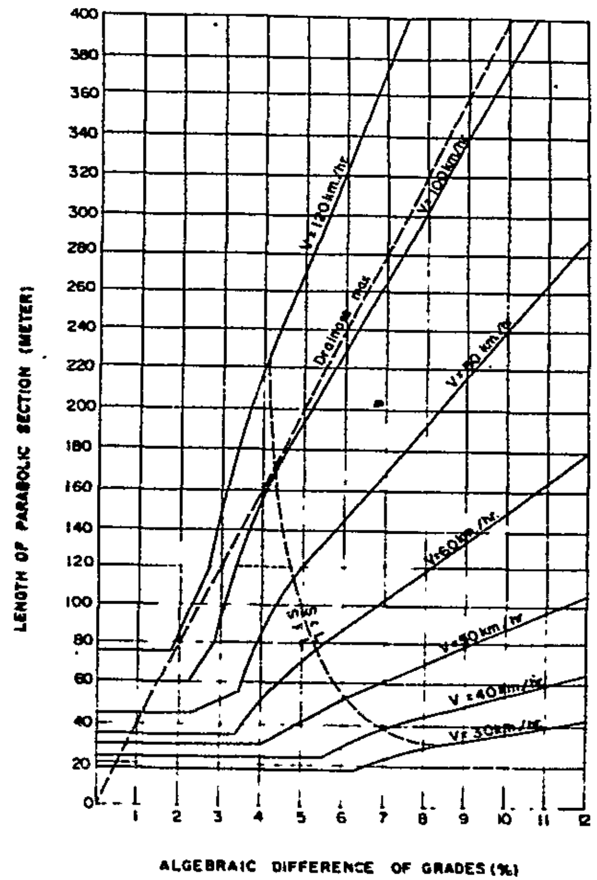


Fig. 7.4 LENGTH OF VERTICAL CURVE (SAG)



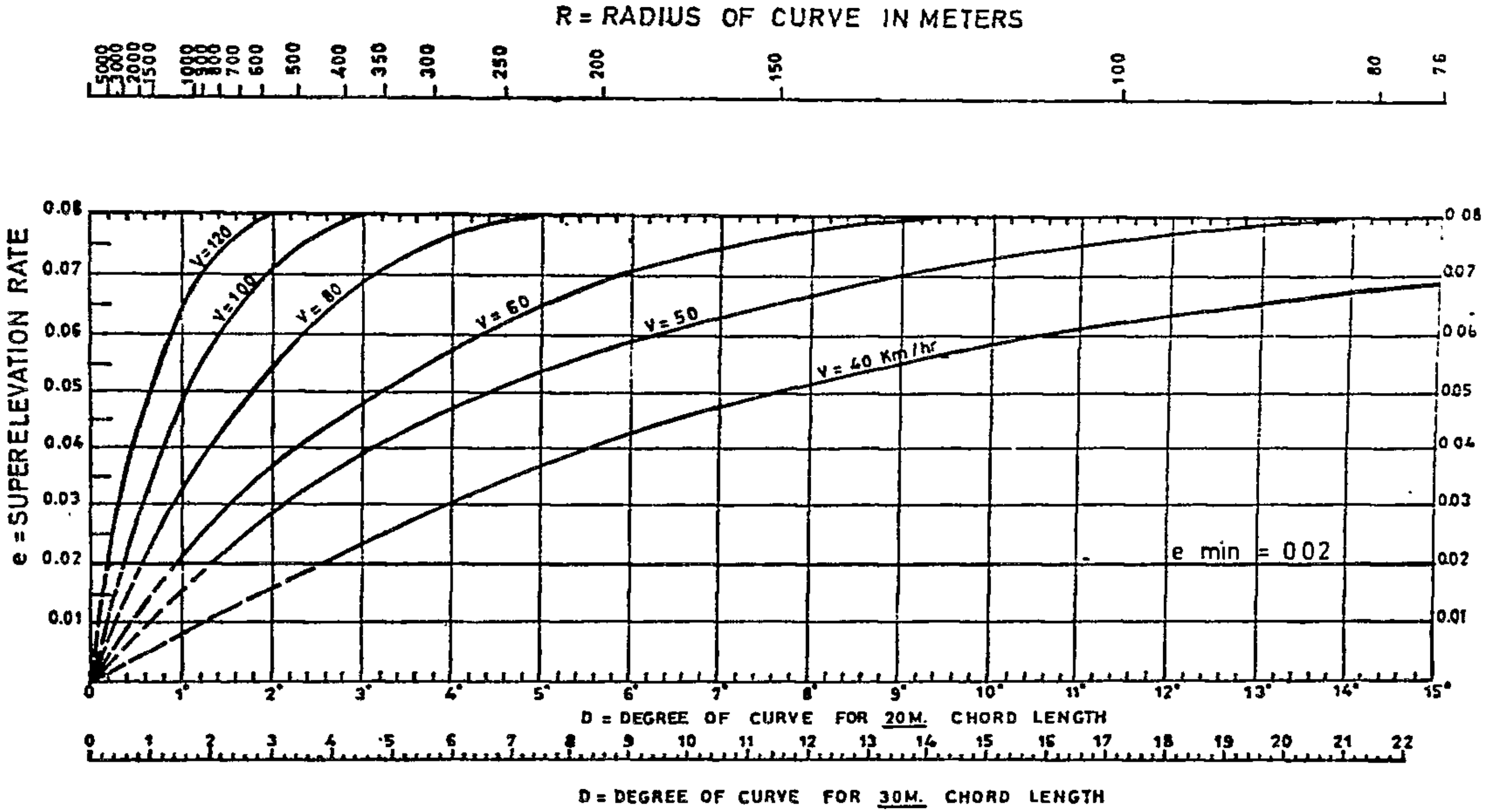


Fig. 7.5 DESIGN SUPERELEVATION RATES

e max, = 0.08

7.3 Alternative Route Study

7.3.1 General

Studies on alternative routes have been carried out for each route which, based on the results of the technical analysis, has looked most effective in the feasibility study.

For the purposes of this study, the field investigations included use of aerial photo mosaics with a scale of 1:2500 to provide a detailed base for the selection of the best route for each Ring Road. Alignment locations have been established for the routing of each Ring Road with due consideration for the following factors:

- Impacts on Communities:

  Social, Economic and Environmental Effects

- Major Right-of-Way Influencing Factors:

  Terrain, Land Use and Adjustment of Land for residential areas, as planned by the Irbid Municipality.

- Coordination with the Plan for Adjustment of Land for Residential areas now in process.

- Effects on the City Streets, Road System and Intersections.

- Traffic Volume

- Engineering Point of View and approximate Construction Costs in each of the relevant sections

- Natural Conditions:

  Mountain Ranges and Valleys

- Aesthetic and Safety Considerations

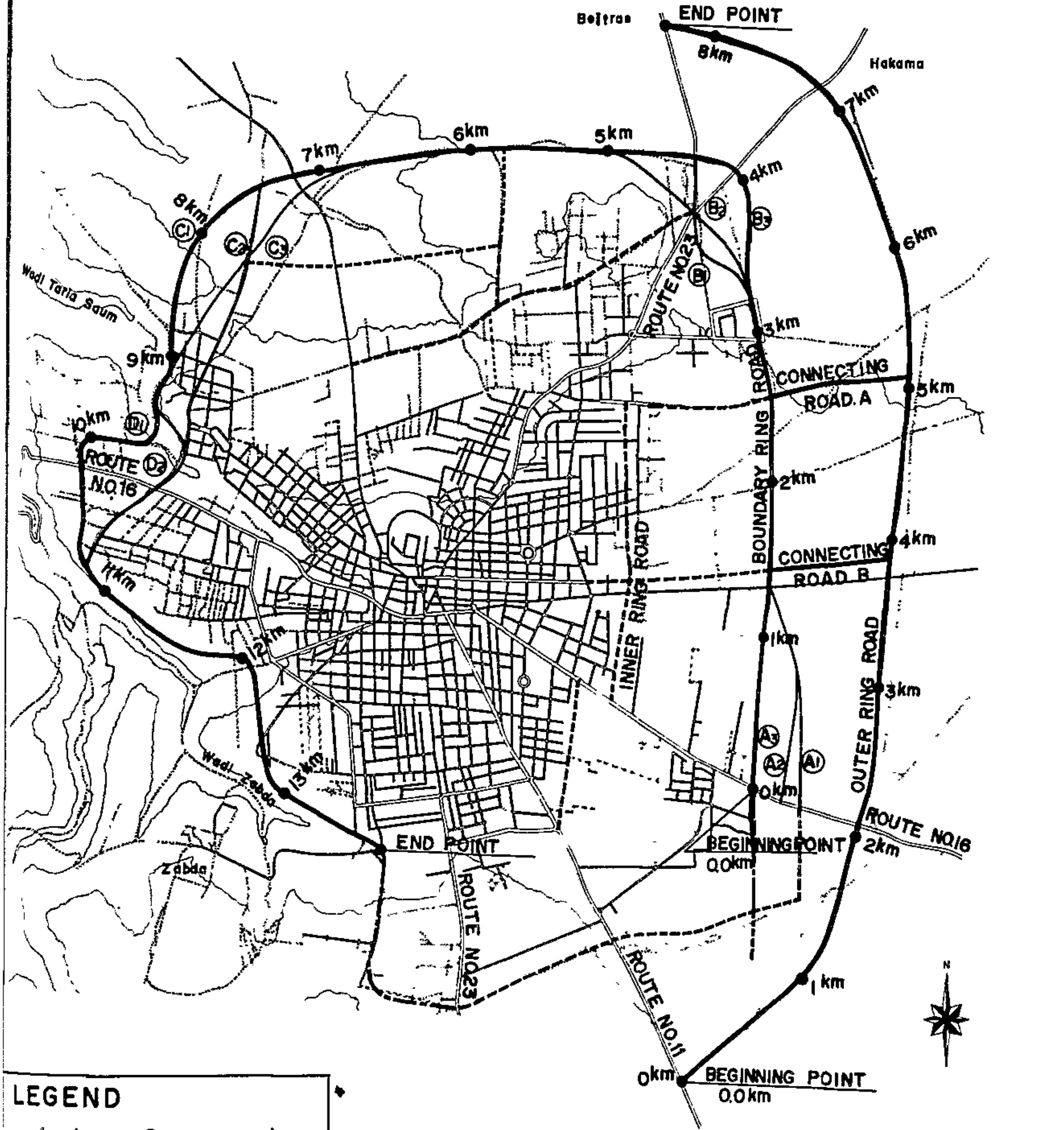
As a result of the study and investigations, the proposed alternative routes are as shown in Figs. 7.6, broken down into four alternative sections A to D.

7.3.2 Study of Alternative Routes

(1) A General Study of the Routes

Routing of the Proposed roads prior to the study of alternative routes was carried out as follows:

FIG. 7.6 ALTERNATIVE ROUTES FOR RING ROADS



LEGEND
- 4 – Lane 2- way road
- 2 – Lane 2- way road
- Alternative Routes
- Roads planned by the City
- Ideal Routes

Scale
S = 1: 40,000

0 10 20

1) Boundary Ring Road (BRR) (Flat/Rolling areas)

The road network of the City of Irbid has been under study since 1970 by the Municipality of Irbid, as part of the re-adjustment planning of the agricultural lands to be assigned as residential areas.

The planned road network was indicated on the plan with a scale of 1:2500 by the Municipality of Irbid as part of the re-adjustment planning.

Accordingly, the proposed routing of the BRR has been based on the existing plan for these sections. At the present time, there is no development within the northern section along the boundary of Irbid City.

For this reason, the BRR in the northern section will be effective as a road for the through traffic rather than as an urban street until urban development reaches the BRR.

Therefore the urban street as planned by the Municipality of Irbid in this section located on the southern side of the BRR running parallel, at a distance of 700 m, should be constructed as early as possible.

2) BRR (Mountainous area)

In this largely developed section, the BRR runs along the side of a Wadi. It is evident that costly earth works, such as box culverts and other structures will be necessary. Therefore, in order to determine the most suitable routing of the BRR, several schemes have been compared.

3) Outer Ring Road (ORR)

The Routing of the ORR has been based on the plan by the Irbid Municipality for the Adjustment of Land for Residential Use. Separated by a distance of some 1 km, the ORR runs almost parallel to the BRR around the outskirts of the city.

4) Connecting Roads (CR)

CR A, has been planned to extend a road now proposed by the City Municipality and CR B, has been planned to extend a road now under construction. CR A, is close to an industrial area and CR B, runs closely parallel to Bishra Street.

(2) Alternative Routes Study

1) BRR (Section A)

In coordination with the plan by the Irbid Municipality for the Adjustment of Land for Residential Use, three alternative plans have been proposed as listed below.

a) Comparison of Alternative Routes A1, A2 and A3.

- Alternative A1 connects directly with the planned road south of Route 16; however the intersection is too close to the ORR and too far from the IRR.
- Alternative A2 follows the route planned by the City Municipality, but the connection between this road and the road planned south of Route 16 is bad, and as above the distance to the ORR is still too close and still too far from the IRR.
- Alternative A3 produces a much better relationship to the ORR and IRR since it is 700 m from the ORR and 1,100 m from the IRR. However, it does not connect at all with the road south of Route 16.

b) Recommendation

The alternatives A1 and A2 do not give smooth alignment of the road over section A and in addition, their relationship to the ORR is bad. They are therefore not recommended. Alternative A3 gives good road alignment over section A and is well positioned between the IRR and ORR. However, it does not connect with the road south of Route 16. For this reason it is recommended that the road south of Route 16 be re-routed to connect with A3.

2) BRR (Section B)

Three alternative plans were considered with regard to the following:

- Social Aspects
- Existing Road Functions
- Compensation for Compulsory Land Sale
- Construction Costs

a) The respective advantages and disadvantages of each scheme are summarized in Table 7.2.

TAble 7.2 Comparison of BRR Section B Alternatives

Item \ Alternative	B1	B2	B3
Social Problems, i.e., Destruction of Existing Community, etc.	Many	Few	Very few
Intersection	Interchange between 5 roads	Interchange between 6 roads	The distance bet-between junctions is more than 300 m this is not a problem.
Construction Costs	Low	High	Low
Compensation	Low	High	Low
Land Aquisition	Expensive	Expensive	Cheap
Environmental Problems during Construction	Substantial	Substantial	Substantial

b) Recommendation

For the following reasons alternative B3 is recommended.

- There is little effect on the existing community.
- The existing and new junctions are conductive to easier traffic control and management.

- Good alignment of the BRR over this section.
- Construction costs and compensation for compulsory land sale are inexpensive.

3) BRR section C

As for section C, three alternatives were considered with regard to the following:

- Social Aspects
- Existing Road Functions
- Compensation for Compulsory Land Sale
- Construction Costs

a) Comparison of alternatives C1, C2 and C3

- Alternative C1 passes on the west side of a graveyard and factory and as far as possible avoids existing buildings.
- Alternative C2 passes on the east side of the graveyard and is nearer to the city than C1.
- Alternative C3 follows the same route as an existing road, Al Jawhary Street, and requires road improvements.

The above advantages and disadvantages are summarized in Table 7.3

Table 7.3 Comparison of BRR Section C Alternatives

Item \ Alternative	C1	C2	C3
Social Problems, i.e., Destruction of Existing Community, etc.			
Design of Project Road	No problems in regard to road junctions. However substantial earthworks are necessary.	Relationship to existing road junctio=s is poor. However very few earthworks are necessary.	Relationship to existing road junctions is poor. However very few earthworks are necessary.
Construction Cost	Slightly High	Low	Low
Compensation	Low	High	Extremely High
Land Aquisition	Low	High	Extremely High
Environmental Problems during Construction	Negligible	Substantial	Substantial

b) Recommendation

For the reasons stated below, we recommend alternative C1.

- There is little effect on the existing community.
- The relationship to existing road junctions makes for easier traffic control and management.
- The required earthworks and construction costs are fairly expensive; however, the extremely high costs involved in land compensation and inevitable problems with rehousing etc., for alternatives C2 and C3, make alternative C1 the best proposition of the three.

4) BRR section D

Two alternative plans were considered with regard to the following:

- Social Aspects
- Existing Road Functions
- Compensation for Compulsory Land Sale
- Construction Costs

a) Comparisons of alternatives D1 and D2

- Alternative D1 crosses over the Wadi Tariq Saum, and runs along an existing road on the plateau to the west of the Wadi. In order to cross over the Wadi, a bridge or other such structure is necessary.

- Alternative D2 runs east of the Wadi and connects with Jerusalem Street; it will require road improvements.

The above advantages and disadvantages are summarized in Table 7.4.

Table 7.4 Comparison of BRR Section D Alternatives

Item \ Alternative	D1	D2
Social Problems, i.e., Destruction of Existing Community, etc.	Few	Many
Design of the Road	Necessitates a bridge or other such structure	As the existing gradient of Jerusalem Street is more than 10%, it will require some road modifications.
Construction Costs	High	Slightly high
Compensation	Low	High
Land Aquisition	Slightly high	Slightly high
Environmental Problems during Construction	Slightly evident	Evident

b) Recommendation

For the following reasons, D1 is recommended:

- Little effect on the existing community
- D2 requires extensive road widening and also necessitates raising the existing road. This will adversely affect the community.
- In order to cross over the Wadi Tariq Saum, a culvert must be constructed. This will be expensive, but cheaper than the costs for compensation and rehousing required in alternative D2.

CHAPTER 8 PRELIMINARY DESIGN OF RING ROADS

8.1 General

In this chapter, a preliminary design is carried out on each alternative route, which has been determined as the most effective in the feasibility analysis, based on the results of the alternative route study in Chapter 7.

The preliminary design is shown on the 1/2,500 aerial photo mosaics.

The purpose of the study is to carry out the Preliminary Engineering to a degree of accuracy that will permit estimates of principal quantities for construction with an accuracy of ± 20% of the final quantities. The principal quantities for construction will include common and rock excavation, base and sub-base materials, surfacing materials, number and size of principal drainage structures and major structures.

8.2 Alignment Study

8.2.1 Route Description

Based on the most appropriate routes, a detailed alignment study was made. A general description of the route of each Project Road is given below:

(1) BRR

1) STa. 0 + 0.0- STa. 4 + 0.0

In this section, the topography is flat, and the land is mainly used for agricultural purposes.

At Station 3, use is made of an existing road that runs through an industrial area.

The BRR begins from Route No. 16, and is separated by some 1,100 m from the Inner Ring Road.

Near STa. 4 + 0.0, the route detours north-eastward, so as to avoid the community, and therefore, minimizes the need for compensation. At the intersection of STa. 4 + 0.0 and STa. 4 + 300.0 with existing roads, the distance form the existing intersection to the south has been taken into account in the alignment study. The route crosses existing roads with an angle of about 90 degrees.

2) STa. 4 + 0.0 - STa. 7 + 0.0

The topography of this section is slightly hilly Rolling Area, sloping down to the west. Land use is predominantly used for agriculture with some parts remaining undeveloped.

The Wadi flows from east to west, and parallel with it, there is a road used for agricultural traffic with a width of 2 - 3 m.

In this section, no suitable control point for route alignment was found. Therefore, the route alignment traces the route of the City Road planned by Irbid.

3) STa. 7 + 0.0 - STa. 8 + 300

The Hilly Area in this section with an altitude of 500 m is used for agricultural purposes. The Route for the proposed road is through hills giving variations in height of some 30 m. The route was determined by taking a factory on the southern slope as a control point.

An at-grade intersection with the existing road south of the factory is impossible to make as the longitudinal slope of the Ring Road is over 6%. The Ring Road is therefore planned to flyover the existing road.

4) STa. 8 + 300 - STa. 9 + 0.0

In this section, some houses are scattered on the slope along the Wadi, where the bed rock is exposed. The control points for route alignment are the places near STa. 8 + 300 and STa. 9 + 0.0, where the road crosses the valley. The route was determined so that the size of structures would be minimal. Along the sloping section along the Wadi, the route was determined so as to minimize earth works.

5) STa. 9 + 0.0 - STa. 10 + 300

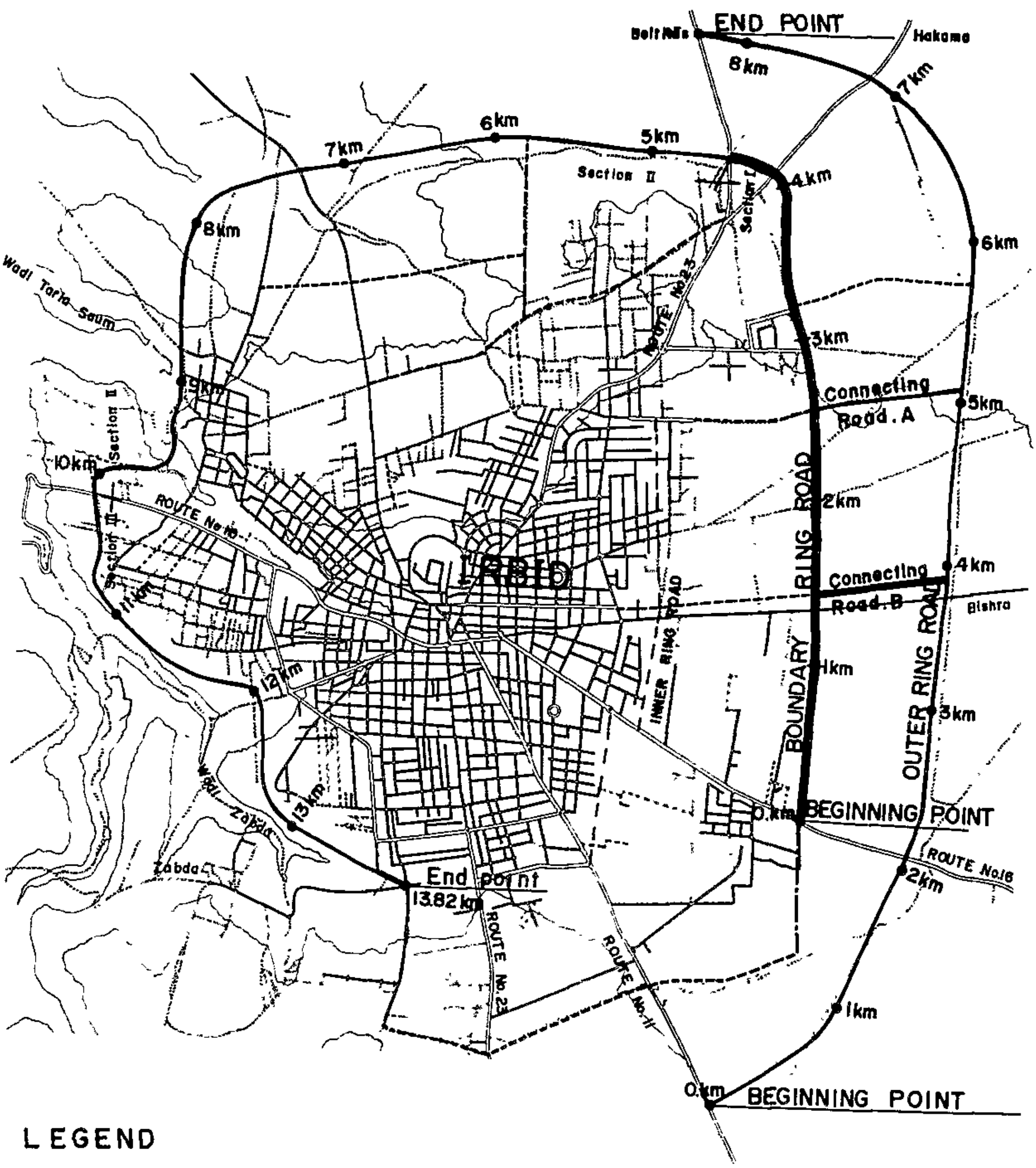
The topography in this section is hilly and the land is made up of olive orchards and residential areas.

Control points for route alignment are the intersection with Route No. 16 and positions of scattered houses, the existing roads are utilized as much as possible for the project road, and the alignment for the project road is planned so as to form a right angle with Route No. 16.

6) STa. 10 + 300 - STa. 13 + 700

The slope along the Wadi in this section is an undeveloped area with scattered housing, and bed rock exposed throughout the surface. Since there are no important control points, the route alignment was determined so that the earth works would be minimal and that the road might cross the valley at STa. 11 + 450 at the lowest possible height.

Fig. 8.1 LOCATION OF THE PROJECT ROADS



LEGEND

- 4-Lane 2-Way road
- 2-Lane 2-Way road
- Roads Planned by the City
- Ideal Routes

Scale
S = 1:40,000
0 10 20

(2) ORR

Flat terrain prevails in this section. The ending point for the road is on a hill. The land in this area is used for agricultural purposes. The route for the DRR was determined so as to run parallel with the BRR separated by a distance of some 900 - 1,000 m. In the main, this route traces the route of the City Road planned by Irbid.

8.2.2 Study of Vertical Alignment

The study for the vertical alignment was made simultaneously with the study for the horizontal alignment and a study of structures such as the calverts. Accordingly, the adjustment of the vertical and horizontal alignments mentioned above was carried out.

Where the Project Road crosses a Wadi, hydrological and hydraulic studies were made in order to determine the high water levels for drainage structures. High water levels determine the required height of culverts and therefore, become important control points in the vertical alignment study.

Basic requirements controlling the engineering aspects of the vertical alignment study were as follows:

- In the Flat and Rolling area, the finished grade of the roadway will be maintained 0.2 - 0.6 m above the natural ground as far as possible taking into consideration the landuse after development
- A minimum gradient of 0.3% will be adopted for roadway surface drainage
- Flatter vertical gradients and a larger length of vertical curve will be adopted near the intersecions as much as possible;
- In the mountainous area, vertical alignment was determined so as to minimize earth works
- The minimum vertical clearance for grade separation structures will be 5.0 m
- A combination of horizontal and vertical alignments will be considered

8.3 Analysis of Road Capacity

The analysis of road capacity was made by using the HIGHWAY CAPACITY MANUAL 1965, U.S. DEPARTMENT OF COMMERCE, BUREAU OF PUBLIC ROADS and the "Japan Road Design Standard".

8.3.1 Throughfare Capacity

The projected road shall be built in several constructional stages. The road capacity for each stage is shown in Table 8.1.

- A maximum gradient of 6.0% will be adopted in consideration of heavy trucks;

In addition to the basic requirements mentioned above, the following primary control points were considered for the determination of vertical alignment

(1) Flat and Rolling Area

- At-grade intersections to be considered at:

  Jarash St. (Route No. 11)
  Baghdad St. (Route No. 16)
  Bishra St.
  Hakama St.
  Beit Ras St. (Route No.23)
  Fouara St.

(2) Mountaineous Area

- At-grade intersection to be considered at;

  Palestine St. (Route No. 16)

- Grade-separation structures to be considered at;

  Sta. 8 + 820 (Existing road south of Factory)

- The Wadi to be considered at:

  STa. 7 + 700
  STa. 8 + 830
  STa. 9 + 480
  STa. 12 + 120

Basic Capacity (PCU/hr.)	Possible Capacity (Veh./hr.)	Design Level	Adjustment of Design Level	Design Capacity (Vhe./hr.)	Peak Factor (%)	Rate of Direction (%)	Design Daily Volume (Veh./Day)	Remarks
CB	C		V/C	CD	K	D	ADT	
,500	1750	1	0.8	1,400	10	60	12,000	Per 1 Lane
,500	1780	1	0.8	1,420	10		14,000	Per 2 Lane
,500	1450	1	0.8	1,160	10		12,000	Per 2 Lane
,500	1780	1	0.8	1,420	10		14,000	Per 2 Lane
,500	1780	1	0.8	1,420	10		14,000	Per 2 Lane
,500	1750	1	0.8	1,400	10	60	12,000	Per 1 Lane

K : Peak Factor (%)

D : Rate of Direction

Table 8.1 Design Traffic Capacity Analysis

Item	Design Speed (KM/hr)	Lane Width (M)	Lateral Clearance: Left (M)	Lateral Clearance: Right (M)	Heavy Vehicles: % of H.V. PT	Heavy Vehicles: Passenger Car Equivalent ET	Coefficient of Adjustment: Lane Width γL	Coefficient of Adjustment: Lateral Clearance γC	Coefficient of Adjustment: Heavy VEH γT	Coefficient of Adjustment: Condition of Sight γI	Coefficient of Adjustment: Total	Basic Capacity (PCU/hr.) CB	Possible Capacity (Veh./hr.) C	Design Level	Adjustment of Design Level V/C	Design Capacity (Vhe./hr.) CD	Peak Factor (%) K	Rate of Direction (%) D	Design Daily Volume (Veh./Day) ADT	Remarks
BRR (Section 1) 4 Lane, 2 Way	80	3.6	0.5	3.0	20	1.75	1.00	0.95	0.87	0.85	0.70	2,500	1750	1	0.8	1,400	10	60	12,000	Per 1 Lane
BRR (Section 2) 2 Lane, 2 Way	80	3.6	3.0	3.0	20	2.05	1.00	1.00	0.83	0.85	0.71	2,500	1780	1	0.8	1,420	10		14,000	Per 2 Lane
BRR (Section 2.3) 2 Lane, 2 Way	60	3.6	3.0	3.0	20	3.40	1.00	1.00	0.68	0.85	0.58	2,500	1450	1	0.8	1,160	10		12,000	Per 2 Lane
ORR 2 Lane, 2 Way	80	3.6	3.0	3.0	20	2.05	1.00	1.00	0.83	0.85	0.71	2,500	1780	1	0.8	1,420	10		14,000	Per 2 Lane
CR - A 2 Lane, 2 Way	80	3.6	3.0	3.0	20	2.05	1.00	1.00	0.83	0.85	0.71	2,500	1780	1	0.8	1,420	10		14,000	Per 2 Lane
CR - B 4 Lane, 2 Way	80	3.6	0.5	3.0	20	1.75	1.00	0.95	0.87	0.85	0.70	2,500	1750	1	0.8	1,400	10	60	12,000	Per 1 Lane

$$\gamma T = \frac{100}{100 - PT + (ET.PT)}$$

$$CD = CB.\ \gamma L.\gamma C.\gamma T\ \gamma I \times V/C$$

ADT (Multiple Lanes)

$$= \frac{5000.CD}{KD}$$

Where

PT : Percentage of Heavy Vehicles

ET : Passenger Car Equivalent of Heavy Vehicles

γL : Coefficient of Adjustment for Lane Width

γC : Coefficient of Adjustment for Lateral Clearance

γT : Coefficient of Adjustment for Heavy Vehicles

γI : Coefficient of Adjustment for Condition of Sight

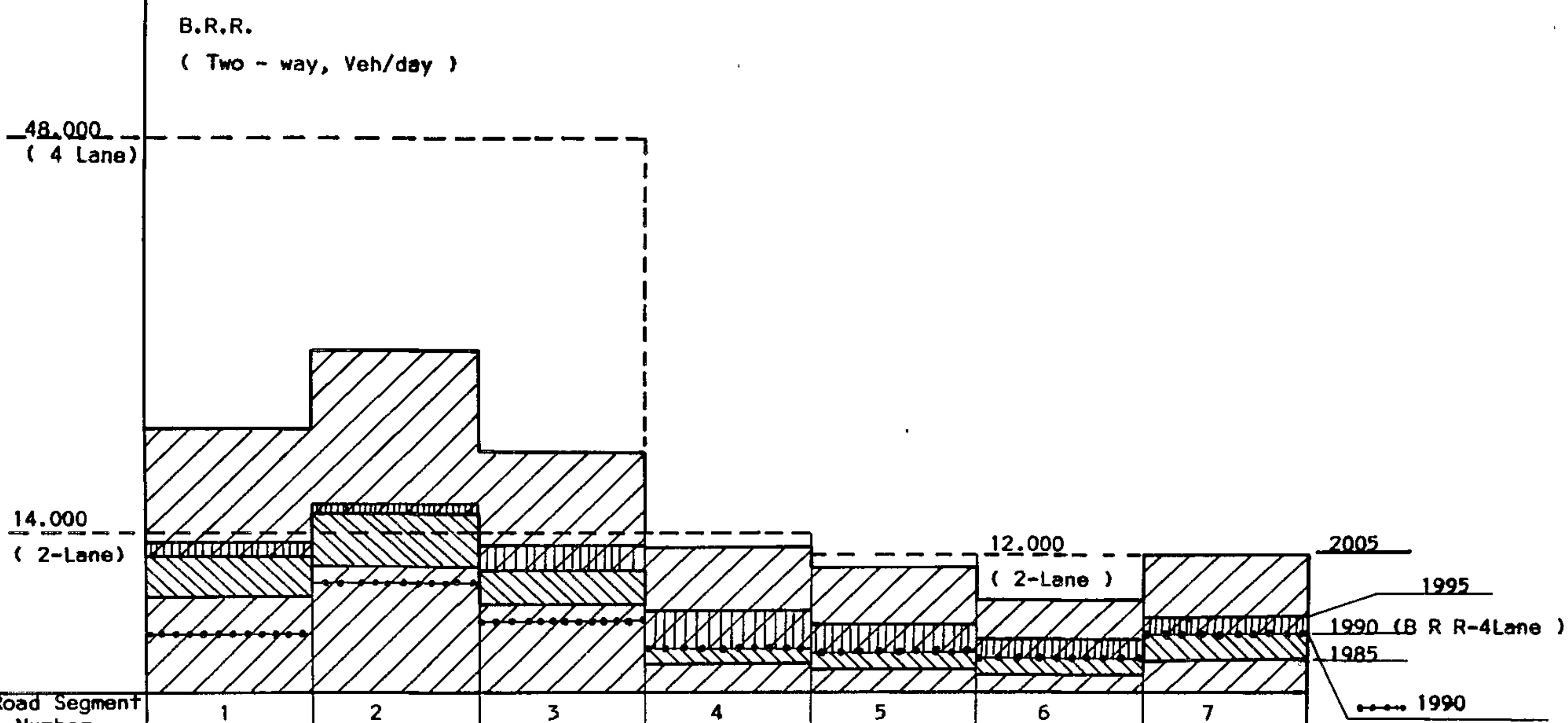
CB : Basic Capacity (PCU/hr.)

CD : Design Capacity (Veh/hr.)

K : Peak Factor (%)

D : Rate of Direction

Fig 8.2 Traffic Flow Volume by Segment



Road Segment Number	1	2	3	4	5	6	7
Road Segment	Baghdad St. -Bishra St.	Bishra St. -Mohe'd F.ST	Mohe'd F.St –Beit Ras St.	Beat ras St. –Fouuara St.	Foa'ra St. -Palestine St	Palestine St. -King F. 2nd	King Faisal2nd –Bab Al Wedd St.
Distance	0.00 Km - 1.32 Km	1.32 Km - 2,60 Km	2.60 Km - 4.40 Km	4.40 Km - 7. 22 Km	7.22 Km - 10.18 Km	10.18 Km -12.11 Km	12.11 Km - 13.82 Km
BRR Section	Section 1			Section 2		Section 3	

8.3.2 Determination of Number of Throughfare Lanes

Based on the analysis of throughfare capacity, two lanes are required for the BRR in the initial stage (See Fig. 8.2)

Four lanes will be required for the BRR (Segment 1) in 1995

8.3.3 Intersection and Functions

The capacity, speed limits and safety of almost all the urban arterial streets are dependant on the number, type and separating distances of the intersecting streets.

The design of at-grade intersections and setting up of traffic controls, therefore, greatly influences the safety and efficiency of arterial streets.

Accordingly, at-grade intersections play a very important role in the city traffic system, and consideration should be taken into account of their design and use. Seven intersections were analyzed (See Fig. 8.3, 8.4) for the year 1995 (10 years after opening to traffic).

(1) Basic Elements and Other Elements

The basic elements used for the analysis of at-grade intersections are as follows:

- Traffic capacity per lane

  Through lanes: 1,800 Veh (PCU)/Green hour

  Right-turn and left-turn lanes: 1,200 Veh (PCU)/Green hour

- Other elements

  Peak Factor: 10%
  Percentage of heavy vehicle: 23%
  Rate per direction at peak hour: 60%

(2) Calculation Results

The results of traffic pattern analysis for 7 selected at-grade intersections are summarized in Table 8.2.

Possibility of signalized traffic control is known by the total value of the integrated congestion ratio (Σ Vi/Cpi). If the total value is less than 0.9, it is possible to control the traffic flow by signals.

Calculation has proved that every intersection satisfies this condition. Therefore, signalized traffic control is possible at all intersections. However, for intersection III, since the value of the congestion ratio is relatively small, signalized traffic control is not required.

Accordingly, signals for traffic control shall be set up at all intersections except III.

Lane arrangements and traffic controlling cycles for each intersection are shown in the same table. Calculation sheets for traffic capacity analysis are attached in the appendix 3.

FIG. 8.3 LOCATION OF INTERSECTION, AND TRAFFIC VOLUME PER DAY FOR THE YEAR 1995

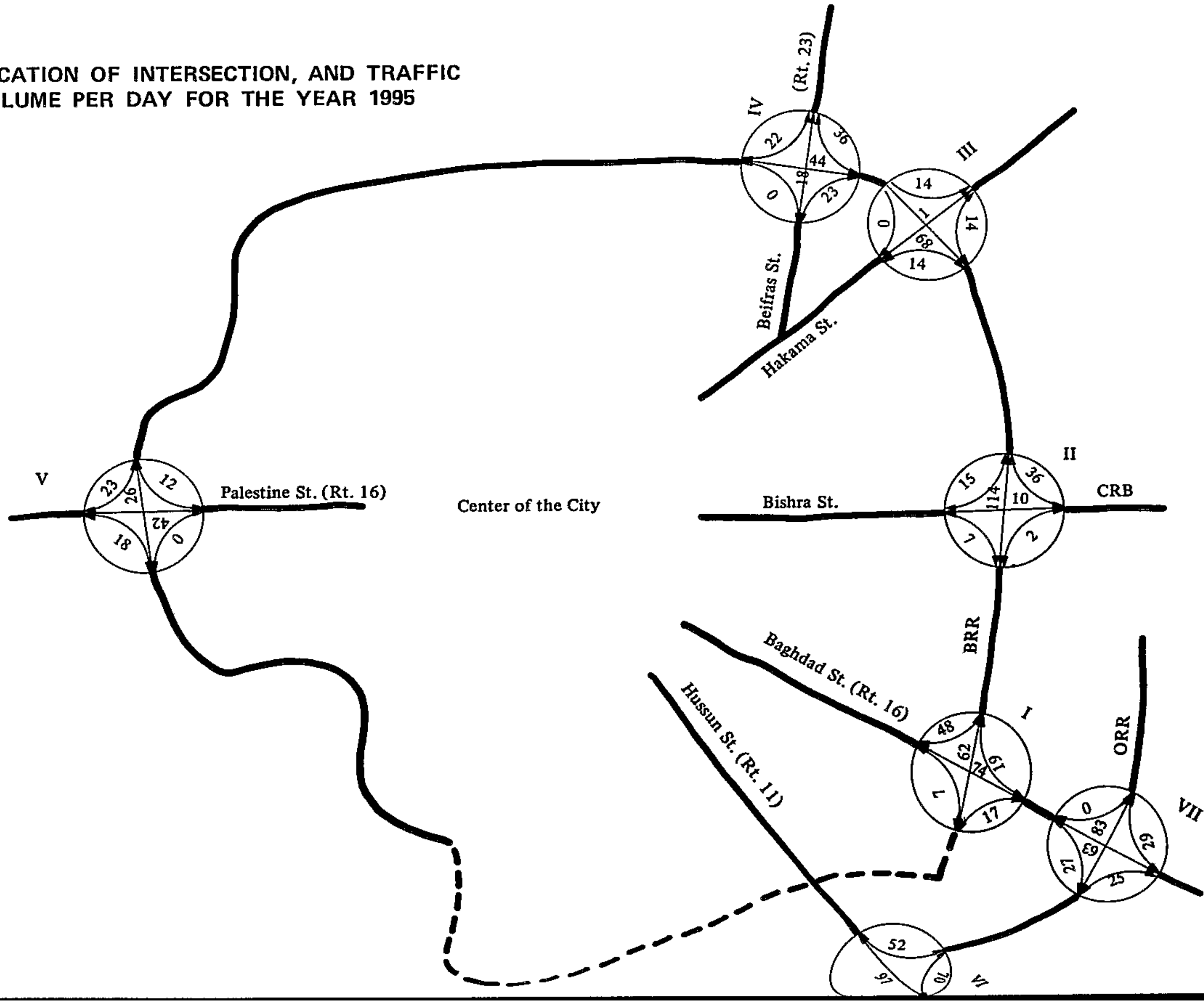


FIG. 8.4 LOCATION OF INTERSECTION AND TRAFFIC VOLUME IN THE PEAK HOUR FOR THE YEAR 1975

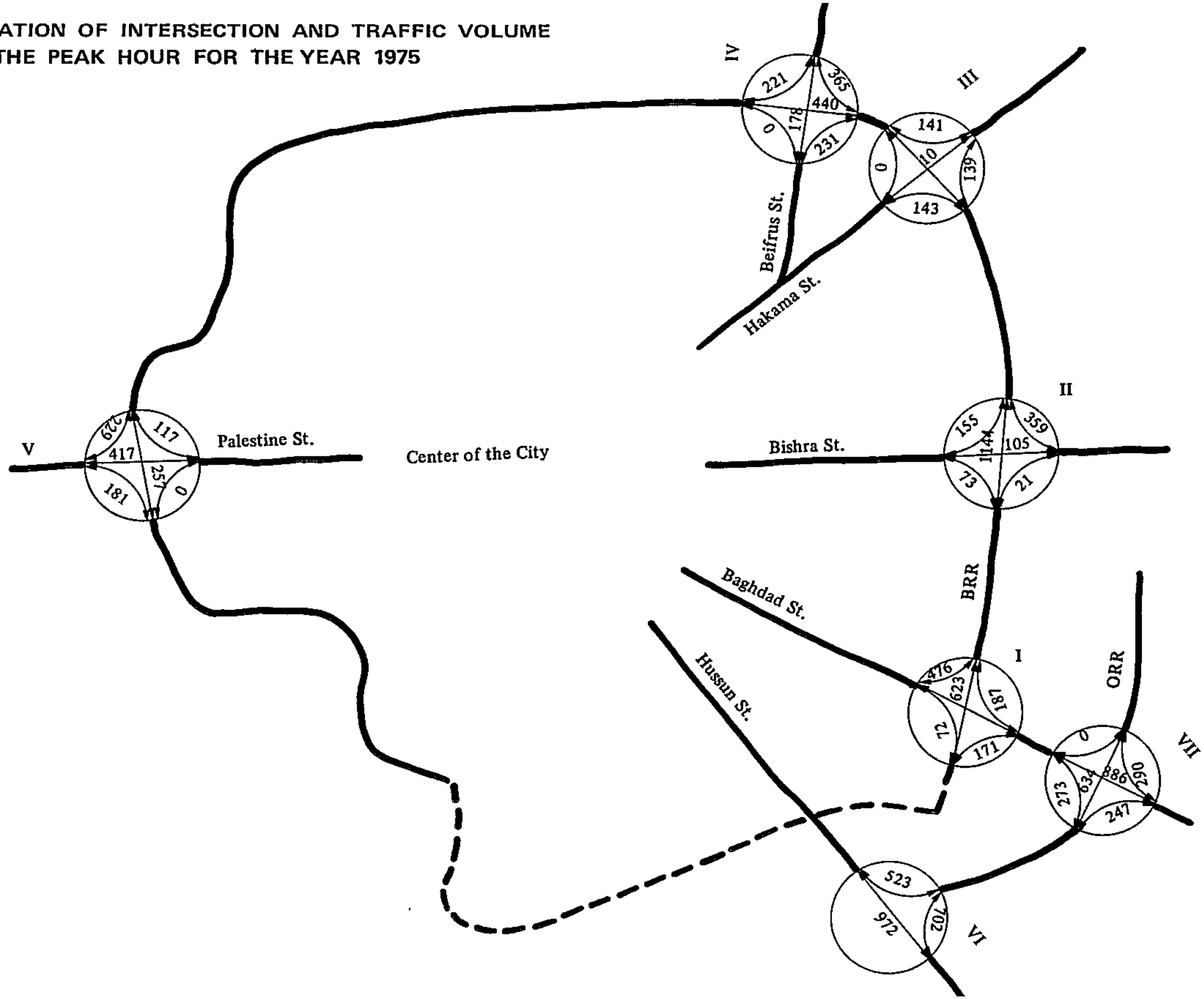
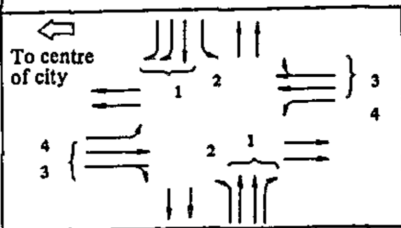
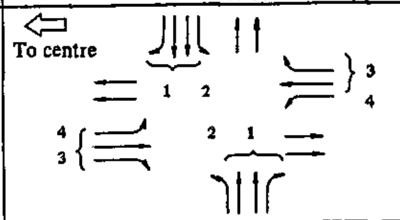
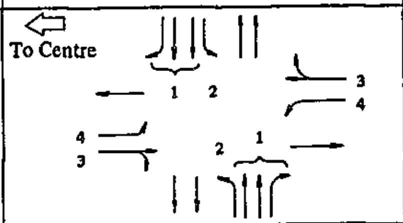
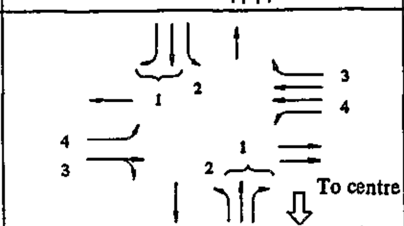
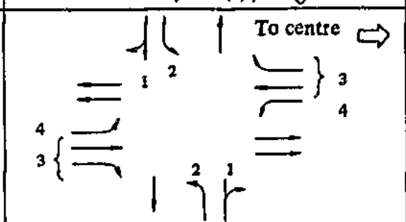
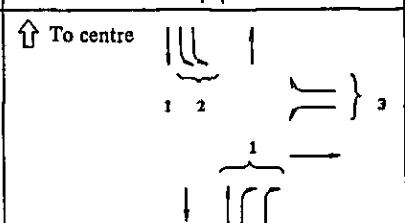
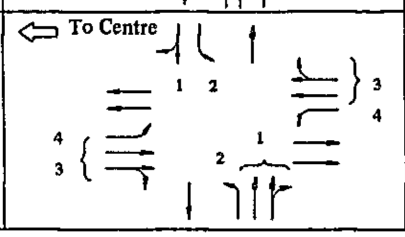


Table 8.2 Traffic Pattern and Phase Time of Intersections

	Lane Arrangement	Total of integrated congestion ratio Y = V/CP *	Phase time
I		0.852	(a) (A) 1) 29 + 3 2) 13 + 3 3) 25 + 3 4) 33 + 3 100 + 12
II		0.737	1) 30 + 3 2) 29 + 3 3) 29 + 3 4) 12 + 3 100 + 12
III		0.430	1) 41 + 3 2) 19 + 3 3) 21 + 3 4) 19 + 3 100 + 12
IV		0.746	1) 18 + 3 2) 29 + 3 3) 35 + 3 4) 18 + 3 100 + 12
V		0.696	1) 41 + 3 2) 15 + 3 3) 25 + 3 4) 19 + 3 100 + 12
VI		0.895	1) 43 + 3 2) 17 + 3 3) 40 + 3 100 + 9
VII		0.841	1) 30 + 3 2) 20 + 3 3) 33 + 3 4) 17 + 3 100 + 12

* Note: Y < 0.9 can be controlled by signals.

8.4 Pavement Design

8.4.1 General

The design method for the flexible pavement structure for the Ring Road construction project is based on the "HIGHWAY DESIGN MANUAL, 1972" in Jordan (MPW) and the "AASHTO INTERIM GUIDE FOR DESIGN OF PAVEMENT STRUCTURES, 1972". The elements of design used in this method are the planned traffic volume, durability in years of the pavement bearing strength of the subsoil and the coefficient for regional characteristics.

In the determination of the pavement thickness and its structure, considerations are made to maintain coordination with the local conditions.

Although the design of the pavement will be for a target of 20 years, to prevent excessive thickness and to reduce initial investment cost, the design will be for an initial thickness to meet traffic requirements of the first 10 years and will be overlaid subsequently to meet future requirements, namely, by stage construction. An economic composition of the stage construction alternative will be made against the alternative of constructing the entire pavement thickness in the initial year.

The asphalt pavement is composed of the subsoil, subbase, base course and surface course.

Each of these layers has a different function and it is necessary to choose the materials compatible to the required function and the structure that is of maximum economy.

The pavement design of the Ring Road for the surface course will be made up of hot-mixed asphalt concrete and the decision of the type of base course and subbase will be made with regard to the local conditions of the region, the workability, and costs, and it is proposed that the base course will be of crushed aggregate and the subbase of unscreened crushed rocks.

The preliminary design method giving estimated thicknesses of flexible pavement for the Ring Road is described as follows:

8.4.2 Design Conditions

(1) Design Traffic Volume

The following results are selected from the results of traffic forecast in chapter 4 for the purpose of determining the design traffic volume in pavement design.

The average daily traffic for the 20 years from 1986 to 2005 and the equivalent frequency of passenger car unit at a single axle weight of 8.2 tons, assuming a heavy vehicle ratio of 22% are as shown in Table 8.3

Table 8.3 Load Frequency of 8.2-ton Equivalent Single Axle Vehicle

Item \ Year	1985 (Opening year (2 lane)	1995 (10 years hence (2 lane)	2000 (15 years hence (2 lane)	2005 (20 years hence (2 lane)
Average Daily Traffic (Vehicle/day)	10,000	16,000	22,000	29,000
Design Traffic Volume (Veh/direction/lane/day)	5,000	7,200	9,900	13,050
Heavy Vehicle (Veh/day)	1,100	1,584	2,177	2,871
8.2 ton equivalent single axle Vehicle Load Frequency	265	382	525	692

Lane Distribution Factor: 1.0 for 2 lanes
0.9 for 4 lanes

8.2 Ton Equivalent Rate

Table 8.4 Equivalent 8.2-ton Single Axle Loads per Day

Vehicle	% Trucks	No. of vehicles in each class (A)	Load Equivalency Factor (B)	Equivalent 8.2-ton Single Axle Loads (C)
2 Axle Single Unit	17.9	179	0.17	30
3 Axle Single Unit	1.4	14	0.51	7
3 Axle Semi-Trailer	0.5	5	0.46	2
4 Axle Semi-Trailer	1.2	12	0.64	8
5 Axle Semi-Trailer	1.0	10	0.64	6
Total	22	220		53

Where;

% Trucks: assumed using the results of traffic surveys.

(A) : No. of Vehicles in each class for 1,000 vehicles.

(B) : Load Equivalency Factor based on Highway Design Manual (MPW)

(C) : (A) + (B)

8.2-ton equivalent rate per 1,000 for heavy trucks = $\frac{53}{220}$ x 1,000 = 241

(2) Relative Strength Index

The pavement thickness index (D) as obtained based on 8.4.2 (3) and its relation with the actual thickness is expressed by the following equation based on the relative strength index of the component materials of each layer.

$$D = a1\ D1 + a2\ D2 + a3\ D3$$

Where, a1, a2, a3 = Relative strength index of each layer
D1 = Thickness of asphalt surface course
D2 = Thickness of base course
D3 = Thickness of subbase cource.

Pavement component materials	Relative strength index
Surface course (plant mixed)	0.17
Base course (crushed aggregate)	0.06
Subbase course (unscreened crushed rock)	0.04

(3) Minimum Thickness of Surface Course

The pavement course structure has to satisfy the pavement thickness index and at the same time the total .minimum thickness of the surface course is determined by the volume of heavy vehicle traffic.

(4) The Bearing Strength Coefficient of Subsoil (SSV)

From the result of soil survey, the design CBR of the project area is determined at 2.5 (see section 6.3), and the bearing strength coefficient of the soil as converted from the CBR determined at SSV = 2.8.

(5) Regional Factor (R)

The regional factor at 1.5 was adopted for this design, considering the adverse conditions in the project area, such as the slight strength loss of the road-bed materials which may occur during the rainy season.

8.4.3 Determination of the Pavement Cross Section

(1) Pavement Thickness Index

The adjusted pavement index for the target years is obtained from figure 11-1 of the AASHTO Interim Guide for Design of Pavement structures, 1972 based on the 8.2 ton equivalent single axle vehicle load frequency of Table 8.5 and the results are as follows:

Table 8.5 Pavement Thickness Index

Item \ Target year	1995 10 year hence	2005 20 year hence
Total Load Frequency	$1,180 \times 10^3$	$3,493 \times 10^3$
Pavement Thickness Index (D)	4.2	5.0

From Table 8.2 which shows the planned heavy vehicle traffic by years, the minimum total thickness of surface course up to 10 years after opening of the road is 5 cm and the final minimum is 10 cm so that the difference may be overlayed at a subsequent stage.

(2) Determination of Pavement Cross Section

Based on the analysis in 8.4.2 and (1). The pavement cross section for 10 and 20 years after opening of the road are respectively shown in Table 8.6 and 8.7.

(3) Economic Comparison between Total Construction and Stage Construction

The costs of total construction and stage construction of pavement converted to a present value of a discount rate of 10% are compared and it is seen that the stage construction is cheaper by 16%.

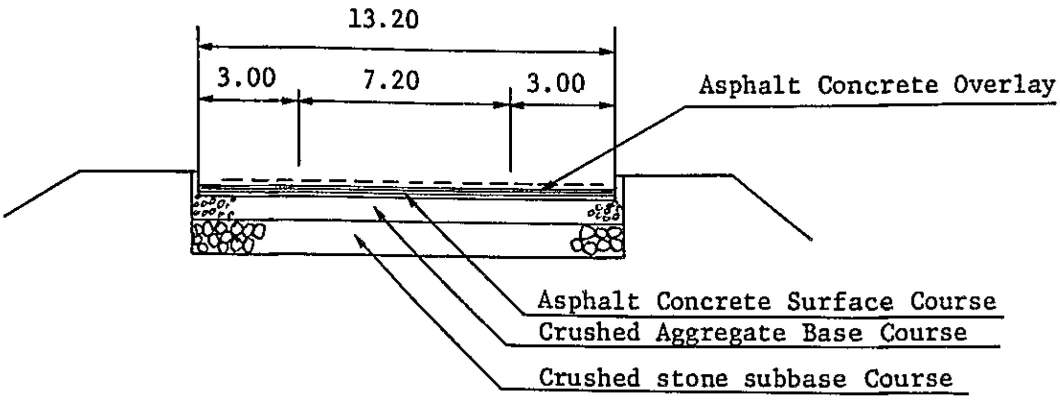


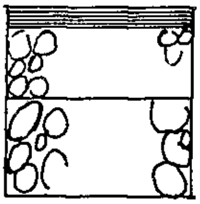
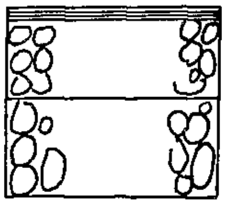
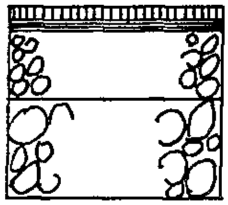
Table 8-6 Determination of Pavement Cross Section (for first 10 years, 1985-1995)

Pavement Structure	Thick-ness Di (cm)	Reflective Strength Index (ai)	Di × ai	Pavement Thickness Index (D)
Asphalt concrete surface course	5	0.176	0.88	4.2
Crushed aggregate base course	30	0.055	1.65	
Crushed stone subbase course	40	0.043	1.72	
Total :	75	-	4.25	

Table 8-7 Determination of Pavement Cross Section (for next 10 years, 1996-2005)

Pavement Structure	Thick-ness Di (cm)	Reflective Strength Index (ai)	Di × ai	Pavement Thickness Index (D)
Overlay (Asphalt Concrete	5	0.176	0.88	5.0
Asphalt concrete surface course	5	0.9 × 0.176	0.79	
Crushed aggregate base course	30	0.055	1.65	
Crushed aggregate subbase course	40	0.043	1.72	
Total :	80	-	5.04	

Note * Reduction ratio by rate of cracks at existing pavement.

Basic Design	First Stage (for 10 years)	Second Stage
 10cm AC, 30cm BC, 40cm SBC	 5cm AC	 5cm AC (over lay)
1.00 M^2 AC 2.60 JD	1.00 M^2 AC 1.30 JD	1.00 M^2 AC 1.30 JD
0.30 M^2 BC 1.05 JD	0.30 M^2 BC 1.05 JD	
0.40 M^2SBC 1.20 JD	0.40 M^2SBC 1.20 JD	

Pavement First Stage 3.55 JD Second Stage 1.30 JD

Cost

Per M^2 4.85 JD

Discounted at 10% (10 years) 0.50 JD

Total present Value 4.05 JD

8.5 Preliminary Design of Drainage Structures

8.5.1 General

The following preliminary engineering work allows the magnitude of construction costs for the project to be determined.

The type and dimensions for structures were determined from existing data on structures of a similar nature, and of base data obtained from the site investigation.

8.5.2 Run-off Analysis

The rainfall intensity was determined as follows:

1- Design storm frequency = 25-year (for Box culvert)

2- Rainfall intensity = see Fig. 6-12

3- Run-off coefficient = 0.8

(Future development was taken into consideration)

8.5.3 Hydraulic Analysis

To determine the size of drainage structures, the following assumptions were made.

Flow velocity

1- Box culvert = 3.0 m/sec

2- Pipe culvert = 1.5 m/sec

3- Water way (open channel) = 2.5 m/sec

8.5.4 Drainage Structures

(1) Flat Area

The Eastern part of Irbid is made up of flat agricultural land, where there are no existing water ways for the waste water.

When this area is developed in the future, the total amount of discharged water will increase, and if the water is collected in the low area, large drainage structures will be needed.

Considering the development plan for this residential area, a dispersive drainage system would be more suitable than a concentrated one.

Therefore, from the beginning points of the roads to HAKAMA street, both in the BRR and the ORR, culvert drainage structures were calculated, and are to be reinforced concrete pipes with a diameter of 800 mm at intervals of about 100 m.

(2) Rolling Area

On the north side of Irbid, the BRR passes through a rolling area alongside the Wadi.

The water from this area pours into the Wadi and flows away. For the water drainage, aside ditch would be necessary on the right of the road. And also, some culverts will need to be constructed.

(3) Mountaineous Area

On the west side of the City, the BRR passes through a mountaineous area along side the Wadi, and across the Wadi in 4 places.

Box culverts and portal culverts will need to be constructed.

Table 8.8 Hydraulic Factors for Drainage Structures in This Project

Route Name	Station	Drainage area (km^2)	Time of (MIN) Concentration	Rainfall Intensity (MM/h)	Peak Discharge (M^2/s)	Flow area (M^2)	Size of Structure (M)
BRR	0+0 - 4+0	2.25	30	48	24.0	22.4	Pipe culvert 0.8 x 35
BRR	7 + 700	9.39	120	22	45.9	15.3	Box culvert (3.0+3.0)x 3.0
BRR	8 + 830	0.50	30	55	6.1	2.0	Box culvert 2.0 x 2.0
BRR	9 + 480	3.99	60	37	32.4	10.8	Portal culvert 4.0 x 3.0
BRR	12 + 120	0.74	30	55	9.0	3.0	Box culvert 2.0 x 2.0
ORR	0+0 - 7+200	10.27	60	32	73.0	48.7	Pipe culvert 0.8 x 68

8.6 Preliminary Design of Structure

The preliminary engineering described has the purpose of determining the magnitude of construction costs for the project. The type and size of structures were determined from existing data on structures of a similar nature or based on data obtained from site investigations.

A total of five culverts are planned on the Project Roads : four culverts to be provided to drain flood and waste water, and one culvert to be provided for the existing road.

The following is a list of culverts to be constructed.

Route name	Station	Type	Size	Use
BRR	7 + 700	Box culvert	(3.0 + 3.0) x 3.0	Drainage
BRR	8 + 820	Box culvert	2.0 x 2.0	Road
BRR	8 + 830	Box culvert	8.0 x 5.0	Drainage
BRR	9 + 980	Portal culvert	4.0 x 3.0	Drainage
BRR	12 + 120	Box culvert	2.0 x 2.0	Drainage

CHAPTER 9 CONSTRUCTION COST ESTIMATE

9.1 General

The Study Team has estimated each construction pay item using the basic cost element such as labour, materials and equipment.

The unit prices were computed in accordance with the following criteria:

1) The estimates are made on the assumption that all construction works will be contracted to general contractors by international tender.

2) The unit prices were computed under the economic conditions prevailing in September, 1981.

3) The cost was estimated for all pay items and was classified into foreign currency and local currency portions, both portions indicated in Jordan Dinars (JD).

   The rates of exchange used to convert the Jordan Dinars currency to US$ are: JD1.00 = US$2.941   US$1.00 = JD0.340

Foreign currency and local currency components of each unit price were computed based on the following classification of basic cost elements:

1) The foreign currency component consists of costs for:

   - Imported equipment, materials and supplies
   - Domestic materials of which the country is a net importer
   - Wages of foreign personnel
   - Overheads and profits of foreign firms

2) The local currency component includes the cost of:

   - Domestic materials and supplies of which the country is a net exporter
   - Wages of local personnel
   - Overheads and profits of local firms
   - Duties and taxes

3) The unit price of each work item is obtainted by accumulating the labour cost, equipment cost, material cost, etc. for the

item and informed opinions on various specific items secured in interviews with individual Ministry of Public Works' engineers and local contractors. The results were checked agasint recent actual figures for the construction work in Jordan.

9.2 Unit Costs

(1) Unit Costs of Materials

The unit cost data of materials was collected; those materials are based on the market prices in the northern part of Jordan. The unit costs of the major material items are shown in Table 9.1.

Table 9.1 Unit Cost of Major Materials

Material	Unit	Unit Cost (JD)		
		Local	Foreign	Total
Cement	ton	27	3	30
Reinforcing Steel Bar	ton	18	162	180
Fine Aggregate	m^3	1.0	1.0	2.0
Coarse Aggregate	m^3	1.0	1.0	2.0
Base Course Material	m^3	0.75	0.75	1.5
Asphalt	ton	4	36	40
Diesel Fuel	lit	0.005	0.045	0.05
Reinforced Concrete Pipe				
ϕ 400	m	6.3	7.7	14
ϕ 600	m	9.0	11.0	20
ϕ 800	m	13.5	16.5	30
ϕ 1,000	m	24.7	30.3	55

Source : Ministry of Public Works and Study Team.

(2) Unit Cost of Labour

The unit labour cost is based on the actual cost prevailing in the northern part of Jordan.

The estimated labour costs include wages, insurance, travel costs, sick leave, etc.

The unit wage rates of the major labour classifications are shown in Table 9.2.

Table 9.2 Local Labour Unit Wage Rates

Description	Wage Rates Per Hour (J.D.)	Wage Rates Per Day (J.D.)
Foreman	2.865	23
Skilled Operator	2.252	18
Semi-Skilled Operator	1.733	12
Mechanic	2.252	18
Site Surveyor	2.355	19
Driver	1.33	11
Skilled Workman	1.33	11
Ordinary Workman	0.613	5

Source: Ministry of Public Works.

(3) Equipment Cost

As assessment of equipment hourly costs was made for the plant that would probably be used in the construction of the project. These equipment rates are shown in Table 9.3.

Thus, the estimated hourly owning costs were calculated based on the estimated CIF unit prices at Aqaba and the operation costs (fuel, lubricant and other expenses) are based on the market prices in Jordan.

Table 9.3 Equipment Hourly Cost

(Unit : JD/hour)

No.	Equipment		Local	Foreign	Total
1.	Bulldozer	17 ton class	4.370	8.700	13.070
2.	Bulldozer	21 ton class	6.791	12.459	19.250
3.	Motor Scraper	(8 m^3)	5.538	9.948	15.486
4.	Convertible Excavator	(0.6 m^3)	3.885	7.423	11.308
5.	Wheel Loader	(1.4 m^3)	3.525	8.126	11.651
6.	Dump Truck	(3.0 m^3)	1.501	1.509	3.010
7.	Flatbed Truck	(4.5 ton)	1.450	1.161	2.611
8.	Fuel Tanker	(5,000 lit)	1.512	1.629	3.141
9.	Track Crane	(10 ton)	3.590	5.750	9.340
10.	Hydraulic Excavator		7.809	14.328	22.137
11.	Motor Grader		4.482	7.931	12.413
12.	Tandem Road Roller	(8 ton)	2.682	3.052	5.734
13.	Macadam Road Roller	(8 ton)	2.295	2.514	4.809
14.	Macadam Road Roller	(10 ton)	2.435	2.804	5.139
15.	Tyre Roller	(9-19 ton)	3.040	3.262	6.302
16.	Sheep's Foot Roller		2.373	2.276	4.649
17.	Vibrator Roller, Hand Guide		0.803	0.818	1.621
18.	Rammer		1.246	2.095	3.341
19.	Stone Crushing Plant		12.478	35.524	48.002
20.	Concrete Mixer Truck	(1.7 m^3)	1.792	1.931	3.723
21.	Concrete Batching Plant	(40 m^3/h)	5.746	7.812	13.558
22.	Road Vibrator		0.648	1.105	1.753
23.	Asphalt Plant	(10 ton/h)	35.759	72.632	108.391
24.	Asphalt Distributor	(4,000 lit)	4.534	5.954	10.488
25.	Bituminous Spreader	(5 m)	8.642	10.775	19.417
26.	Asphalt Kettle	(5,000 lit)	1.289	3.920	5.209
27.	Mechanical Broom		1.002	1.534	2.356
28.	Portable Air Compressor		9.950	18.411	28.361
29.	Generator	30 KVA	2.675	5.747	8.422
30.	Generator	50 KVA	4.158	8.807	12.965

Source : Ministry of Public Works and Study Team.

(4) Unit Cost of Work Items

The unit cost by work item is calculated from the material cost, labour cost, equipment cost, etc., taking into consideration the local conditions.

The results of the major unit costs by work items are shown in Table 9.4.

Table 9.4 Major Unit Cost of Work Item

(JD)

Item	Unit	L.C.	F.C.	Total
1. Mobilization	Ls	(52%)	(48%)	(100%)
2. Clearing & Grubbing	m^2	0.04	0.04	0.08
3. Common Excavation	m^3	0.41	0.52	0.93
4. Borrow Excavation	m^3	0.79	1.01	1.80
5. Rock Excavation	m^3	2.2	2.8	5.0
6. Structure Excavation	m^3	1.1	1.0	2.1
7. Base Course (300 m/m)	m^3	1.86	1.64	3.5
8. Sub-base Course (200 - 400 m/m)	m^3	1.6	1.4	3.0
9. Asphalt Concrete Surface (50 m/m)	m^2	0.54	0.76	1.30
10. Box Culverts	m^3	38.4	33.0	71.4
11. Pipe Culverts (ϕ 800)	m	28.5	24.5	53.0
12. Retaining Wall	m^3	21.4	13.6	35.0
13. Stone Masonry	m^2	6.7	3.3	10.0
14. Other Drainage Facilities	Km	1,830	1,170	3,000
15. Concrete Curb	m	2.0	1.5	3.5
16. Concrete Tiled Sidewalk	m^2	2.3	1.7	4.0
17. Lighting with Post	each	26	124	150
18. Traffic Signal	each	196	1,504	1,700
19. Other Incidental Work (road signs, guard rail, painting, etc.)	Km	1,650	4,350	6,000

Source : Ministry of Public Works and Study Team.

Notes: Ls ; Lump Sum
L.C. ; Local Currency
F.C. ; Foreign Currency

9.3 Land Acquisition and Compensation Costs

The land acquisition and housing compensation costs were calculated according to the data on land prices and compensation prices in September 1981, obtained from Irbid Municipality.

(1) Land Acquisition

According to an Irbid City official, land owners along the proposed route are obliged to provide the municipality with 25 percent of their land free of charge.

At the present time, a readjustment plan for most of the land for the proposed roads has been carried out by Irbid Municipality.

However, it is necessary to urgently modify the readjustment plan if the proposed roads can be outed on the 25 percent provided by the land owner since the land acquisition cost is free of charge; if not, some land acquisition funding is necessary.

The cost estimation has been calculated partially based on the assumptions provided by an Irbid Municipality official.

Land prices range from JD 10 to JD 20 per m^2 in Irbid City.

(2) Compensation

Date obtained from the Municipality of Irbid and the field survey are as follows:

- House Construction Cost

Kind of House	Unit Cost JD/m^2
Stone	85
Concrete	70
Block	60

- Demolition Cost

JD 650/house (500 - 800 JD/house)

- Land price of existing houses on proposed road

JD 14/m^2 (12 - 16 JD/m^2)

- Land area of existing houses

500 m^2/house (400 - 600 m^2/house)

- Total floor area of existing houses

  150 m^2/house (120 - 180 m^2/house)

- Number of houses affected by proposed roads:

Kind of House	Number
Stone	4
Concrete	16
Block	10
Total	30

9.4 Construction Cost Estimate

The preliminary construction cost estimates are made based on the quantities estimated in the preliminary design and on the unit costs by work items.

The cost is split into foreign currency and local currency components.

The summary of estimated construction costs listed in Table 9.6 and the construction cost of road sections are shown in Tables 9.7 to 9.14.

The total project cost of the Ring Roads is estimated at JD. 7.563 million (US$22.243 million) based on 1981 prices.

Foreign currency component of the total project cost is JD2.919 million (US$8.585 million).

Table 9.6 Total Estimated Construction Cost

(JD)

Item	Unit	Quantity	L.C.	F.C.	Total
1. Mobilization	LS		8,980	8,270	17,250
2. Clearing & Grubbing	m^2	450,900	18,036	18,036	36,072
3. Common Excavation	m^3	266,700	109,347	138,684	248,031
4. Borrow Excavation	m^3	201,000	158,790	203,010	361,800
5. Rock Excavation	m^3	105,000	231,000	294,000	525,000
6. Structure Excavation	m^3	3,909	4,300	3,909	8,209
7. Base Course (300 m/m)	m^3	110,328	205,210	180,938	386,148
8. Sub-base Course (200-400m/m)	m^3	112,700	180,320	157,780	338,100
9. Asphalt Con Surface (50m/m)	m^2	* 713,120	385,085	541,971	927,056
10. Box Culverts	m^3	2,193	84,211	72,369	156,680
11. Pipe Culverts (ϕ800m/m)	m	2,930	83,505	71,785	155,290
12. Retaining Wall	m^3	680	14,552	9,248	23,800
13. Stone Masonry	m^2	3,880	25,996	12,804	38,800
14. Other Drainage Facilities	Km	28.36	51,899	33,181	85,080
15. Concrete Curb	m	51,140	102,280	76,710	178,990
16. Concrete Tile Sidewalk	m^2	127,600	293,480	216,920	510,400
17. Lighting with Post	each	568	14,768	70,432	85,200
18. Traffic Signal	each	51	9,996	76,704	86,700
19. Other Incidental Work	Km	28.36	46,794	123,366	170,160
20. Total Construction Cost (Item 1 to Item 19)			2,028,549	2,310,117	4,338,666
21. Land Acquisition	Ls		1,598,300	-	1,598,300
22. Compensation	Ls		410,700	133,800	544,500
23. Total (Item 21 to Item 22)			2,009,000	133,800	2,142,800
24. Contingencies (10% of Item 20 & 23)			403,755	244,392	648,147
25. Engineering Supervision (10% of Item 20)			202,855	231,012	433,867
26. Total Project Amount (Item 20+23+24+25)			4,644,159	2,919,321	7,563,480

Length of Road = 23,960 m
Area of Road = 531,700 m^2

* Including over-lay, total area in item 9 of Tables 9.7 to 9.14.

Table 9.7 B.R.R. Section 1 (1st stage)

(JD)

Item	Unit	Quantity	L.C.	F.C.	Total
1. Mobilization	Ls		880	820	1,700
2. Clearing & Grubbing	m^2	66,000	2,640	2,640	5,280
3. Common Excavation	m^3	27,200	11,152	14,144	25,296
4. Borrow Excavation	m^3	-	-	-	-
5. Rock Excavation	m^3	-	-	-	-
6. Structure Excavation	m^3	840	924	840	1,764
7. Base Course (300 m/m)	m^3	14,454	26,884	23,705	50,589
8. Sub-base Course (400 m/m)	m^3	19,270	30,382	26,978	57,810
9. Asphalt Con Surface (50m/m)	m^2	45,980	24,829	34,945	59,774
10. Box Culverts	m^3	-	-	-	-
11. Pipe Culverts (ϕ800 m/m)	m	1,050	29,925	25,725	55,650
12. Retaining Wall	m^3	-	-	-	-
13. Stone Masonry	m^2	700	4,690	2,310	7,000
14. Other Drainage Facilities	Km	4.4	8,052	5,148	13,200
15. Concrete Curb	m	8,800	17,600	13,200	30,800
16. Concrete Tile Sidewalk	m^2	13,200	30,360	22,440	52,800
17. Lighting with Post	each	88	2,288	10,912	13,200
18. Traffic Signal	each	16	3,136	24,064	27,200
19. Other Incidental Work	Km	4.4	7,260	19,140	26,400
20. Total Construction Cost (Item 1 to Item 19)			201,452	227,011	428,463
21. Land Acquisition	Ls		225,950	-	225,950
22. Compensation	Ls		19,420	5,945	25,365
23. Total (Item 21 to Item 22)			245,370	5,945	251,315
24. Contingencies			44,682	23,296	67,978
25. Engineering Supervision			20,145	22,701	42,846
26. Total Project Amount			511,649	278,953	790,602

Length of Road = 4,400 m

Area of Road =66,000 m^2

Table 9.8 B.R.R. Section 1 (2nd stage)

(JD)

Item	Unit	Quantity	L.C.	F.C.	TOTAL
1. Mobilization	Ls		730	670	1,400
2. Clearing & Grubbing	m^2	66,000	2,640	2,640	5,280
3. Common Excavation	m^3	14,200	5,822	7,384	13,206
4. Borrow Excavation	m^3	-	-	-	-
5. Rock Excavation	m^3	-	-	-	-
6. Structure excavation	m^3	-	-	-	-
7. Base Course (300 m/m)	m^3	14,454	26,884	23,705	50,589
8. Sub-base Course (400 m/m)	m^3	19,270	30,382	26,978	57,810
9. Asphalt Con Surface(50m/m)	m^2	45,980	24,829	34,945	59,774
10. Box Culverts	m^3	-	-	-	-
11. Pipe Culverts (ϕ800 m/m)	m	-	-	-	-
12. Retaining Wall	m^3	-	-	-	-
13. Stone Masonry	m^2	700	4,690	2,310	7,000
14. Other Drainage Facilities	Km	4.4	8,052	5,148	13,200
15. Concrete Curb	m	8,800	17,600	13,200	30,800
16. Concrete Tile Sidewalk	m^2	13,200	30,360	22,440	52,800
17. Lighting with post	each	88	2,288	10,912	13,200
18. Traffic Signal	each	8	1,568	12,052	13,600
19. Other Incidental Work	Km	4.4	7,260	19,140	26,400
20. Total Construction Cost (Item 1 to Item 19)			163,555	181,504	345,059
21. Land Acquisition	Ls		225,950	-	225,950
22. Compensation	Ls		19,420	5,945	25,365
23. Total (Item 21 to Item 22)			245,370	5,945	251,315
24. Contingencies			40,892	18,745	59,637
25. Engineering Supervision			16,356	18,150	34,506
26. Total Project Amount			466,173	224,344	690,517

Length of Road = 4,400 m
Area of Road = 66,000 m^2

Table 9.9 B.R.R. Section 2

(JD)

Item	Unit	Quantity	L.C.	F.C.	TOTAL
1. Mobilization	Ls		2,500	2,300	4,800
2. Clearing & Grubbing	m^2	95,600	3,824	3,824	7,648
3. Common Excavation	m^3	102,000	41,820	53,040	94,860
4. Borrow Excavation	m^3	167,000	131,930	168,670	300,600
5. Rock Excavation	m^3	23,000	50,600	64,400	115,000
6. Structure Excavation	m^3	1,682	1,850	1,682	3,532
7. Base Course (300 m/m)	m^3	23,760	44,194	38,966	83,160
8. Sub-base Course (200 m/m)	m^3	15,160	24,256	21,224	45,480
9. Asphalt Con Surface(50m/m)	m^2	76,300	41,202	57,988	99,190
10. Box Culverts	m^3	2,043	78,451	67,419	145,870
11. Pipe Culverts (ϕ800 m/m)	m	400	11,400	9,800	21,200
12. Retaining Wall	m^3	680	14,552	9,248	23,800
13. Stone Masonry	m^2	900	6,030	2,970	9,000
14. Other Drainage Facilities	Km	5.78	10,577	6,763	17,340
15. Concrete Curb	m	11,560	23,120	17,340	40,460
16. Concrete Tile Sidewalk	m^2	36,400	83,720	61,880	145,600
17. Lighting with Post	each	116	3,016	14,384	17,400
18. Traffic Signal	each	4	784	6,016	6,800
19. Other Incidental Work	Km	5.78	9,537	25,143	34,680
20. Total Construction Cost (Item 1 to Item 19)			583,363	633,057	1,216,420
21. Land Acquisition	Ls		371,300	-	371,300
22. Compesnation	Ls		34,380	8,920	43,300
23. Total (Item 21 to Item 22)			405,680	8,920	414,600
24. Contingencies			98,904	64,198	163,102
25. Engineering Supervision			58,336	63,306	121,642
26. Total Project Amount			1,146,283	769,481	1,915,764

Length of road = 5,780 m
Area of road =115,600 m^2

Table 9.10 B.R.R. Section 3

(JD)

Item	Unit	Quantity	L.C.	F.C.	TOTAL
1. Mobilization	Ls		1,400	1,300	2,700
2. Clearing & Grubbing	m^2	12,000	480	480	960
3. Common Excavation	m^3	23,000	9,430	11,960	21,390
4. Borrow Excavation	m^3	34,000	26,860	34,340	61,200
5. Rock Excavation	m^3	82,000	180,400	229,600	410,000
6. Structure Excavation	m^3	267	294	267	561
7. Base Course (300 m/m)	m^3	14,400	26,784	23,616	50,400
8. Sub-base Course (200 m/m)	m^3	1,320	2,112	1,848	3,960
9. Asphalt Con Surface(50m/m)	m^2	48,000	25,920	36,480	62,400
10. Box Culverts	m^3	150	5,760	4,950	10,710
11. Pipe Culverts (ϕ800m/m)	m	80	2,280	1,960	4,240
12. Retaining Wall	m^3	-	-	-	-
13. Stone Masonry	m^2	100	670	330	1,000
14. Other Drainage Facilities	Km	3.64	6,661	4,259	10,920
15. Concrete Curb	m	-	-	-	-
16. Concrete Tile Sidewalk	m^2	-	-	-	-
17. Lighting with Post	each	73	1,898	9,052	10,950
18. Traffic Signal	each	3	588	4,512	5,100
19. Other Incidental Work	Km	3.64	6,006	15,834	21,840
20. Total Construction Cost (Item 1 to Item 19)			297,543	380,788	678,331
21. Land Acquisition	Ls		393,300	-	393,3000
22. Compensation	Ls		337,480	112,990	450,470
23. Total (Item 21 to Item 23)			730,780	112,990	843,700
24. Contingencies			102,832	49,378	152,210
25. Engineering Supervision			29,754	38,079	67,833
26. Total Project Amount			1,160,909	581,235	1,742,144

Length of Road = 3,640 m
Area of Road = 72,800 m^2

Table 9.11 O.R.R.

(JD)

Item	Unit	Quantity	L.C.	F.C.	TOTAL
1. Mobilization	Ls		2,030	1,870	3,900
2. Clearing & Grubbing	m^2	166,800	6,672	2,272	13,344
3. Common Excavation	m^3	79,600	32,636	41,392	74,028
4. Borrow Excavation	m^3	-	-	-	-
5. Rock Excavation	m^3	-	-	-	-
6. Structure Excavation	m^3	1,088	1,197	1,088	2,285
7. Base Course (300 m/m)	m^3	34,020	63,277	55,793	119,070
8. Sub-base Course (400 m/m)	m^3	45,360	72,576	63,504	136,080
9. Asphalt Con Surface (50m/m)	m^2	110,000	59,400	83,600	143,000
10. Box Culverts	m^3	-	-	-	-
11. Pipe Culverts (ϕ800 m/m)	m	1,360	38,760	33,320	72,080
12. Retaining Wall	m^3	-	-	-	-
13. Stone Masonry	m^2	690	4,623	2,277	6,900
14. Other Drainage Facilities	Km	8.34	15,262	9,758	25,020
15. Concrete Curb	m	16,680	33,360	25,020	58,380
16. Concrete Tile Sidewalk	m^2	53,400	122,820	90,780	213,600
17. Lighting with Post	each	167	4,342	20,708	25,050
18. Traffic Signal	each	20	3,920	30,080	34,000
19. Other Incidental Work	Km	8.34	13,761	36,279	50,040
20. Total Construction Cost (Item 1 to item 19)			474,636	502,141	976,777
21. Land Acquisition	Ls		305,300	-	305,300
22. Compensation	Ls		-	-	-
23. Total (Item 21 to Item 23)			305,300		305,300
24. Contingencies			77,994	50,214	128,208
25. Engineering Supervision			47,464	40,214	97,678
26. Total Project Amount			905,394	602,569	1,507,963

Length of Road = 8,340 m
Area of Road = 166,800 m^2

Table 9.12 C.R. (A)

(JD)

Item	Unit	Quantity	L.C.	F.C.	TOTAL
1. Mobilization	Ls		210	190	400
2. Clearing & Grubbing	m^2	19,000	760	760	1,520
3. Common Excavation	m^3	6,700	2,747	3,484	6,231
4. Borrow Excavation	m^3	-	-	-	-
5. Rock Excavation	m^3	-	-	-	-
6. Structure Excavation	m^3	32	35	32	67
7. Base Course (300 m/m)	m^3	3,810	7,087	6,248	13,335
8. Sub-base Course (400 m/m)	m^3	5,080	8,128	7,112	15,240
9. Asphalt Con Surface (50m/m)	m^2	12,500	6,750	9,500	16,250
10. Box Culverts	m^3	-	-	-	-
11. Pipe Culverts (φ800 m/m)	m	40	1,140	980	2,120
12. Retaining Wall	m	-	-	-	-
13. Stone Masonry	m	620	4,154	2,046	6,200
14. Other Drainage Facilities	Km	0.95	1,739	1,112	2,851
15. Concrete Curb	m	1,900	3,800	2,850	6,650
16. Concrete Tile Sidewalk	m	6,000	13,800	10,200	24,000
17. Lighting with Post	each	19	494	2,356	2,850
18. Traffic Signal	each	-	-	-	-
19. Other Incidental Work	Km	0.95	1,568	4,133	5,701
20. Total Construction Cost (Item 1 to Item 19)			52,421	51,003	103,415
21. Land Acquisition	Ls		-	-	-
22. Compensation	Ls		-	-	-
23. Total (Item 21 to Item 23)			-	-	-
24. Contingencies			5,241	5,100	10,341
25. Engineering Supervision			5,241	5,100	10,341
26. Total Project Amount			62,894	61,203	124,097

Length of Road = 950m
Area of Road = 19,000m^2

Table 9.13 C.R. (B)

(JD)

Item	Unit	Quantity	L.C.	F.C.	TOTAL
1. Mobilization	Ls		260	240	500
2. Clearing & Grubbing	m^2	25,500	1,020	1,020	2,040
3. Common Excavation	m^3	14,000	5,740	7,280	13,020
4. Borrow Excavation	m^3	-	-	-	-
5. Rock Excavation	m^3	-	-	-	-
6. Structure Excavation	m^3	-	-	-	-
7. Base Course (300 m/m)	m^3	5,430	10,100	8,905	19,005
8. Sub-base Course (400 m/m)	m^3	7,240	11,584	10,136	21,720
9. Asphalt Con Surface (50m/m)	m^2	17,800	9,612	13,528	23,140
10. Box Culverts	m^3	-	-	-	-
11. Pipe Culverts (ϕ800m/m)	m	-	-	-	-
12. Retaining Wall	m^3	-	-	-	-
13. Stone Masonry	m^2	170	1,139	561	1,700
14. Other Drainage Facilities	Km	0.85	1,556	995	2,551
15. Concrete Curb	m	3,400	6,800	5,100	11,900
16. Concrete Tile Sidewalk	m^2	5,400	12,420	9,180	21,600
17. Lighting with Post	each	17	442	2,108	2,550
18. Traffic Signal	each	-	-	-	-
19. Other Incidental Work (Road Signs, Guard Rail, Painting etc..)	Km	0.85	1,403	3,698	5,101
20. Total Construction Cost (Item 1 to Item 19)			62,076	62,751	124,827
21. Land Acquisition	Ls		76,500	-	6,500
22. Compensation	Ls		-	-	-
23. Total (Item 21 to Item 23)			76,500	-	76,500
24. Contingencies			13,858	6,275	20,133
25. Engineering Supervision			6,208	6,275	12,483
26. Total Project Amount			158,642	75,301	233,943

Length of Road 850 m
Area of Road 25,500 m^2

Table 9.14 Over-lay of Asphalt Con Surface

(JD)

Item	Unit	Quantity	L.C.	F.C.	TOTAL
1. Mobilization	Ls		970	880	1,850
2. Clearing & Grubbing	m^2				
3. Common Excavation	m^3				
4. Borrow Excavation	m^3				
5. Rock Excavation	m^3				
6. Structure Excavation	m^3				
7. Base Course (300 m/m)	m^3				
8. Sub-base Course (200-400m/m)	m^3				
9. Asphalt Con Surface (50m/m)	m^2	*356,560	192,542	270,986	463,528
10. Box Culverts	m^3				
11. Pipe Culverts (ϕ800 m/m)	m				
12. Retaining Wall	m^3				
13. Stone Masonry	m^2				
14. Other Drainage Facilities	Km				
15. Concrete Curb	m				
16. Concrete Tille Sidewalk	m^2				
17. Lighting with Post	each				
18. Traffic Signal	each				
19. Other Incidental Work (Road Signs, Guard Rail, Painting etc.,)	Km				
20. Total Construction Cost (Item 1 to Item 19)			193,512	271,866	465,378
21. Land Acquisition	Ls				
22. Compensation	Ls				
23. Total (Item 21 to Item 23)					
24. Contingencies			19,351	27,187	46,538
25. Engineering Supervision			19,351	27,187	46,538
26. Total Project Amount			232,214	326,240	558,454

* Total area in item 9 of Tables 9,7 to 9.13.

9.5 Maintenance Costs

The maintenance cost of the projected road was estimated based on the data obtained from the Ministry of Public Works.

The following types of maintenance activities are included in the maintenance cost:

Routine Maintenance

- Culvert and waterway clearing
- Clearing and shaping ditches
- Renewal of marking and signs
- Repair of guard rail, side-walks and curb
- Repair of lighting and signal facilities
- Emergency repairs and patching

Periodic Maintenance

- Surface treatment of bitumous surfaces

(1) Routine Maintenance

Most of the work is not traffic dependant. The actual countrywide maintenance expenditure in 1976-1977 on 2-lane primary roads was about JD 80/km.

The Study Team considers that an allowance of JD 150/km at 1981 values would be appropriate for routine maintenance.

(2) Periodic Maintenance

Periodic maintenance will consist basically of re-sealing surface treatment.

The thickness and frequency of overlays will be dictated by the traffic to be carried. The interval between re-sealing will be governed by the traffic frequency as follows:

Traffic Frequency of vehicles per day	Interval between re-sealing in years
Under 5,000	5
5,000 - 10,000	4
Over 10,000	3

The estimated cost of re-sealing is JD. $0.35/m^2$; i.e. JD. 4,620 per kilometer for a 13.2 m wide road.

9.6 Economic Cost

The total road construction costs are divided into three primary components:
construction costs, property costs (land acquisition, compensation for houses) and other (coningency and engineering supervision).
In order to estimate the actual cost of the project to the Jordanian economy, duties were deducted from the estimated costs and the results were used in the benefit cost analysis.

Most foreign construction machines are duty free and are charged at only 4 percent for import licensing plus 2 percent for surtax.

The custom duties on construction materials ranged from 10 percent to 30 percent (average 20 percent).

The average income tax rate was estimated to be 2 percent of the overall labour cost.

Duties on the sale of property in Jordan amount to 8 percent of the actual sale values. Within this percentage, 2 percent is usually paid by the vendor and 6 percent by the purchaser.

A summary of the estimated economic construction cost excluding maintenance cost is shown in Table 9.15.

The conomic cost of Alternatives I and II including maintenance cost are shown in Tables 9.16 and 9.17, and are referred to in Chapter 11, Implementation Program.

Table 9.15 Summary of Economic Construction Cost

(JD)

Item	Financial cost	Component %	Economic Cost
1. Mobilization	17,250	93.0	16,043
2. Clearing & Grubbing	36,072	94.8	34,196
3. Common Excavation	248,031	94.8	235,133
4. Borrow Excavation	361,800	94.8	342,986
5. Rock Excavation	525,000	94.8	497,700
6. Structure Excavation	8,209	95.4	7,831
7. Base Course (300 m/m)	386,148	88.7	342,513
8. Sub-base Course (200-400 m/m)	338,100	88.7	299,895
9. Asphalt Con. Surface (50m/m)	927,056	86.9	805,612
10. Box Culverts	156,580	88.0	137,790
11. Pipe Culverts (ϕ800m/m)	155,290	88.0	136,655
12. Retaining Wall	23,800	88.2	20,992
13. Stone Masonry	38,800	89.5	34,726
14. Other Drainage Facilities	85,080	88.2	75,041
15. Concrete Curb	178,990	88.4	158,227
16. Concrete Tile Sidewalk	510,400	88.4	451,194
17. Lighting with Post	85,200	84.8	72,250
18. Traffic Signal	86,700	83.2	72,134
19. Other Incidental Work (Road Signs, Guard Rail, Painting etc. .)	170,160	86.8	147,699
20. Total Construction Cost (Item 1 to Item 19)	4,338,666	(89.6)	3,888,617
21. Land Acquisition	1,598,300	92.0	1,470,436
22. Compensation	544,500	92.0	500,940
23. Total (Item 21 to Item 22)	2,142,800	92.0	1,971,376
24. Contingencies (10% of Item 20 and 23)	648,147	(90.4)	585,999
25. Engineering Supervisior (10% of Item 20)	433,867	(89.6)	388,862
26. Total Project Amount (Item 20+23+24+25)	7,563,480	(90.40)	6,834,854

Table 9.16 Summary of Economic Cost Cashflow

(Unit: 1,000 JD)

Year	Alternative I						Alternative II					
	Engineering	Compensation	Construction	Overlay	Maintenance	Economic Cost	Engineering	Compensation	Construction	Overlay	Maintenance	Economic Cost
	89.6%	92.0%	89.6%	86.9%	91.1%		89.6%	92.0%	89.6%	86.9%	91.1%	
1982	76.2	1,084.7				1,160.9	49.3	1,084.7				1,134.0
1983	76.2	1,083.8				1,160.0	49.3	1,083.7				1,133.0
1984	82.4		1,738.2			1,820.6	54.7		1,138.8			1,193.5
1985	81.5		1,738.2			1,819.7	53.8		1,138.8			1,192.6
1986					3.3	3.3					2.5	2.5
1987					3.3	3.3					2.5	2.5
1988					3.3	3.3					2.5	2.5
1989					3.3	3.3	49.3				2.5	51.8
1990					99.0	99.0	60.0		1,198.8		74.7	1,333.5
1991					3.3	3.3					3.3	3.3
1992					3.3	3.3					3.3	3.3
1993					3.3	3.3					3.3	3.3
1994	31.4				3.3	34.7	26.9				3.3	30.2
1995	35.8		340.5	387.6	99.0	862.9	31.4		340.5	292.9	99.0	763.8
1996					3.9	3.9					3.9	3.9
1997					3.9	3.9					3.9	3.9
1998					3.9	3.9					3.9	3.9
1999					113.7	113.7					99.0	99.0
2000					3.9	3.9	9.0			94.7	3.9	107.6
2001					3.9	3.9					3.9	3.9
2002					3.9	3.9					3.9	3.9
2003					113.7	113.7					113.7	113.7
2004					3.9	3.9					3.9	3.9
2005	5.4			57.4	3.9	66.7	5.4			57.4	3.9	66.7
2006					99.0	99.0					99.0	99.0
2007					3.9	3.9					3.9	3.9
2008					3.9	3.9					3.9	3.9
2009					113.7	113.7					113.7	113.7
2010					3.9	3.9					3.9	3.9

Table 9.17 Economic Cost Flow of Alternative II by Road Segment

(Unit : 1,000 JD)

Year	Boundary Ring Road			Outer Ring Road	Total
	Sec.1	Sec.2	Sec.3		
1982	262.5	238.7	414.1	218.7	1,134.0
1983	262.5	238.7	414.3	217.5	1,133.0
1984	274.5	-	350.0	569.0	1,193.5
1985	274.3	-	349.8	568.5	1,192.6
1986	0.8	-	0.5	1.2	2.5
1987	0.8	-	0.5	1.2	2.5
1988	0.8	-	0.5	1.2	2.5
1989	0.8	49.3	0.5	1.2	51.8
1990	22.4	1,258.8	14.9	37.4	1,333.5
1991	0.8	0.8	0.5	1.2	3.3
1992	0.8	0.8	0.5	1.2	3.3
1993	0.8	0.8	0.5	1.2	3.3
1994	16.8	0.8	4.2	8.4	30.2
1995	439.8	24.3	98.8	200.9	763.8
1996	1.4	0.8	0.5	1.2	3.9
1997	1.4	0.8	0.5	1.2	3.9
1998	1.4	0.8	0.5	1.2	3.9
1999	22.4	24.3	14.9	37.4	99.0
2000	1.4	104.5	0.5	1.2	107.6
2001	1.4	0.8	0.5	1.2	3.9
2002	1.4	0.8	0.5	1.2	3.9
2003	37.1	24.3	14.9	37.4	113.7
2004	1.4	0.8	0.5	1.2	3.9
2005	64.2	0.8	0.5	1.2	66.7
2006	22.4	24.3	14.9	37.4	99.0
2007	1.4	0.8	0.5	1.2	3.9
2008	1.4	0.8	0.5	1.2	3.9
2009	37.1	24.3	14.9	37.4	113.7
2010	1.4	0.8	0.5	1.2	3.9

Notes; Connecting Road (A) is included in Sec. 1 of Boundary Ring Road.
Connecting Road (B) is included in Outer Ring Road.