PRELIMINARY DESIGN REPORT

ON

THE DAHR EL BAIDAR TUNNEL PROJECT

IN

LEBANON

MARCH 1964

OVERSEAS TECHNICAL COOPERATION AGENCY OF JAPAN

PRELIMINARY DESIGN REPORT

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11

SUMMARY AND CONCLUSION

In response to the request made by the Government of the Republic of Lebanon, the preliminary study was carried out inclusive of technical and economic feasibility as to the realization of the "Dahr El Baidar Tunnel Project" programmed in order to solve the transportation problem of the Beyrouth - Damascus Road which is the international autostrade of Lebanon. The study was conducted by Japanese Survey Team for the above Project consisting of the engineers of Pacific Consultants, K.K., dispatched by Overseas Technical Cooperation Agency of Japan, and has been compiled into this Preliminary Design Report.

The conclusion and main points are briefed in this Summary and Conclusion. Individual items of the studies are detailed in the main text of this Preliminary Design Report.

I. Location of Tunnel Routes and Access Highway Routes

Several possible routes and access routes to cross the Lebanese mountains from the Beyrouth side were investigated in the field with regard to the topography, geology, meteorology and other natural conditions. Results of the studies made from every possible viewpoint have revealed that the route indicated in Fig. 1 is most recommendable.

This route is the closest to the existing Beyrouth - Damascus road. Access road to pass Aley and Bhamdoun and connect with the tunnel entrance is to be constructed in Hammana district. The tunnel shall be 7,850 meters in total length, and out of the tunnel the road leads to Chataura, The route seems to settle the traffic problem most effectively.

It was cleared by the geological survey that the lower layer of the tunnel construction site is of jurassic lime stone, which indicates that there will be no difficulty in construction a tunnel there.

II. Future Traffic Volume

Based upon the present traffic volume of the existing Beyrouth - Damascus Road and the rate of yearly increase of the traffic during the past ten years, the future increase has been estimated as follows taking into account the benefit and convenience the proposed tunnel route would provide:

Year	Annual Volume of Traffic	Daily Volume of Traffic			
		Total	Passenger Car	Bus	Truck
1963	1,175,300	3,220	2,821	54	345
1964	1,322,760	3,624	3,174	62	388
1965	1,483,725	4,065	3,560	69	436
1970	2,303,150	6,310	5,528	106	676
1975	3,293,760	9,024	7,905	152	967
1980	4,520,890	12,386	10,850	209	1,327
1985	6,223,615	17,051	14,935	289	1,827
1986	6,686,435	18,319	16,046	310	1,963

As the above table indicates, in the year 1986 it is presumed that 20,000 vehicles per day, at the maximum, shall utilize the route. That fact was taken into consideration to design the tunnel section, number of lanes, ventilation system and others. Daily volume of the traffic, thus, may be divided as follows:

			Speed Km/h
Max. traffic capacity/day -- 20,000	(Passenger Car	17,600	60
	(Bus	300	50
	(Truck	2,100	50

III. Tunnel Facilities

Every possible occurrence and situation were taken into consideration to determine the necessary facilities for the tunnel (ref: Fig. 2):

a. Tunnel Length   7,850 meters

b. Grade   ± 1.075% & ± 0.25%

c. Route   Straight

d. Section

  Interior width   11.0 meters (two lane)

  Interior height   7.0 meters

e. Ventilation System

Downward half traverse ventilation system with three (3) shafts:

Ventilation Stations --- 4 (1 at each shaft
(1 at the entrance on Kabb Elias side

f. Lighting System

Natrium lights on both sides (80W) 4,500 lights in total

Road luminocity --- 50 lux

g. Emergency Facilities

Motor Pool with repair shop

First Aid Station

Fire Station

h. Others

Telephone

Signal System

Drainage

IV. Estimated Construction Cost and the Work Schedule of the Tunnel

It is understood that the construction of the access road is separately done by the Lebanese Government. Thus, here is shown the rough estimation of the construction cost and the work schedule of the tunnel.

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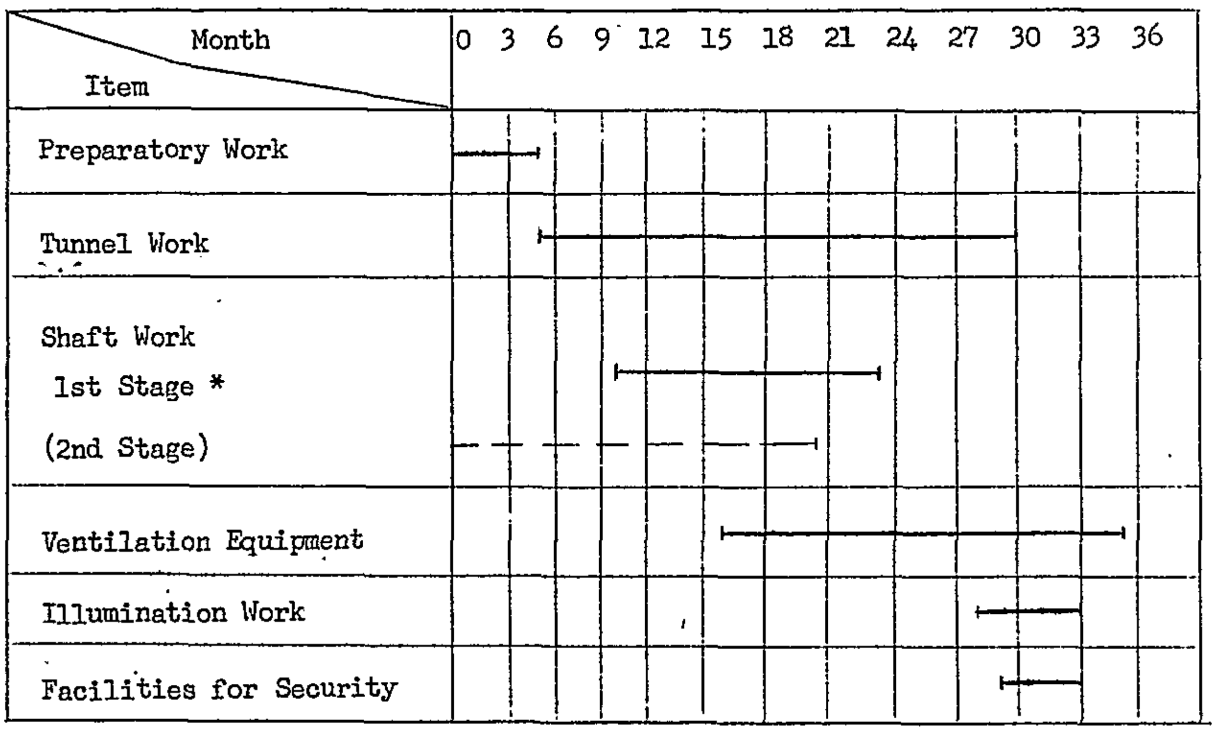
a. Estimated Construction Cost (US$)

Item	Quantity	Unit Cost	Total Cost
Preparatory Work	1 set		398,000
Tunnel Construction	696,000 m^3	22.84	15,899,000
Shaft Construction (1st Stage	13,500 m^3	52.30	706,000
Shaft Construction (2nd Stage	37,000 m^3	41.46	1,563,000
Ventilation Facilities (1st Stage	Ventilation Fans 10 ea.		2,622,000
Ventilation Facilities (2nd Stage	" 7 ea.		813,000
Lighting Facilities	4,500	126.5	569,000
Public Safety Measures	1 set		566,000
Freight	1 set		620,000
Import Tax	1 set		1,220,000
Engineering and Administration Fee	1 set		1,600,000
Total			26,576,000

b. Work Schedule



Note: * 1st Stage - The scale of construction is based upon the presumed volume of traffic in the year 1981 -- 14,000 vehicle/day.

2nd Stage - The scale on the 2nd stage is of the year 1986 - 20,000 vehicle/day

The total construction estimated is US$26,600,000. The period for the construction is estimated totally 36 months. (the construction for the 2nd shall be commenced in the year 1978 it is estimated to take 20 months to complete.)

V. Necessary Fund and the Financial Arrangement

The necessary fund for the construction may be divided to be managed by Lebanese Pound and by a foreign fund as follows:

Item	Total Construction Cost	Foreign Fund	Lebanese Fund
Preparatory Work	398,000		398,000
Tunnel Construction	15,899,000	6,675,000	9,224,000
Shaft Construction	2,269,000	823,500	1,445,500
Ventilation Facilities	3,435,000	2,589,000	846,000
Lighting Facilities	569,000	406,000	163,000
Public Safety Measures	566,000	446,000	120,000
Freight	620,000	587,000	33,000
Import Tax	1,220,000		1,220,000
Engineering and Administration Fee	1,600,000	1,600,000	
Total:	26,576,000	13,126,500	13,449,000
(1st Stage - 23,961,000.-)			
(2nd Stage - 2,615,000.-)			

Annual allocation of the fund in US Dollars shall be as follows:

Year	Foreign Fund	Lebanese Fund	Total
First Stage: 1st year	3,326,000	4,573,200	7,899,200
2nd year	4,810,500	4,876,500	9,687,000
3rd year	3,945,000	2,429,800	6,374,800
Total	12,081,500	11,879,500	23,961,000
Second Stage:	1,045,000	1,570,000	2,615,000
TOTAL:	US$13,126,500	US$13,449,500	US$26,576,000

Remarks : The amount mentioned above is not inclusive of interest during the construction period

VI. Benefit the New Tunnel May Provide

As the result of the study and comparison made as to the benefit cost ratio between the :

Existing Road vs Tunnel Road - - - - 4.5
Existing Road vs New Road - - - - 3.9
New Road vs Tunnel Road - - - - 2.9

which prove it is wisest to construct the tunnel road studying from every angle economically and practically.

VII. Reasonable Toll Rate

Similar study and comparison are made as in the Item VI above as to the road user cost, and the following rates are recommended as reasonable :

Passenger Car - - - - $0.6/per car
Bus & Truck - - - - $1.5/per vehicle

VIII. Redemption Plan

The total fund (Tunnel Construction Cost + Maintenance Cost + Interest to principal cost) are redeemable in Sixteen (16) years and Five (5) months by the above-mentioned toll rate.

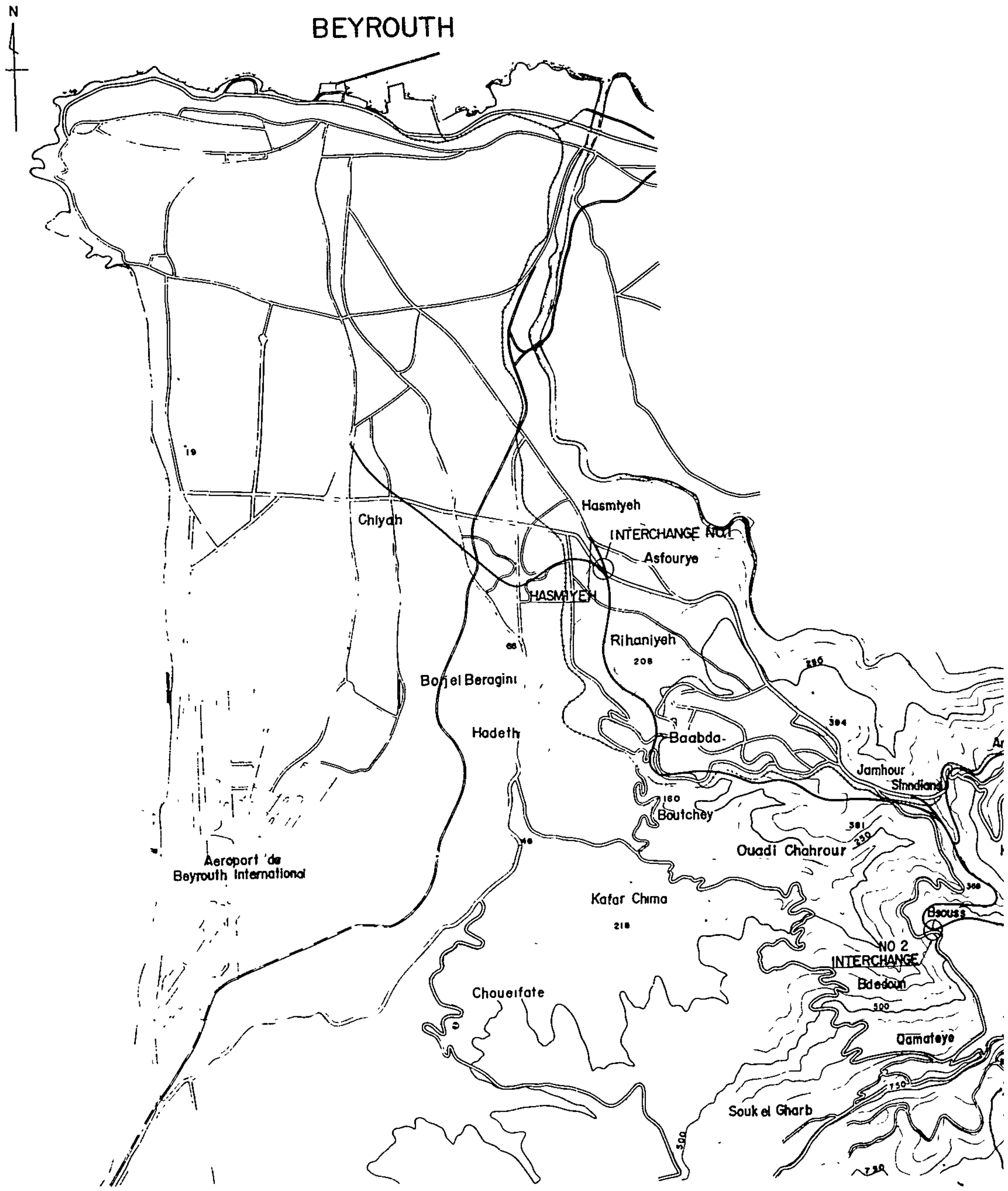
The toll rate mentioned in Item VII is based upon the direct benefit of the road users. Therefore, considering the indirect advantage and fix the toll rate for passenger car as $0.7/per car, it is possible to redeem the total fund in Fourteen (14) years and Ten (10) months - final year shall be 1983 (Ref : Table 38).

IX. Recommendation

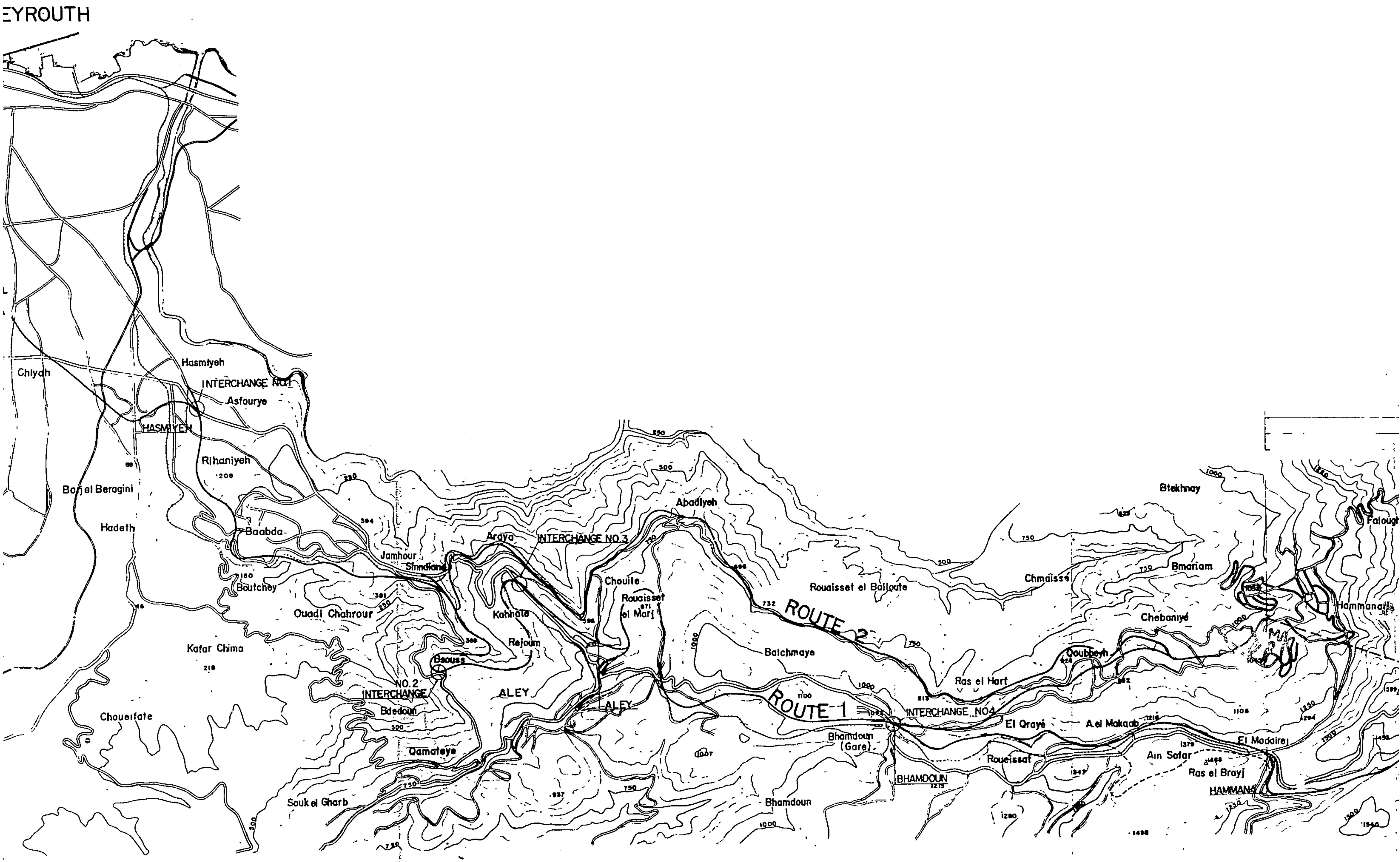
a. As a conclusion, the completion of the Dahr El Baidar Tunnel Project greatly provide benefit and comfort to road users and by the same reason, remarkably helpful for the development of the country itself. This is the main reason we recommend the realization of the Project. With the present tunnel construction technique, it is possible to complete the construction in Three (3) years. There is no fundemental difficulty in geological condition for the construction. If the access road construction group start the work in time so the completion of the tunnel and the road can be done at the same time, it immediately facilitates the users and improves the traffic problem of Lebanon. Moreover, when the cost is redeemed within Fifteen (15) or so years, it is recommendable by all means to, also from the financial planning phase, materialize the project.

b. Every item mentioned above is the definite skeleton of the study made for this project. However, at such stage as it is actually be realized, in order to execute the tunnel construction detail study of the following phase is necessitate :

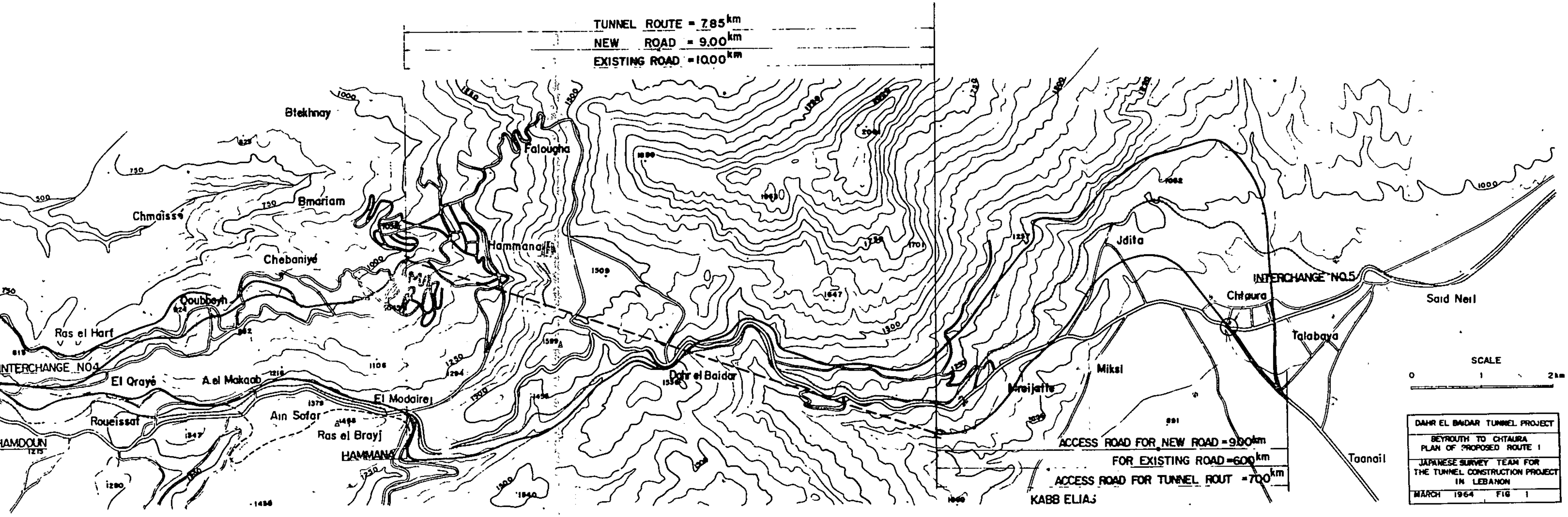
(1) Detail topographic survey along the tunnel route and determine the center line location.
(2) Detail geological survey of the tunnel line
(3) Detail design of the tunnel and installed facility
(4) Detail study of the tunnel construction plan
(5) Detail study of the construction materials and equipment obtainable through Lebanese sources
(6) Detail study of the materials, equipment and others must be obtained through foreign sources
(7) Detail specification
(8) Detail breakdown of construction cost
(9) Detail study of financing plan



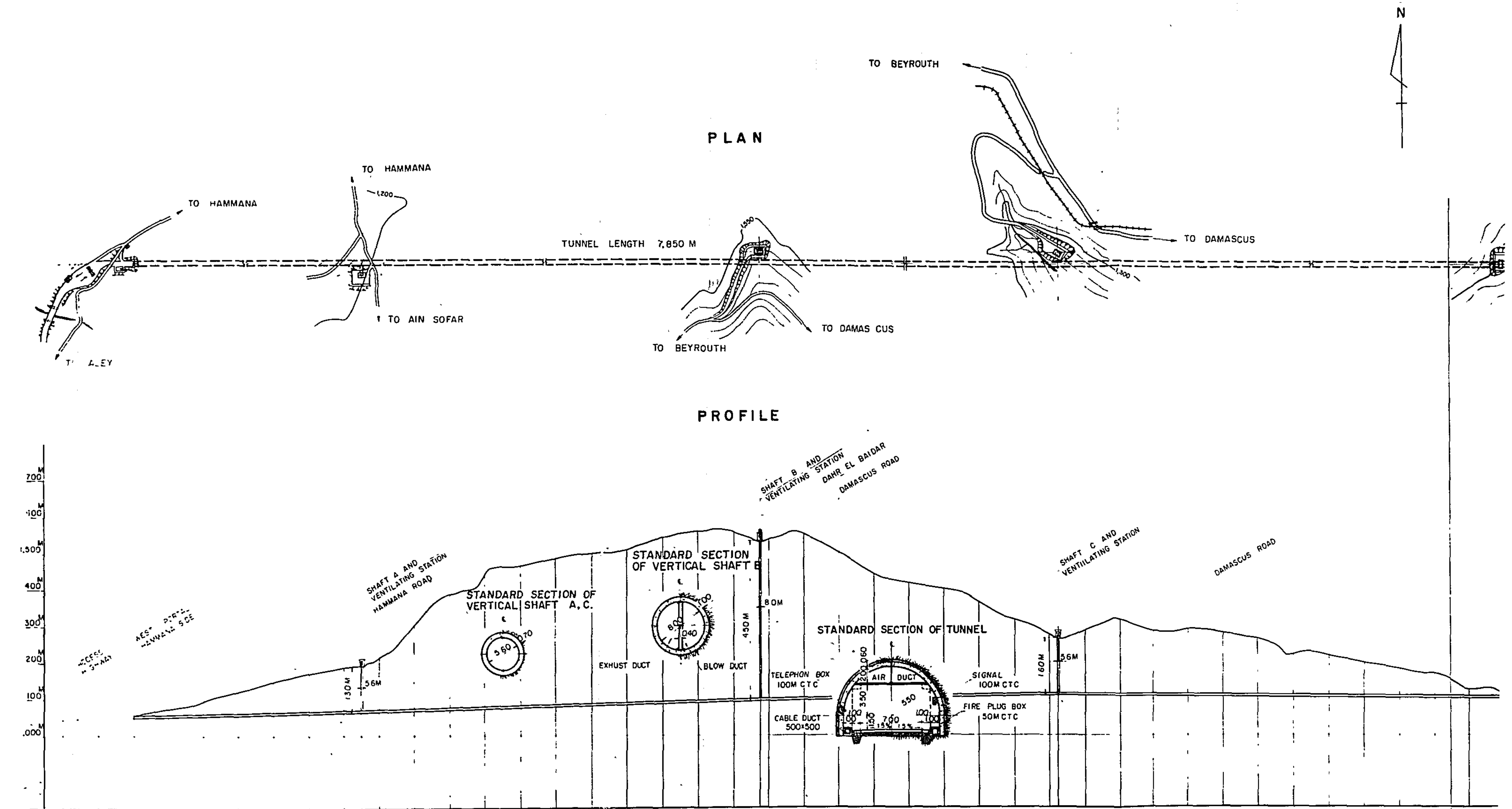
N
BEYROUTH
Hasmiyeh
INTERCHANGE NO.1
Asfourye
Chiyah
HASMIYEH
Rihaniyeh
208
Borj el Beragini
Hadeth
Baabda
Jamhour
Boutchey
160
Ouadi Chahrour
Aeroport de
Beyrouth International
Kafar Chima
218
Choueifate
Bsouss
NO 2
INTERCHANGE
Bdedoun
Qamateye
Souk el Gharb
500
750



EYROUTH
Chiyah
Hasmiyeh
INTERCHANGE NO.1
Asfourye
HASMIYEH
Rihaniyeh
Borj el Beragini
Hadeth
Baabda
Boutchey
Ouadi Chahrour
Kafar Chima
Choueifate
Jamhour
Sinndiana
Araya
INTERCHANGE NO.3
Kahhale
Rejoum
Bsouss
NO.2
INTERCHANGE
Bdedoun
Qamateye
Souk el Gharb
ALEY
Chouite
Rouaisset el Marj
Abadiyeh
Batchmaye
ROUTE 2
ROUTE 1
Rouaisset el Balloute
INTERCHANGE NO.4
Bhamdoun (Gare)
BHAMDOUN
Bhamdoun
Ras el Harf
El Qrayé
A.el Makaab
Roueissat
Ain Sofar
Ras el Brayj
HAMMANA
El Modairej
Chmaissé
Btekhnay
Bmariam
Chebaniyé
Qoubbeyh
Hammana
Falougha

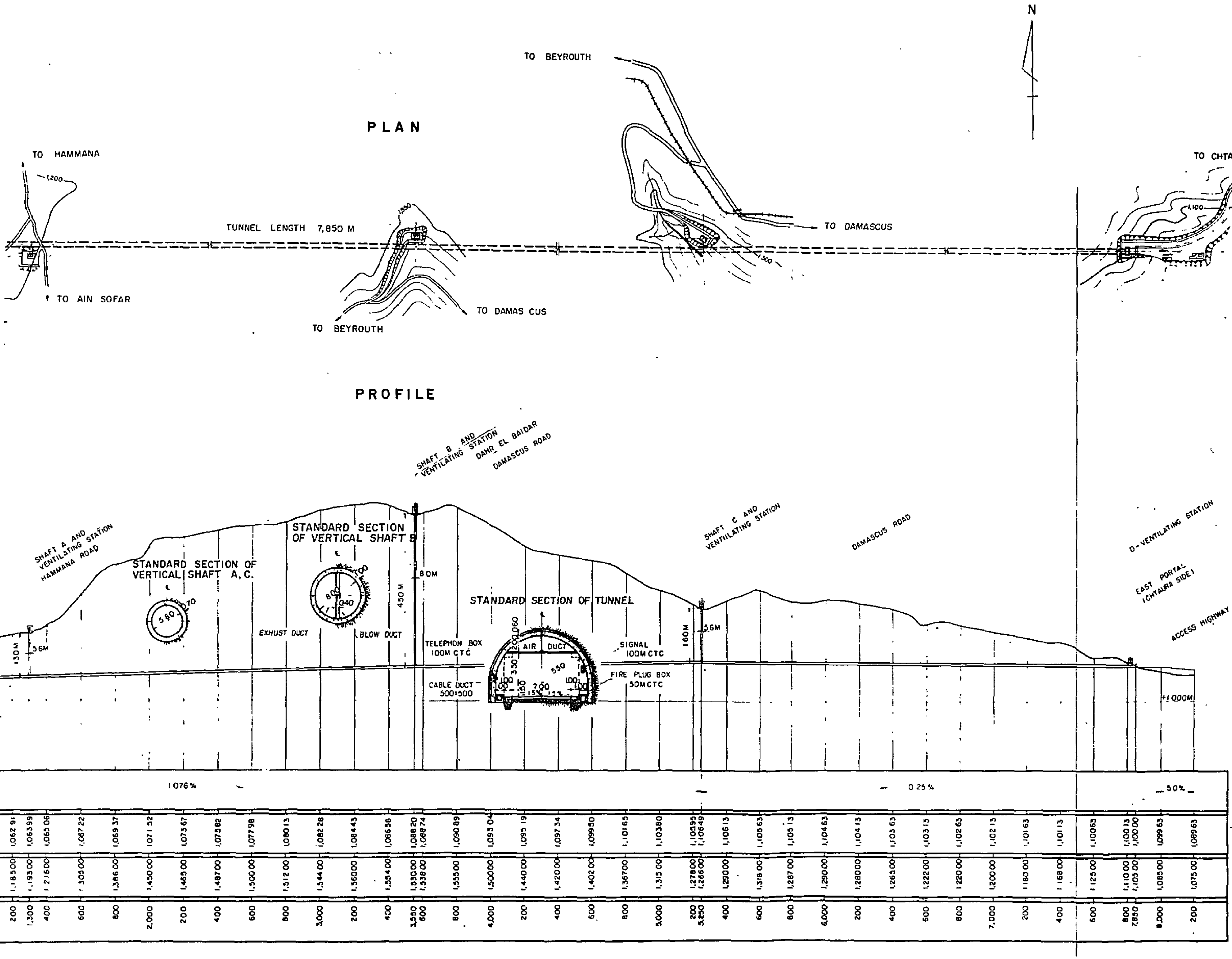


DAHR EL BAIDAR TUNNEL PROJECT
BEYROUTH TO CHTAURA
PLAN OF PROPOSED ROUTE 1
JAPANESE SURVEY TEAM FOR THE TUNNEL CONSTRUCTION PROJECT IN LEBANON
MARCH 1964 FIG 1



GRADE %: 1.076% — 0.25%

DISTANCE M	GROUND HEIGHT M	FORMATION LEVEL M
-400		1,045 70
-2[illegible]		1,04[illegible]85
	[illegible]	[illegible]
2[illegible]	[illegible]500	[illegible]
400	[illegible]	[illegible]
600	[illegible]20 00	,055 46
800	1,150 00	1,058 61
,000	1,170 00	1,060 76
200	1,185 00	1,062 91
1,300	1,193 00	1,063 99
400	1,216 00	1,065 06
600	1,305 00	1,067 22
800	1,386 00	1,069 37
2,000	1,450 00	1,071 52
200	1,465 00	1,073 67
400	1,487 00	1,075 82
600	1,500 00	1,077 98
800	1,512 00	1,080 13
3,000	1,544 00	1,082 28
200	1,560 00	1,084 43
400	1,554 00	1,086 58
3,550	1,530 00	1,088 20
600	1,538 00	1,088 74
800	1,555 00	1,090 89
4,000	1,500 00	1,093 04
200	1,440 00	1,095 19
400	1,420 00	1,097 34
600	1,402 00	1,099 50
800	1,367 00	1,101 65
5,000	1,315 00	1,103 80
200	1,278 00	1,105 95
5,250	1,266 00	1,106 49
400	1,290 00	1,106 13
600	1,318 00	1,105 63
800	1,287 00	1,105 13
6,000	1,290 00	1,104 63
200	1,280 00	1,104 13
400	1,265 00	1,103 63
600	1,222 00	1,103 13
800	1,220 00	1,102 63
7,000	1,200 00	1,102 13
200	1,180 00	1,101 63
400	1,168 00	1,101 13
600	1,125 00	1,100 63



DAHR EL BAIDAR TUNNEL PROJECT

PROFILE, PLAN AND SECTION OF PROPOSED TUNNEL

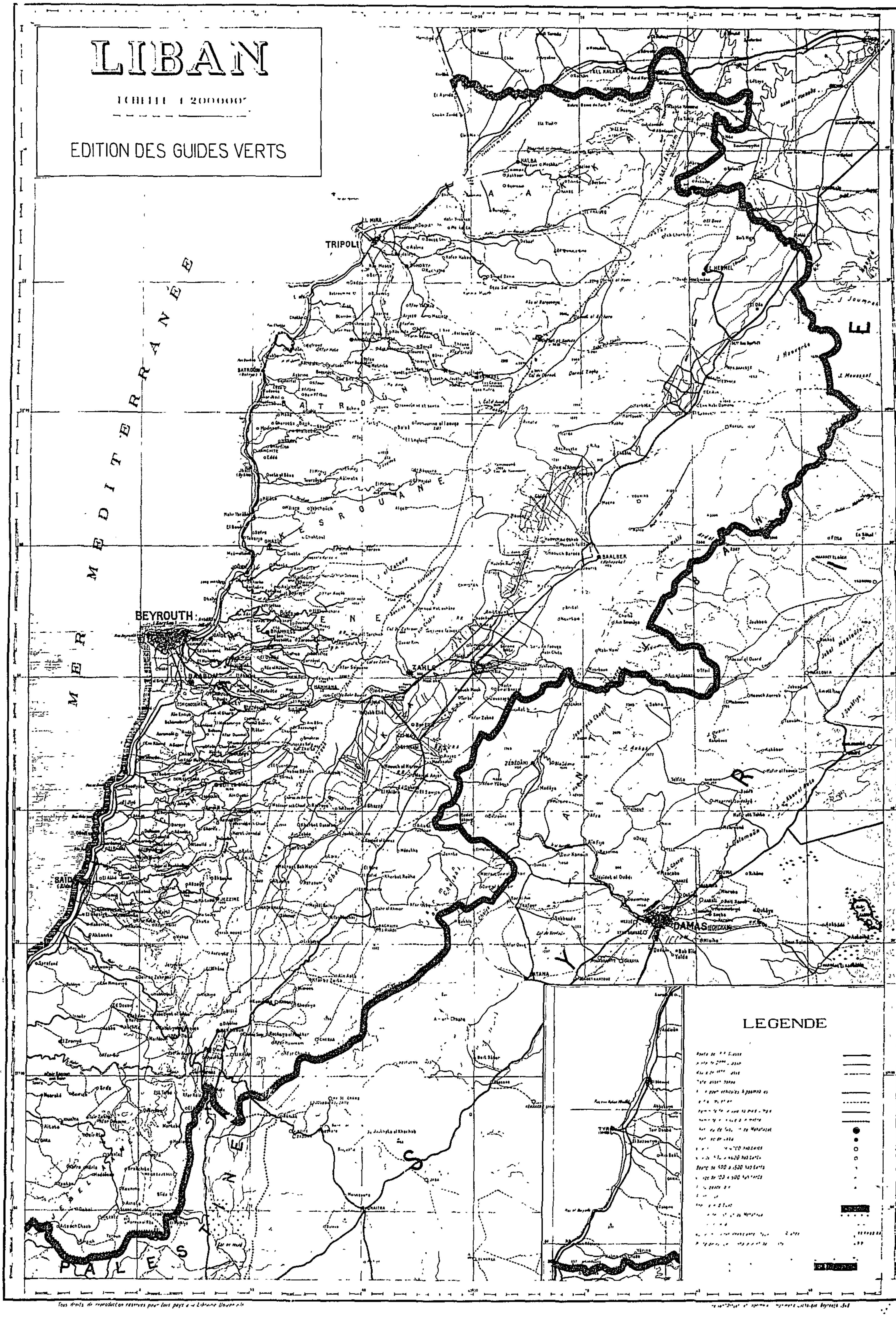
JAPANESE SURVEY TEAM FOR THE TUNNEL CONSTRUCTION PROJECT IN LEBANON

MARCH 1964 | FIG 2

I N D E X

L I S T

FIGURE CONTENTS


LIBAN
ECHELLE 1:200000
EDITION DES GUIDES VERTS
MER MEDITERRANÉE
TRIPOLI
BEYROUTH
BATROUN
SAÏDA
ZAHLÉ
BAALBEK
DAMAS
TYR
EL HERMEL
ZEBDANI
KESROUANE
LIBAN
SYRIE
PALESTINE
LEGENDE

§ I Introduction

1. <u>PURPOSE OF SURVEY TEAM AND CIRCUMSTANCES DEVELOPED FOR ITS DESPATCH</u>

Of the total length of the roads, approximately 5,700 km., in Lebanon Republic, the highway occupies its 9% making 500 km. Among the main highways are the Beyrough-Damascus Road starting from the capital Beyrouth eastward through the Beka Hills and across Mt. Anti Liban to Damascus; and the highway stemed from the Beyrough-Damascus Road at Chtaura and running up to the north through Baalbek; and that stemed at Mejdel Aujar and going down to the south; and that running in the north-south direction a long the Mediterranean Sea through Beyrough; and so forth.

On these highways are passing all types of vehicles such as passenger car, bus and truck. Especially, the Beyrouth-Damascus Road accomodating the heavy traffic at all time, plays a very significant role in the traffic and transportation of Lebanon, stretching to the Beka Hills, the most productive area of agriculture of the land, and further to its neighboring summer resort areas. What is more important as an international highway, the Road connects with Syria and Jordan, and it serves the purpose of transporting the various materials besides a drive way.

The Road makes a slope way over the Dahr El-Baidar which situated at 1,450 m above sea-level. Its shape and conditions between Beyrough and Chtaura is; being of 16 - 20 m in the minimum diameter, about total 600 m at the gradient of 7 - 8%, and 600 m of 9 - 10.5 %. Such as the case, the Road is bound to remain a two-lane. When a car come across a bus or truck on an up-slope, hampered by the latter's slow running speed being at 20 km per hour on an average, an extremely heavy congestion is brought about.

In the winter time, the snowfall would usually cause no thoroughfare on the road for more than two weeks in an year. When the road is frozen or suffers the fog, the vehicles are forced to slow down or to wait for the other cars passed, bringing on the consequential trouble in traffic.

Such being the troublesome circumstances, the Lebanon Government had been planning on breaking the difficulty in traffic for a long time. In this connection, there had been held several meeting since February 1963 between Public Work authorities of the Lebanon Government and the PCKK who has its representative office in the country.

It was the original intention of the Government that it was having the public works to face the urgent requirements and not to afford the immediate betterment of the road for the time being, but that if PCKK should give an intensive study on the road improvement project from a technical and financial point of view, submitting a consistent proposal, the Lebanon Government would be willing to accept it to study the feasibility.

After several discussion since then, it developed to the stage that PCKK was provided the basic data necessary for planning by the Government. Then PCKK started its activity as consultant for the project and carried out a feasibility study. As a result, PCKK submitted to the Government its conclusion, technical and economical, together with its recommendation for completing the project. At the same time, PCKK suggested that if the Government might grant the project enough to adopt, it would be quite possible for Japan to cooperate with Lebanon in materializing the project in one way or other.

The Lebanon Government decided upon the proposed project and its request was made to the Japanese Government in May 1963 that the feasible study should be conducted by PCKK at the Japan's expenses. Upon the request, the Japanese Government organized a survey team through the Overseas Technical Cooperation Agency and despatched it to Lebanon for the site investigation. That was, for the period of about 5 weeks from 23rd October 1963, the team carried out the basic survey necessary for the preliminary study, inclusion of the collection of data, topographical survey, geological survey and meteorological study, etc. Following the survey, PCKK presumed the work and made further preparatory study for the same purpose. This report was thus compiled to cover up all the survey results entailed from the efforts of the survey team and PCKK.

2. ORGANIZATION OF SURVEY TEAM

Name: JAPANESE SURVEY TEAM FOR THE TUNNEL CONSTRUCTION PROJECT IN LEBANON

Chief Survey Team	Mr. Yonekichi Yanagizawa	Adviser, Overseas Technical Cooperation Agency
Member	Mr. Yasuo Kawano	Managing Director & Chief Engineer of Pacific Consultants, K. K.
	Mr. Hideo Chiba	Responsible Engineer
	Mr. Satoru Umemoto	Geological Engineer
	Mr. Giichi Yoshida	Civil Engineer
	Mr. Toshio Nemoto	Civil Engineer
	Mr. Shigenobu Matsusa	Civil Engineer

Mr. Tsukasa Noto Geologist

Mr. Seiji Sugihori Geologist

The Pacific Consultants, K. K. hereby extends heartiest appreciation and gratitude to the following offices of the Government of Republic of Lebanon for the kindest favour and cooperation given for the successful accomplishment of the Tunnel Survey of the Company:

Ministry of Public Works and Transport

Geological Department of Army

Governor of Beirut

Municipality of Beirut

Water Department

Laboratory Engineering Department

Our sincere is also extended to Mr. Mohammad Ali Itani, Chief, Road Maintenance Section, Ministry of Public Works and Transport who took leave from his office to come to Japan to assist the staff of the PCKK supplying the up-to-date statistics of the economy and practices of the existing highway and roads in Lebanon to prepare the Preliminary Report.

§ II. Field Investigation

As stated in the preface, the aid of our investigation is to study the feasibility of Beyrouth-Damascus New Road plan. To solve the increase of traffic volume on this road, the construction of the highway tunnel was planned for passing all the vehicles smoothly through the year, escaping from the traffic difficulty on Dahr el Baidar Pass. Our investigation was carried out for this plan, and at the same time our investigation was directed to the study for the feasibility of connecting the new Beyrouth-Damascus Road have too many sharp curves as well as heavy slops that yield traffic difficulties. Followings are the contents of our basic investigations.

1. Topographic Survey

We investigated the outstanding conditions of the now existing Beyrouth-Damascus Road, traffic conditions, the condition of cities and villages along this road, and the natural features near the scheduled area of the tunnel. Beside these surveys, we carried out the detailed investigations for the access-road around the existing road between Beyrouth city and Tunnel site, in order to find the road which can be connected to the scheduled tunnel. Furthermore, we were extended the favour of Lebanon Government, to get the many kinds of data, such as maps, aerial-surveyed pictures, the existing road maps, the record of traffic volumes, weather data etc.

2. Geological Survey

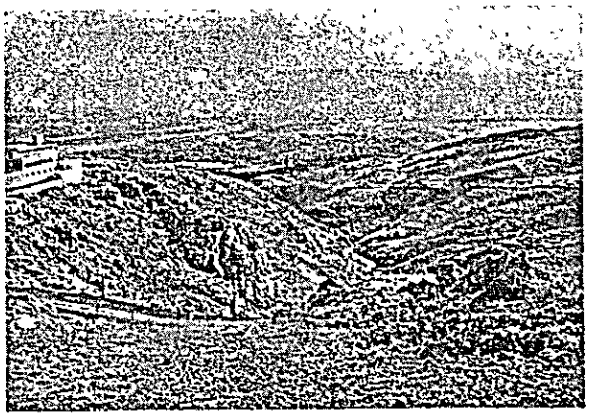
Based on the geological data of Lebanon Government, we carried out the surface geological survey on the whole area of scheduled tunnel. Beside above survey, in order to study the geological condition of the scheduled tunnel openings in detail, our support team and survey team had the seismical investigations for fifteen days in cooperation with Lebanese staffs.

3. Meteorologic Investigation

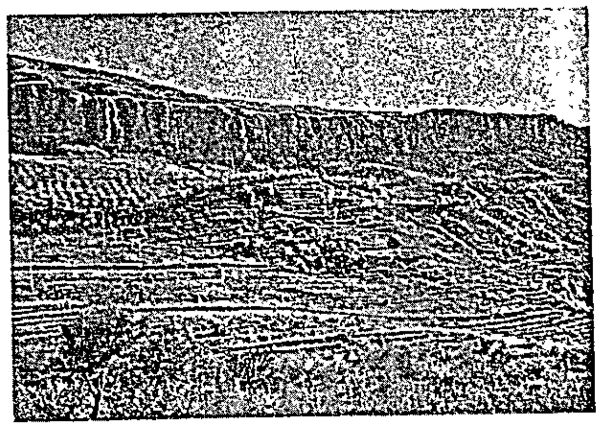
Through the whole area, we gathered up the data on wind, rainfall, snowfall, and underground water, and confirmed these data by the actual investigation.

4. Collection and Investigation on Statistics Data

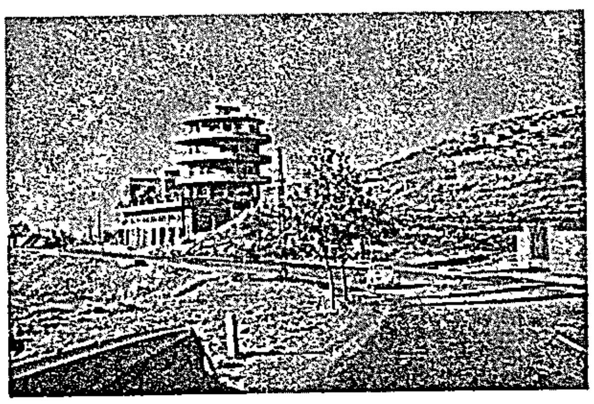
We collected many kinds of statistics data on traffic volume, numbers of automobiles, transportation volume data (road, railway, surface facility).



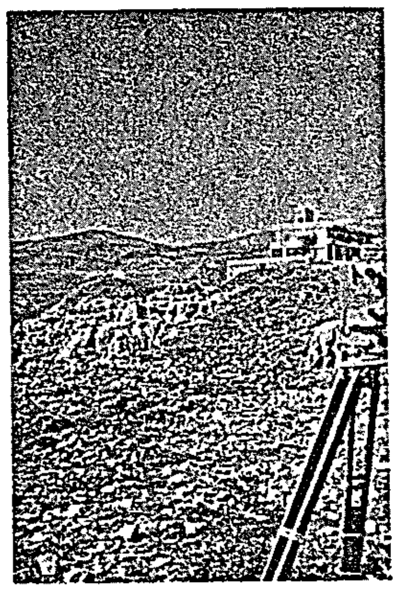
LOOKING BEKA HEIGHTS FROM
DAHR EL BAIDAR PASS



VIEW OF THE PROPOSED PORTAL
AT HAMMANA SITE



BEYROUTH-DAMASCUS ROAD AT
DAHR EL BAIDAR



VIEW OF DAHR EL BAIDAR PASS

§ III Routes Study

We have to decide both tunnel route and access road. These two routes should not be decided separately, but tunnel routes should be planned in the most suitable place where access road is to be constructed. Among these we should as the work of selecting satisfactory tunnel routes and access roads each other, finally finding the best road in the view point of economic and technic, which meets the aid of our traffic policy. Our studies are as follows.

1. Tunnel Route

1-1 Comparison of the route

We celected three routes in the scheduled area.

Plan A (Fig. 4)

This route is of the distance of total 7,850m, portal in the south of Hammana at the height of 1,050m, passing just right bellow the Dahr el Baidar Pass, terminating in the north of Kabb Elias at 1,100m high. As to the geological condition of this route, we have not any particular difficulty, inspite of that this route is not best among other routes, which will be stated in the following paragraphs. Since each three plans of our tunnel are so called "long tunnel", the tunnel section should be decided in a deliberate consideration on ventilation method. The study for this ventilation method are also stated in the following chapters, from which we decided that we need a shaft for ventilating facility in the future. In this route we can get the suitable shaft site. The tunnel run through with the slope of 1,076% and 0.25% as we will describe later on.

Plan B

Plan B is of distance of 9,550m, with the west portal in Kalass, north side of Hammana at the height of 1,000m, and the east exit in Mreijicatte of 1,000m high, which run under En Nemlie. From the geological point of view, this plan have some trouble and need the shaft of 500m depth.

Plan C

The whole distance is 8,950m. The west portal is west of Harik el Trad with 900m height, and the east portal is at Tolita of 1,000m high, running under Touarel el Haouz and Kfar Seloune. The geological condition of this plan is best among three, however the length of the shaft exceeds 350m, and this route is the furthest from the present Beyrouth and Damascuss Road.

1-2 Cross Section of Tunnel

We well known factors diciding the tunnel section are as follows.

1) Tunnel distance

2) Capacity to allow the traffic volume in the future

3) Longitudinal slope of tunnel

4) Geological condition

5) Weather condition

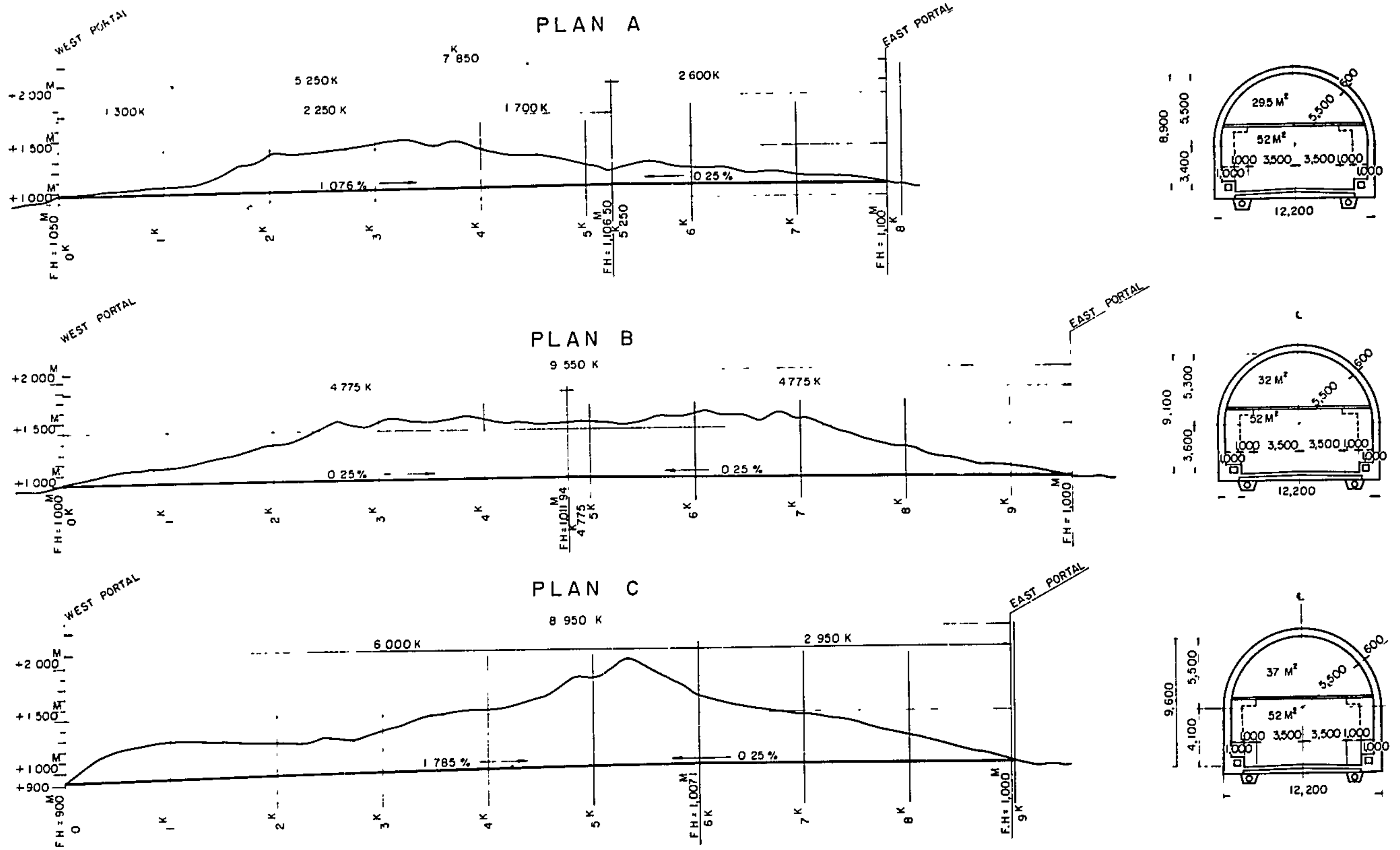
6) Ventilation

The tunnel sections should be decided in consideration of the above mentioned factors. However, before we decide the section form of each plan, we studied each plan with general conditions, after which we decided the form of the selected plan. The details in this respect are stated in "Preliminary Design of Tunnel". The outline of longitudinal section are as per following figure.

1-3 Comparison of each plan

It is not so difficult to discuss the comparative merits of the each plan from their sections and longitudinal condition, if the geological conditions are agreeable. The above three plans were selected from the posibility of geological conditions as well as the viewpoint to satisfy the purpose of new road construction which also contains the good connection with the route of access road. Three plans were studied in all their aspects, and we

PROFILE, PLAN AND SECTION OF PROPOSED TUNNELS



concluded that Plan A, which can be combined with the access route 1, is the most satisfactory for our aid. Also the technical condition of the present tunnel driving method, and economical condition, which minimumize the cost of construction among three plans, have made us choose the Plan A.

From above-mentioned conclusion, we escaped from the effect in designing and calculating the cost of each plans, but concentrated our best only in Plan A.

2. Access Highway Routes (Fig. 1, Fig. 4)

2-1 Between Beyrouth and Tunnel

The routes which can be connected to the above three tunnel or even some of them are three or four.

Route 1 is the nearest one to the existing Beyrouth - Damascus Road, and connected to it at Araya and Bhamdoun.

Beyrouth - Borjel Beragini - Ouadi Chahrour - Kahnale - Aley - Bhamdoun - Qoubheyh - Hammana - Tunnel - Chtaura.

Route 2 run 500m - 2,000m north of Route 1. Beyrouth - Ouadi Chahrour - Araya - Abaliyeh - Qoubheyh - Hammana - Tunnel - Chtaura.

Route 3 run north of the Beyrouth River, and terminate at Hammana.

a) Beyrouth - El Mansouryet - Ein Saade - Broummana - Baabdate - Salima - Qounayel - Btekknay - Hammana - Tunnel - Chtaura.

b) Diverge from above-mentioned a) Route at El Mansouryet.
Beyrouth - El Mansouryet - Zandouka - Qortada - Rasel Metene - Deirel el Harf - Btehnay - Hammana - Tunnel - Chtaura

Route 4 run northward along Beyrouth - Tripoli Road, diverge near Antelias and pass north of Beyrouth River to Narikel Trad.

Beyrouth - Tell ed Dib - Autelias - Dik el Mahdi - Zikrit - Qornet Chahouane - Bikfaiya - Ech Chaueir - Quata Mroiy - El Mtaine - Harik el Trad - Tunnel - Chtaura.

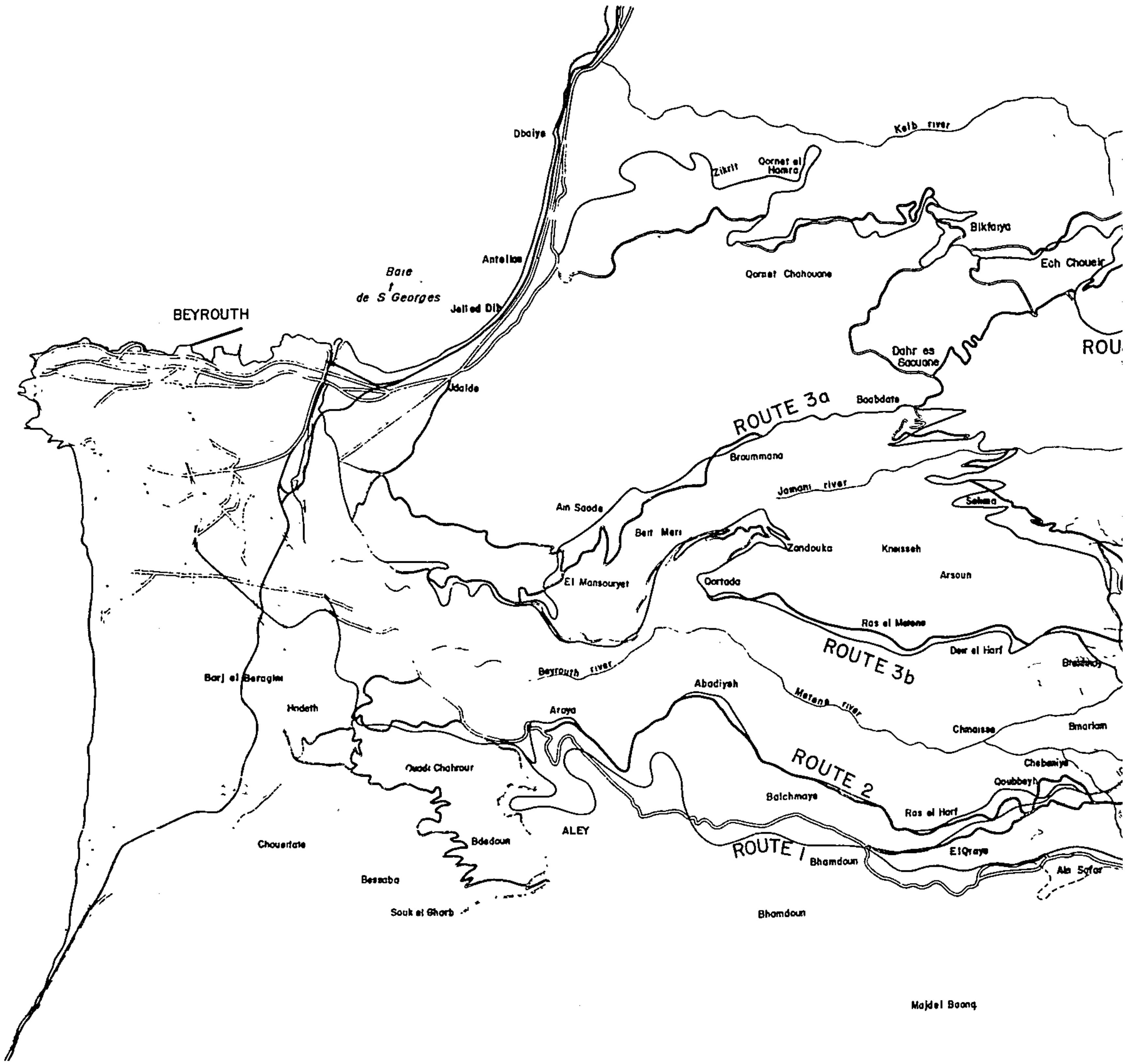
Route 5

There are many combinations of routes, if we combine above routes portionlly, which are as per Table 1. Among above routes plan, we selected Route 1 - 4, which we will study in more details as follows.

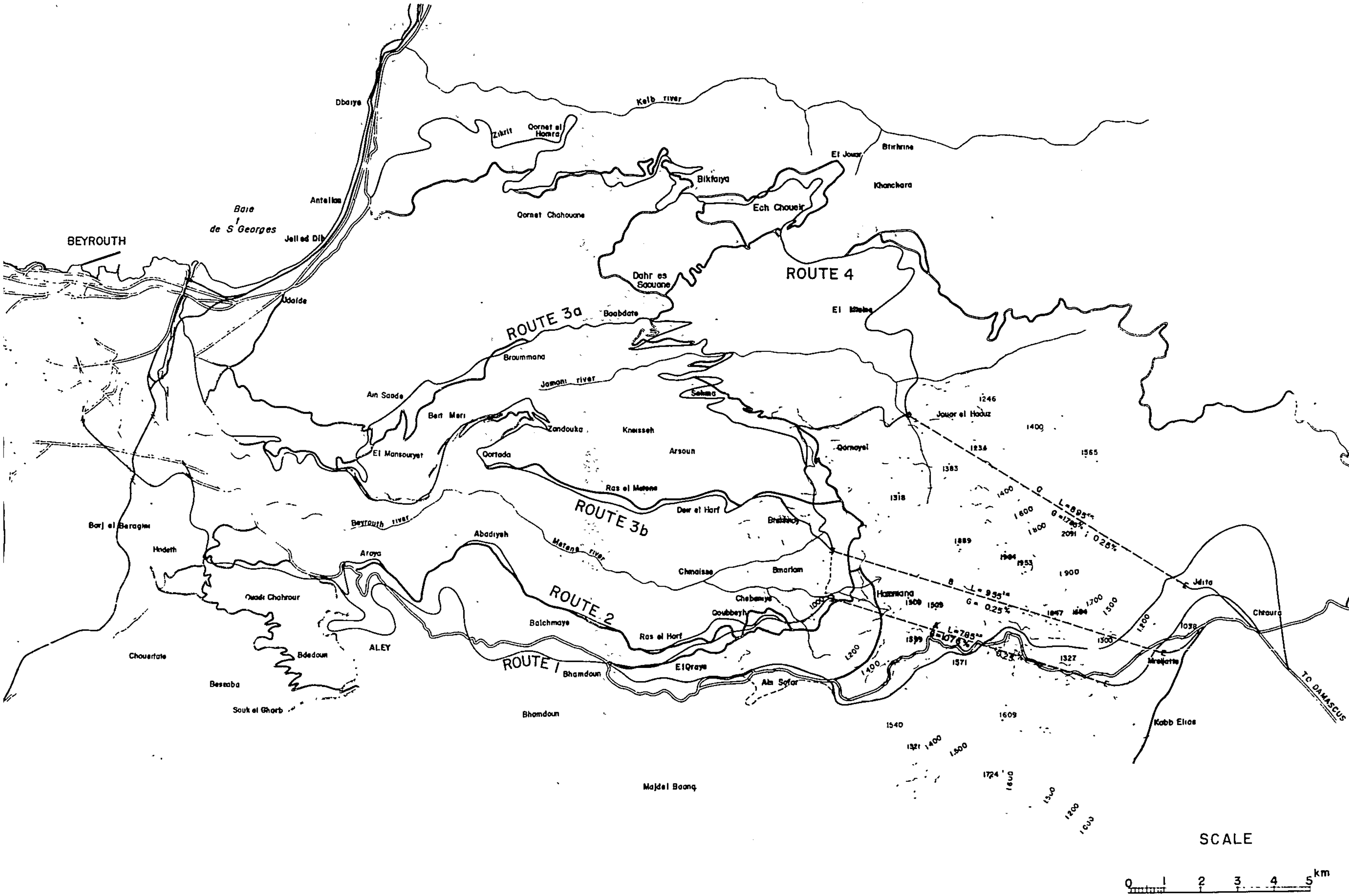
COMPARATIVE TABLE OF ROUTE

	Approach (Westside)				Tunnel			Approach (Eastside)				Total Length (km)
	Route		Length (km)	Grade (%)	Route	Length (km)	Grade (%)	Route		Length (km)	Grade (%)	
1	2	Beirut - Hammana	34.50	5	A	7.85	1.076 0.25	1'	Kabb Elias - Chtaura	7.00	5	48.35
2	3-a	"	44.50	5	A	7.85	1.076 0.25	1'	"	7.00	5	59.35
3	3-b	"	37.00	5	A	7.85	1.076 0.25	1'	"	7.00	5	51.85
4	4	"	57.00	5	A	7.85	1.076 0.25	1'	"	7.00	5	71.85
5	1	"	34.50	5	B	9.55	0.25	3'	Mreijette - Chtaura	4.00	5	48.05
6	3-a	"	43.50	5	B	9.55	0.25	3'	"	4.00	5	57.05
7	3-b	"	36.00	5	B	9.55	0.25	3'	"	4.00	5	49.55
8	4	"	56.00	5	B	9.55	0.25	3'	"	4.00	5	69.55
9	1	Beirut-Louar el Haduz	42.00	5	C	8.95	"	3'	Jdita - Chtaura	2.50	5	53.45
10	3-a	"	46.00	5	C	8.95	"	4'	"	2.50	5	57.45
11	3-b	"	43.50	5	C	8.95	"	4'	"	2.50	5	54.95
12	4	"	48.50	5	C	8.95	"	4'	"	2.50	5	59.95

Table-1



Dbaiye
Kelb river
Zikrit
Qornet el Hamra
Bikfaya
Ech Choueir
Antelias
Baie de S Georges
Qornet Chahouane
Jalled Dib
BEYROUTH
Dahr es Saouane
ROU
Jdaide
ROUTE 3a
Baabdate
Broummana
Jamani river
Salima
Ain Saade
Beit Meri
Zandouka
Kneisseh
El Mansouryet
Qortada
Arsoun
Ras el Metene
Deir el Harf
ROUTE 3b
Beyrouth river
Abadiyeh
Metene river
Borj el Beragine
Hadeth
Araya
Chnaisse
Bmariam
Chebaniye
Ouadi Chahrour
ROUTE 2
Qoubbeyh
Batchmaye
Ras el Harf
ALEY
Bdadoun
Choueifate
ROUTE 1
Bhamdoun
El Qraye
Ain Sofar
Bessaba
Souk el Gharb
Bhamdoun
Majdel Baana



DAHR EL BAIDAR TUNNEL PROJECT

BEYROUTH TO CHTAURA

ALTERNATE ROUTES PLAN

JAPANESE SURVEY TEAM FOR THE TUNNEL CONSTRUCTION PROJECT IN LEBANON

MARCH 1964 FIG. 4

Route 1

Route 1 is the nearest one to the present Beyrouth - Dammascus Road, running parallelly with B-D Road, and connected to the tunnel Plan A passing through the main villages on the way, such as Aley, Bhamdoum. The total distance (including tunnel) from a center of Beyrouth to Chtaura is about 48 km. Since running through main villages, it is very convenient for transportation of passengers and cargo, and has a high value in the sight-seeing viewpoint. This approach access route is passing through near the international airport which is located in the south of the city. There are enough spares in case of constructing the terminal in the future.

Route 2

Route 2 runs on the same line with Route 1 as far as Ouadi Chahrour, and diverges to the north at Aley and leads to Qcubbeya, passing Araya and Abaliyeh. The route can be connected to Aley, diverging from Route 1 at west of Araya. Accordingly it will develop Araya and Abaliyeh in the future, and will have a large merit as the direct transportion road from Beyrouth to Chtaura. Other conditions are same as Route 1.

Route 3

Route 3 approachs to Beyrouth from the northern side of Nahr Beyrouth River, and is useful to develop the north area of the Beyrouth River. There are two plans; a) is of 55km distance, and b) 49km. Both routes have many sharp slopes and curves. To shorten the distance can be available with connecting small tunnels on the way, but we study the route in accordance with the natural feature. The problems on this route is, as stated above, too many curves. Among two, Plan b) is shorten than a), but it has a bottle neck between El Mansouryet and Qortada, crossing the Beyrouth River. In order to shorten this curve points, we should build a bridge, but as the geological position has the sharp cliff, span rises over 500m and also the cost will be large accordingly.

With the view to escaping this, and passing the villages where have been developed to some extent, a) is more suitable than b). a) does not need a bridge. Another point is the approach to Beyrouth. In the future Beyrouth City Planning, we need to construct the terminal in the suburbs. As the planned terminal, the narrow place with the mountain overwhelming in the rear side must be avoided. In this point, the systematic policy for traffic density in the future can not accept this route.

Route 4

Route 4 is about 59km long, and purpose to develop the wider area of northern area than Route 3. Also this route has many curves with small radius of curvature. Since this route runs northward to some extent, it needs not lead to Hammana to across the Beyrouth Ranges, and taking the present road into consideration, we planned the tunnel construction near Hurik el Jrad. In this area there are no problems in the geological condition, but in an even good place. However in an actual tunnel construction, we have the trouble of the position of shaft (h = 500m over). To solve these troubles, we must build several bridges over vallies, which forces us to carry out considerably troublesome works both horizontally and longitudinally. Another problem is the approach to Beyrouth. This route will join to the old Road, which is even now very busy, and so also this route leads the terminal construction which is common for each plans and must be realized in all aspects and standpoint for future traffic policy. As above, we studied several combination of tunnel and routes. Which plan we should adopt will reveal obvious before detailed cost calculation or redemption estimation.

We can think above four routes as two groups, Route 1 & 2 and Route 3 & 4, and compared these two groups as follows.

The first study is as to Routes 3 & 4.

I) When we compare two groups of routes on the both sides of Beyrouth River, one is routes in northern area, and the other is routes which are running near the present Beyrouth - Dammascus Road, Routes 3 & 4 do not meet with our outstanding aid of solving the traffic density on Beyrouth - Dammascus Road, since they are a little far from the Road. If our new-road construction enterprise would have another purpose to develop the area along the road, Routes 3 & 4 would have another merit. However the said other purpose depends on Lebanon Government road-construction policy as well as general Industrial policy to be decided according to the order of requirement. Therefore the consideration to this matter should be studied in our next step.

II) If we have to realize the above plan, the Route have too many curves provided it will be constructed in accordance with the present natural features. And on the hand, if we want to have short-cut, we have to construct many special buildings.

III) In the present traffic condition in Lebanon, especially in Beyrouth City, the indispensable condition to solve the beary density, is to construct the terminal in the suburb of the city, connecting the roads running outward of the city. For this purpose we have not enough spare for the approach to solve the problem in the future, unless the particular planning would be set up.

IV) In the standpoint of sightseeing, which is one of the purposes of our road plan, Routes 3 & 4 are inferior to the present Beyrouth - Dammascus Road.
On the second, we study Route 1 & 2.

1) Route 1 & 2 are very near to Beyrouth - Dammascus Road, and pass through the many main villages on the way, and can be connected to the

present main road in many places. For these reasons, this road plan are recommended as the most suitable road for our present aid.

2) Route itself does not have so many curves comparatively with the other, and the total distance to short.

3) Connecting tunnel is also satisfies with the geologically and the technically, and is the shortest among other plans.

4) The view of landscope is better than others.

5) From the point of approaching to Beyrouth City, since there are enough spaces in the south of the city, near the Airport, we can construct the terminal considerably easily, which is important for solving the traffic density.

As the result of above study, we recommend the group of Route 1 and 2 as the first step and the most suitable route to solve the traffic density in the future for Lebanon Government. Furthermore we suggest the following steps as the most suitable policy at this stage that in the first step we construct Route 1, which is planned in the view to connecting the villages on the old road and improving the road condition, and as the second step construct Route 2 in the near future for another purpose to develop the neibouring area.

According to our above conclusion, we are going to execute the new road plan of Route 1. In our study, we only decide the main road section with assuming the future traffic volume in the main points on the route excluding the tunnel, on the basis of Highway Design Standard of Lebanon, but do not proceed until calculating the construction expenses. As to traffic sensus, details are stated in the fifth section of "Traffic Investigation". As the result, we planned the road-width as 6 lanes between Beyrouth and Aley, and 4 lanes for further area.

2-2 Between Tunnel and Chtaura

It is necessary to improve the area between the point where the route joins the old road and the exit of the tunnel. This route is as per Fig. 3. The basis of deciding the line is same with the one of 2-1.

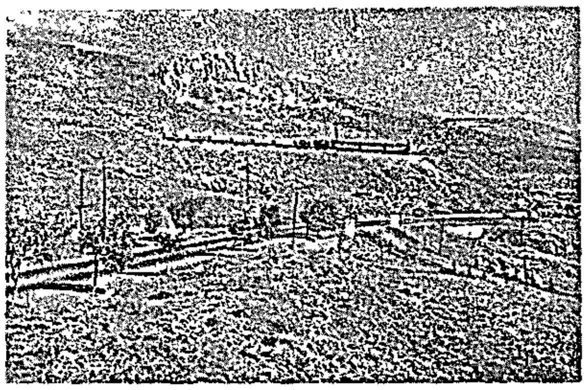
3. New Road

In the previous paragraph 1 and 2, we studied the tunnel route including the access road, and we need the further studies in this matter. However before we further proceed, we must study whether we can plan the improved road without the tunnal in the substitute of the old road, especially in the economical point.. For this purpose, we studied the new road plan which diverges at Ain Safa from Route 1 and pass Dhar el Beidar as per Fig. 3. This road is to be connected to Route 1 combining the large village, and have a maximum grade 5%. This road is the best one in the substitute of the road with tunnel.

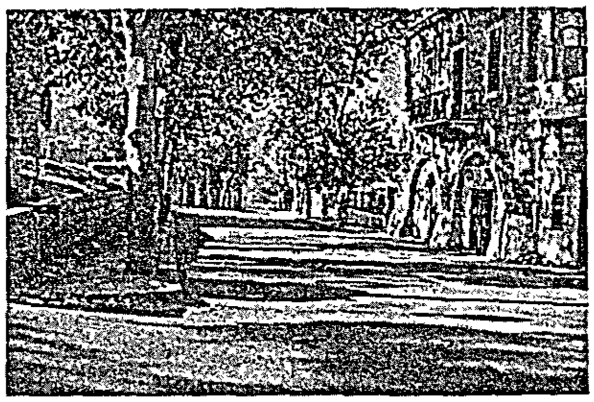
4. Conclusion

As stated above, we compared the two roads, one with tunnel and the other without tunnel as an improved road plan of Beyrouth - Dammascus Road. As to the former, we can escape from the weather condition, but need the large cost of construction and as to the latter, we need not such large expenses as the tunnel-driving case, but too much depend on the weather condition. We compared these two plans, and concluded that Route 1 with Tunnel A is best in the other plans.

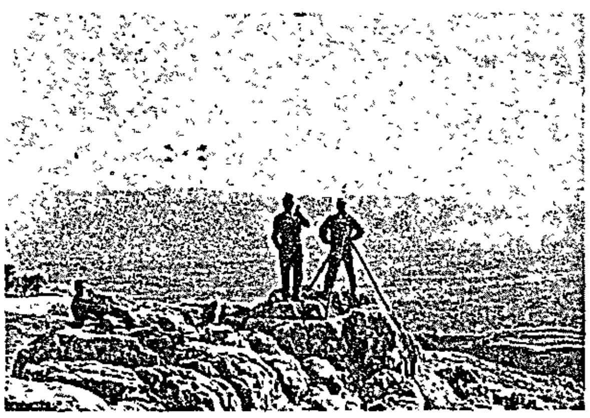
We will be back to the tunnel problem, and according to the result of geological investigation, proceed to the study on the detailed tunnel-driving plan.



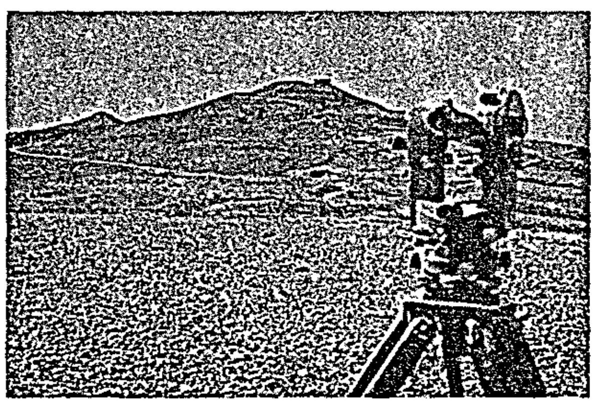
BEYROUTH–DAMASCUS ROAD AT DAHR EL BAIDAS



BEYROUTH–DAMASCUS ROAD AT AIN SOFAR



SURVEYING



SURVEYING

§ IV The Result of Geological Survey

1. Outline (Fig.5)

The results of the geological survey around the places through which the tunnels are bored are as follows: These places are composed of the bluish grey limestones of the upper jurassic layer, on which are they based, the nearly horizontally heaped layer of the sandstones and limestones of the Cretaceous period, and the cliff cones of the splinters at the foot of the mountains. Several lines of faults are perceived on the eastern side, among which the large one running in the eastern part of Hammana, on the southern foots of Jabal el Knisse and across Dahr el Chir is the most prominent. Although this fault covered with the cliff cones of splinters can not be seen directly from outside, its height is estimated as high as at least 200m in its west end in Hammana.

2. Jurassic Layer

The jurassic layers can be seen widely in the west of Falougha, of west portal area, and widely in the region around the south Mreijitte and Kabb Elias and near Jdita, where the east portal is planned.

Among these, in west area, rocks have clad shape with few crevices, and homogeneous ones can be used as construction materials. However in east area, the surface looks much rough, which are formed by the rain stream. Most of them in west area reveal naked layer, and in some places we found rocks contain chart of about 10 - 30 cm diameter. In east area, especially north of Kabb Elias, there found that concaves portion, which were formed by the rain stream, are covered by the weathered clays, and in flat places, these weathered clays form this surface layer. According to Dubirtret these are classified in the upper Jurassic layer, and are named Kesrouane limestone. The thickness is up to 400 - 500 m. and are grouped into the four C_1 - C_4

layers from the bottom. In most places they are heaped up nearly horizontally with a slight inclination of about ten degrees.

The basic sandstone (C_1) forms the lowest part and is distributed in the northern region of the cliff cones in the south of Hammana and partially in the west of Kabb Elias. It has a dark brown color and sometimes contains clay layers of greyish black color. The layer (C_{2a}) which is mainly composed of sandstones and clay-states is 50 - 150 m in thickness.

3. Cretaceous Layer

The Cretacrous layers are mostly consisted of limestones and are grouped into four C_1 - C_4 layers from the bottom. In most places they are heaped up approximately horizontally with a slight inclination of about ten degrees. In some particular places, there found these with about twenty-five degrees, which are considered to have been formed by dislocation. These area is inclining to north-west direction in western side of Dahr el Beida Pass, but in east area of Hammana, inclining to east-south. They are forming rear-inclining construction.

3-1 Basic Sandstone (C_1)

The Basic Sandstone (C_1) forms the lowest part and is distributed in the northern region of the cliff cones in the south of Hammana and partially in the west of Kabb Elias. It has a dark brown color and sometimes contains thin clay layers of greyish black color. They seemed to be littaral deposit, formed by the strong tide stream. These in east side are solidifying tightly, but in west side Hammana area, are not so solid, but so fragile that can be easily crashed by hammer even if the appearance look like rock. In some places they are just like of sandlayers. The most remarkable district of this layer is south of Hammana of cliff cone, where is planned to be the tunnel opening. The thickness are about 250 m. In the area of 1290 m north of El Modairej, they are digged out as the sand of construction.

3-2 The Layer which is mainly composed of sandstones and clay-slates (C_{2a})

This layer is 50 - 150 m in thickness and contains fassils. In Hammana side there found in partial a mixed layer mainly composed by lignitic clay-slates, but mostly covered with the upper cliff cones. On the other hand, in the mountain of south side of Dahr-Beider-Mraijatte, the layer reveals itself with sandstones of dark red brown. However in this interim area it is not naked for the reason of its height. As stated above, the surface investigation manifested that there are considerable changes of layer features in a horizontal direction, and the thickness are decreasing with proceeding eastward.

3-3 The mixed Layer mostly composed of block limestone. (C_{2b})

This layer is about 80 m in thickness, and is characterized as having in its from dense limestone in blocks of corals, called Maraille de Blanche, which we can see on the cliff cone in Hammana district. Over it there is thin clay-plate rock and on the top red sand of about 10 m thickness. This block limestones layers are widely distributed in Lebanon, and have less horizontal change of features than C_{2a}. Their layer-structure is comparatively regular, but there found many little faults of 10 - 20 m thickness. For instance on the cliff of Hammana, where is planned to be the west portal in Plan A, the layer is divided in step-shape as per Fig. 6, and the west portal is as per Fig. 7. In limestone, we have sometimes vertical joint.

3-4 The Layer mainly composed of splinter limestone. (C_3)

This layer is widely distributed from the top of the cliffs in Hammana, across Dahr el Beidar and far to the east.

It is 100 - 150 m in thickness, with pale yellow, and sometimes composed of thin limestone layers. Comparing with the limestone of Muraille de Blanche, it is fragile, composed of marl stone.

3-5 The mixed layer of limestones and marls. (C_4)

This layer forms the uppermost layer of the Cretaceous period distributed in this region and consists of mixtures of pale yellow limestones and brounish yellow marls with a thickness of 50 cm. The vertical joint.

(refer to Fig. 8

This layer on the cliff of Hammana, at the angle point of 1599 m high inclines to north-west by about 25% degree, and a portion inclines to the opposite direction, south-east by 25% degree. Therefore it has a considerablly sharp slope at the both edge of east and west.

4. Cliff Cones of the fourth Period

The cliff cones of the fourth period are distributed all around the west Hammana and near east Jdita. They are composed of splinters cracked out from the upper rocks; those in Hammana are composed of limestones of the Cretaceous period and those in Jdita are of limestones of jurassic period, and the former are distributed more widely than the latter. Generally speaking, considerablly large stones are found near the cliffs, and especially in Hammana blocks of rocks with diameter of over 20 m are found locating in the middle of the cliff cones. Moreover in the bottom sandstones, apart from the cliff line by 1 km westward, the limestones are revealing their naked features in three places. These were considered at the begining as the jurassic limestones which were left in an erosion action, as a result of the later survey, they proved to be above-mentioned large rocks, which the seismic prospecting, which will be stated in a later part, testifiged this fact.

The thickness of the cliff cone here were presumed to be 50 m maximum. On the other hand in Jdita side, the block of rocks is small. Most of all are of 10 - 30 cm diameter, and even maximum does not exceed 3 m. The maximum thickness if presumed to be about 20 m.

5. Structure

As outlined above, this region are composed of jurassic and Cretaceous layers, which are heaped up nearly horizontally, and no where we found folding. The fault running east to west is prominent, especially as to the one running east to west on the south foot of Jabal el Knissi Range, the southern side is lower by 200 m relatively. This fault is covered with the cliff cone splinters, cracked out from the mountain side. We can see hardly them directly, while at the west end of fault appearing on the cliffs in the east side of Hammana can be observed to compose one of crashed fault belt of at least there stepaise dislocation in almost parallel position to each other with the width of 50 m.

6. Conditions of Underground Water

The average rainfall in Beyrouth is approximately 800 mm per annum, but in these area of high-lands the rainfall pipes up to 1,300 mm and we have a heavy rainy season four months in winter (November through next February). Through the whole area of Lebanon, these are over 2,000 springs, and the flow volume of all these springs are measured once every year by the Hydrological Service of the Minitry of Public Enterprice. Among these, we got the data of four springs mentioned bellow.

Chaghour, Hammana (Ch)

Kabb Elias (K)

Barake Chtaura (B)

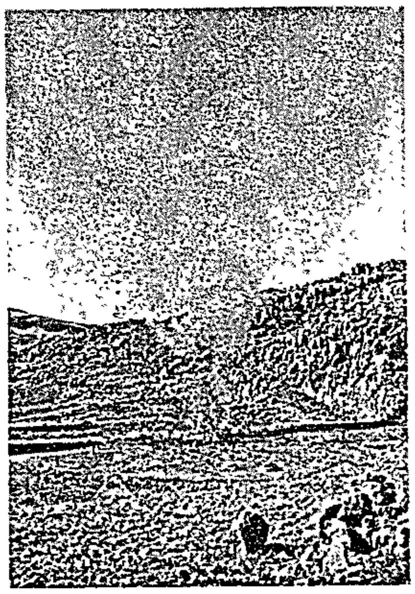
Nebu Chtaura (N)

The volume of these four springs are stated in Table 2. Beside these, the main springs in Hammana are Ain el Meytri (My), Ain el Hossah (H), and Ein el Midan (Md). The volume are told 30 - 100 m^3/day respectively. Above springs make seasonal changes in their volume according to rainfall, and generally December through next April is the peak of the year. To talk of chaghour, the biggest spring in Hammana area, we suppose, the rain water stream down to the dense Maraille de blanche, and well forth from its summit after being screened through the layers over the splinter limestone (C_3) of the upper portion of Cretaceous layers. But Partially the water go further downwards through little faults or along the vertical crevices, and stopped again by the basic layer of jurassic limestone. These water routes are presumed to form a source of groups of little springs in Hammana village. Anyway are convinced that the high-lands in the rear of Hammana is the origin area, and we also suppose the big fault running on the south foot of Jabal el Knisse Range have much volume of water. On the other hand, east area, Kabb Elias-Chtaura area is also supposed to be the sourse of water, since the basic layer of jurassic limestone is not so dense as west area. Kabb Elias is the spring which well forth along a weak line in limestone layer, and two springs in chtrauna are the underground water in the alluvial layer of Bekaa Highlands. (Reference Table 2)

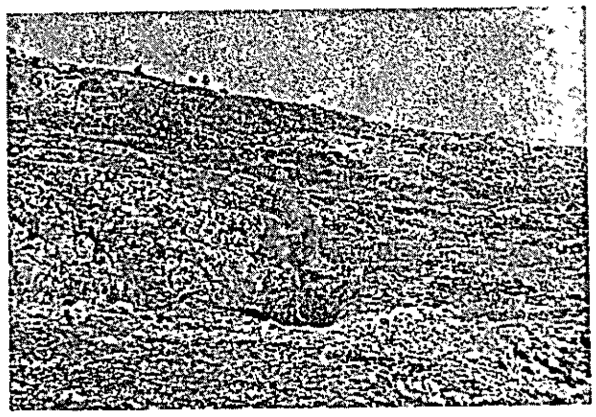
7. Seismic prospecting

In our survey, beside the general geological survey on the area including Tunnel Line, are carried out the seismic prospecting on the both portal spots of Plan A, which we decided after a deliberate comparison with their plans. The special machine is used in this survey is of model 305 of Century, U.S.A.

7-1 West side, Hammana (Fig. 9 through 11)

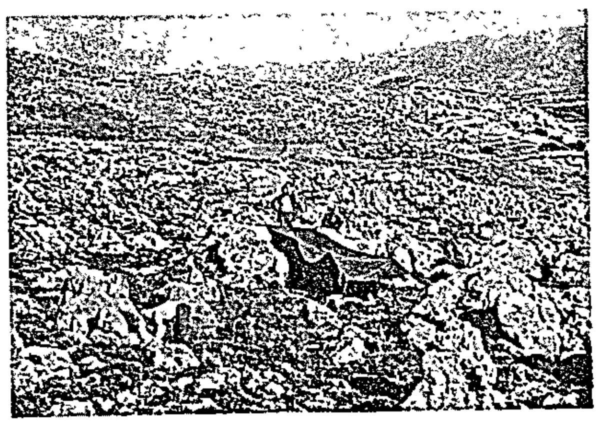


SEISMIC SURVEY (BLASTING OPERATION)



SEISMIC SURVEY (BLASTING OPERATION)

SEISMIC SURVEY (OBSERVATION POST)



SEISMIC SURVEY (PREPARATION FOR BLASTING)

As previously stated, this area is formed of fragile sandstone. In order to measure the thickness of this layer down to the basic layer, set a survey line. A principal survey line was set with 500 m of length in a vertical direction to the tunnel line, and two subordinate-survey line of 300 m crossing it with 90 degree, making total 1,100 m, and set up the explosion points in every 100 m distance. The results were measured in each 10 m. The test manifested that in the surface layer there are the layers with about 5 m of width, wave speed 700 - 1,000 m/sec., and under them the layers which allow wave speed within 2,500 m/sec. of middle speed are lieing, down to the depth of 150 m from the surface.

The thin low-speed layer in the surface is composed mainly of splinter limestone, and the middle-speed layer is composed of fragile sandstone (G) of the lowest Crataceous layer. And the basic layer in this area is presumed to reach lower position than the height of 1,050 m. Moreover, we concluded that three points of naked limestone in the west edge had not any influences to the elastic wave, and they are only big rocks, which was proved by the surface survey.

7-2 East side, Kabb Elias (Fig. 12 through 13)

This area is located in the south side of Beyrouth - Dammascus Road, 1.5 km west from Kabb Elias. The neighbouring area is formed of comparatively hard jurassic limestone, but the surface reveals the features of saw-teethline, which are supposed to have been formed by the rain stream, and concaves are covered by weathered clay, Jerra Rassa Clay. A principal survey line was set approximately in a horizontal direction to tunnel line with 400 m of length, and we had a subordinate survey line of 200 m crossed it diagnally according the natural feature, measuring with the same method with the west portal. As a result, we found that in the surface layer, the layers of 3 - 10 m of thickness, wave speed 1,000 m/sec. are partially distributed, and under there middle speed layer of 1,300 - 2,000 m/sec. At the lowest bottom, wave marked 2,500 - 5,000 m/sec, which high-speed proves that the layer is much uneven. From these results, we concluded that the low-speed layer is formed weathered clays and in the middle speed layer weathering is now in process, and the bottom is the basic layer of limestone.

That in middle and lowest layer, the wave speed has a wide allowance shows us that the rate of weathering action is different in each portions, and also that there are many little crevices that have nothing to show on the curves on the gauge.

8. Geological Study to the Tunnel Lines (Fig. 6 - 7)

From the above-mentioned geological conditions in this area, we studied the planed tunnel line as follows.

8-1 Plan 4

Although the west opening is formed of lower most Creteceous sandstones, the portal position is located near to a basic layer of above mentioned layer, and every upper layers of this area are slightly including to the north-west direction. Provided we suppose that this structure covers down to lower layers, a tunnel will enter the hard jurassic limestone layer, in a process of digging to the east direction. The geological condition, surveyed by the seismic prospecting will not allow us an easy work, but we can not say that this sort of layer is specially bad condition for tunnel-driving. As to the east portal, we concluded that we have not any difficult problem to dig through the jurassic limestone layer, but the elastic waves shows us that there are many crevices, among which some have about 10 m of width and depth, and we covered by the weathered clays. So we should be careful to the near area of the portal,covered with thin clays. However, since an up-to-date tunnel-driving method can easily solve the difficulty, we have not any particular bottle-neck for our work.

8-2 Plan B

The weakest point of this plan is that a west half of a whole line meets a fault line which crosses the south foot of Jabal el Kneisse Range from east to west. Therefore the stone fall as well as welling waters are unavailable. However since the faults are presumed to incline slightly in the lower part, the neck can be delated of the position for formation will remove according to it. Nevertheless, it is true that the crashed fault area like this contains a difficulty. As to the east portal, we have to take care of supporting since this area is of Cretaceous splinter limestone layers.

8-3 Plan C

In this plan the formation are executed in the basic layer of hard jurassic layer. We have nothing inconvenient in a geological standpoint. The above assumptions were concluded by a general surface survey and an seismic prospecting executed in some particular area. We can not say that everything proved to be obvious. However we have reached the decision on the position of tunnel formation. And, needless to say, for an actual execution, we have to have further geological surveys by means of baring etc. in order to get a precise and exact conclusion. From our above studies, we concluded as follows.

Plan C is the most suitable in an geological viewpoint.

Plan A is possible to be formed in technical conditions or others.

Plan B is to be the one, not so suggested.

Further to this geological conclusion, we added other facters concerned, and studied our Tunnel Line with connecting route.

Table - 2

Hydrological Measurements on some Springs in Lebanon (1)

Name of Spring: Chaghour at Hammana

Date			Flow liter/ sec	m^3/min	Remarks
Jul.	23	1957	37.15	2.23	
Mar.	19	1960	298.0	17.88	
Apr.	30	"	67.0	4.02	
Jul.	15	"	15.0	0.90	
Sept.	21	"	10.0	0.60	
Nov.	25	"	26.0	1.56	
Mar.	13	1961	447.0	26.82	
Apr.	19	"	385.0	23.10	
Jul.	19	"	21.0	1.26	
Aug.	18	"	11.95	0.72	
Sept.	18	"	11.9	0.71	
Oct.	19	"	5.8	0.35	
Jan.	25	1962	231.0	13.86	
Jan.	29	"	250.0	15.00	
Feb.	9	"	375.0	22.50	
Feb.	28	"	500.0	30.00	
Mar.	26	"	269.0	16.14	
Apr.	26	"	181.0	10.86	
Jun.	26	"	13.0	0.78	Estimated
Aug.	21	"	26.5	1.59	
Oct.	27	"	9.0	0.54	

Hydrological Measurements on some Springs in Lebanon (2)

Name of Spring : Quabb Elias

Date			Flow liter/sec	m3/min	Remarks
Oct.	18	1956	524	31.44	
Aug.	28	1957	684	41.04	
Oct.	18	"	417	25.02	
Mar.	2	1960	430	25.80	
Apr.	6	"	684	41.04	
May	9	"	320	19.20	
Jul.	6	"	296	17.76	
Aug.	3	"	332	19.92	
Sep.	7	"	356	21.36	
Oct.	5	"	387	23.22	
Dec.	7	"	303	18.18	
Jan.	11	1961	613	36.78	
Mar.	7	"	1,020	61.20	
Apr.	12	"	692	41.52	
May.	8	"	625	37.50	
Jun.	27	"	371	22.26	
Jul.	17	"	482	28.92	
Sept.	22	"	341	20.46	
Dec.	11	"	424	25.44	
Feb.	12	1962	1,246	74.76	
Mar.	7	"	1,458	87.48	

N.B. : After March 1962 the flow measurements are done by the LITANI. Just after the hydroelectric power plant was constructed, the measurements has been constructed.

Hydrological Measurements on some Springs in Lebanon (3)

Name of Spring : Baraké at Chtaura.

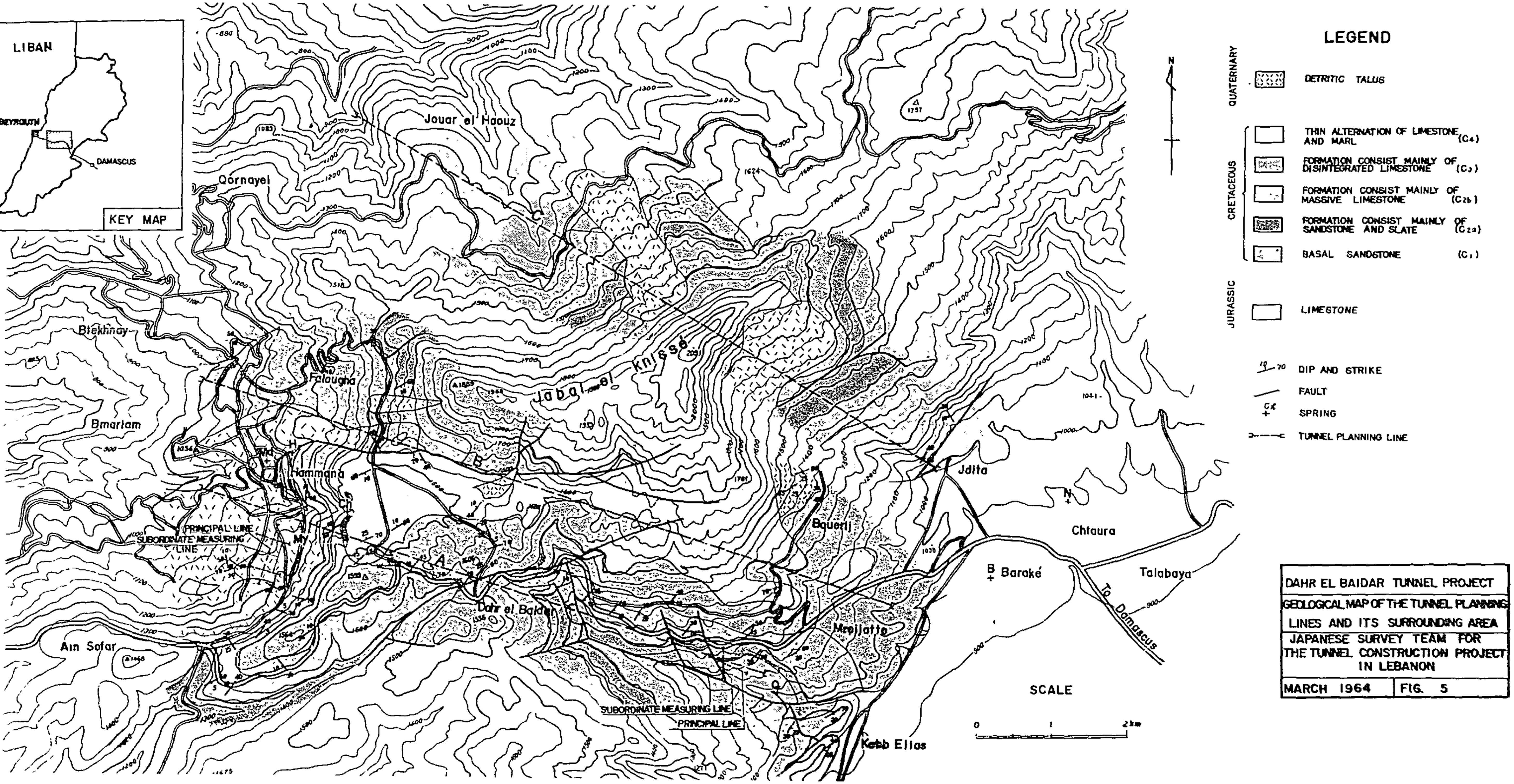
Date			Flow liter/sec	Flow m^3/min	Remarks
Jan.	31	1962	28.0	1.68	
Feb.	12	"	27.0	1.62	
Mar.	7	"	31.0	1.86	
Apr.	3	"	36.0	2.16	
Apr.	24	"	18.0	1.08	
May.	22	"	11.0	0.70	
Jun.	5	"	11.0	0.66	
Aug.	10	"	5.0	0.30	
Sep.	18	"	4.0	0.24	Estimated
Oct.	30	"	12.0	0.72	
Dec.	26	"	13.6	0.82	

Hydrological Measurements on some Springs in Lebanon (4)

Name of Spring : Chtaura

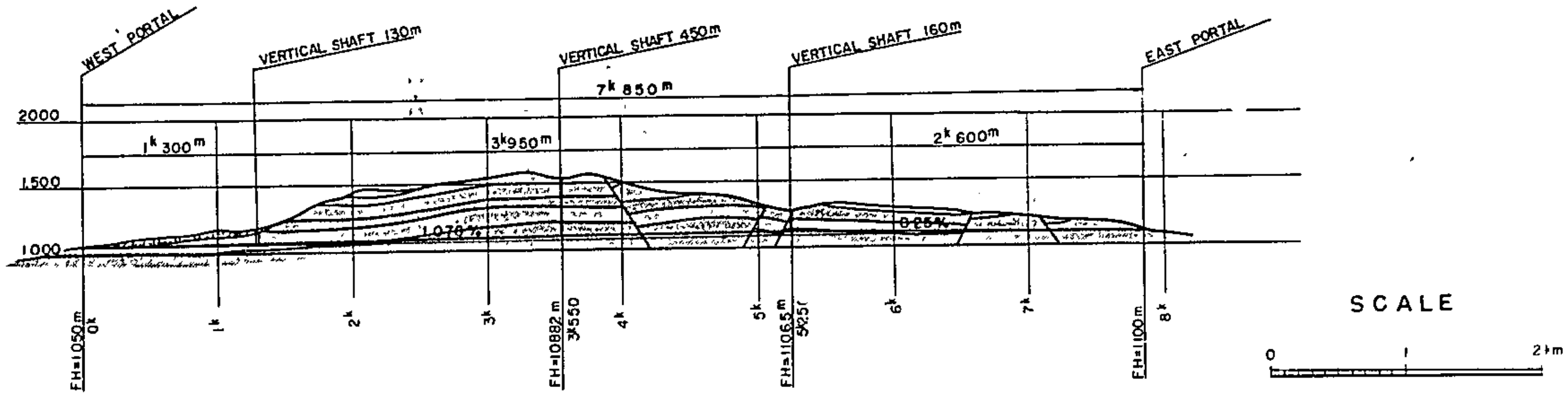
Date			Flow liter/sec	Flow m^3/min	Remarks
Oct.	18	1956	103.0	6.18	
Sep.	28	1957	243.0	14.58	
Oct.	15	"	136.0	8.16	
Mar.	2	1960	203.0	12.18	
Apr.	6	"	469.0	28.14	
May.	9	"	504.0	30.24	
Jul.	6	"	246.0	14.76	
Aug.	3	"	194.0	11.64	
Sept.	7	"	152.0	9.12	
Oct.	5	"	132.0	7.92	
Nov.	3	"	114.0	6.88	
Dec.	7	"	136.0	8.16	
Jan.	11	1961	116.0	6.96	
Feb.	9	"	501.0	30.06	
May.	8	"	476.0	28.56	
Jun.	27	"	265.0	15.90	
Jul.	17	"	196.0	11.76	
Aug.	18	"	150.0	9.00	
Sept.	22	"	127.0	7.62	
Nov.	10	"	144.0	8.64	
Dec.	11	"	134.0	8.06	
Feb.	3	"	766.0	45.96	
Feb.	28	"	1,144.0	68.64	
Mar.	7	"	816.0	48.96	

N.B. : After March 1962 the flow measurements are done by LITANI.

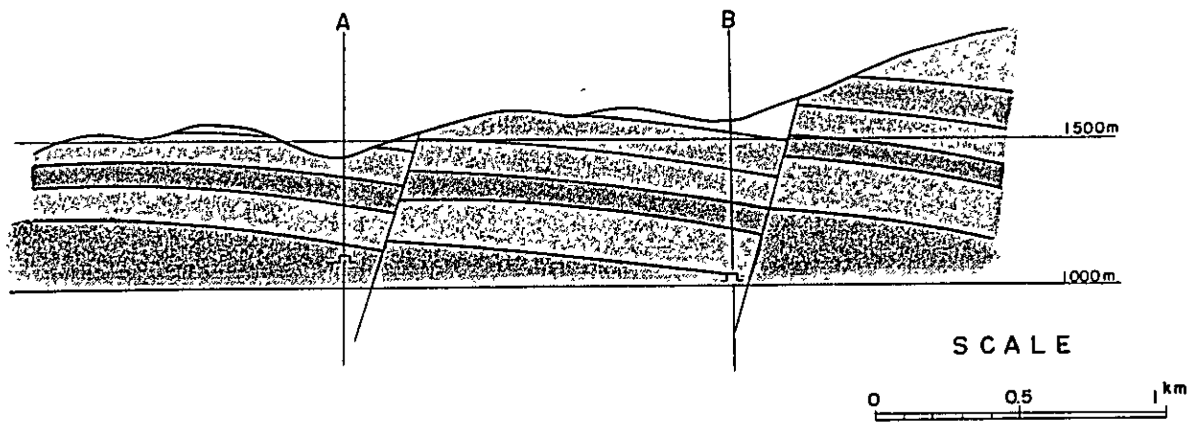


DAHR EL BAIDAR TUNNEL PROJECT
GEOLOGICAL MAP OF THE TUNNEL PLANNING LINES AND ITS SURROUNDING AREA
JAPANESE SURVEY TEAM FOR THE TUNNEL CONSTRUCTION PROJECT IN LEBANON
MARCH 1964 | FIG. 5

LONGITUDINAL SECTION OF TUNNEL ROUTE A

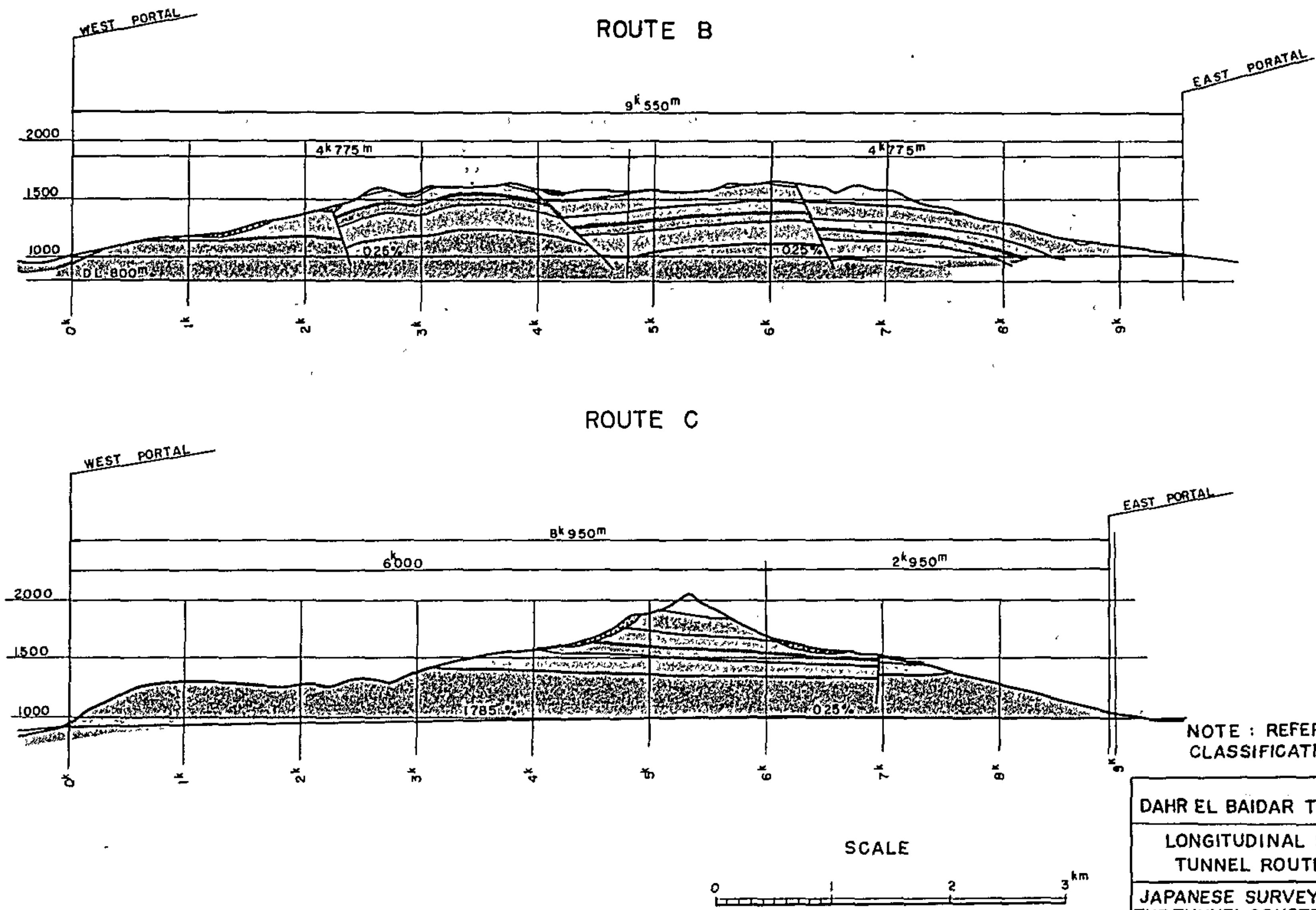


GEOLOGICAL CROSS SECTION OF PROPOSED TUNNEL LINES



NOTE : REFER FIG. 5 FOR CLASSIFICATION OF STRATA

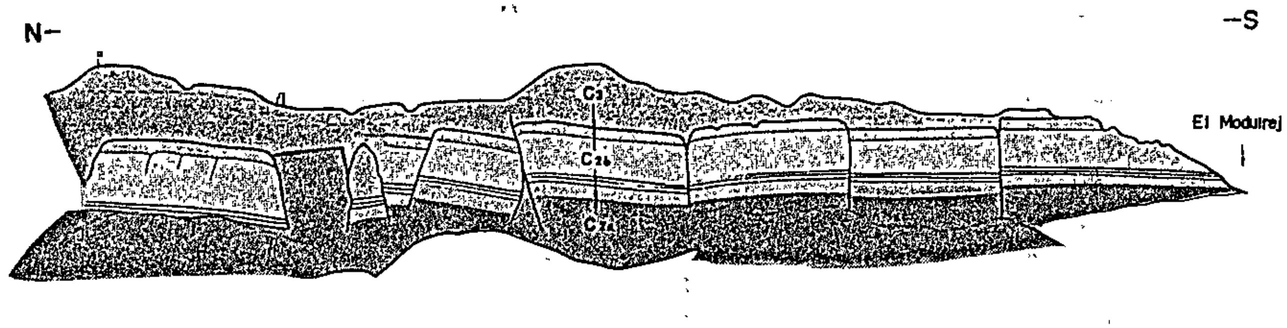
DAHR EL BAIDAR TUNNEL PROJECT	
LONGITUDINAL AND CROSS SECTION OF TUNNEL ROUTE A	
JAPANESE SURVEY TEAM FOR THE TUNNEL CONSTRUCTION PROJECT IN LEBANON	
MARCH 1964	FIG. 6



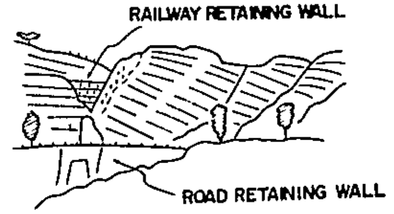
NOTE : REFER FIG. 5 FOR CLASSIFICATION OF STRATA

DAHR EL BAIDAR TUNNEL PROJECT	
LONGITUDINAL SECTION OF TUNNEL ROUTES B AND C	
JAPANESE SURVEY TEAM FOR THE TUNNEL CONSTRUCTION PROJECT IN LEBANON	
MARCH 1964	FIG. 7

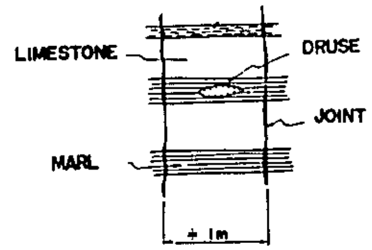
GEOLOGICAL SEQUENCE AND NUMEROUS MINOR FAULTS IN THE HAMMANA PRECIPICE
(REFER FIG.5 FOR CLASSIFICATION OF STRATA)



FEATURE OF SMALL FAULTS DEVELOPED AT MREIJATTE AREA



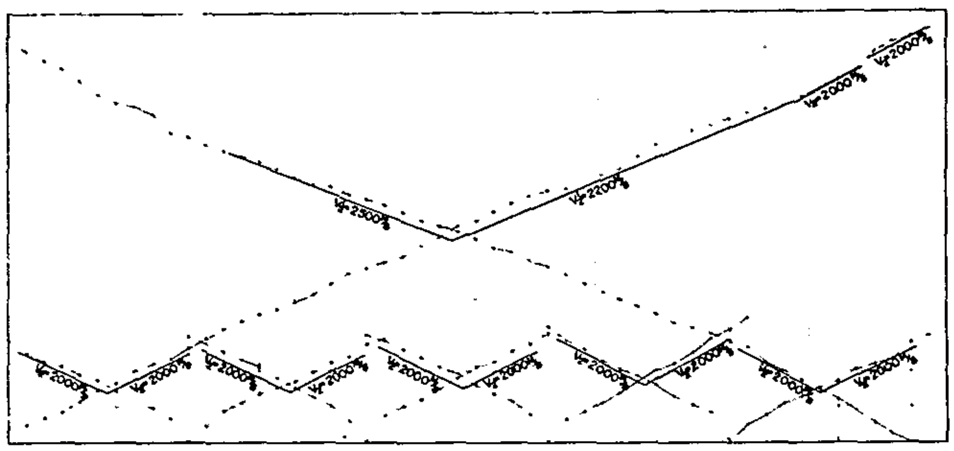
DIAGRAMMATIC ILLUSTRATION OF THE THIN ALTERNATION OF LIMESTONE AND MARL



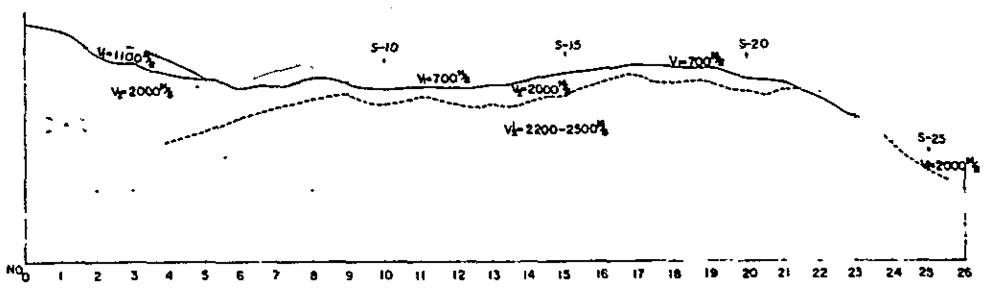
DAHR EL BAIDAR TUNNEL PROJECT	
SKETCH SHOWING GEOLOGICAL CONDITIONS	
JAPANESE SURVEY TEAM FOR THE TUNNEL CONSTRUCTION PROJECT IN LEBANON	
MARCH 1964	FIG. 8

HAMMANA AREA PRINCIPAL MEASURING LINE

TIME-DISTANCE CURVE



LONGITUDINAL GEOLOGIC SECTION



DAHR EL BAIDAR TUNNEL PROJECT

GRAPH OF

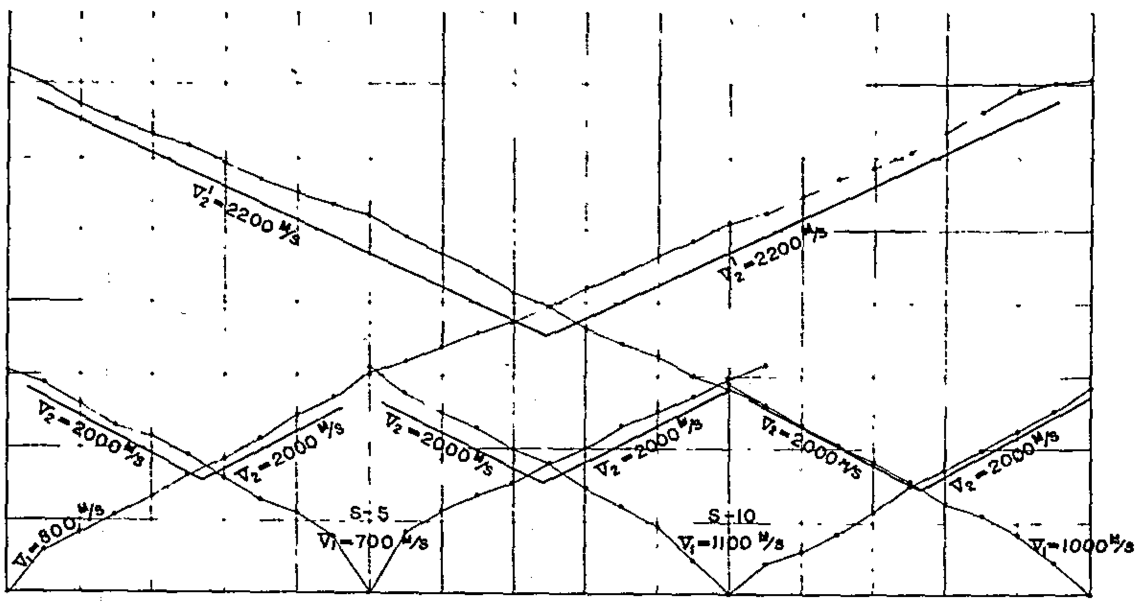
SEISMIC PROSPECTING RESULT-1

JAPANESE SURVEY TEAM FOR
THE TUNNEL CONSTRUCTION PROJECT
IN LEBANON

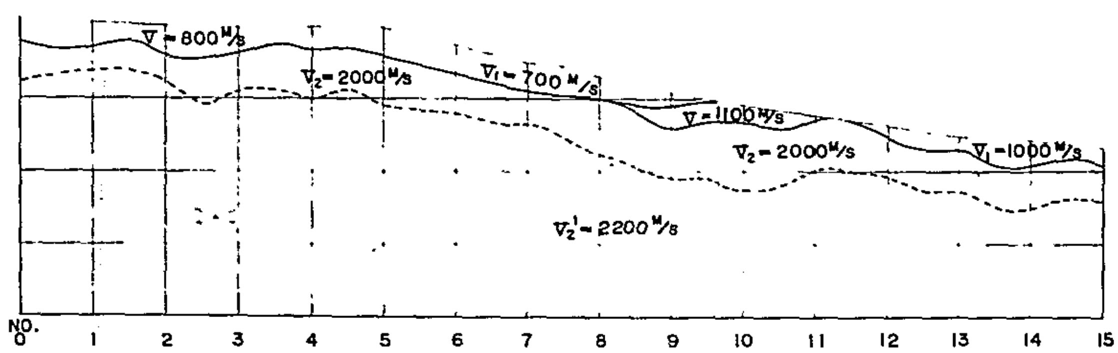
MARCH 1964 FIG 9

HAMMANA AREA SUBORDINATE MEASURING LINE (HA)

TIME-DISTANCE CURVE



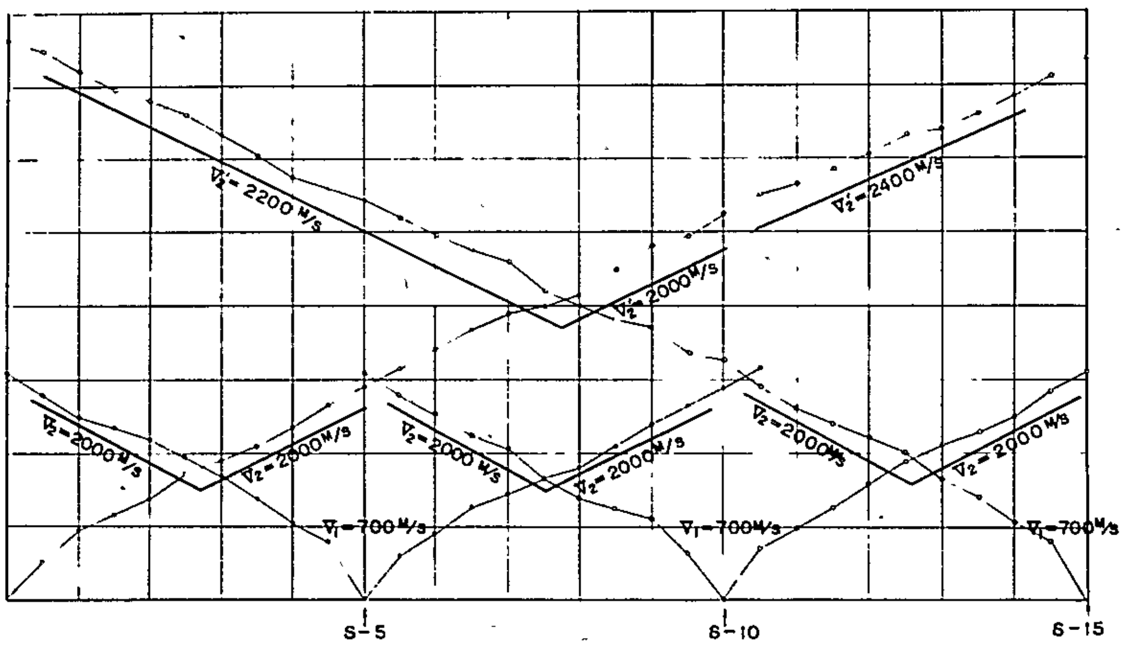
LONGITUDINAL GEOLOGIC SECTION



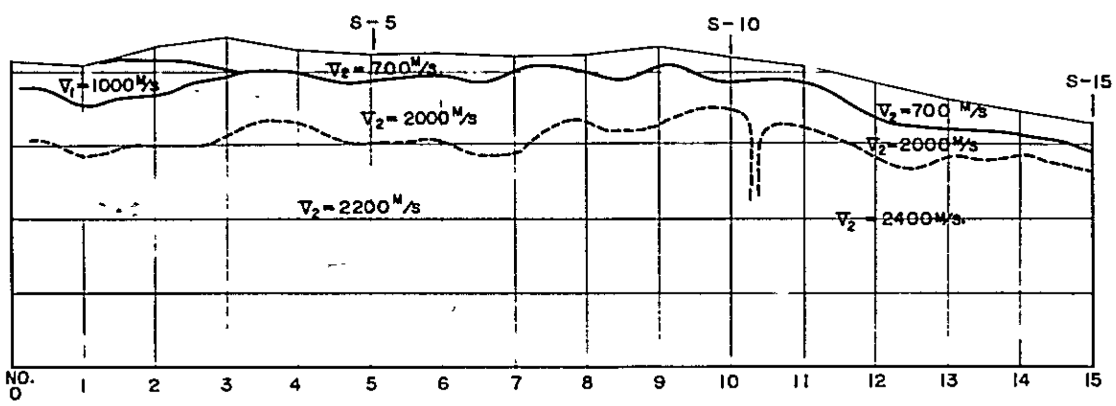
DAHR EL BAIDAR TUNNEL PROJECT	
GRAPH OF SEISMIC PROSPECTING RESULT-2	
JAPANESE SURVEY TEAM FOR THE TUNNEL CONSTRUCTION PROJECT IN LEBANON	
MARCH 1964	FIG. 10

HAMMANA AREA SUBORDINATE MEASURING LINE(HB)

TIME-DISTANCE CURVE



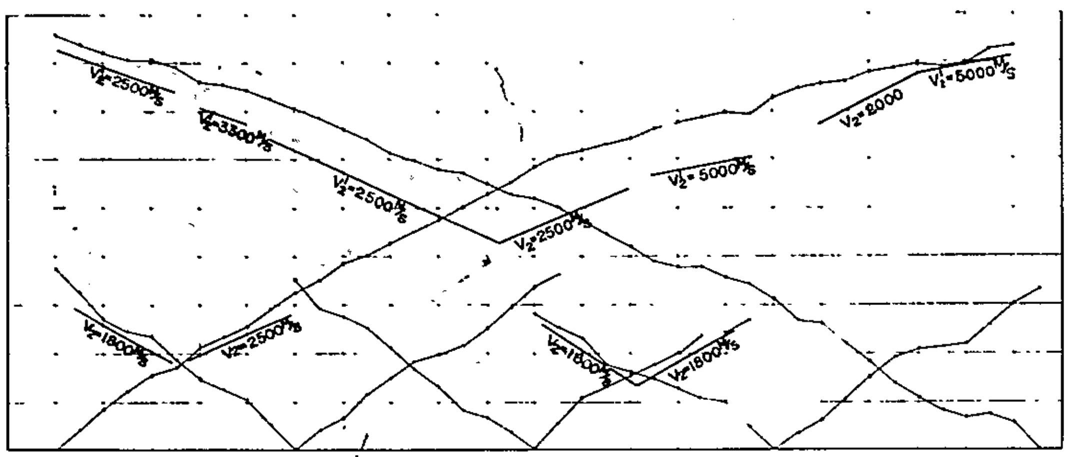
LONGITUDINAL GEOLOGIC SECTION



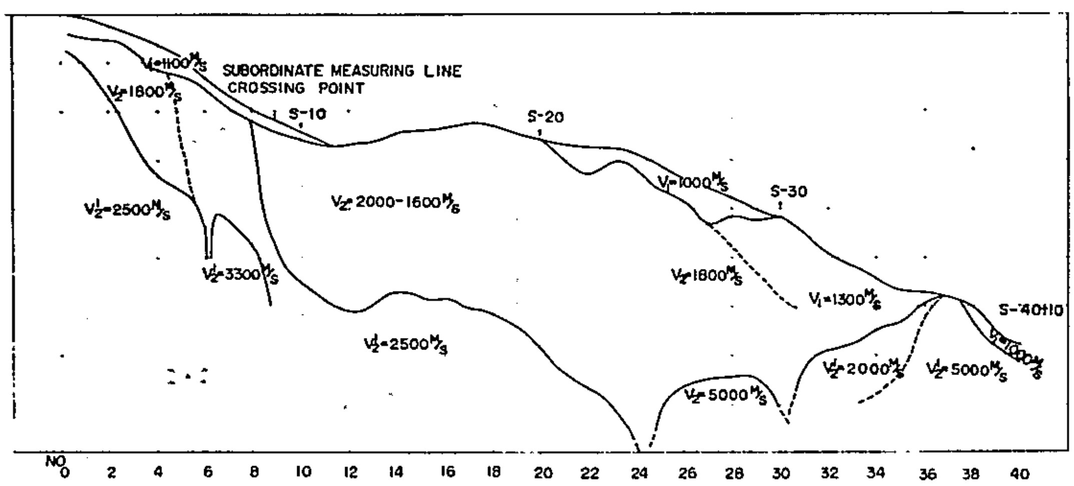
DAHR EL BAIDAR TUNNEL PROJECT	
GRAPH OF SEISMIC PROSPECTING RESULT- 3	
JAPANESE SURVEY TEAM FOR THE TUNNEL CONSTRUCTION PROJECT IN LEBANON	
MARCH 1964	FIG. 11

KABB ELIAS AREA PRINCIPAL MEASURING LINE

TIME-DISTANCE CURVE



LONGITUDINAL GEOLOGIL SECTION



DAHR EL BAIDAR TUNNEL PROJECT

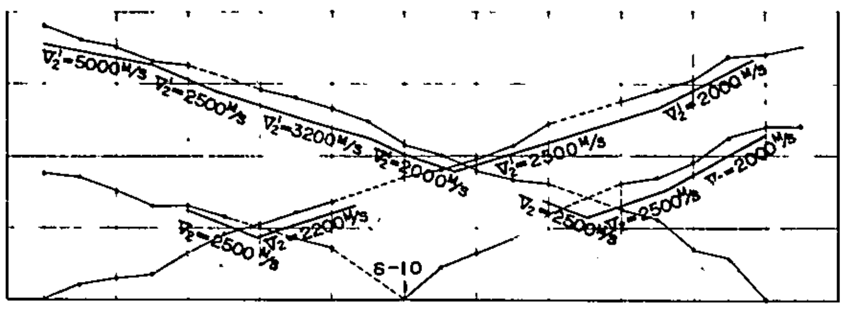
GRAPH OF
SEISMIC PROSPECTING RESULT-4

JAPANESE SURVEY TEAM FOR
THE TUNNEL CONSTRUCTION PROJECT
IN LEBANON

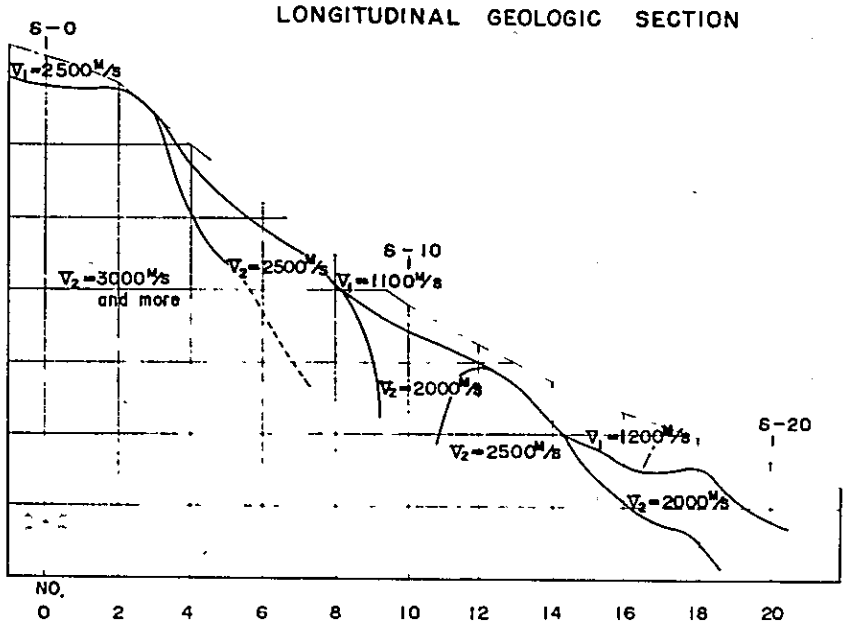
MARCH 1964 | FIG 12

KABB ELIAS AREA SUBORDINATE MEASURINGLINE

TIME-DISTANCE CURVE



LONGITUDINAL GEOLOGIC SECTION



DAHR EL BAIDAR TUNNEL PROJECT	
GRAPH OF SEISMIC PROSPECTING RESULT- 5	
JAPANESE SURVEY TEAM FOR THE TUNNEL CONSTRUCTION PROJECT IN LEBANON	
MARCH 1964	FIG. 13

§ V. Traffic Investigation.

1. General

Among several sorts of premises necessary for presumption of the traffic volume in the future, the first to be done is the decision of planned route and the second to fixed figure of the outstanding traffic volume. Above two premises are important points to decide how many vehicles can be converted to the newly constructed road. The third is the method to assume the traffic volume in the schedule year according to the outstanding date. The method basically adopted is that many kinds of economic index-numbers, such as national income, industrial products, the growth rate of population, and the growth rate of vehicles are taken into consideration. Our study, fully using the basic statistics data which have been got until now was executed in accordance with the popular principle that "the road traffic increase in proportion to the growth of vehicles". The fourth is the assumption what percentage of the traffic increase will be converted to the new road at a time of its completion. The factors for traffic conversion from one road to others are time, operating cost, the condition of the road surface, habits, and whether it is comfortable for drivers to run on its road, etc. Among these, only time and driving cost are the measurable factors. Setting up a equation for trial calculation with these two factors, we presume a convert the traffic volume. The time was calculated with average speed of each kinds of vehicles, and the distance of the existing road, new road and tunnel route respectively.

The operating cost was calculated on the basis of actual data, such as the rate of fuel consumption, maintenance charges, and the distance and condition of old and new road and tunnel route respectively. As for the old and new road, the influence of snow, fog and frost was taken into consideration. From above basic data, we got the total driving cost of each route, and calculated the rate of conversion.

2. The decision of the actual traffic volume

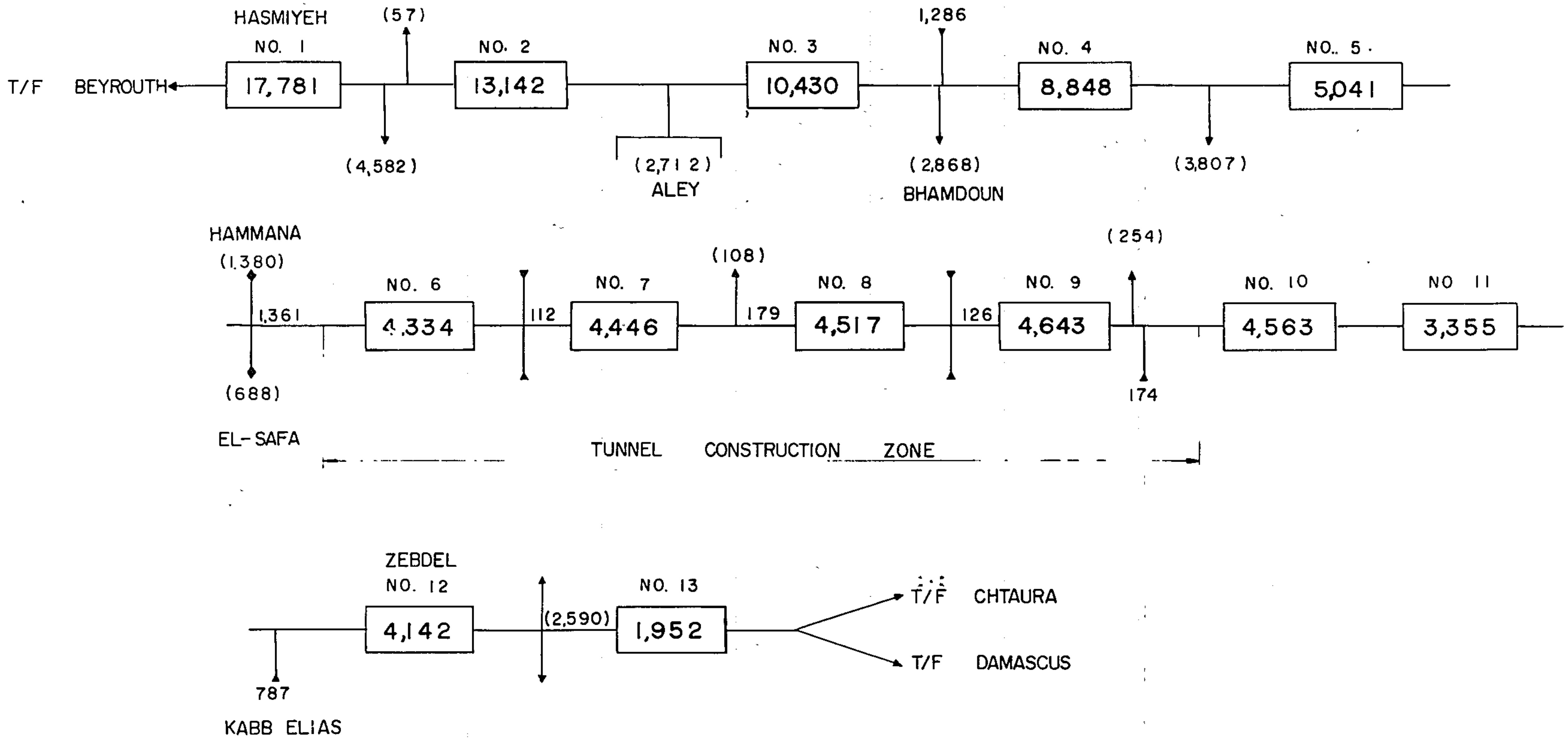
An orthodox method to catch the actual traffic volume is an origin-destination survey for each vehicle. The reason why above origin-destination survey is recognized as an orthodox method, and popularly adapted is that by a counter survey on the road, sectional traffic can not be distinguished from passing traffic, since even if sectional traffic in a short distance is very busy, and exceed the capacity of the existing road, the convertion to the new road is not so remarkable, and when long distance traffic is busy, the numbers of converting vehicles will increase. Nevertheless, due to the particular traffic condition in the place where we executed our servey, we had difficulty in executing O.D. survey, and our data are very scarce. Partial data which we got with O.D. survey on the spot far from our plan can not be used for our study.

We used, therefore, the traffic investigation data of Lebanon Government 1962. We checked the result which we got from this data comparing with the sectional O.D. survey data, and we did not find a large difference.

We pictured with this data the traffic flow on Beyrouth-Damascus Road in both direction. (Fig 13)

FIG. 1.4

BEYROUTH – DAMASCUS ROAD AVERAGE DAILY TRAFFIC VOLUME FOR 1962



ESTIMATED VEHICLES PASS THROUGH : (A. D. T.)

1	AT HASMIYEH	= 17,781	(NOT CONSIDERED TRAFFIC CONVERSION)
2	AFTER ALEY	= 10,430	
3	AFTER BHAMDOUN	= 8,848	
4	TUNNEL	= 4,334 – 428 = 3,906	

The tunnel in this planned route corresponds survey point number No.6 through No.10, and so the vehicles passing in and out between No.7, 8, 9 have nothing to do with the tunnel. Therefore we may think the number of vehicles in the turnel are same as 4,334 at survey point No.6, but we reduced 428 of number of passing in vehicles on the way.

$$4{,}334/\text{day} - 428 = 3{,}906/\text{day}$$

With above figure, we assume the number of vehicles passing through the tunnel are 3,906 in 1962.

3. Calculation of Convertible Traffic Volume.

For our calculation of convertible traffic volume, we set up a trial-calculative equation with time and driving cost.

3-1 Calculation of operating cost.

a) We devide all the vehicles into three groups, passenger car, bus, truck, and aggregate the factor such as fuel and oil consumption, maintenance and repair and then calculated P/km/each. (Table 3).

Table - 3

Road user costs 1

1) Passenger car

Running Speed (km/hr)	Gradient %	Fuel (P/km)	Tire "	Oil "	Maint. and Repairs "	Depreciation	Sub. Total Oper. Costs "	Time "	Confort. Conv. "	Total Costs (p/km)	
20	0-3	5.58	1.01	0.48	4.80	2.0	13.87	13.17	1.00	28.04	
	3-5	6.05	1.14	0.50	5.20	2.10	14.99	13.17	1.00	28.16	
	5-7	6.95	1.46	0.53	5.60	3.20	16.74	13.17	1.00	30.91	
	7-9	8.88	1.92	0.55	6.00	2.30	19.65	13.17	1.00	33.82	
40	0-3	5.52	1.42	0.540	4.80	2.00	14.28	8.28	1.00	23.56	
	3-5	5.88	1.62	0.540	5.20	2.10	15.34	8.28	1.00	24.62	
	5-7	6.34	2.08	0.540	5.60	2.20	16.76	8.28	1.00	26.04	
	7-9	7.59	2.76	0.540	6.00	2.30	19.19	8.28	1.00	28.47	
50	0-3	5.24	2.11	0.60	4.80	2.00	14.75	6.58	1.00	22.37	
	3-5	5.54	2.42	0.63	5.20	2.10	15.89	6.58	1.00	23.47	
	5-7	5.92	3.10	0.66	5.60	2.20	17.48	6.58	1.00	24.06	
	7-9	6.98	4.11	0.69	6.00	2.30	20.08	6.58	1.00	26.66	
60	0-3	4.20	0.53	0.34	2.40	2.0	9.47	5.28	1.00	15.75	
	3-5	4.41	0.63	0.36	2.60	2.1	10.10	5.28	1.00	16.38	
	5-7	4.66	0.80	0.30	2.80	2.2	10.84	5.28	1.00	17.12	
	7-9	5.32	1.08	0.40	3.00	2.3	12.10	5.28	1.00	18.38	
30	0-3	4.03	0.38	0.28	2.4	2.0	9.090	10.54	1.00	20.63	
	3-5	4.20	0.42	0.29	2.60	2.1	9.61	10.54	1.00	21.15	
	5-7	4.53	0.54	0.36	2.80	2.2	10.38	10.54	1.00	21.92	

2) Bus

Running Speed (km/hr)	Gradient (%)	Fuel (P/km)	Tire "	Oil "	Maint. and Repairs "	Depreciation "	Sub-Total Oper. Costs "	Time "	Confort and Convenience "	Total Costs (P/km)	
20	0-3	7.81	1.41	0.67	6.72	2.80	19.41	18.44	1.40	39.25	
	3-5	8.47	1.60	0.70	7.28	2.94	20.99	18.44	1.40	40.83	
	5-7	9.73	2.04	0.74	7.84	3.08	23.43	18.44	1.40	43.27	
	7-9	12.43	2.69	0.77	8.40	3.22	27.51	18.44	1.40	47.35	
40	0-3	7.73	1.99	0.76	6.72	2.80	20.00	11.59	1.40	32.99	
	3-5	8.23	2.27	0.76	7.28	2.94	21.48	11.59	1.40	34.47	
	5-7	8.88	2.91	0.76	7.84	3.08	23.47	11.59	1.40	36.46	
	7-9	10.63	3.86	0.76	8.40	3.22	26.87	11.59	1.40	39.86	
50	0-3	7.34	2.95	0.84	6.72	2.80	20.65	9.21	1.40	31.26	
	3-5	7.76	3.39	0.88	7.28	2.94	22.25	9.21	1.40	32.86	
	5-7	8.29	4.34	0.92	7.84	3.08	24.47	9.21	1.40	35.08	
	7-9	9.77	5.75	0.97	8.40	3.22	28.11	9.21	1.40	38.72	
60	0-3	5.88	0.74	0.48	6.72	2.80	16.62	7.39	1.40	25.41	
	3-5	6.17	0.88	0.50	7.28	2.94	17.77	7.39	1.40	26.56	
	5-7	6.52	1.12	0.53	7.84	3.08	19.09	7.39	1.40	27.88	
	7-9	7.45	1.51	0.56	8.40	3.22	32.14	7.39	1.40	40.93	

3) Truck

Running Speed (Km/hr)	Gradient (%)	Fuel (P/km)	Tire "	Oil "	Maint. and Repairs "	Depreciation "	Sub-total Operational Costs "	Time "	Confort and Convenience	Total Costs (P/km)
20	0-3	9.43	1.71	0.81	8.11	3.38	23.44	22.26	1.70	47.40
	3-5	10.22	1.93	0.85	8.79	3.55	25.34	22.26	1.70	49.30
	5-7	11.75	2.47	0.90	9.46	3.72	28.30	22.26	1.70	52.26
	7-9	15.01	3.24	0.93	10.14	3.89	33.21	22.26	1.70	57.17
40	0-3	9.33	2.40	0.91	8.11	3.38	24.13	13.99	1.70	39.82
	3-5	9.94	2.74	0.91	8.79	3.55	25.93	13.99	1.70	41.62
	5-7	10.71	3.52	0.91	9.46	3.72	28.32	13.99	1.70	44.01
	7-9	12.83	4.66	0.91	10.14	3.89	32.43	13.99	1.70	48.12
50	0-3	8.86	3.57	1.01	8.11	3.38	24.93	11.12	1.70	37.75
	3-5	9.36	4.09	1.06	8.79	3.55	26.85	11.12	1.70	39.67
	5-7	10.00	5.24	1.12	9.46	3.72	29.54	11.12	1.70	42.36
	7-9	11.80	6.95	1.17	10.14	3.89	33.95	11.12	1.70	46.77
60	0-3	7.10	0.90	0.57	8.11	3.38	20.06	8.92	1.70	30.68
	3-5	7.45	1.06	0.61	8.79	3.55	21.46	8.92	1.70	32.08
	5-7	7.88	1.35	0.64	9.46	3.72	23.05	8.92	1.70	33.67
	7-9	8.99	1.83	0.68	10.14	3.89	25.53	8.92	1.70	36.15

From the Table 3, we calculated the road user cost for three comparative routes, existing road, new road and tunnel route, considering the slope, operating speed and the distance in the same area. (Table 4)

Table 4

Road user coets in accordance with general condition

Route	Gradient (%)	Length (Km)	Design Speed		User Cost		
			Pass. Car	Bus & Truck	Pass. Car	Bus	Truck
Exist. Road	7 - 9	16	40 km/h	20 km/h	28.47 P.L.	47.35 P.L.	57.17 P.L.
New road	5	18	50	30	23.47	40.83	49.30
Tunnel route	5	7	50	30	23.47	40.83	49.30
	1	7.85	60	50	15.75	31.26	39.67

Operating speed of passenger car is 40 Km/h on the old road, 50 Km/h on the new road, and 60 Km/h in the tunnel. Those of bus and trucks are respectively 20 Km/h, 30 Km/h and 50 Km/h. Passenger cars average speed in tunnel is limited within 60 Km/h, since in tunnel, passenger car inspite of having 70 Km/h speed.can not pass bus and trucks running in 50 Km even if pararelly passing through in double lanes.

b) Secondaly on the road excluding the tunnel, we have snow, frost and fog as inconvenience items, which we took into consideration in our calculation.

Snow

We assume that we have snow averagely 10 days in a year. Riding persons of passenger consist of 2 productive persons and 1 unproductive person, and bus has 35 persons (2/3 productive 1/3 unproductive) and truck have 2 productive. When we presume that the revenue during snowfall decrease $10^{L.L}$/day for one productive (unproductive $0^{L.L}$), the loss of one passenger car (total revenue per one car is $20^{L.L}$) x 10/365 day = $0.55^{L.L}$/day/each car

∴ Loss of bus

$$(10^{L.L} \times 35 \times 2/3) \times 10/365 \text{ days} = 233 \times 0.03 = 6.99^{L.L}/\text{day}$$

Loss of truck

$$(10^{L.L} \times 2) \times 10/365 \text{ day} = 20 \times 0.03 = 0.60^{L.L}/\text{day}$$

Frost

Frost period is averagely 30 days in a year. But as half of day may be neglected, actual harmfull days by first are 30/2=15 days.

Loss of Passenger car (10 x 2) x 15/365 = 20 x 0.04 = 0.8 L.L/day

" of Bus (10 x 35 2/3) x 15/365 = 233 x 0.04 = 9.32 L.L/day

" of Truck (10 x 2) x 15/365 = 20 x 0.04 = 0.80 L.L/day

Fog

The period while traffic difficulty are yielded by fog is averagely 50 days a year. Same as frost case, for 12 hours it is fair.

Loss of Passenger Car (10 x 2) x 25/365 = 20 x 0.07 = 1.40 L.L/day

" of Bus (10 x 35 2/3) x 25/365 = 233 x 0.07 = 16.31 L.L/day

" of Truck (10 x 2) x 25/365 = 20 x 0.07 = 1.40 L.L/day

Table - 5

Road user costs under the meteorological condition (unit. L.L/day)

	Snow	Frost	Fog	Total
Passenger car	0.55	0.80	1.40	2.75 L.L/day
Bus	6.99	9.32	16.31	32.62
Truck	0.60	0.80	1.40	2.80

In presumption that in each case of 20 60 km/h operating speed (actual time 8 hours a day) we calculate loss of operating cost at unit distance as follows.

Table - 6

	20	30	40	50	60 (km/h)
Passenger car	1.72 P/Km/Car	1.15	0.86	0.69	0.57 P/km/Car
Bus	20.39 "	13.60	10.21	8.16	6.78 "
Truck	1.75 "	1.17	0.88	0.70	0.58 "

Even if we presume that in case of snow or frost about half of users who want to go from Buyrough to Dammascus stay at Beyrouth and the balance go southward, passing through Saida and Onaitra and leading to Dammascus, users have tc make a detour of over 100 Km compared with Beyrough - Dammascus Road. And the extra cost of detour is larger than loss from staying in Dammascus. From this result, we proceed our study with the loss from staying, not with making a detour. Fog is rather an inconvenience item. But at a result, fog will yield also loss, and so we add this item to our study.

From above studies, we have got final user costs with the loss from obstruction and inconvenience for our three cases as follows:

Table - 7

Final user costs on Beyrouth - Dammascus Road

(Table - 4 + Table - 6)

Route	Grade %	Length (Km)	Speed Km/h		Road user costs (P)		
			Pass. Car	Bus & Truck	Pass. Car	Bus	Truck
Exist. Road	7 - 9	16	40	20	29.33 (0.10)	67.74 (0.23)	58.92 (0.20)
New Road	5	18	50	30	24.16 (0.08)	54.43 (0.18)	50.47 (0.17)
Tunned Road	5	7	50	30	23.47 (0.08)	40.83 (0.14)	49.30 (0.16)
	1	7.85	60	50	15.75 (0.05)	31.26 (0.10)	39.67 (0.13)

Note 1. Tunnel Route is diveded to tunnel itself (L = 7.85 Km) and new access road (L = 7.0 Km) north side of Chtaura.

2. The figure in ( ) is the conversion to $.

3-2 Traffic Conversion Factor

In above paragraph we have got user costs per unit. We calculate the operating cost with multiplying the length of the new road to user costs. Furthermore we take necessary time for passing through of each kinds of vehicles and speeds into consideration, ( ) with which we calculate the traffic conversion rate on from the Existing road to the tunnel and from the new road to the tunnel as follows.

a) C_1 = Operating cost on Existing road $/Km

C_2 = " " on new " "

C_3 = " " on tunnel route "

Operating Cost

Kind of Vehicle \ Speed		20 Km/hr	30 Km/hr	40 Km/hr	50 Km/hr	60 Km/hr
C_1 $/Km	Passenger Car			0.10		
	Bus	0.23				
	Truck	0.20				
C_2 $/Km	Passenger Car				0.08	
	Bus		0.18			
	Truck		0.17			
C_3 $/Km	Passenger Car				0.08	0.05
	Bus		0.14		0.10	
	Truck		0.16		0.13	

Table 8

b Calculation of Conversion Factor

CONVERSION FACTOR TABLE

Kind of Vehicles	HAMMANA - CHTAURA														
	Existing Road					New Road					Tunnel Route				
	Length of Route L (Km)	Operating Speed V (Km/hr)	Time V_1 $= \frac{L}{V} \times 60$ (min)	Operating Cost C_1 $= c_1L$ ($)	S_1 $= T_1C_1$	Length of Route L (Km)	Operating Speed V (Km/hr)	Time T_2 $= \frac{L}{V} \times 60$ (min)	Operating Cost C_2 $= c_2L$ (¢)	S_2 $= T_2C_2$	Length of Route L Km	Operating Speed V V (Km/hr)	Time T_3 $\frac{L}{V} \times 60$ (min)	Operating Cost $= c_3L$ (-)	S_3 $= T_3C_3$
Passenger Car	16	40	24.00	1.60	38.40	18	50	21.60	1.44	31.10	Access R. 7.00 Tunnel R. 7.85	50 60	8.40 7.85 16.25	0.56 0.39 0.95	15.44
Bus	16	20	48.00	3.68	176.64	18	30	35.64	3.24	115.47	Access R. 7.00 Tunnel R. 7.85	30 50	13.86 9.42 23.28	0.98 0.79 1.77	41.21
Truck	16	20	48.00	3.20	153.60	8	30	35.64	3.06	109.06	Access R. 7.00 Tunnel R. 7.85	30 50	13.86 9.42 23.28	1.12 1.02 2.14	49.82

Conversion Factor P (%)		
E.R. Thr. Tunnel	N.R. Thr. Tunnel	E.R. Thr. New Road
$P= S\,\frac{S_1}{S_1+S_3}\,x100$	$P= \frac{S_2}{S_2+S_3}x100$	$P=\frac{S_1}{S_1+S_2}x100$
71.3	66.8	55.2
81.1	73.7	60.5
75.5	68.6	58.5

4. Presumption to Traffic Volume in the future

4-1 Presumption to numbers of vehicles in the future

The numbers of vehicles of Lebanon 1950 through 1963 are as per Table 8. We calculated the rate of growth by many kinds of method on the presumption that this rate of growth remain unchanged in the future. However since during 6 years from 1950 through 1955 there are big changes in numbers, we exclude this period from our study.

a) When we presume the rate of growth shows a line, we get a following equation.

$$y = 11{,}000\chi + 50{,}000 \qquad \chi = \text{elapsed year}$$

$$y = \text{numbers after } \chi \text{ year}$$

b) After and before 1959 we observed big change in growth rate. With the figure after 1959, we set up a following equation.

$$y = 1{,}310\chi^{1.72} + 7{,}800\chi + 50{,}000$$

Based on this, we calculated the numbers after 1963, as per Table 10, and the figure of a) and b) as per Fig. 14.

Table 9

NUMBER OF VEHICLES REGISTERED IN EACH YEAR

		1950		1951		1952		1953		1954		1955		1956	
		Cars	Ratio	Cars	Ratio	Cars	Ratio	Cars	Ratio	Cars	Ratio	Cars	Ratio	Cars	Ratio
1	Passenger Cars	11,573	75.8	13,861	78.1	15,976	79.4	18,044	81.1	21,085	82.3	24,574	81.0	29,185	84.3
2	Buss	679	4.4	652	3.4	671	3.4	880	4.0	1,009	3.9	1,087	3.6	1,154	3.3
3	Trucks	3,019	19.8	3,235	18.2	3,448	17.2	3,307	14.9	3,544	13.8	4,683	15.4	4,298	12.4
	Total	15,271	100	17,748	100	20,095	100	22,231	100	25,638	100	30,346	100	34,637	100

		1958		1959		1960		1961		1962		1963	
		Cars	Ratio	Cars	Ratio	Cars	Ratio	Cars	Ratio	Cars	Ratio	Cars	Ratio
1	Passenger Cars	37,064	83.9	41,753	84.5	51,316	85.8	61,897	86.9	71,314	87.4	82,129	87.8
2	Buss	1,253	2.9	1,320	2.6	1,389	2.4	1,446	2.0	1,488	1.8	1,590	1.7
3	Trucks	5,843	13.2	6,359	12.9	7,079	11.8	7,915	11.1	8,825	10.8	9,846	10.5
	Total	44,160	100	49,432	100	59,784	100	71,258	100	81,627	100	93,565	100

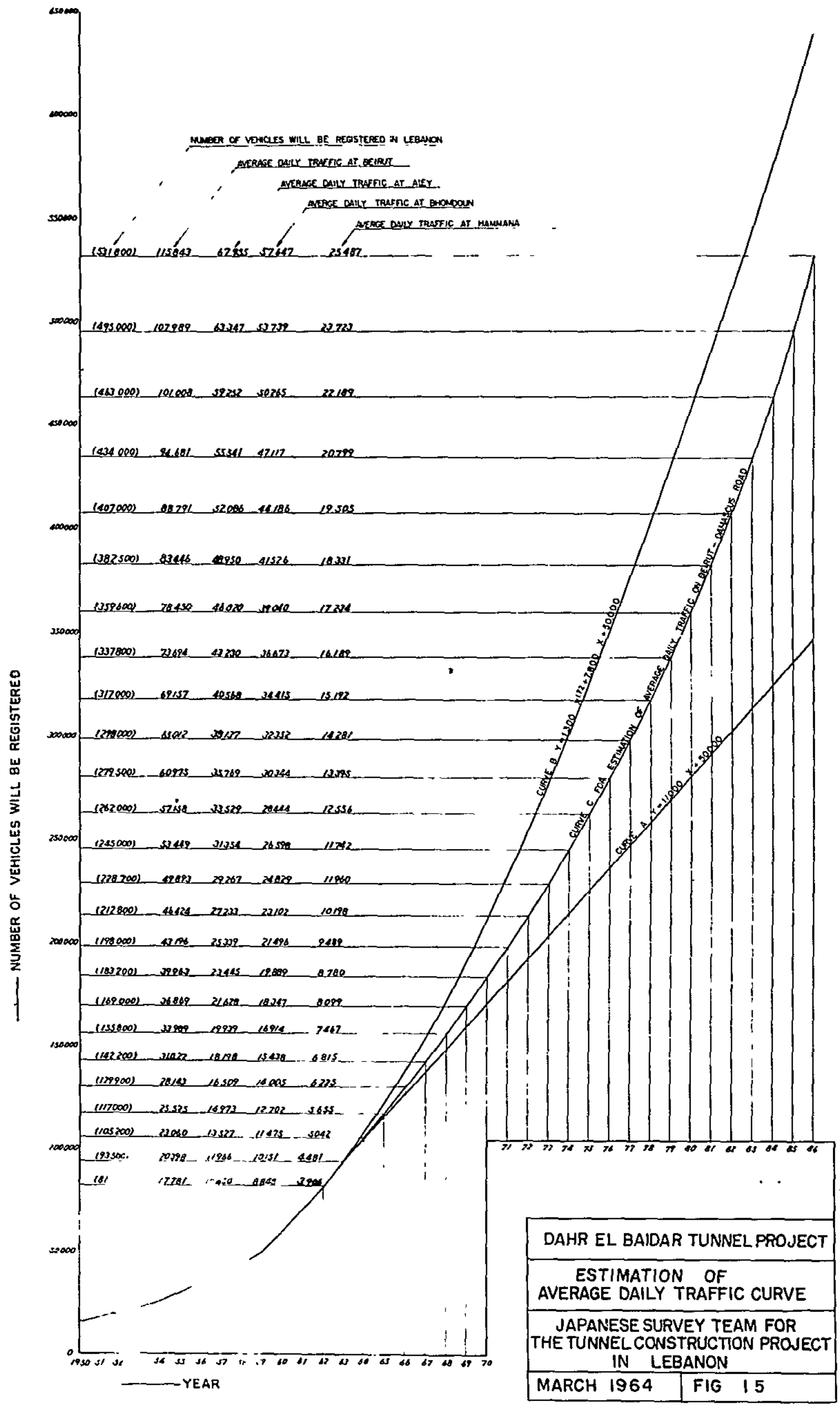
Note: 1. Passenger Cars, Taxis, Motorcycles.
2. Private Buss, Commercial Buss.
3. Private Tracks, Commercial Tracks.

Table - 10

Estimation of number of vehicle to be registered in future.

(b) $y = 1,310x^{1.72} + 7,800x + 50,000$

x	YEAR	$x^{1.72}$	$1,310\ (x)^{1.72}$	7,800	
3	1962	6.62	8,672	23,400	82,072
4	63	10.42	13,650	31,200	94,850
5	64	15.90	20,829	39,000	109,829
6	65	21.00	27,510	46,800	124,310
7	66	28.40	37,204	54,600	141,802
8	67	35.70	46,767	62,400	159,167
9	68	43.80	57,378	70,200	177,578
10	69	52.50	60,775	78,000	196,775
11	70	62.00	81,220	85,800	217,020
12	71	72.00	94,320	93,600	237,920
13	72	82.00	107,420	101,400	250,820
14	73	93.50	122,485	109,200	281,585
15	74	105.00	137,550	117,000	304,550
16	75	118,00	154,580	124,800	329,380
17	76	130.00	170,300	132,600	352,900
18	77	144.00	188,640	140,400	379,040
19	78	158.00	206,980	148,200	405,180
20	79	173.00	226,630	156,000	432,630
21	80	187.00	244,970	163,800	458,770
22	81	203.00	265,930	171,600	487,530
23	82	220.00	288,200	179,400	517,600
24	83	237.00	310,470	187,200	547,670
25	84	253.00	331,430	195,000	576,430
26	85	270.00	353,700	202,800	606,500



DAHR EL BAIDAR TUNNEL PROJECT

ESTIMATION OF AVERAGE DAILY TRAFFIC CURVE

JAPANESE SURVEY TEAM FOR THE TUNNEL CONSTRUCTION PROJECT IN LEBANON

MARCH 1964 | FIG 15

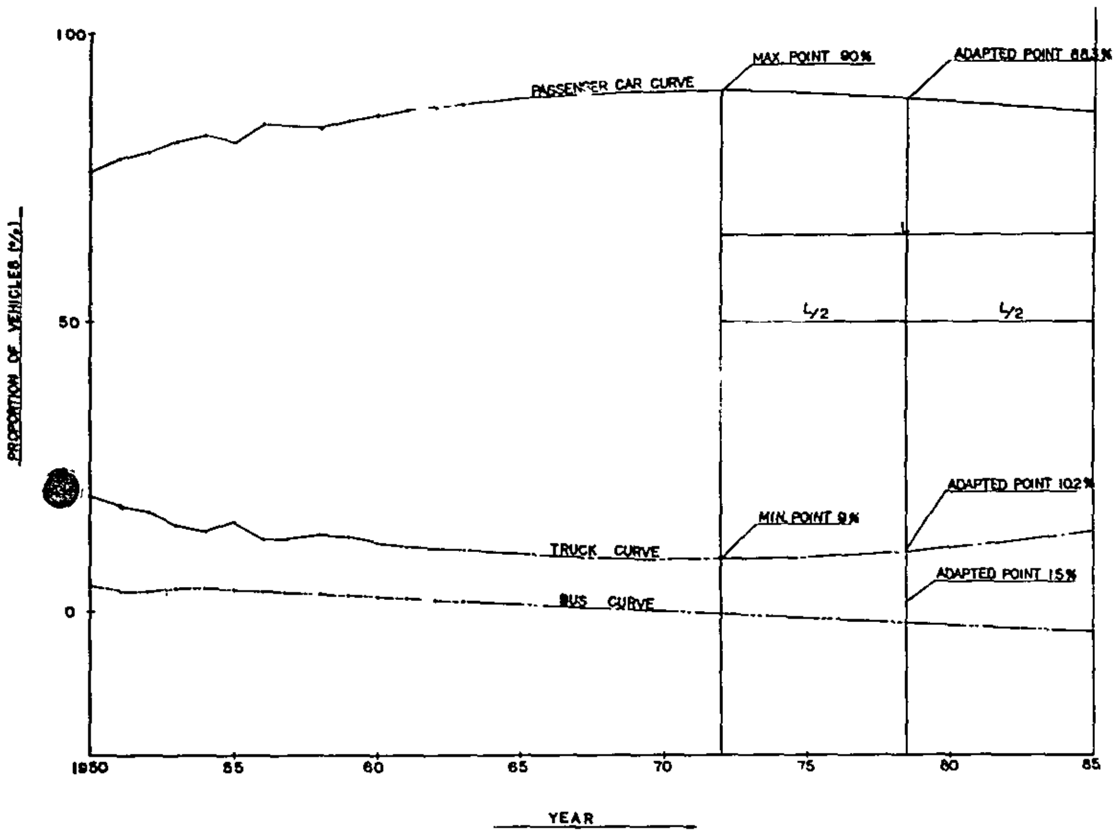
1) The straight line growth in (a) model is, generally speaking right, but from the fact that the growth of the present world civilization is very elastic, it leads to under estimation that the line growth will continue in the future. With the growth of the civilization, we have increases of income, population and numbers of vehicles, the growth rate of which would be of the shape of concave curve.

2) Accordingly (b) model seems to show the actual growth. However this model was got from the data for four years, and according to this model the increase approaches maximum during rather short internals, but in a next period the growth rate is already dealing. This model does not show a reasonable growth for Lebanese present situation such as space, population and industry.

3) Through our study for model (a) and (b), we have got a compromising idea for (a) and (b). The curvature pictured with this model is as per Fig. 15.6. With this assumption, we calculated average daily traffic in tunnel.

4-2 Rate of kind of Vehicles

We classified the numbers of vehicles according to the kinds of vehicles as per Table 9 and also figured as per Fig. 16.



DAHR EL BAIDAR TUNNEL PROJECT

CURVE FOR ESTIMATION OF INCREASING RATE EACH VEHICLE

JAPANESE SURVEY TEAM FOR THE TUNNEL CONSTRUCTION PROJECT IN LEBANON

MARCH 1964 | FIG. 16

Passenger cars have a trend of decreasing, and bus are in a trend of gradual decreasing in recent years. But actually they could not decrease below zero, and we will adopt the figure around 1978 as an average for our study. As a result Passenger car 88.3%, Bus 10.2%, Truck 1.5%. Above results are as per Fig. 15, with which we calculated the numbers of each kind of vehicles and average daily traffic as per Table 11.

Table - 11

Estimation of Average Daily Traffic at Tunnel

Year	Register Cars	Total A.D.T.	Passenger Cars (88.3%)	Buss (1.5%)	Truck (10.2%)
1963	93,500	4,481	3,957	67	457
64	105,200	5,042	4,452	76	514
65	117,000	5,655	4,993	85	577
66	129,900	6,225	5,497	93	635
67	142,200	6,815	6,018	102	695
68	155,800	7,467	6,593	112	762
69	169,000	8,099	7,151	122	826
70	183,200	8,780	7,753	131	896
71	198,000	9,489	8,379	142	968
72	212,800	10,198	9,005	153	1,048
73	228,700	10,960	9,678	164	1,118
74	245,000	11,742	10,368	176	1,198
75	262,000	12,556	11,087	188	1,281
76	279,500	13,395	11,828	201	1,366
77	298,000	14,281	12,610	214	1,457
78	317,000	15,192	13,415	227	1,550
79	337,800	16,189	14,295	243	1,651
80	359,600	17,234	15,218	258	1,758
81	382,500	18,331	16,186	275	1,870
82	407,000	19,505	17,223	292	1,990
83	434,000	20,799	18,366	312	2,121
84	463,000	22,189	19,593	333	2,263
85	495,000	23,723	20,947	356	2,420
86	531,800	25,487	22,505	382	2,600

4-3 Decision of Traffic Volume in the future.

As a result of above study, we can get traffic conversion volume on the routes with multiplying average Daily Traffic by conversion rate, which is as per Table 12.

According to this, for instance, convertible volume on a an average day in 1986 are 16,834 of passenger cars, 376 of bus, and 2,046 of trucks, making total 19,256, which is 76% of full vehicles of 25,487.

Table 12

AVERAGE DAILY TRAFFIC THOUGH THE TUNNEL BY YEARS 1963 - 1986

YEAR	A.D.T.	FULL VEHICLE			CONSIDERED CONVERSION, E. TO T.				CONSIDERER CONVERSION, N. TO T.				CONSIDERED CONVERSION, E. TO N.			
		Passen-ger Car (88.3%)	Bus (1.5%)	Truck (10.2%)	Passen-ger Car (71.3%)	Bus (81.1%)	Truck (75.5%)	TOTAL	Passen-ger Car (66.8%)	Bus (73.7%)	Truck (68.6%)	TOTAL	Passen-ger Car (55.2%)	Bus (60.5%)	Truck (58.5%)	TOTAL
1963	4,481	3,957	67	457	2,821	54	345	3,220	2,643	49	314	3,006				
64	5,042	4,452	76	514	3,174	62	388	3,624	2,974	56	353	3,383				
65	5,655	4,993	85	577	3,560	69	436	4,065	3,335	63	396	3,794				
66	6,225	5,497	93	635	3,919	75	479	4,473	3,672	69	436	4,177				
67	6,815	6,018	102	695	4,291	83	525	4,899	4,020	75	477	4,572				
68	7,467	6,593	112	762	4,701	91	575	5,367	4,404	83	523	5,010				
69	8,099	7,151	122	826	5,099	99	624	5,822	4,777	90	567	5,434	3,947	74	483	4,504
70	8,780	7,753	131	896	5,528	106	676	6,310	5,179	97	615	5,891	4,280	79	524	4,883
71	9,489	8,379	142	968	5,974	115	731	6,820	5,597	105	664	6,366	4,625	86	566	5,277
72	10,198	9,005	153	1,048	6,421	124	791	7,336	6,015	113	719	6,847	4,971	93	613	5,677
73	10,960	9,678	164	1,118	6,900	133	844	7,877	6,465	121	767	7,353	5,342	99	654	6,095
74	11,742	10,368	176	1,198	7,392	143	904	8,439	6,926	130	822	7,878	5,723	106	701	6,530
75	12.556	11,087	188	1,281	7,905	152	967	9,024	7,406	139	879	8,424	6,120	114	749	6,983
76	13,395	11,828	201	1,366	8,433	163	1,031	9,627	7,901	148	937	8,986	6,529	122	799	7,450
77	14,281	12,610	214	1,457	8,991	174	1,100	10,265	8,423	158	1,000	9,581	6,961	129	852	7,942
78	15,192	13,415	227	1,550	9,565	184	1,170	10,919	8,961	167	1,063	10,191	7,405	137	907	8,449
79	16,189	14,295	243	1,651	10,192	197	1,247	11,636	9,549	179	1,133	10,861	7,891	147	966	9,004
80	17,234	15,218	258	1,758	10,850	209	1,327	12,386	10,166	190	1,206	11,562	8,400	156	1,028	9,584
81	18,331	16,186	275	1,870	11,541	223	1,412	13,176	10,812	203	1,283	12,298	8,935	166	1,094	10,195
82	19,505	17,223	292	1,990	12,280	237	1,502	14,019	11,505	215	1,365	13,085	9,507	177	1,164	10,848
83	20,799	18,366	312	2,121	13,095	253	1,601	14,949	12,268	230	1,455	13,953	10,138	189	1,241	11,568
84	22,189	19,593	333	2,263	13,970	270	1,709	15,949	13,088	245	1,552	14,885	10,815	201	1,324	12,340
85	23,723	20,947	356	2,420	14,935	289	1,827	17,051	13,993	262	1,660	15,915	11,563	215	1,416	13,194
86	25,487	22,505	382	2,600	16,046	310	1,963	18,319	15,033	282	1,784	17,099	12,423	231	1,521	14,175

Note: E .... *Existing Road*
N .... New Road

4-4 Presumption to traffic volume in the future on access road.

We have studied the tunnel route including new road, and estimated the traffic volume in the future. Here we will do our work to presume the traffic volume for deciding the scale of access road with same method as before. We need assume several intervals containing main villeges on the route, and study on each interval. We set up three intervals. The order is as follows.

(i) Traffic volume on an average day on each intervals in the future.

a) We write numbers of vehicles 1963 through 1986. (Fig. 15)

b) We calculate total Average Day Traffic on HAZMIEH in 1962 with multiplying numbers of vehicles after 1963 by the rate between A.D.T. and numbers of vehicles.

c) We calculate the A.D.T. of each kinds of vehicles with multiplying total A.D.T. by the rate of numbers of vehicle kinds (Fig. 16)

d) With just same method, we calculate total A.D.T. Aley and Dhamdoun, the result of which is shown in Table 13.

(ii) Conversion rate from Existing road to Access Road

Presuming the distance of each point, HAZMIEH-ALEY-BHAMDOUN-HAMMANA as 11 km. 5.5 km. and 6.8 km. on Existing road respectively, and 13.8 km, 7.3 km, 6.5 km on access road, we calculate the conversion rate (Table 14) with a same method as Table 8.

(iii) Final A.D.T. on each interval in the future.

We calculate A.D.T. on each interval of NAZMIEH-ALEY-BHAMDOUN-HAMMANA with multiplying Table 13 by conversion rate in Table 14. (Table 15)

As a result, we presumed Average Day Traffic in 1986.

(20 years after construction of Access Road)

Table 13

AVERAGE DAILY TRAFFIC BY YEARS 1963 - 1986

YEAR	Register Vehicles	AT HAZMIEH				AFTER ALEY				AFTER BHAMDOUN			
		Total A.D.T.	Passenger Car (88.3%)	Bus (1.5%)	Truck (10.2%)	Total A.D.T.	Passenger Car (88.3%)	Bus (1.5%)	Truck (10.2%)	Total A.D.T.	Passenger Car (88.3%)	Bus (1.5%)	Truck (10.2%)
1963	93,500	20,398	18,011	306	2,081	11,966	10,566	179	1,221	10,151	8,963	153	1,035
64	105,700	23,060	20,362	346	2,352	13,527	11,944	203	1,380	11,475	10,132	173	1,170
65	117,000	25,525	22,539	382	2,604	14,973	13,221	225	1,527	12,702	11,216	190	1,296
66	129,000	28,143	24,850	422	2,871	16,509	14,577	248	1,684	14,005	12,366	210	1,429
67	142,200	31,022	27,392	466	3,164	18,198	16,069	273	1,856	15,438	13,632	231	1,575
68	155,800	33,989	30,012	510	3,467	19,938	17,605	299	2,034	16,914	14,935	254	1,725
69	169,000	36,869	32,555	553	3,761	21,628	19,098	324	2,206	18,347	16,200	276	1,871
70	183,200	39,967	35,291	599	4,077	23,445	20,702	352	2,391	19,889	17,562	298	2,029
71	198,000	43,196	38,142	648	4,406	25,339	22,374	380	2,585	21,496	18,981	322	2,193
72	212,000	46,424	40,992	697	4,735	27,233	24,047	408	2,778	23,102	20,399	347	2,356
73	228,700	49,893	44,056	748	5,089	29,267	25,843	439	2,985	24,829	21,924	372	2,533
74	245,000	53,449	47,195	802	5,452	31,354	27,686	470	3,198	26,598	23,486	399	2,713
75	262,000	57,158	50,471	857	5,830	33,529	29,606	503	3,420	28,444	25,116	427	2,901
76	279,500	60,975	53,841	915	6,219	35,769	31,584	537	3,648	30,344	26,794	455	3,095
77	298,000	65,012	57,406	975	6,631	38,137	33,675	572	3,890	32,352	28,567	485	3,300
78	317,000	69,157	61,066	1,037	7,054	40,568	35,822	608	4,138	34,415	30,388	517	3,510
79	337,800	73,694	65,072	1,105	7,517	43,230	38,172	649	4,409	36,673	32,382	550	3,741
80	359,600	78,450	69,271	1,177	8,002	46,020	40,636	690	4,694	39,040	34,472	586	3,982
81	382,500	83,446	73,683	1,252	8,511	48,950	43,223	734	4,993	41,526	36,667	623	4,236
82	407,000	88,791	78,402	1,332	9,057	52,086	45,992	781	5,313	44,186	39,016	663	4,507
83	434,000	94,681	83,603	1,421	9,657	55,541	49,043	833	5,665	47,117	41,604	707	4,806
84	463,000	101,008	89,190	1,515	10,303	59,252	52,320	888	6,044	50,265	44,384	754	5,127
85	495,000	107,989	95,354	1,620	11,015	63,347	55,935	951	6,461	53,739	47,452	806	5,481
86	531,000	115,843	102,289	1,738	11,816	67,955	60,004	1,020	6,931	57,647	50,902	865	5,880

Table 14

CONVERSION FACTOR TABLE

from Existing road to Access road

Kind of Vehicles	Beirut - Hammana										Conversion factor P(%)
	Existing Road					Access Road					
	Length of Route L (km)	Operating Speed V (km/h)	Time T_4 $=\frac{L}{V}\times 60$ (min)	Operating Cost C_4 $=c_1L$($)	S_4 $=T_4C_4$	Length of Route L (km)	Operating Speed V (km/h)	Time T_5 $=\frac{L}{V}\times 60$ (min)	Operating Cost C_5 $=c_2L$($)	S_5 $=T_5C_5$	$P=\frac{S_4}{S_4+S_5}\times 100$
Passenger Car	HAZMIEH 11.00 ALEY	40	16.50	0.99	16.34	13.80	50	16.56	1.10	18.22	47.2
	- 5.50 BHAMDOUN		8.25	0.50	4.13	7.30		8.76	0.58	5.08	44.8
	6.80 HAMMANA		10.20	0.61	6.22	6.50		7.80	0.52	4.06	60.5
Bus	(H) 11.00 (A)	20	33.00	1.76	58.08	13.80	30	27.60	1.93	53.27	52.2
	5.00 (B)		16.50	0.88	14.52	7.30		14.60	1.02	14.89	49.4
	6.80 (HA)		20.40	1.09	22.24	6.50		13.00	0.91	11.83	65.3
Truck	(H) 11.00 (A)	20	33.00	2.09	68.97	13.80	30	27.00	2.21	59.67	53.6
	5.50 (B)		16.50	1.05	17.33	7.30		14.60	1.17	17.08	50.4
	6.80 (HA)		20.40	1.29	26.32	6.50		13.00	1.04	13.52	66.1

Note: C_1: Unit running cost of Vehicle ($/km) on Existing road.
C_2: Unit running cost of Vehicle ($/km) on Access road.

Table 15

AVERAGE DAILY TRAFFIC WHICH CONSIDERED CONVERSION FACTOR

YEAR	HAZMIEH TO ALEY				ALEY TO BHAMDOUN				BHAMDOUN TO HAMMANA			
	Passenger Car (47.2%)	Bus (52.2%)	Truck (53.6%)	Total	Passenger Car (44.8%)	Bus (49.4%)	Truck (50.4%)	Total	Passenger Car (60.5%)	Bus (65.3%)	Truck (66.1%)	Total
1963	8,501	160	1,115	9.776	4,734	88	615	5,437	5,423	100	684	6,207
64	9,611	181	1,261	11,053	5,351	100	696	6,147	6,130	113	773	7,016
65	10,638	199	1,396	12,233	5,923	115	770	6,808	6,786	124	857	7,767
66	11,729	220	1,539	13,488	6,530	123	849	7,502	7,481	137	945	8,563
67	12,929	243	1,696	14,868	7,199	135	935	8,269	8,247	151	1,041	9,439
68	14,166	266	1,858	16,290	7,887	148	1,025	8,060	9,036	166	1,140	10,342
69	15,366	289	2,016	17,671	8,556	160	1,112	9,828	9,801	180	1,237	11,218
70	16,657	313	2,185	19,155	9,274	174	1,205	10,653	10,625	195	1,341	12,161
71	18,130	338	2,362	20,830	10,024	168	1,303	11,515	11,484	210	1,450	13,144
72	19,348	364	2,538	22,250	10,773	202	1,400	12,375	12,341	227	1,557	14,125
73	20,794	390	2,728	23,912	11,578	217	1,504	13,299	13,264	243	1,674	15,181
74	22,276	419	2,922	25,617	12,403	232	1,612	14,247	14,209	261	1,793	16,263
75	23,822	447	3,125	27,394	13,263	248	1,724	15,235	15,195	279	1,918	17,392
76	25,413	478	3,333	29,224	14,150	265	1,839	16,254	16,210	297	2,046	18,553
77	27,096	509	3,554	31,159	15,086	283	1,961	17,330	17,283	317	2,181	19,781
78	28,823	541	3,781	33,145	16,048	300	2,086	18,434	18,385	338	2,320	21,043
79	30,714	577	4,029	35,230	17,101	321	2,222	19,644	19,591	359	2,473	22,423
80	32,696	614	4,289	37,599	18,204	341	2,366	20,911	20,856	383	2,632	23,871
81	34,778	654	4,562	39,994	19,364	363	2,516	22,243	22,184	407	2,800	25,391
83	39,461	742	5,176	45,379	21,971	412	2,855	25,238	25,170	462	3,177	28,809
84	42,098	791	5,522	48,411	23,439	439	3,046	26,924	26,852	492	3,389	30,733
85	45,007	846	5,904	51,757	25,059	470	3,256	28,785	28,708	526	3,623	32,857
86	48,280	907	6,333	55,520	26,882	504	3,493	30,879	30,796	565	3,887	35,248
		7,240				3,997				4,452		

Sec. VI PRELIMINARY DESIGN

A. Tunnel

1. Outline

As before mentioned, we chose the A draft plan as the best for the tunnel route, and in this chapter we would enter into detail to study it.

The decision of the sectional design of tunnel is dependent upon the settlement on the problem of the ventilation. Following is the study on the basic requirements for ventilation, upon which the ventilation in the proposed tunnel will be selected and accordingly the tunnel construction be designed.

2. Ventilation

In consideration of designing a length of tunnel, the ventilating system should be first taken into account so that the fresh air might be sent in the tunnel to delute the interior air contaminated from the automobile's poisonous exhausted gas to such an extent allowable for the man's safety. Among the relative factors enabling to calculate the necessary ventilation are the traffic volume of vehicle, proportionate composition of running vehicle by kind, width of tunnel resulted from the above-mentioned two factors, the exhausting gas volume, and vehicle's running speed. As the air duct to send in the fresh air must be constructed, parallel with the construction of the tunnel, so the section of the air duct must be decided before the sectional design is finally drawn up.

2-1 Various factors relating Ventilation.

First of all, the foundamental study should be made in principal upon the importance of ventilation, and the generated poisonous gas and smoke, so as to set up a certain standard, upon which the examination would be given to the various requirements for the ventilation design.

a) Importance of Ventilation

As the general objective of the consideration for the ventilation of the road tunnel, there should be the following of the automobile's exhausting gas:-

1) Density of Carbon dioxide affecting the human physiology.
2) Density of the smoke to secure the safe sight and comfortable driving.

The allowable density of carbon dioxide should be considered on the standards set for (a) the relation between the degree of affected physiology of healthy people and the density of carbon dioxide, (b) the inhalation time of carbon dioxide and its influence upon the human health, and (c) the past data as the limited density adopted in the existing tunnel.

As for the influence of carbon dioxide upon human physiology, many experients reveal such data as shown below:-

Table - 16

	Symptoms	CO_2 Density (%)	Blood Contamination
1.	No symptom recognized in several hours.	0.01	
2.	No symptom recognized within one hour.	0.04 - 0.05	10%
3.	Headache felt in one hour.	0.06 - 0.07	20%
4.	Headache, strange pulsation felt and fainted. No danger to life if within one hour.	0.1 - 0.12	20 - 40%
5.	Fainted within one hour and falls in danger.	0.15 - 0.20	40 - 50%
6.	Dead within one hour.	over 0.4	70%
7.	Dead in three minutes.	3.0	

Mr. Murayama, professor of Kyoto University, presented the theory on the relation between the carbon dioxide in the human blood and the safe inhalation time. According to his theory, it seems that at the point of 0.1% of carbon dioxide in blood, as a curving point, a sudden bad influence should be caused to the human health. In the meantime, the examples of the maximum vallowable density of carbon dioxide which used for the tunnel constructed in the past are as follows:-

Table - 17

Examples of Carbon Dioxide allowed for the tunnel.			
Tunnel	Country	Length	Allowed CO_2 (%)
Holland Tunnel	U.S.A.	2,830	0.04
Mersey Tunnel	U.K.	4,629	0.025 - 0.04
Queen Midtower T.	U.S.A.	1,950	0.025
Kanmon Tunnel	Japan	3,460	0.04

As seen from the above-listed data, a very small amount of of CO_2 is extremely poisonous, and even when its existence of 0.04 -0.05% (400 -500 ppm) in the air is observed, a headache is resulted in about one hour; over 0.08% of CO_2 may make life fall in danger.

Besides of running through the tunnel by car, the working hour is needed for the repair, maintenance and control of the tunnel, which should be at least for one hour. The required density of CO_2 is 0.04%, but the recent design of tunnel is considered to add the precautions factors against the possible existence of small of gasoline, stimulative, and smoke. In this design,mtherefore, the limited amount of CO_2 in the tunnel is made out to be 0.025%.

2) In order to secure the safe sight and comfortable driving, the limited density of smoke may be taken up to study. It is related to the problem: when the smoke is diffused throughout the tunnel, what percentage of light penetrating rate can be admitted?

In this connection, it should be well noted that human eye sight is given by a comparative figure, and that, with the sight less 25% than usual, people could drive cars with the same safety feeling. Therefore, a man with the minimum eyesight of 0.7 cannot be affected with his safety feeling in the condition that his eyesight is down to $0.7 \times 0.75 = 0.5$. Consequently, the adequate brightness or light- penetrating rate necessary for the man with 0.5 eyesight should be enough to be given in the tunnel.

To be noted in this regard is that a special relationship is shaped-among the intensity of illumination, light-penetrating rate and eyesight: Generally the more intensive the light is, the better sight is given. However, in case the smoke exists, a larger intensity of illumination causes a light-screen phenomenon hampering the signt to the contrary. It is known that no light-screen should take place within the degree of 30 -100 Lux at the surface of road.

Accordingly, within the extent of illumination the ventilation of the smoke should be accomplished. The relation between these factors are presumed from the data, and when 50 Lux is made as 1.0, the compensation coefficient of light- penetrating rate is as indicated in the following list.

Table - 18

Road surface Luminocity and Compensation Coefficient

Road Surface Luminocity	Compensation Coefficient
10 Lux	1.300
20	1.225
30	1.150
40	1.075
50	1.000

Further, it should be taken in account to decide the allowable limit that (1) a clear enough sight should be given when driving at the proposed speed as well as the braking can be effected in time and that (b) a comfortable driving is ensured.

According to the experiments of the illumination academic society, the relation between the safe braking stop distance to the given objectives at the illumination of 50 Lux and the light-penetrating rate per 100 m is as follow:-

Table - 19

Speed and Safe Braking Distance

Speed Km/h	Safe Braking Distance (m)	Wood		Doll		Car	
		#	Smoke Density	#	Smoke Density	#	Smoke Density
80	110	87	0.60×10^{-3}	68	1.68×10^{-3}	46	3.37×10^{-3}
70	93	70	1.55×10^{-3}	55	2.60×10^{-3}	38	4.20×10^{-3}
60	74	51	2.92×10^{-3}	37	4.32×10^{-3}	26	5.85×10^{-3}
50	58	31	5.08×10^{-3}	22	6.58×10^{-3}	15	8.24×10^{-3}

Note: # is symbol of Light-penetrating Rate per 100 m(%)

As a result, at the speed of 50 Km/h, 22% (in case of Doll) is given against the braking stop distance, and agaihst after-braking distance of 65 m (Explanation for Road Construction Order) and as a car is the objective in sight, it is given:-

$$15\% + \frac{65 - 58}{64 - 58}(26 - 15) = 20\%.$$

Therefore, if the surface is at 20 Lux, it is quoted from Table - 21 :-

$$20\% \times 1.225 = 24.5\%.$$

All these figures are worked out just from a safety point of view, with which no comfortable driving cannot be expected.

Concerning the comfortability, the measurement by brightness gauge held at the Kammon Tunnel showed the results as to the dimness as follows:-

Table - 20

Penetrating Rate and Comfortability

Light-transmitting Rate (%)	Comfortability
100 - 65	Comfortable
65 - 56	Slightly dim
56 - 36	Thickly smoky
Below 36	Deep smoke, very comfortable.

20 Lux at surface, 100 m measurement distance according to this table, the allowable limit should be made more than 56% if possible, and more than 36% at least.

In this design, the limited density allowable for smoke is made not to be 50%.

b) Generation of CO_2 and Smoke.

Amount of generated CO_2

The comparative amount in volume of CO_2 only to the entire volume of the automobile's exhausting gas is as follows:-

Table - 21

CO Rate in automobile's exhausting gas in volume (%)

	CO_2 Rate		Running Condition
	Gasoline Car	Diesel Car	
S.A.E. National Diesel Eng. Meeting.	11.7 3.0 5.5	0 0.05 0 0	By inertia Accelerated Running Slowed down
Civil Work Institute National Sanitary Lab. Japan Road Corp.	0.5 - 3.5	0.02	
Minsei Diesel Ind.	3.0 - 5.0	0.01 - 0.05	General
Average	5.52	0.016	
Average Rate	345	1	

According to this table, the generated CO_2 is remarkable of gasoline cars, and of diesel car almost nothing of CO_2 is generated. What is more about gasoline cars, there are notable differences in the generating amount of CO_2 dependent on their running conditions.

Judging from the results of the various experiments made by the Civil Work Institute of Japanese Government, National Sanitary Laboratory and Japan Road Corporation about the Japanese-make motor cars for the various conditions covering kinds of surface, gradient, speed, kinds of vehicle, weight of vehicle, new or old engine, good or poor maintained vehicle, payload, skillness of driving, the average generating amount of CO_2 per can will be safely anticipated to be 20 /unit/minute.

Generated Amount of Smoke

There exist differences in the generated amount of dependent upon various conditions given. The following is the results of Japan Road Corporation's investigation on the individual model of car and type of engine to see the exhausting gas valume.

Table - 22

Exhausting Gas Volume by Kind of Vehicle

Kind of Vehicle		Exhausting Gas (m^3/Km)
Car	normal size	3.4
	small	1.5
Truck	Large Gasoline	4.5
	" Diesel	4.8
	Small Gasoline	1.5
Bus	Gasoline	6.5

Density of Smoke by Exhausting Gas

The definition of the density of smoke is: "The density of smoke is given when the intensity of illumination at the point of 1 m away from the light source is 10^{-8} compared to the state being nothing of smoke." That is, the following formula is set up between distance (ℓ^{m}) and light-transmitting Rate (τ):-

$$\tau = \frac{E}{E_0} = 10^{-8\ell}$$

where:-

E_0 = illumination at clear air

E = " at contaminated air

τ = Penetrating Rate

δ = Density of smoke

ℓ = Distance

According to the exhausting gas Examination, the automobile's exhausting gas generally grows larger in direct proportion to the increase of payload, speed, burning ratio and gradient, but there is a little fructuation observed.

As to the data relating these factors, the Civil Work Institute of Japanese Government, National Sanitary Laboratory and Japan Road Corporation together make public the study results made on the gradient changes.

Table - 23

Smoke Density of Automobiles Exhausting Gas

(for gradient change)

Kind of Vehicle		Up-gradient	Flat	Down-gradient
Diesel Car	Average	0.633	0.593	0.499
	Standard variation	0.543	0.504	0.436
Gasoline Car	Average	0.125	0.046	0.066
	Standard variation	0.097	0.025	0.063

As apparent from this table, the smoke density of diesel cars shows about 5 -10 times as much as that of gasoline cars.

The generated amount of smoke in the tunnel is:-

Amount of Smoke = (Exhausting Gas Volume)
x (Smoke Density)

c) LIMITATION OF NATURAL VENTILATION

The natural ventilation inside tunnel is caused by the following conditions:

(1) Natural wind

(2) Difference of altitude between shafts and portals, and atmospheric pressure due to adjacent topography

(3) Difference of temperature inside and outside of tunnel

(4) Induced ventilation due to traffic

(1) The ventilation caused by natural wind is most effective. The required ventilation, by converting it into wind velocity, will be 13.5 meters per second at a traffic condition of 2,000 cars per hour. The ventilation required by this tunnel, therefore, cannot rely on natural wind.

Even in the case of a traffic condition of 1,000 cars per hour, a wind velocity of 6 - 7 meters per second will be required. The exterior wind velocity should become far larger taking into account the resistance of portals, frictional resistance of tunnel interior.

In consequence, constant natural wind that meets the requirement could not be always expected.

(2) Static pressure difference due to difference of altitude is very small in the case of tunnel without shafts and it will only be effective for a tunnel with shafts. However, this static pressure is extremely small when compared with atmospheric pressure. The static pressure is generally affected by temperature difference. This item will be neglected in this study.

(3) The static pressure due to temperature difference is caused by difference in temperatures of tunnel interior and exterior which

will help to cause natural ventilation by shafts.

The temperature rise and drop of open air varies in the summer and winter season and in consequence the variation changes wind direction.

In case that the temperature difference between the air outside the shafts and internal air is 20°C, the static pressure is approximately 14mm aq. However, the static pressure required to have satisfactory ventilation should be more than 100 mm aq. Thus, natural ventilation hardly satisfy the requirement. Ventilation by natural wind is possible in case there is one shaft. If there are two or more shafts, it is not possible to ventilate the section between shafts. The section should be ventilated with other means.

(4) Induced ventilation by traffic may be expected to a considerable extent in case of a tunnel with one-way traffic. This tunnel with facing traffic, however, could not expect the induced ventilation. The natural ventilation may be occurred by the conditions described above as long as a projected tunnel is short. A long tunnel as this could not satisfy its requirement by natural ventilation. As the ventilation of tunnel is a serious matter affecting people's lives, the projected tunnel should be equipped with mechanical ventilation system although it is costly.

d) Poisonous Gas Dependent on Vehicle Traffic Composition.

The objective of the study on ventilation are the density of CO_2 in relation to the human physiology and the smoke density in relation to the clear sight connecting with the safety and comfortability of driving.

e) Ventilation System.

All the abovementioned conditions satisfied, use still have to draw up the design so as to enable the construction and future maintenance cost to be the minimum. And attaining the purpose, a further study should be made to work out the ventilation system which is most economical and adequate to meet the required amount of ventilation.

f) Meteorological Condition.

When is studied the meteorological conditions, namely, temperature difference between the outside and inside of the tunnel, wind direction and its speed, these factors may sometimes be used as natural and/or traffic ventilation, favored by the vehicle traffic composition and wind direction. Of course, such cases must be made the most of the factors. These measurement figures are not only of help to designing the ventilation system but to the future operation of the air-sending duct. It is so desirable to study in detail as possible.

g) Vertical Shaft.

The motor necessary for ventilation stands in direct proportion with the triple ratio of the total

length of tunnel, so the extent of ventilation section should be as short as possible.
Thus, in the part where no thick earth coverage is laid, it is advantageous to open vertical or horizontal pits dividing the section into short ones. According to the order so far described,mthe design of ventilation and the decision of the sectional design of tunnel are processed together in parallel with each other.

2-2 Decided Ventilation System

As the result of comparison study of the many possible systemed reflected the present status, the plan adopted to use a sending-air downward half transverse system.
As need demands, the fan may be run in the reverse direction so that the system turns out a sending-air upward one. Following is the study we made in particular:-

1) For the long tunnel like the proposed one in the plan, the amount of natural ventilation from the opening of tunnel and from the vertical shaft may be neglegible, and the mechanical ventilation system is of course needed.

2) The study on the possible mechanical ventilation methods are as follows:-

a) Vertical Streaming Ventilation

A comparatively simple system to cause the air stream along the vertical direction of tunnel. Economical mechanical system. Among the system are: (1) Jetting Vertical streaming ventilation which is caused wind along to the vertical direction of tunnel by jetting spout, and (2) the air-blower one making partial ventilation, and (3) the one by vertical shaft.

The jetting vertical streaming ventilation is that the jetting stream caused by the air duct at the portals of tunnel will be mixed with the fresh outside air and sent in along the vertical direction by up-going pressure to overcome the friction against the tunnel walls. This system is suitable for the one-way tunnel constructed at the place where naturally existing pressure remains for a long time.

The example of this system is seen at the Lammer-Buckel Tunnel (620 m) of South Germany and at the Rendsbury Tunnel (640 m) of North Germany and the Coen Tunnel (587 m) of Netherland.

Next, the vertical streaming ventilation by air-blower of vertical shaft will work by air-blower constructed in the vertical shafts. Same as the regular natural ventilation by vertical shaft. Generally, the system is fitted for the occasion that the pressure different between the both portals are almost settled in the face-to-face traffic tunnel. For the example is given the St-Clonde Tunnel (830 m) of Paris.

The vertical streaming ventilation by the two air sending in and out vertical shaft is: the sending-out of air is carried out at the one shaft at the central shaft, and the sending-in of air at the next shaft. The system is effective only for the one-way traffic, the example of which is seen at the Liberty Tunnel (1,780 m) of Pitsburg, U.S.A. As stated, generally speaking the vertical streaming system was no need of constructing any special ducts, but the tunnel section can be utilized to itself, costing rather cheap in construction. However, there are those drawbacks like the following:-

1) The required ventilation volume must streamed by a large vertical direction speed.

2) When fire breaks out, the long interior of the tunnel may be enveloped with smoke.

3) When traffic comes to stop, the automobile's exhausting gas may be carried in the wrong direction.

4) In a lengthy tunnel, the response to the control is tend to delay comparatively, and at a sudden rush of traffic the density of gas will grow too large.

b) Half Transverse Ventilation.

With one air duct to be used in either sending in air or out, the other way of sending air is effected through the tunnel itself. Compared to the horizontal streaming system, half of sectional area of duct is required and accordingly half of the power needed, but because the drive way itself is used for the purpose of a duct, a vertical direction speed takes place somewhat.

There are two; by sending-in duct and by sending-out duct. In the former, the sent-in air runs through the entire length of tunnel, and the equal amount of air will be thrown in the drive way from the slots placed at the same interval. When no difference of pressume exists in the tunnel, the sent-in air will be devided into two at the center and sent out from the both ends. The system will not lose its advantage even in case one-way traffic is practised and the pressure difference exists at the both portals of tunnel, being capable of streaming in the tunnel from the drive-way in opening.

Different from the vertical streaming system, the fresh air can be sent at any desired places directly into the tunnel. Therefore, no relation is so regarded with the vertical direction speed and the direction, that it has the advantage that no outside conditions such as meteorological, temperatural and traffic ones would affect the system. This system is devided in 4 types in accordance with the spouting direction of the fresh air; upward (downward) sending-air semi-horizontal streaming system, up-and-downward sending-air semi horizontal streaming system, sideward sending-air semi-horizontal streaming.

The up-and-down sending-air half transverse system has the sent-in duct at the lower part of the sectional area of tunnel and spout the fresh air upward. The instance of this type is seen at the Mersey Tunnel (3,220 m) of England and the Baytown Tunnel (912 m) of U.S.A., etc. Both advantage and drawback are observed, and particularly in case of the construction of tunnel through a mountain, a large sectional area for the duct sometimes can be hardly practical.

On the other hand, the downward sending-air half transverse system sends in the fresh air from the ceiling duct. The adoptation of this system is seen at the Bopueron Tunnel (1,820 m) of Venezuela, the Tenno-zan Tunnel and the Kajiwara Tunnel (814 m) of Meishin Highway in Japan. It is advantageous to be able to utilize the tunnel section, but due to the gushing of air from upside, the vehicles exhausting gas may remain at the height of the eyesight, and may give an unpresent feeling. However, not so much trouble would happen in reality.

The half transverse ventilation by sending-out duct is that the fresh air will taken in from the openings of tunnel and the contaminated air out by the sending-out duct.

If the one-way traffic and the reverse pressure occurs, or if no difference of pressure exists in the face-to-face traffic, at the some part around the center of tunnel. The point with nil vertical direction speed takes place causing too thick a gas density. Meanwhile, the vehicle's exhausting gas and ducts will be taken out, and the very clear sight be provided. This gave the comfortability of driving into the tunnel, and if a fine break out, heat and smoke can be expelled through the duct. For the system there are 4 types as same as in sending-in system. The examples are: Elizabeth River Tunnel (1,620 m) of America, Bankhead Tunnel (948 m), Almendas River Tunnel (216 m) of Cuba.

Further, there is a half transverse system in which the sending-in duct and the sending-out we are combined jointly.

c) Transverse System

The system is that the air stream is caused in the transverse direction, and consequently no wind speed takes place along the vertical direction. The system can maintain a given density for the total length of tunnel; safe against fire, capable of taking in the fresh air from the many place. Therefore, it makes possible to ventilate a lengthy tunnel, but because of the necessity of constructing the both sending in-and-out ducts, the sectional area is enlarged, resulting the rise of the construction out and power cost, just double as the case of Half-Transverse ventilation system. This system also has 4 types identified by the transversing direction of streaming. The instances of this system are: Holland Tunnel (2,610 m) of America, Liucolu Tunnel (2,445 m), Queens Midtown Tunnel (1,950 m), Brooklyn Battery Tunnel (2,780 m), and in Europe, Anverse Schelde Tunnel (1,770 m) of Belgium, Mass Tunnel (1,070 m) of Netherland; and the Kanmon Tunnel (3,461 m) of Japan.

Above-stated is the systems available at present. In consideration of deciding the ventilation system, we gave the study on:-

1). No danger anticipated when is used the ventilation system.

2) Effective and cheap in construction cost.

3) As no difficulty is felt for the location of shaft from the topographical view, many blocks can be sectioned to be ventilated and at large to accommodate the ventilation for the lengthy tunnel.

4) make the best use of the sectional area of tunnel.

5) Reversing the fan will make the sending-in duct to be the sending-out one, available to use the advantages of both types.

With these points in mind, thorough examinations had been given to choose the downward half transverse ventilation system as the best for the plan.

3. Design of Ventilation

As resulted from the study above-stated about the factors for ventilation, we decided the foundamental requirements for designing as follows, and are proceeding with the design.

3-1 Foundamental Requirement of Designing.

a. Traffic Volume 2,000 vehicles/hour

The traffic volume through tunnel in 1986 sought for in Table - 12 is 18,319 vehicles/day, and giving some room to the figure the traffic per day is 20,000 vehicles.
Supposed that the operation time per day is 10 hours, the traffic volume is calculated 2,000 vehicles/hours.

b. Kind and Weight of Vehicle

Kind	Diesel Car	Gasoline Car					Total
	Truck	Car		Bus	Truck		
Size	Large	Large	Normal	Large	Large	Normal	
Traffic per h.	84	600	1,160	30	84	42	2,000
%	4.2	30	58	1.5	4.2	2.1	100
	4.2		88	1.5		6.3	
Weight (ton)	10	1.8	1.1	6.5	8.0	5.0	

c. Vehicle's Speed in Tunnel 60 Km/h.

Though the speed in the tunnel was made to be 60 Km/h for cars and 50 Km/h for buss and trucks when the traffic bolume was presumed. This chapter deals with than at an equal 60 Km/h.

d. Illumination in Tunnel 50 Lux

e. Allowable Limit of CO_2 K = 250 ppm (0.025%)

f. Allowable density of Smoke 50%

(Lighting Penetration Factor)

g. Ventilation system.Downward Half Transvers Ventilation System.

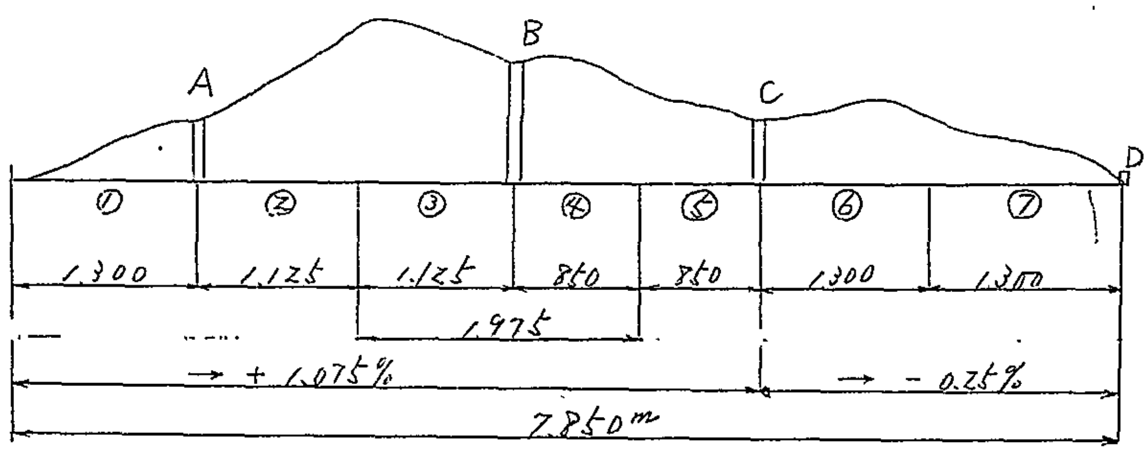
h. Exhausting Gas Volume by Kind of Vehicle.

Kind	Diesel Car	Gasoline Car				
	Truck	Car		Bus	Truck	
Size	Large	Large	Normal	Large	Large	Normal
Exhausting Gas m^3/Km	4.8	6.5	4.5	3.4	3.4	1.5

3-2 Calculation of Ventilation Volume

At the time of designing the ventilation, the most economical one must be selected after the comparison study made between the location and number of shafts. As an example, the case with 3 shafts is calculated to show the process as follows:-

(Fig. 17)



Traffic Volume of Pass.Car Np = 1,160 + 600 = 1,760 veh/h.

Average Weight of Pass.Car Gp = (1.8x0.3 + 1.1x0.58) 0.88 =

= 1.34 ton

Average Weight of Bus, Truck Nt = 84 + 84 + 42 + 30 = 240 ton

Traffic Volume of Bus, Truck Gt = (8x0.042 + 5.0x0.021)

+ 6.5x0.015 + 10x0.042) 0.12

= 8.04 veh/h

V = 60 Km, the compensation coefficient of gradient for

G = ± 1.076%.

Up $\beta p = 1.2$ $\beta t = 1.5$, Down $\beta p = 0.85$ $\beta t - 0.75$

the compensation coefficient of altitude

$\alpha = 1.35, \quad \gamma = 1.1$

Allowable limit of CO_2 $K = 250$ ppm

Then, the ventilation volume required by the density of CO_2 is given by:

$$Q = \frac{Np \cdot Gt \times 0.017 \beta p + Nt \cdot Gt \times 0.012 \beta t}{3600 \times K} \times 10^6 \times \alpha \gamma$$

The traffic volume is separated into that in the up-way lane and that in down-way lane.

On the up-way lane, 2/3 of the schemed traffic volume passes, and on the down-way lane 1/3 passes.

In the above formula, the figures are placed.

$$Q_1 = 91,128 \ m^3/sec/Km$$

$$Q_2 = 28,294 \ m^3/sec/Km$$

Total: $$Q = Q_1 + Q_2 = 119,422 \ m^3/sec/Km$$

$$\doteqdot 120 \ m^3/sec/Km$$

When the gradient is at ± 0.25%, the same process is taken, resulting in:-

$$Q = 100 \ m^3/sec/Km$$

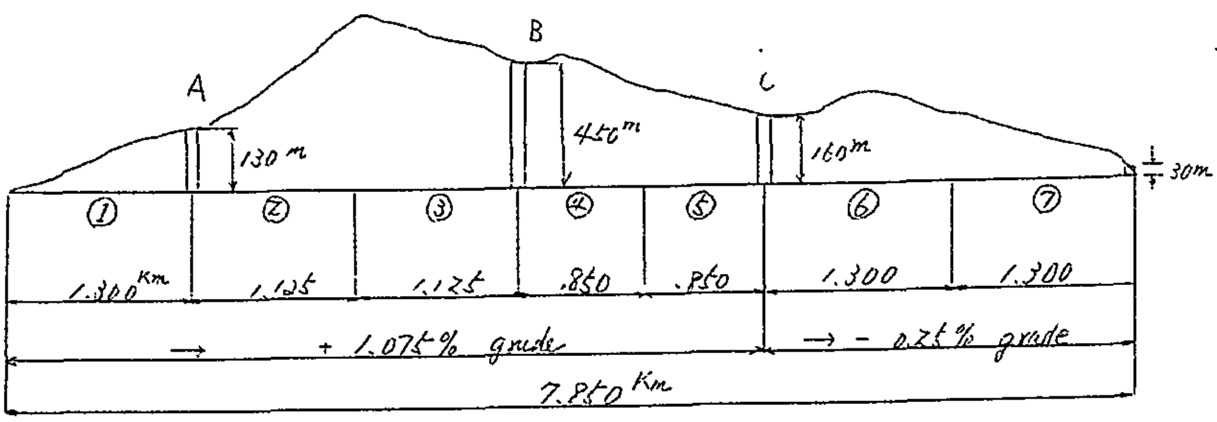
From this figure, the ventilation volume required for each portion is as follows:-

Portion	1	2	3	4	5	6	7
Q m^3/sec/km	120	120	120	120	120	100	100
L km	1.30	1.125	0.85	0.85	1.3	1.3	1.3
Q m^3/sec	156	135	135	102	102	130	130

3-3 Calculation of Electricity for Ventilation.

T The electricity required for the ventilation calculated for the case with 3 shafts on the same condition as dealt in previously.

i) Amount of Electric Power



Calculation of Electricity for Ventilation required in portion 1.

a. Interior pressure of Duct

Design Requirements

Extended Ventilation	L = 1,300 m
Width of Lane	W = 9.0 m (2-lane face-to-face traffic)
Gradient	G = 1.075 %
Height of Vertical Shaft	G = 130 m
Sectional area of Duct	A = 11 m
Standard Measurementof Duct	$d = 4A/P = \frac{4x11}{18} = 2.5$ m (P ≡ perimeter = 18 m)
Ventilation Volume	$Q = 156\ m^3/sec.$
Velocity at Duct End	V = Q/A = 14.2 m/sec.
Sectional area of stem pipe	$a = \frac{Q/2}{L/1}\frac{1}{5}\quad\frac{156/2}{1300/5}\frac{1}{5} = 0.05$

Stem pipe pitch $l = 5$ m

Number of all stem pipes $N = L/l = 260 = n$

Resistance coefficient of stem pipe slot $\xi = 0.9$

Loss coefficient of streaming in stem pipes $\zeta = 1.1$

Minimum point of static pressure within the interior of duct $m = \frac{2d}{\lambda l} = \frac{2x2.5}{0.02x5} = 50$

Acceleration of gravity $g = 9.8$ m/sec^2

Weight of Air per unit cubic $\gamma = 1.22$ kg/m^3

" " Water " $\gamma_{aq} = 1.00$ "

(pressure unit is indicated by mm, $\gamma_{aq} = 1.0$)

Then, the interior pressure of duct (hd) is given by the following formula:-

$$hd = \left[\left\{(1+\xi)\left(\frac{A}{a}\right)^2+(\zeta-1)m^2+\left(\frac{\lambda\cdot n\cdot l}{3d}-1\right)n^2-\left(\frac{\lambda}{3}\frac{m\cdot l}{d}-1\right)m^2\right\}/N^2\right] x\frac{V^2}{2g}\frac{\gamma}{\gamma_{aq}} \quad \ldots\ldots (A)$$

$$hd = \left[\left\{(1+0.9)\left(\frac{11}{0.05}\right)^2+(1.1-1)50^2+\left(\frac{0.02}{3}\frac{260x5}{2.5}-1\right)260^2-\left(\frac{0.02}{3}\frac{50x5}{2.5}-1\right)50\right\}/260^2\right] x \frac{14.2^2}{2x9.8}\frac{1.22}{1.00} = \underline{\underline{48.217 \text{ mm}_{aq}}}$$

b. Interior Pressure of Vertical Pit

Requirements

Height of Shaft $\ell = 130$ m

Ventilation Volume $Q = 156$ m^3/sec.

Sectional Area of Shaft $A = 12$ m^2

Wind Velocity $V = Q/A = 13.0$ m/sec.

Standard Measurements of Shaft $d = 4A/P = 4x12/14 = 34$ m

Loss Coefficient for Friction $\lambda = 0.02$

b-1 Loss in Velocity (he)

$$he = \lambda \frac{\ell}{d} \frac{V^2}{2g} \frac{\gamma}{\gamma_{aq}} \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \text{(B)}$$

$$\therefore \; he = 0.02 \; \frac{130}{3.4} \; \frac{(13)^2}{19.6} \; \frac{1.22}{1.00} = \underline{8.047 \; mm_{aq}}$$

b-2 Loss in Curving (hb)

$$hb = \zeta_b \frac{V^2}{2g} \frac{\gamma}{\gamma_{aq}} \quad \cdots\cdots\cdots\cdots\cdots\cdots \text{(C)}$$

Loss coefficient for Curving 90^0, at 2 points

$$\zeta_b = 0.2 \times 2 = 0.4$$

$$\therefore \; hb = 0.4 \; \frac{13^2}{19.6} \times \frac{1.22}{1.00} = \underline{4.208 \; mm_{aq}}$$

b-3 Loss in intake opening (hi)

$$hi = \zeta_i \frac{V^2}{2g} \frac{\gamma}{\gamma_{aq}} \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \text{(D)}$$

Loss coefficient at intake opening $\zeta_i = 0.11$

$$\therefore \; hi = 0.11 \; \frac{13^2}{19.6} \; \frac{1.22}{1.00} = \underline{1.157 \; mm_{aq}}$$

b-4 Other Loss $\underline{10 \; mm_{aq}}$

Therefor›, the total interior pressure of vertical shaft =

$8.047 + 4.208 + 1.157 + 10 = \underline{\underline{23.412 \; mm_{aq}}}$

c Pressure Interior of Drive Way

c-1 Air friction loss of Vehicle

Requirements:

Sectional Area of Drive Way	$A = 53 \; m^2$
Ventilation Volume	$Q = 156 \; m^3/sec.$
Wind Velocity in Drive Way	$u = 156/53 = 3.0 \; m/sec.$

Standard Measurement	$d = 4x53/30.2 = 7.0$ m
Vehicle Speed	$v = 16.7$ m/sec. (60 km/hr)
Resistance Coefficient of Vehicle	$\zeta_m = 0.55$
Area of Front of Vehicle	$A_m = 2.5\ m^2$

Converted Number of Vehicles Running in Tunnel

$$n = \frac{1}{3,600} \frac{L}{v} (Np + 1.5\ N_T)$$

$$= \frac{1}{3,600} \frac{1,300}{16.7} (1,760 + 1.5 \times 240)$$

$$\fallingdotseq 46$$

Then, the Air friction loss in the driveway (hm) is:-

$$hm = \zeta_m \frac{nAm}{A} \frac{(\mu + v)^2}{2g} \frac{\gamma}{\gamma_{aq}} \text{ .... (E)}$$

$$hm = 0.55 \frac{46x2.5}{53} \frac{(3+16.7)^2}{2x9.8} \frac{1.22}{1.00} = \underline{28,830\ mm_{aq}}$$

c-2 Wind Pressure in Drive Way

Requirements:-

Resistance Coefficient	$\zeta = 0.9$
Number of all stem pipes	$N = 260 = n$
Sectional Area of Slot	$a = 0.06$
Standard Measurements	$d = 7.0$ m
Sectional Area	$A = 53\ m^2$
Friction Coefficient	$\lambda = 0.02$
Stem pipe pitch	$\ell = 5$ m
Diversion coefficient of stem pipe	$\zeta = 0.03$
Wind Velocity	$V = 3.0$ m/sec.

Given formula

$$hn = \left\{ (1+\zeta)\frac{1}{N^2}\left(\frac{A}{a}\right)^2 + \left(\frac{\lambda}{3}\frac{nl}{d} + 1 + \frac{N\lambda}{3}\right) \right\} \frac{v^2}{2g} \frac{\gamma}{\gamma_{aq}}$$

$$\ldots\ldots\ldots\ldots\ldots (F)$$

$$hn = \left\{ (1+0.9)\frac{1}{260^2}\left(\frac{53}{0.06}\right)^2 + \left(\frac{0.02}{3}\frac{260x5}{7} + 1 + \frac{260x0.03}{3}\right\} x$$

$$\frac{3^2}{19.6}\frac{1.22}{1.00} = \underline{15.00\ mm_{aq}}$$

Therefore the total pressure interior of Drive Way

$$hm + hn = 28.83 + 15.00 = \underline{\underline{43.83\ mm_{aq}}}$$

Then, the required wind pressure for ventilating machine to send in the portion 1 is given by the sum of the resulted figures:-

$$H = hd + he + hb + hi + 10 + hm + hn$$

$$= 48.217 + 8.047 + 4.208 + 1.157 + 10 + 28.830 + 15.00$$

$$= 115.459\ mm_{aq}$$

The obtained value gives the required electric power.

$$HP = \frac{H.Q}{102x0.7} = \frac{115.459x156}{71.4} = 252.16\ kw$$

For the other portions we can calculated in accordance with the formula (A) - (F) on the same requirements for design as follows:-

Table 24

Ventilation Portion	1	2	3	4	5	6	7
Extended Ventilation (m)	1,300	1,125	1,125	850	850	1,300	1,300
Longitudinal Gradient (%)	1.075	1.075	1.075	1.075	1.075	0.25	0.25
Extended Vertical Shaft (m)	130	130	450	450	160	160	30
Ventilation Volume (m^3/sec.)	156	135	135	102	102	130	130
Interior Pressure of Duct	48.217	30.916	30.916	18.914	18.914	33.307	33.307
Interior Pressure of Vertical Shaft	23.412	20.131	35.091	24.198	16.527	20.536	14.984
Interior Pressure of Drive Way	43.830	38.193 43.830	38.193 38.193 43.830	30.642 2 x 38.193 43.830	30.641 2 x 39.051	39.051 39.051	39.051
Total Pressure (mm_{aq})	115.459	133.07	186.233	193.970	144.184	131.945	87.342
Electric Power (KW)	252.16	251.50	351.96	276.99	205.89	240.14	159.03

Note: Interior Pressure of Drive Way is given by the sum, for instance, at Portion 2 the pressure is given by the sum of that at 1 and 2, and so forth. In the same way, at Portion 4, the pressure is given by the sum of those of 1, 2, 3 and 4 included. From Portion 5 to the right, the pressures are accumulated to add those consecutively from the right opening of tunnel.

3-4 Scale and Estimated Construction Cost

Comparision among possible Draft plan.

Changed the location and number of the vertical shaft, each case is calculated is the same process as in 3-2 and 3-3 in order to give the required ventilation volume and electric power as follows. (Table-25) However, the comparison table does not cover the case where no vertical shaft are constructed abd the case 5 shafts are provided. This is why such cases goes beyond the extent of comparison for the following reasons:-

1. When no vertical shaft is constructed, the ventilation stations are just installed at the both openings of tunnel, making the ventilation block very large. Consequently, the sectional area of duct becomes double as large as the case with two vertical shafts, and this makes larger the required sectional are of tunnel, the cost of which would need as almost same as in the transvers system.
2. As in the case with 5 vertical shafts each block becomes shorter and the required sectional area of duct, and the entire sectional area as well, becomes smaller. But the width is confined, there should be a certain limit to make small the shape of the crown, and would come in the same sectional area as in the case with 4 vertical shaft, when the special meaning to build 5 shafts is lost. On the other hand, the construction cost would be larger than in the case with 4 shafts ($26,300,000.-)

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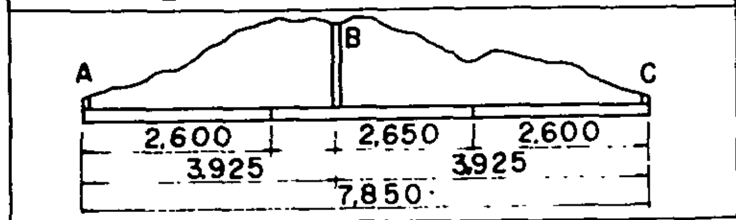
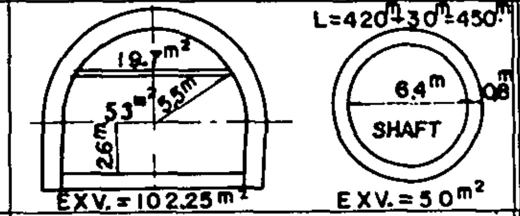
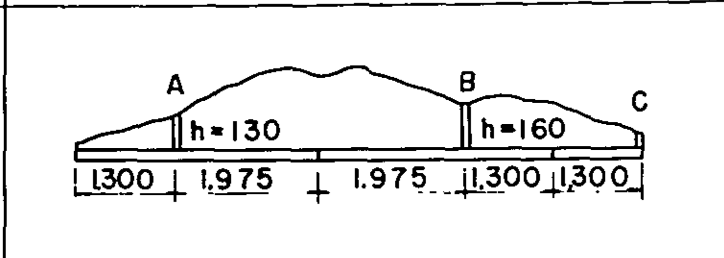
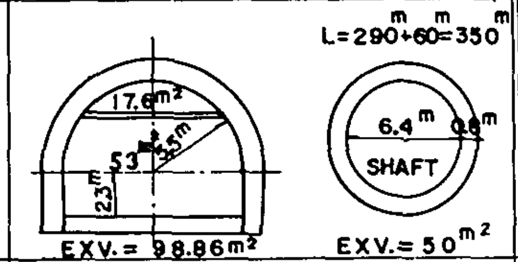
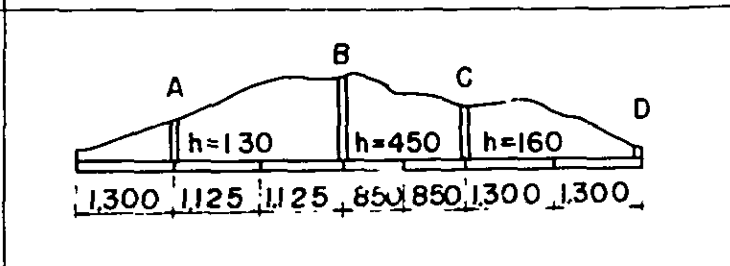
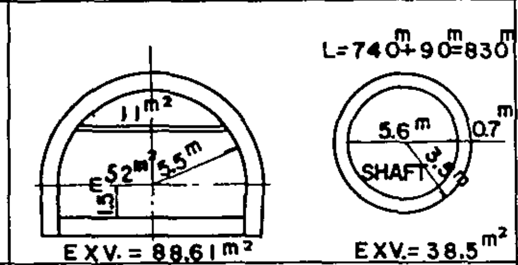
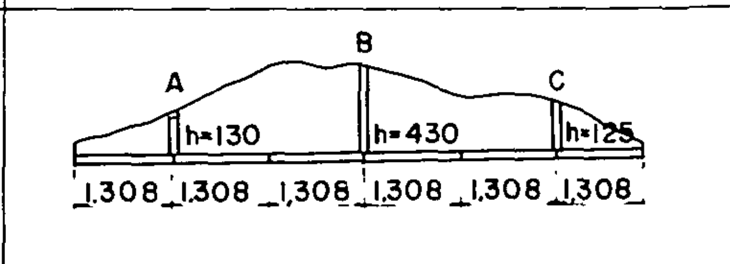
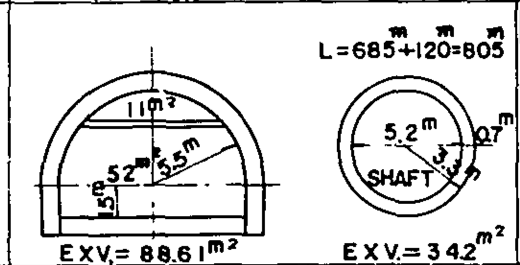
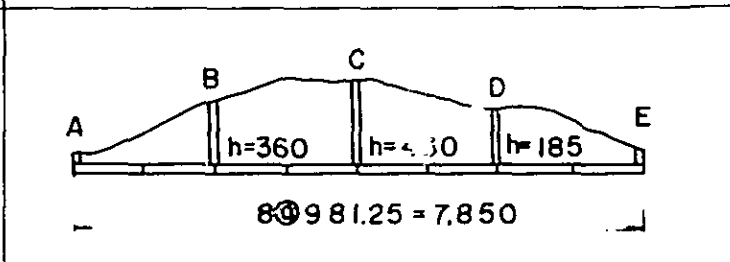
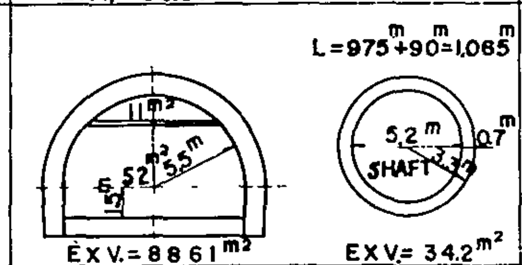
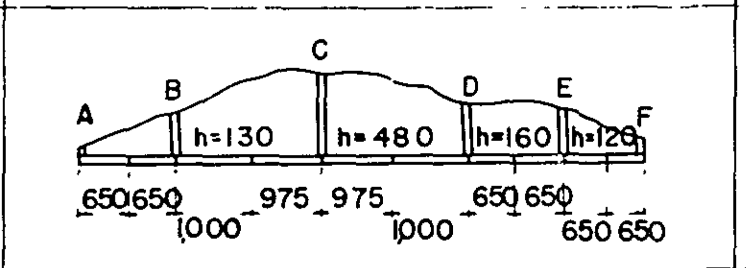
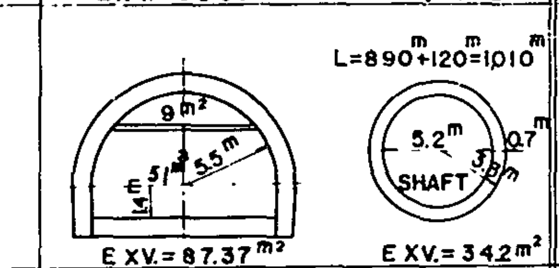
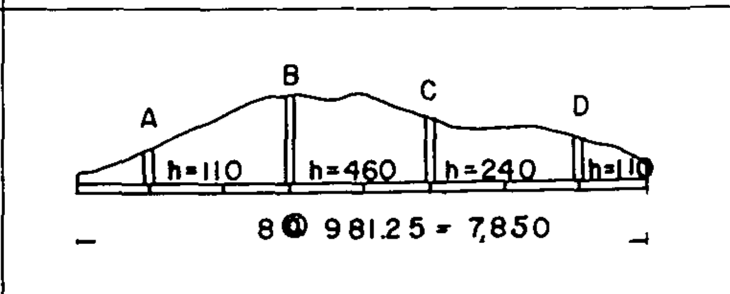
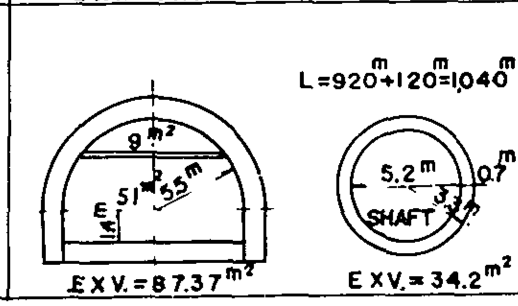
TABLE 2.5 COMPARISON TABLE ON SCALE AND ESTIMATED CONSTRUCTION COST FOR POSSIBLE DRAFT PLAN

	LONGITUDINAL SECTION	CROSS SECTION	VENT. STATION	Q m³/sec	H mmaq	HP kw	TUNNEL	SHAFT	VENTILATION	OTHERS
1			A	312	198	865	802,700 m³	22,500 m³	2,510 kw	
			B	318	470	1,050	@25 /m³	@52 /m³		
			C	260	163	595	20,068,000 $	1,170,000 $	4,629,000 $	3,165,000 $
			TOTAL	890		2,510	TOTAL		29,032,000 $	
2			A	393	300	830	776,000 m³	17,500 m³	1,855 kw	
			B	367	348	895				
			C	130	71.3	130	19,403,000 $	910,000 $	3,920,000 $	3,165,000 $
			TOTAL	890		1,855	TOTAL		27,398,000 $	
3			A	291	248.5	504	695,590 m³	32,000 m³	1,738 kw	
			B	237	380	629				
			C	232	276	446				
			D	130	87.3	159	17,390,000 $	1,664,000 $	3,879,000 $	3,165,000 $
			TOTAL	890		1,738	TOTAL		26,098,000 $	
4			A	314	265.7	585	695,590 m³	27,540 m³	1,940 kw	
			B	314	425.4	940				
			C	262	226.0	415	17,390,000 $	1,432,000 $	3,931,000 $	3,165,000 $
			TOTAL	890		1,940	TOTAL		25,918,000 $	
5			A	118	78.1	130	695,590 m³	36,430 m³	1,589 kw	
			B	236	260	430				
			C	236	354.3	590				
			D	200	235	330				
			E	100	.74	105	17,390,000 $	1,895,000 $	4,037,000 $	3,165,000 $
			TOTAL	890		1,589	TOTAL		26,487,000 $	
6			A	78	56	65	685,900 m³	34,600 m³	1,715 kw	
			B	198	231	325				
			C	234	445	730				
			D	185	307	400				
			E	130	164	150	17,148,000 $	1,800,000 $	4,089,000 $	3,165,000 $
			F	65	45	45				
			TOTAL	890		1,715	TOTAL		26,202,000 $	
7			A	236	195	325	685,900 m³	35,570 m³	1,655 kw	
			B	236	347	575				
			C	221	328	510				
			D	197	175	245	17,148,000 $	1,850,000 $	3,997,000 $	3,165,000 $
			TOTAL	890		1,655	TOTAL		26,160,000 $	

Note: 1. In the Comparison Table, the Cases with the vertical shafts ranging from 1 to 4 are considered. Draft Plan with one shaft is made so that the shaft is constructed at the center of longitudinal length of tunnel. As to the 2-shafts plan, each shaft is to cover almost equally devided area for ventilation, and located at the place with the height as short as possible.

2. Concerning the 3-shafts plan, two drafts are made out; that for the almost equally devided ventilation (4, 5) and that for the most effective blocking (3). The 4-shafts plan. The draft is made for the equally devided ventilation block and for otherwise.

With the estimated cost comparison, the relation between the number of shafts and the construction cost is presumed. (Fig.-18). From the point of view on the construction cost, the 4-shafts plan cost the least. To be well noted, due to the decrease of the sectional area of tunnel in accordance with the increased number of shafts, the wind velocity in the drive way is increasing. The designed wind velocity in the drive way should be 10 m/sec. at the maximum. This would affect the comfortability of passerby, and therefore should be avoided to increase as possible. Then, a revised plan is considered that it should required the same sectional area as lone for the 3-shafts plan. For this reason, the 4-shafts plan was discarded.

The next best plan is that with 3-shafts, (Table-25, 3,4) on which is further studied.

1. Plan 4 in Table-25 is little more expensive as a whole rather than plan 3 because of its operation cost, so plan 3 is more reasonable.
2. In this plan-3 the wind velocity in the drive way is about 8.5 m/sec, still too fast for comfortability. To reduce the velocity, if the central one shaft is to be used for exhaust out of air, the almost same sectional area is needed as for the 2-shafts plan and the larger cost is to be required.
3. The second revision is made that the central shaft is built so as to work in both sending in air and out. The central shaft is considered to separate at the center of its section, with the diameter enlarged to be 8 m. However, the sectional area of tunnel remains same as the original, and further the logical maximum wind velocity in the drive way is reduced to 6.3 m/sec. Meanwhile, the construction cost is estimated to be $26,676,000.- increasing by 2.5% more than the original. (Fig. 19)

   After deliberation given to both economical and technical aspects of the construction, we reached the conclusion that the revision of the 3-shafts plan should be adopted.

FIG. 18

RELATION BETWEEN NUMBER OF SHAFT AND THE ESTIMATED CONSTRUCTION COST

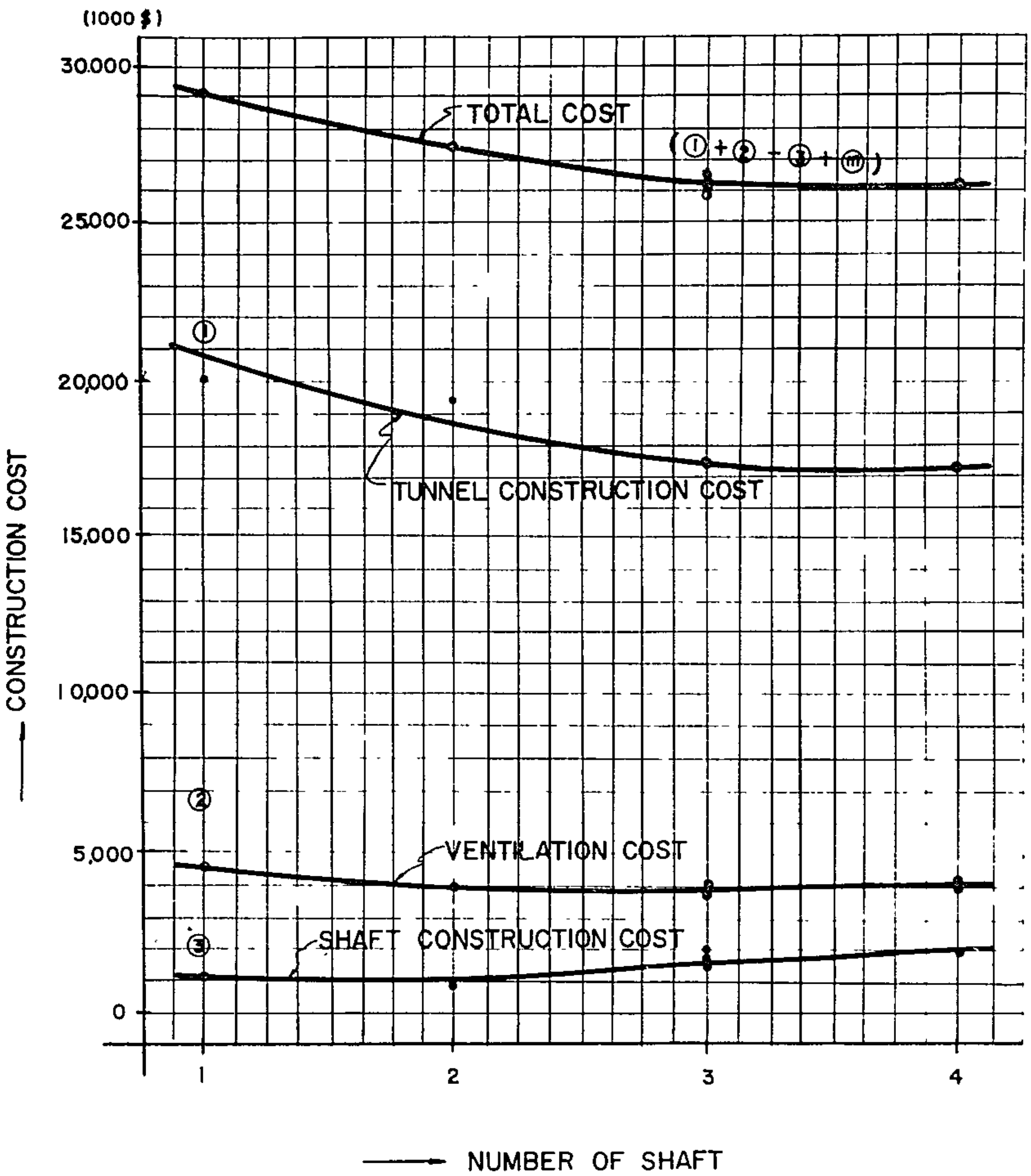
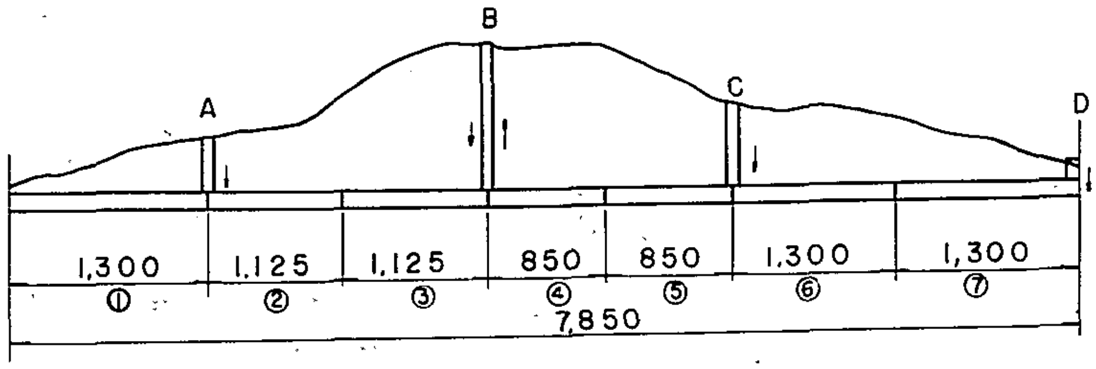
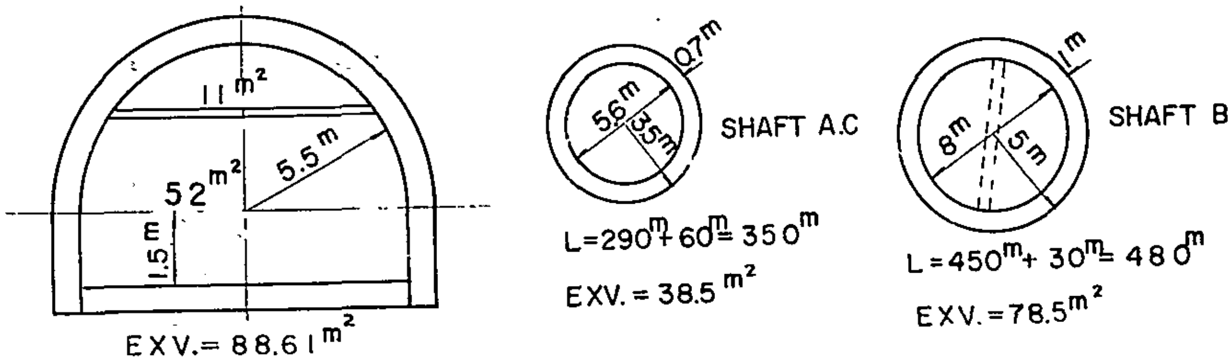


FIG. 19 REVISED PLAN FOR 3-SHAFTS

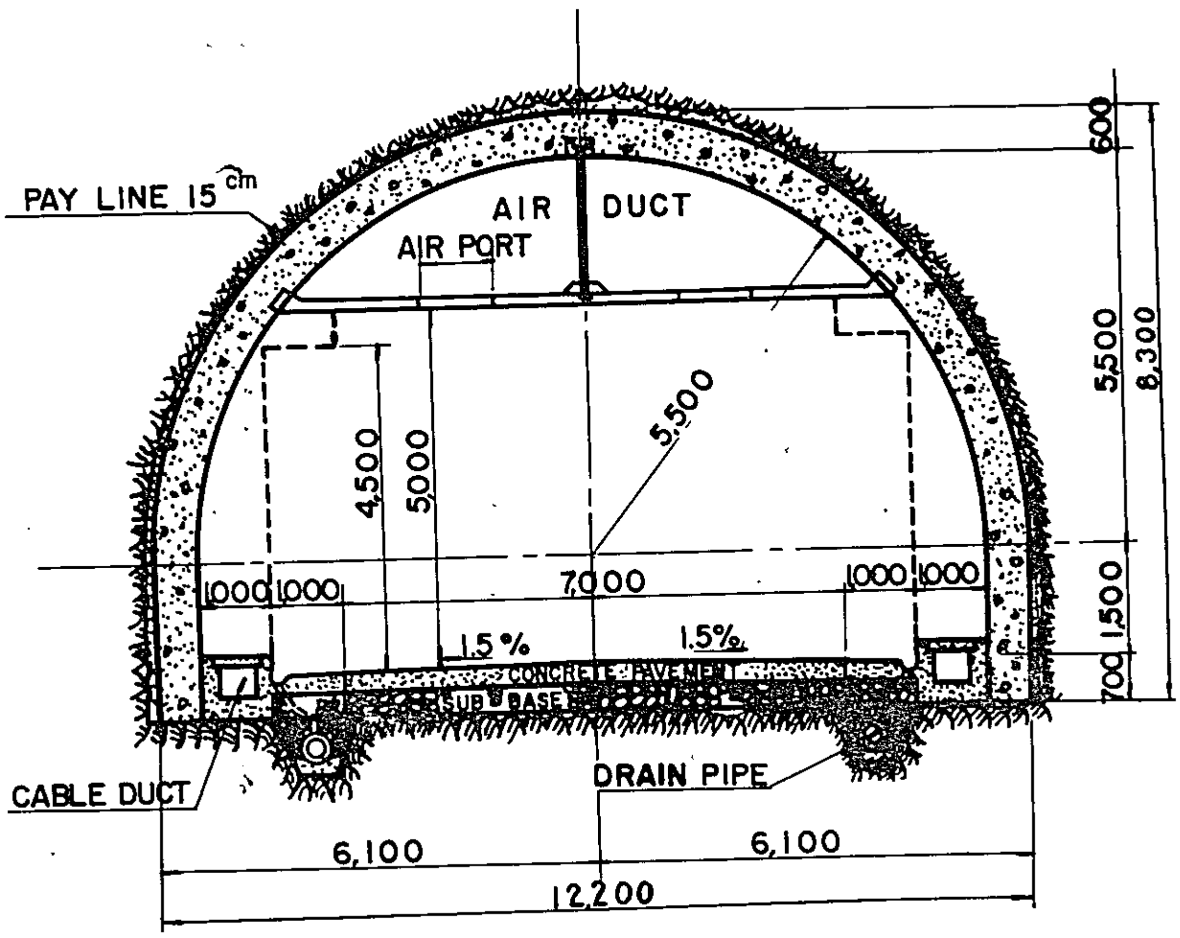




VENTILATION STATION	Q m^3/sec	H mmaq	HP kw
A	291	249	507
B B_1 (BLAST)	237	178	295
B B_2 (EXHAUST)	23[illegible]	60	20[illegible]
C	232	276	450
D	130	87	160
TOTAL	890 (237)		1,612

ESTIMATED CONSTRUCTION COST

TUNNEL	696,000 m^3 @	23.4 $	= 16,297,000 $
SHAFT	51,200 m^3 @	44.3 $	= 2,269,000 $
VENTILATION	[illegible] kw @	2,130 $	= 3,435,000 $
OTHERS			4,5[illegible]5,[illegible]00 $
TOTAL			26,576,000 $



AIR DUCT	11.0 m²/m
DRIVEWAY	52.0 m²/m
EXCAVATION	88.61 m²/m

DAHR EL BAIDAR TUNNEL PROJECT		
STANDARD CROSS SECTION OF THE PROPOSED TUNNEL		
JAPANESE SURVEY TEAM FOR THE TUNNEL CONSTRUCTION PROJECT IN LEBANON		
MARCH 1964	SCALE 1/100	FIG. 20

4. ESTIMATION OF CONSTRUCTION COSTS AND MAINTENANCE EXPENSES:

The construction costs and maintenance expenses for the 3-shafts improved tunnel studied in the previous chapter will be estimated in detail in this section.

a. Stages of Construction

The construction costs and maintenance expenses amount considerably high. Therefore, such equipment and utilities absolutely necessary should be provided so as to minimize expenses and shorten the period of Redumption. It would be no use to install from the beginning a complete equipment and utilities which meet the requirements 20 years later. It is recommended that only necessary equipment and utilities be installed in the 1st construction stage, i.e. first 10 years. Additional equipment and utilities necessary to meet the requirements 20 years later will be provided in the 2nd construction stage. In the 1st construction stage, the shafts, A, C and the portals will be constructed and the remaining shaft, B, be constructed in the 2nd construction stage. In this way, the traffic of the final year (1981) will be handled for 13 years with the equipment and utilities installed in the 1st construction stage.

The amount of ventilation at the wind velocity inside the tunnel of 6 m/second and the sectional area of tunnel of $52m^2$ will be:

$$52 \times 6 = 312 \ m^3/sec.$$

Therefore, the total of both portals will be:

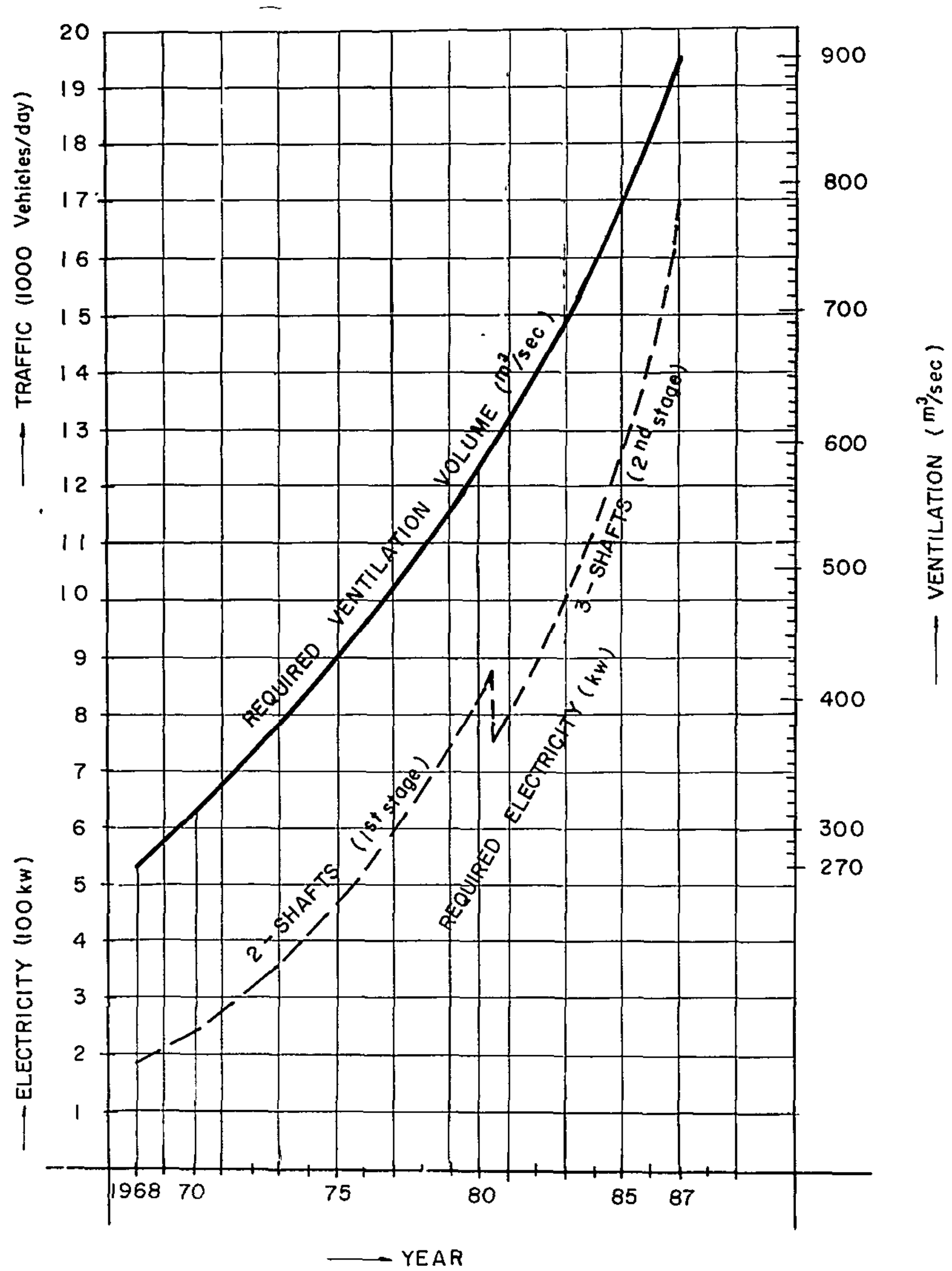
$$Q = 312 \times 2 = 624 \ m^3/sec.$$

Now we find out how much electricity would be necessary for the equipment to meet the ventilation demand and in what year such ventilation demand become necessary.

From the Fig. 21, the traffic volume against $Q = 624 \ m^3/sec$ is

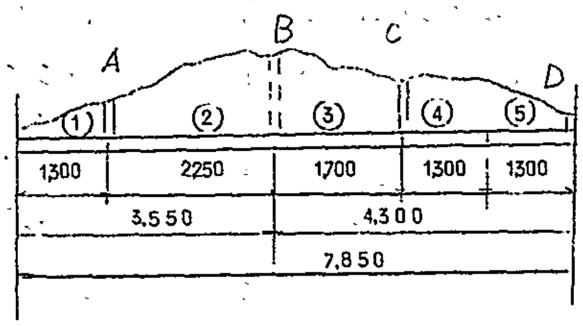
FIG. 21

RELATION BETWEEN THE TRAFFIC AND VENTILATION



approximately 13,200 cars/day. This traffic volume will appear in 1981.

The following calculation is based on a traffic volume of 1,400 cars/day:



1st const. Stage	Q m^3/sec.	110 + 189 = 299		143 + 91 = 234	91 91	Σ = 624 m^3/sec.
	H mmaq	249.3		212.6	53.7	
	HP kw	522		348	70	Σ = 940 kw
	Installed Capacity	170^{kw} x 4 sets		150^{kw} x 4	80^{kw} x 2	Σ = 1,440 kw (10 sets)
2nd const. Stage	HP kw		295 (200)		90	$1{,}612-940=672^{kw}$
	Installed Capacity		150^{kw}x3 (100^{kw}x3)		80^{kw}x1 set	830^{kw} (7 sets)
	Q m^3/sec.	291	237(237)	232	130	Σ = 890(237) m^3/sec.
Total	HP kw	507	295 (200)	450	160	Σ = $1{,}612^{kw}$
	Installed Capacity	170^{kw}x4sets	50^{kw}x3 (100^{kw}x3)	150^{kw}x3	80^{kw}x3	Σ = $2{,}270^{kw}$ (17 sets)

As shown above, the 1st stage construction will require the installed capacity of 1,440 KW. Now that the supplemental equipment and utilities may be completed until the beginning of the 2nd construction stage (1980), the construction of shaft "B" will be completed in the end of 1979 if it is commenced from 1978 and presuming its construction period as about 20 months.

The construction costs will be estimated on the plan mentioned above.

b. Estimation of Construction Costs:

The results of estimation are summerized below:

Its details are shown in the tables to follow. (unit: us $)

	Items	1st Stage Construction	2nd Stage Construction	Total
1.	Preparatory Works	346,000	52,000	398,000
2.	Tunnel Construction	15,899,000	0 -	15,899,000
3.	Shafts Construction	706,000	1,563,000	2,269,000
4.	Ventilation Facilities	2,622,000	813,000	3,435,000
5.	Lighting Facilities	569,000	0	569,000
6.	Public Safety Measures	566,000	0	566,000
7.	Freight	1,088,000	132,000	1,220,000
8.	Import Duties	565,000	55,000	620,000
9.	Engineering and Administration Fee	1,600,000	0	1,600,000
	Total	23,961,000	2,615,000	= 26,576,000

Note: 1) The shafts construction cost for the 1st construction stage includes:

A = 130 m

C = 160 m

Connecting gallary with a inside diameter of 5.60 m

Exacavated earth volume of 13,500 m^3

The cost for the 2nd stage covers;

B = 480 m

Inside diameter = 8.0 m

Excavated earth volume = 37,700 m^3

2) The cost for ventilation facilities is devided into as follows:

For the 1st stage -

940 KW

10 sets of fan

3 ventilating towers

For the 2nd stage -

672 KW

7 sets of fan

1 ventilating tower

The overhead duct of tunnel will be constructed in the 1st construction stage.

C. ESTIMATION OF MAINTENANCE EXPENSES

The annual maintenance expenses covers ventilation, illumination, security, maintenance, etc. Fig - 21 shows the result of our study on the relation between traffic volume and required ventilation volume, i.e. required electric power. The annual expenses based on this will be as follows:

For the 1st Construction State -

Operating Expenses

The electric power required for ventilation annually is an average of 446 KW according to Table 21. Considering the ratio of actual operation as 2/3;

$446^{KW} \times 12^{h} \times 365^{day} \times 2/3 \times 0.023^{\$}$	$= 30,000^{\$}$
Illumination	
$360^{KW} \times 16^{h} \times 365 \times 0.023^{\$}$	$= 48,400^{\$}$
Others	$= 10,100^{\$}$
Sub Total	$88,500^{\$}$

Maintenance Expenses

Maintenance Expense for average of 4 fans/year

		4 x 4,200$	= 16,800$
Various Machinery		20%	= 3,400$
Tunnel			= 15,000$
Facilities for Security			= 7,000$
Illumination	½ of all illumination	4,500 x ½ x 20$	= 45,000$
Sub Total			87,200$

Direct Personal Expenses

Superintendent	1	560$ x 12	= 6,720$
Engineer	2	350$ x 2 x 12	= 8,400$
Operator	6	250$ x 6 x 12	= 18,000$
Assist. Operator	3	220$ x 3 x 12	= 7,920$
Clerical Worker	2	170$ x 2 x 12	= 4,080$
Inspector	2	180$ x 2 x 12	= 4,320$
Sub Total			49,440$
Total			225,140≑226,000$

For the 2nd Construction Stage

Operating Expenses

Annual mean electric power for fans according to Fig. No. 21 = 985 KW

985 KW x 12h x 365 x 2/3	= 66,334$
Illumination	= 48,400$
Others	= 10,100$
Sub Total	124,834$

Maintenance Expenses

Fans	6 x 4,200	= 25,200$
Various Machinery	20%	= 5,000$
Tunnel		= 15,000$
Facilities for Security		= 7,000$
Illumination		= 45,000$
Sub Total		97,200$
Direct Personal Expenses		= 58,000$
Total		280,000$

Table 26

Construction Cost Estimate

- A -

	1st Stage Construction			2nd Stage Construction			Total
	Imported Construction Materials & Engineering Service from Japan ($)	Construction Materials & Labor provided at site ($)	Sub Total ($)	Imported Construction Materials, Engineering Service from Japan ($)	Construction Materials & Labor provided at site ($)	Sub Total ($)	($)
1 Preparatory Works	-	346,000-	346,000-	-	52,000-	52,000-	398,000-
2 Tunnel Construction	6,675,000- (7,260,000-)	9,224,000-	15,899,000- (16,484,000-)	- -	- -	- -	15,899,000- (16,484,000-)
3 Shafts Construction	343,500- (515,500-)	362,500	706,000- (878,000-)	480,000- -	1,083,000- -	1,563,000- -	2,269,000- (2,441,000-)
4 Ventilation Facilities	2,074,000-	548,000-	2,622,000-	515,000-	298,000-	813,000-	3,435,000-
5 Lighting Facilities	406,000-	163,000-	569,000-	-	-	-	569,000-
6 Public Safety Measures	446,000-	120,000-	566,000-	-	-	-	566,000-
7 Freight	537,000-	28,000-	565,000-	50,000-	5,000-	55,000-	620,000-
8 Import Duties	-	1,088,000-	1,088,000-	-	132,000-	132,000-	1,220,000-
9 Engineering and Administration Fee	1,600,000-	-	1,600,000-	-	-	-	1,600,000-
Total	12,081,500- (12,838,500-)	11,879,500-	23,961,000- (24,718,000-)	1,045,000- -	1,570,000- -	2,615,000- -	26,576,000- (27,333,000-)

Note: Figures of Items 2 & 3 include the hire of construction machinery. For comparison their purchasing prices are listed in parentheses. The figure in parentheses is total column includes prices of construction machinery.

Table 26
Construction Cost Estimate
- B -

		1st Stage Construction			2nd Stage Construction			Total
		Imported Construction Materials, Engineering Service from Japan ($)	Construction Materials & Labor provided at site ($)	Sub Total ($)	Imported Construction Materials, Engineering Service from Japan ($)	Construction Materials & Labor provided at site ($)	Sub Total ($)	($)
1	Construction Materials	2,673,500-	6,216,500-	8,890,000-	210,000-	620,000-	830,000-	9,720,000-
2	Labor	-	4,547,000-	4,547,000-	-	583,000-	583,000-	5,130,000-
3	Construction Machinery	1,828,000 (2,585,000-)	- -	1,828,000- (2,585,000-)	- 210,000	- -	- 210,000-	1,828,000- 2,795,000-
4	Installed Machinery	3,150,000-	-	3,150,000-	575,000-	-	575,000-	3,725,000-
5	Freight	537,000-	28,000-	565,000-	50,000-	5,000-	55,000-	620,000-
6	Import Duties	-	1,088,000-	1,088,000-	-	132,000-	132,000-	1,220,000-
7	Miscellanous Expenses at site	2,293,000-	-	2,293,000-	-	230,000-	230,000-	2,523,000-
8	Engineering and Administration Fee	1,600,000-	-	1,600,000-	-	-	-	1,600,000-
Total		12,081,500- (12,838,500-)	11,879,500- (11,879,500-)	23,961,000- (24,718,000-)	1,045,000-	1,570,000-	2,615,000-	26,576,000- (27,333,000-)

Note: Figure of Item 3 include the hire of construction machinery.
For comparison their purchasing prices are listed in parentheses.
The figure in parentheses is Total column includes the prices of construction machinery.

B. Access Road

1. Outline

The presumed traffic volume in future on the access road was obtained in the Traffic Study 5. For the volume, the section of road is to decided. The access road runs from Hazmieh to Hammana for about 28 km through the main villages of Aley and Bhamdoun. Besides, the branch roads have to be taken into consideration so as that they pass through neighboring several villages. When further consideration is given to the neighboring topograph, it is difficult that the provision concerning Freeway of Lebanon Highway Design Standard may be applicable for this plan as it is. Therefore, the access road is designed an expressway as on classification. The definition of expressway in the design standard is that "a devided arterial highway for thorough traffic with full or partial control of access and generally with grade separation at intersection."

2. Decision of various factors regarding the section of road.

According to "Design Capacity of Traffic lanes of Multilane Rural Highway Table III" of the Design Standard, the definition of the expressway is such as follows:-

Table - 27

Item	Width of lane in meter	Percentage of commercial vehicles	Design capacity Average / Lane of V.P.H. Expressway, Rural	
			Level	Rolling
1	3.5	0	1,000	1,000
2	3.5	10	910	770
3	3.5	20	830	630
4	3.25	0	970	970
5	3.25	10	880	750
6	3.25	20	810	610

In considering our case, the comparative ratio between the traffic volume per hour and the commercial vehicles as of 1986 is the abovementioned 3 sections, the following figures is obtained from Table 15, when the running hour per day is placed as 10 hours.

Table 28

V.P.H. for Each Section of Access Road

	HAZMIEH TO ALEY			ALEY TO BHAMDOUN			BHAMDOUN TO HAMMANA		
YEAR	Passenger Car	Commercial Car	% of Com. Car.	Pass. Car	Com. Car.	% of Com. Car	Pass. Car	Com. Car	% of Com. Car
1986	4,828	724	15%	2,688	400	15%	3,080	445	14%

Judging from Table 27 and Table 28, the percentage of commercial vehicle is nearly 15(%) and the design capacity average 1 lane of V.P.H. between the level blocks is made to be approximately 870 vehicles, presumed from Table 27. As the total number of vehicle amount to 5,552, the required number of lanes are: $\frac{5,552}{870} = 6.4$

In the same way, between Aley and Bhamdoun is calculated the required number of lane, 3.6. Between Bhamdoun and Hammana, 4. With all the figures put together into account, the following design is resulted:-

Table 29 Scheme of Access road dimensions

Section	Total Vehicles V.P.H.	% of Com. Car	Number of Lanes	Width of Lane (m)	Lateral Clearance (m)	Grade (%)
Hazmieh to Aley	5,552	15	6	3.50	1.8	Less than 5
Aley to Bhamdoun	3,088	15	4	3.50	1.8	"
Bhamdoun to Hammana	3.525	15	4	3.50	1.8	"

In the above design the allowable traffic volume per lane is a little upward of the design standard, the site for road should be prepared at present for the future extension or enlargement.

The study was made that the road be as an expressway, and it revealed that a considerable number of place should be formed as interchange at the present intersection points with branch roads. At the following points at least, the interchange should be set up to be a highway.

Interchange No.	Place	Direction of Interchange Activity
1	HASMIYEH	Route I to/From Beyrouth
2	BSOUSS	Route I to/From South
3	ALEY	Route I to/From Aley
4	BHAMDOUN	Bhamdoun & sofa to/From West
5	CHTAURA	Route I to/From North, South & West

The further detailed study should be based on the site investigation, and no more study is extended in this plan.

C. Execution planning of Tunnel construction.

i) Excavation

We adopt the excavation method basically to at the first step proceed through a Bottom heading, and secondly dig whole section. This technical method is adopted due that excavation are executed with the simultaneous geological survey, and also in the consideration for Spring-water.

a) Bottom heading

The demensions of the section are 3m x 3.5m (sectional area 7.6m^2). We use 2 - 3 sets of Leg rock-drill, and set the timbering of H steel 100x100 at each 1.5m. The work is done by three shift per day, and aid to excavate 250m of distance per month. use Rocker Shovel (RS-75) of 2 m^3/min. capacity, and put the milk on steel-cart (5m^3 capacity), connecting

6 carts to one, take out by battery cars of 10t.

b) Excavation whole section

We use Jambo with heavy-drifters TY150B for crushing rocks. Jambo - boom is all hydraulic. The work is by three shift per day, and excavated distance is 250m per month. In the places necessary of timbering, steel supports (200x200 or 250x250) are used every 1.5m. 2 sets of electric shovel of 4 m^3/m capacity are used, and cherry-picker 2 sets are used for changing steel-cart. The 6 steel-carts are combined to the train, and taken out muck by battery cars of 10t.

ii) Lining

For Concrete lining, steel mobil frame (L=25m) are used, and concreting are done by 2 sets of concrete-pump of 50 HP 250m per month is the aid. The conveyance of concrete is carried out by conveyar from agitation car (4m^3) up to the position of concrete-pump. The materials are as follows.

a) Cement

The cements used are Portland cement and blast-furnace cement. The storage is in the cement Silo, and keeps the volume of 30 days. Cement are conveyed by cement-car, and put into silo through air-flow, and also between silo and batcher plant supplied through air-flow.

b) Fine Aggregate

Rough sand 5mm - 12mm , separated from small stones of less 1.2mm are stand according to size in two places. The storage volume are 500 m^3.

c) Coarse Aggregate, separated from large stones of 55 mm - 30 mm and small stones 30mm - 5 mm , are stored in each kinds of sizes in two places. The storage volume is 500 m^3.

d) Measuring & mixing

Batcher-Plant with automatic measuring equipment are operated by 2 units of mixer (45 m^3/H) of one batch capacity 0.8 m^3, and the products are conveyed by agitator car.

iii) Blasting Ventilation

Explasion for excavation to be done by using DS detonator Electrically. Ventilation of tunnel are done 3 units ob by turbo-blower of 100 HP and through the pipe of 76cm. And 30 kg rails are used and constructed by three lane method of 36 inch gauge.

iv) Construction of Vertical shaft

A & C vertical shaft are bored by 7 units of Sinker drilling machine, and H steel 100x100 (17.2 kg/m) are used as timbering every 1m. The works are by three shift per day, and boring including living should be 25m distance per month. The muck are lifted by winch of 300 HP. B Shaft is bored by 12 units of Sinker boring machine, and H steel 100x150 (315 kg/m) supports are placed every 1m, and bored 25m per month. The muck are lifted by winch of 300 HP.

v) Compressor Facilities

The air-compressors are set in the following place with the following capacity. When boring machines are operated simaltaneously, we have to take the height of place into consideration, and allowable operating machine numbers have to be decided according to air consumption volume.

Cross-reference table of operating rock-crasher numbers and compressed air volume at each height.

Height	Number of rock-breaker 1	2	3	4	5	6	7	8	9	10	12	15	20
m	Coefficient												
0	1.00	1.8	2.7	3.4	4.1	4.8	5.4	6.0	6.5	7.1	8.1	9.5	11.7
300	1.04	1.9	2.8	3.5	4.3	5.0	5.6	6.2	6.8	7.4	8.4	9.9	12.2
600	1.08	1.9	2.9	3.7	4.4	5.2	5.8	6.5	7.0	7.7	8.8	10.3	12.6
900	1.12	2.0	3.0	3.8	4.6	5.4	6.1	6.7	7.3	8.0	9.1	10.7	13.1
1200	1.16	2.1	3.1	3.9	4.8	5.6	6.3	7.0	7.6	8.2	9.4	11.0	13.6
1500	1.21	2.2	3.3	4.1	5.0	5.8	6.5	7.3	7.9	8.6	9.8	11.3	14.2
2000	1.26	2.3	3.4	4.3	5.2	6.1	6.8	7.6	8.2	9.0	10.2	12.0	14.8

Note: Operating rate= coefficient/numbers of breaker

The calculation of air consumption in each works is as follows:

a) Rock-Drilling

Drilling of whole section - Heavy Drifter 18 setx4.5m^3/m = 81m^3/min

Bottom Heading - Leg Drill 3setx2.7" = 8.1m^3/min

Underground Water - Coal-Pick 10 set x 0.9" = 9.0 m^3/min

b) Timbering

Whole section arch air-hoist 7.5 HP 2 sets Efficiency 0.8

5.3 m^3/min x 2 x 0.8 = 8.4 m^3/min

c) Cart for conveyance of muck

Heading RS-75 1 set Efficiency 0.8

13 m^3/min x 1 x 0.8 = 10.4 m^3/min

d) Batcher-Plant Efficiency 0.7

5 m^3/min x 2 x 0.7 = 7.0 m^3/min

e) Forge, Repair Plant and others Efficiency 0.7

10 m^3/min x 0.7 = 7.0 m^3/min

Comparing as above, we find that air consumption is largest in the Heading work. The air volume is as follows. The operating rate when 18 Drills being operated is about 13/18 in the previous table.

$$(81 + 9.0) \times 13/18 + 10.4 + 7.0 + 7.0 = 89.3 \ m^3/min \doteqdot 90 \ m^3/min$$

The necessary horse power assuming capacity of 100 HP compressor is 12 m^3/sec.

$$90/12 \times 100 \ HP = 750 \ HP$$

We planned to set up 200 HP x 5 sets = 1,000 HP (one opening) compressor, less leakage from the connectors of pipes, and valves from above caluculated figure.

d. Compressors installation in Vertical Shaft.

A.C. Vertical Shaft

Excavation Sinker – 2.7 m^3/min , 7 units, 18.9 x 0.9 = 17 m^3/min

Batcher Plant & etc. Necessary horse power 2.7 m^3/min = 12 x 100 HP
225 HP

Therefore we install 100HP x 1 unit, 150 HP x 1 unit.

B Vertical Shaft

Excavation Sinker 2.7 m^3/min x 12 x 0.85 = 27.5 m^3/min

Batcher-Plant, etc. 10 m^3/min

Necessary horse-power 37.5 m^3/min ÷ 12 x 100 HP ≒ 313 HP

Therefore we install 100 HP x 2 unit, 150 HP x 1 unit.

vi) Construction Schedule

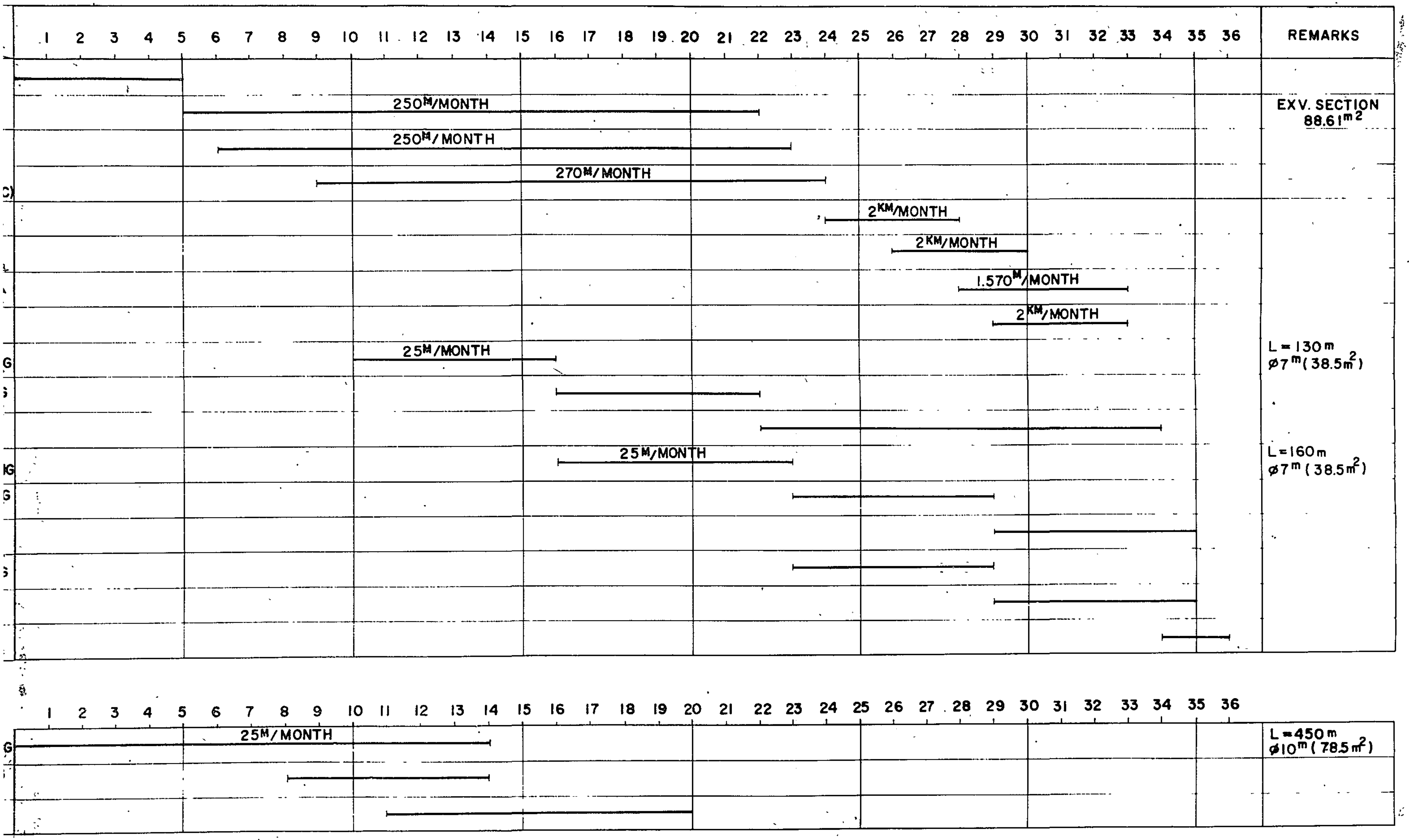
TABLE 30 CONSTRU

Stage	Shaft	ITEM \ MONTHS	1	2	3	4	5	6	7	8	9	10	11	12	13	14
FIRST STAGE		PREPARATORY WORKS														
		EXCAVATION											250^{M}/MONTH			
		CONCRETE LINING											250^{M}/MONTH			
		MISCELLANEOUS WORKS (CABLE DUCTS DRAINAGE, ETC)														
		SUBGRADE CONCRETE PAVING WORKS														
		AIR DUCT SLAB WORKS														
		ILLUMINATION EQUIPMENT														
		EMERGENCY EQUIPMENT (SIGNAL, TELEPHONE, ETC)														
	A SHAFT	EXCAVATION AND LINING											25^{M}/MONTH			
	A SHAFT	VENTILATING BUILDING WORKS														
	A SHAFT	EQUIPMENT														
	C SHAFT	EXCAVATION AND LINING														
	C SHAFT	VENTILATING BUILDING WORKS														
	C SHAFT	EQUIPMENT														
	D	VENTILATING BUILDING														
	D	EQUIPMENT														
		SETTLEMENT AND TEST WORKING														

Stage	Shaft	ITEM	1	2	3	4	5	6	7	8	9	10	11	12	13	14
SECOND STAGE	B SHAFT	EXCAVATION AND LINING							25^{M}/MONTH							
	B SHAFT	VENTILATING BUILDING WORKS														
	B SHAFT	EQUIPMENT														

TABLE 30 CONSTRUCTION SCHEDULE

TUNNEL LENGTH 7K850M



ii) OUTLINE OF MACHINARY INSTALLATION FOR TUNNEL CONSTRUCTION (West Portal)

Equipment	Specification	Unit	Quantity	Remarks
Compressor	200 1-P	Set	10	
Blast Pipe	8 inch	m	9,000	
"	3 inch	m	2,000	
"	2 inch	m	2,000	
Drill Jamboo	w/18 boom hydronlic	Set	2	
Rock Drill	Heavy drifter TY-150B	Set	70	
"	Leg Hunmmer TY-24-L1)		20	
"	Leg Hunmmer w/transit for stopper		20	
"	Coal-pick CA-7		40	
Loading machine	Conway 100 (4m3/min)		6	
"	R S - 75 (2 m3/min)		4	
"	Train - Coader		2	
Protector	15 m cap., steel-mobile		2	
Carrige Cart	5 m 3 Capacity		50	
Chipler	"		2	
Bulldoza			4	
Still mobile frame	1 = 25 m		2	
Concrete - pumps	50 1-P		4	
Batcher Plant	Centomati c 0.8 m3 x 2		2	
Battery car			20	
Mercury Rectifier	30 kw		24	
Drainage Pumps	100 1-P		3	
Agitator Car			16	
Belt-Conveyor		m	500	
Aggregate Stock bin			12	
Cement Siro			2	
Supplying Pumps	20 1-P		6	
Water Pipe	3 inch	m	9,000	
"	2 inch	m	1,000	
"	1½ inch	m	3,000	
Rail	30 Kg.	m	27,000	

Nomenclature	Sprecification	Unit	Q'ty	Remarks
Crossing		set	40	
Timbering process machine	for H-shape steel	set	2	
Air-hoist			6	
Winch	15-30 HP		6	
Wood mill plant			2	
Repair machine			2	
Mis. machine			1	
Truck	7-10 t		8	
Light truck			4	
Passenger car			4	
Repair parts			1	

Viii) Outline of Machinery Installation for Vertical Shaft work (3 shafts)

Eqipment	Specification	Unit	Q'ty	Remarks
Compressor	150 HP		2	
"	100 HP		3	
Blast pipe	3 inch		400	
"	8 inch		600	
Rock drill	Sinker		40	
"	Coal Pick CA7		18	
Scaffold		set	2	
Batcher-plant	$0.4m^3$ 2 mixers w/accessaries		2	
Hoist	300 HP		2	
Drainage pump	200 HP		3	
Belt-conveyer	70 m/m width		200	
Aggregate stock bin	300 m^3		6	
Cement Siro			1	
Water Supplying pump	10 HP		3	
Air Hoist	2 inch		1,000	
Winch			3	
Truck	15 HP		3	
Mis. machines	7t - 10t		6	
Repair Parts			1	

ix) Outline of Electric Plant for Tunnel Construction (for one porter)

Use	Unit Capacity	Q'ty	Total Capacity
Compressor	200 HP	4	800 HP
Turbo-Blower	100	3	300 HP
Conway Shovel	100	1	100 "
Concrete Pumps	50	2	100 "
" Jamboo	5	2	10 "
Conveyer	5	2	10 "
Vivrator	2	10	20 "
Drainage Pump	100	1	100 "
Batcher Plant	30	2	60 "
Belt-Conveyor	30	2	60 "
"	10	3	30 "
"	5	3	15 "
Supplying Pump	20	2	40 "
Winch	30	2	60 "
Repair Plant		1	20 "
Lumber Mill			20 "
Sub-total			1,745 "
1,745 HP x 0.75 =			1,310 KW
Murcury Rectifier	30 kw	10	300 KW
Electric Welding Machine	10 kw	1	10 "
Lamps		1	100 "
Others			80 "
Total			1,800 KW

The efficiency is decided by combination of works. Assuming this o.6, actual capacity is:

1,800 KW x 0.6 = 1,100 KW

A. The electric capacity of A.C. Vertical Shaft.

Compressor	150 HP
Blower	100 "
Hoist	300 "
Drainage Pump	200 "
Winch	30 "
Others	20 "
Total	800 HP

800 HP x 0.75 = 600 KW

Necessary electric consumption during lifting muck is the largest.

100 + 300 + 200 + 20 = 620 HP

Actual capacity is 620 HP x 0.75 = 465 KW

Therefore we set 500 KW capacity.

B. The electrical capacity of B vertical Shaft.

Compressor	250 HP
Blower	150 "
Hoist	300 "
Drainage Pump 200 HP x 2	400 "
Winch	30 "
Others	70 "
Total	1,200 HP

1,200 HP x 0.75 = 900 KW

150 + 300 + 400 + 70 = 920 HP

Actual capacity 920 x 0.75 = 690 KW

We set 700 KW capacity.

As a result, electrical capacity is as follows:

1.	West Portal	1,100 KW
2.	Shaft A	500 "
3.	" B	700 "
4.	" C	500 "
5.	East Portal	1,100 "
	Total	3,900 KW

§ VII Study of Economic Feasibility

1. Judgement of Economic Value

1-1. Outline

The tunnel route which we intend to construct will be required much expense. In every case of highway constructions, it goes without saying that the analysis is required for judging whether the expense of plan of highway is suitable and effective or not. Especially in case of comperative plans, they must be examined carefully. The basic idea of highway engineer is "A minimum of expense is, of course, highly desirable, but the road which is truly cheapest is not the one which has cost the least money, but the one which makes the most profitable returns in proportion to the amount which has been expended upon it."

There are basic terms which is the object of the economic examination as follows.

a) The solvency of each groups of Highway System.

b) The benefit which is caused from the construction and the improvement of highway.

c) Costs for construction or improvement of highway.

d) Upkeep of the highway and equipment belonging to the highway.

e) The benefit of road user of improved highway (The decrease of operation cost of vehicles and saving of time)

f) The improvement of comfort and convenience for road user.

g) The reduction of accident on highway.

Item c), d), e) and f) are possible to treat in detail herein. However, about other 3 items, it is impossible to express by figure because of it's character and the lack of value appears on the surface. Therefore, the project, which is mentioned here cannot be considered that it is the economic analysis in the wide sence.

As this is the analysis of correlation between road user benefit and capital cost, it cannot be the base of accurate decision of value regarding the road improvement plan in the strict sence. Neverthe-less, these are useful for comparison and examination of plan and the more elements are to be added to these, the more useful for determining of priority of any plan. Now, we are going to express the necessity and profit, by means of study of direct profits which could be calculated, and furthermore we express the indirect profits.

1-2. Analysis of direct benefit

This method is a means of comparison with the difference of annual cost of road user who have used the exist road and improved road. Again back to the table 7 we mention the road user cost which is our object of study. The difference of length in table from table 7 is due to the scope of object of study was limited by tunnel portion.

Table 31 Road user cost-2

Route	Length km	Road user cost $/km			cost $/car		
		Passenger Car	Bus	Truck	Passenger Car	Bus	Truck
Exst. Road	10	0.1	0.23	0.20	1.00	2.30	2.0
New Road	9	0.08	0.18	0.17	0.72	1.62	1.53
Tunnel Route	7.85	0.05	0.10	0.13	0.39	0.79	1.02

For the purpose of the calculation of road user benefit, we pick up and compare with the expense of every year from each plan. We study the ratio of deference of two plan of which expense of road user during basic period and the total charge for improvement, upkeep and working capital. We suppose the basic period is 40 years for both of the tunnel which we intend to construct and of new or exist road. In consequence, the benefit cost ratio would be expressed as follows

$$(\text{Benefit cost ratio}) = \frac{(\text{Benefits})}{(\text{Costs})} = \frac{\text{Diff. in Road user costs}}{\text{Diff. in Highway costs}} (1) \ldots (1)$$

The accrument for capital of improvement of road would be mentioned as the benefit of road user. Annual road user cost is the total of the cost for operating car and time cost.

Annual highway cost is the total of annual capital cost and, operating cost including cost of all equipments and maintenance.

And annual capital cost is the redeem throughout of year.

i) Calculation of Highway Cost

Calculation is as follows:

a) Tunnel route (basic bearing period 40 years)

Construction Cost (1st stage + 2nd stage)	$26,600,000
Operation Cost (mean value of 1st stage & 2nd stage)	$ 266,500

Rate of interest 4%

$$\text{Annual highway cost} = \frac{26,600,000}{40} + 0.04\ \frac{26,600,000}{40}$$

$$+ \ 266,500 = 958,100 \text{ per year}$$

b) Existing road (basic bearing period 40 years)

(In this case, repavement every 10 years)

Paving cost 450,000 x 4 = $180,000.00

Cost for removing snow $100,000.00 per year

4 x $100,000 = $4,000,000

Annual highway cost

$$= \frac{1,800,000 + 4,000,000}{40} = \$145,000 \text{ per year} \quad \ldots\ldots\ldots\ldots (3)$$

c) New road (basic bearing period 40 years)

Construction cost (the repairs would be construct every 20 years. Also in this case 4 lanes highway and the cost $200,000 per km).

($200,000 x 9) x 2 = 1,800,000 x 2 = $3,600,000.-

maintenance cost (6.8% of construction cost)

= 1,800,000.- x 36 x 0.068 = $4,406,400.-

Paving cost (25% of construction cost, every 10 years period)

= 1,800,000.- x 0.25 x 2 = $900,000.-

Cost for removing the snow

40 x 100,000 = $4,000,000.-

Total = $12,906,400.-

$$\text{Annual highway cost} = \frac{12,906,400}{40} + 0.04 \; \frac{12,906,400}{40}$$

$$= 322,650 + 12,900$$

$$= \$335,550 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

ii) Calculation of Annual road user cost

a) Average number of vehicle year between 1969 and 2008

Formerly in table 12 we mentioned the average daily traffic by 1986, moreover add 22 years' traffic to 40 years of the basic bearing period --- for simple expression, we look for the total of traffic after 1987 is as follows.

Table 32

Average Number of Vehicles Years Between 1969 and 2008

Year	Exist road to tunnel			New road to tunnel			Exist road to new road		
	Passenger Car	Bus	Truck	Passenger Car	Bus	Truck	Passenger Car	Bus	Truck
1969	5,099	99	624	4,777	90	567	3,947	74	483
1986	16,046	310	1,963	15,033	282	1,784	12,423	231	1,521
1987	16,046x22	310x22	1,963x22	15,033x22	282x22	1,784x22	12,423x22	231x22	1,521x22
2008	=353,012	= 6,820	= 43,186	=330,726	= 6,204	=39,240	=274,700	= 5,082	= 33,462
Total	528,129	10,201	64,612	494,790	9,278	58,719	410,355	7,603	50,064
Average	13,203	255	1,615	12,370	232	1,466	10,259	190	1,252

b) Annual road user cost

Table 33 Annual road user cost

	Toute	Type of Car	Average Vehicle N (from Table 14)	Cost/Car/day (from Table 12) C_1 $	Cost/Car/year C_2 $=C_1 x 365$ $	Cost/year C $= N \times C_2$ ($)	Total Cost ($)
1	Existing Road	Passenger Car Car	13,203 (10,259)	1.0	365.0	4,819,100 (3,744,500)	
		Bus	255 (190)	2.3	839.5	214,100 (159,500)	
		Truck	1,615 (1,252)	2.0	730.0	1,179,000 ((914,000)	6,212,200 (4,818,000)
2	New Road	Passenger Car Car	12,370 (10,259)	0.72	262.8	3,250,800 (2,696,000)	
		Bus	232 (190)	1.62	591.3	137,200 (112,300)	
		Truck	1,468 (1,252)	1.53	558.5	819,900 (699,200)	4,207,900 (3,507,500)
3	Tunnel Route	Passenger Car	13,203 12,370	0.39	142.4	1,880,100 1,761,500	
		Bus	255 232	0.79	288.4	73,500 66,900	
		Truck	1,615 1,468	1.02	372.3	601,300 546,500	2,554,900 2,374,900

Note:

1. Division ① in average vehicle number N column expressed the traffic conversion from Existing Road to Tunnel. The figure in parenthesis express the vehicles will convert from existing road to new road. Calculation of benefit cost ratio between two routes, we use the one traffic volume for those two routes for example, for calculating the ratio between new road and tunnel route. It must be used the figure on first line on division ② and the figure on second line on division ③

2. The figure expressed by parenthesis on the column of the cost/year and total cost are corresponded to the figure expressed by paremthesis on the column of average vehicle N.

iii) Determination of benefit Cost Ratio

The expression of benefit cost ratio which was formerly mentioned could express in other words as follows

$$\text{Benefit cost ratio} = \frac{R - R_1}{H_1 - H}$$

For explaining simply ① = Exist road ② = New road.

R = annual road user cost of existing road (compare with ① and ② or ③)
New road user cost of new road (compare with ② and ③)

R_1 = Annual road user cost of tunnel route (compare with ③ and ① or ②)
- " - of new Road (② and ③)

H = Annual highway cost of exist road (① and ② or ③)
- " - new road (② and ③)

H_1 = Annual highway cost of tunnel route (③ and ① or ②)
- " - new road (① and ②)

According each benefit cost ratio could be calculated as follows;

1) Comparison between new road and tunnel route.

Refer the table-31, (2) and (3)

$$B.\ R\ (E/T) = \frac{R - R_1}{H_1 - HH} = \frac{6,212,200 - 2,554,900}{958,100 - 145,000} = 4.5$$

2) Comparison between new road and Tunnel route

Refer table-31, (2) and (4)

$$B.\ R\ (N/T) = \frac{R - R_1}{H_1 - H} = \frac{41,207,900 - 2,374,900}{958,100 - 335,550} = 29$$

3) Comparison between Exist road and New road

Refer table-31, (4)

$$B.\ R\ (E/N) = \frac{R - R_1}{H_1 - H} = \frac{4,818,000 - 3,507,500}{335,550 - 0} = 3.9$$

Note that the remodeling cost for the existing road is made equal zero, that because of it will not be required in case of the new road is constructed near the existing road, and the vehicles will convert on better condition of the new road. From the above 3 result we come to conclusion as follows.

$$(E/T) > (E/N) > (N/T)$$

$$4.5 > 3.9 > 2.9$$

The benefit cost ratio between existing road and tunnel is larger than the ratio of new road and existing road and tunnel. Accordingly, this result shows that the tunnel plan is the most profitable construction only upon the direct benefit.

3. Study for Indirect Benefit

In the items stated in (1) for our exonomic study, a) b) g) are very important, although they can not be showed in the figures directly. In this project, many indirect benefits are written but following are lust major benefits.

1) We can escape from snow, frost, and fog on Dahr El-Beida Pass.

2) Without traffic difficulty, passing hours can be shortened, and th all the schedules can be carried out smoothly.

3) As transportain volume by vehicles increase, the business can be done efficiently.

4) The access road does not have a bad effect to sightseeing (8 minutes, 60 km), but even dedicate a new value to it.

5) In tunnel, it is comfortable since the change of temperature is not so remarkable.

6) Since the traffic between Beyrouth and Damascus becomes smooth in a short time, the people of Beyrouth City can easily remove to Bekaa High Lands. In consequences the traffic condition in the city are improved, and also it is helpful to the population policy. To the peoples in the nearest areas it gives much advantages in many aspects.

7) To for those who are living in narrow Beyrouth City without any desire to improve the traffic condition, the tunnel contributes a new concept that one hour drive from suburbs to the city center is very comfortable for people specially workers.

8) Safely drive increases by construction of tunnel; the traffic accidents, which are now yielded by sharp curves as well as snow, frost and fog, will decrease. Beside actual decrease of accident, each drivers get free from the fear to accident.

9) Due to the aggregate of above metnioned benefits, the transportations of cargo in Beyrouth city and harbour are smoothly carried out, helping the development of industry.

Beside these, there are many benefits. Anyway with the realization of this plan , the effects to the other industries are very much prominent, which contribute to the development of Beyrouth City.

2. Reasonable Toll Rate

The decision of toll fee should be done with road user's costs. As stated above, there are direct and indirect benefits for road users. The user costs of each new road, old, and tunnel are as per Table 31 The difference of cost, yielded by the traffic conversion from old road to tunnel are as follows.

Passenger Car	1.00 \$ - 0.39 \$ = 0.69 \$
Bus	2.30 \$ - 0.79 \$ = 1.51 \$
Truck	2.0 \$ - 1.02 \$ = 0.98 \$

From above, we decide the reasonable toll fee. However we must be careful that above figures are conservative. Especially as to truck, the said figure are not including the loss from loading delay, and so actually there is the costs down exceeding to 0.98 \$.

Therefore, 0.69 \$ of passenger car, and 1.51\$ of bus & truck are still conservative. Beside this direct benefit (cost-down) there are indirect benefits. For this reason, if we charge to users 100% of direct benefits, this fee will not too high. The actual examples of Toll fee in the other countries are often overcharged the benefits received. From these examples, we presumed the fee within the benefits.

Passenger	0.6 \$
Bus	1.5 \$
Truck	1.5 \$

3. Redemption Plan

A. The amortization plan for this project is as follows:

a) Condition

		1st Stage (until 1979)	2nd Stage (after 1980)
1	Shaft	2	3
2	Construction Cost	23,961,000 ≒24,000,000 $	2,615,000 ≒2,650,000 $
3	Annual Expenses	226,000 $	280,000 $
4	Construction Period	3 years	1.5 years
5	Interest	4% per annum	
6	Commencement of Construction	1966	1980
7	Commencement of Business	1969	
8	Toll Rate	a. Passenger Car	0.6 $
		b. Bus	1.5 $
		c. Truck	1.5 $

Business Revenue

	Passenger Car	Bus	Truck
Toll Rate/Vehicle	0.6 $	1.5 $	1.5 $
Vehicle ratio	0.883	0.015	0.102

Table 34 Business Revenue Table-1

The Period	The Year	Traffic Volume / day				Income (unit : $1,000)			
		Passenger Car	Bus	Truck	TOTAL	Passenger Car Px0.6x365	Bus Bx1.5x365	Truck Tx1.5x365	TOTAL
1	69	5,099	99	624	5,822	1,117	54	342	1.513
2	70	5,528	106	676	6,310	1,211	58	370	1,639
3	71	5,974	115	731	6,820	1,308	63	400	1,771
4	72	6,421	124	791	7,336	1,406	68	433	1,907
5	73	6,900	133	844	7,877	1,511	73	462	2,046
6	74	7,392	143	904	8,439	1,619	78	495	2,192
7	75	7,905	152	967	9,024	1,731	83	529	2,343
8	76	8,433	163	1,031	9,627	1,847	89	564	2,500
9	77	8,991	174	1,100	10,265	1,969	95	602	2,666
10	78	9,565	184	1,170	10,919	2,095	101	641	2,837
11	79	10,192	197	1,247	11,636	2,232	108	683	3,023
12	80	10,850	209	1,327	12,386	2,376	114	727	3,217
13	81	11,541	223	1,412	13,176	2,527	122	773	3,422
14	82	12,280	237	1,502	14,019	2,689	130	822	3,641
15	83	13,095	253	1,601	14,949	2,868	139	877	3,884
16	84	13,970	270	1,709	15,949	3,059	148	936	4,143
17	85	14,935	289	1,827	17,051	3,271	158	1,000	4,429
18	86	16,046	310	1,963	18,319	3,514	170	1,075	4,759
19	87								

Table 35 Redemption Plan-1

(Unit: $1,000)

Period	Calendar Year	Construction Cost on Remaining Redemption	Interest (A)	Expenses for Tunnel (B)	TOTAL (A)+(B) = (C)	Business Revenue (D)	Amount to be allocated for Redemption (D)-(C)
	1966	8,000	320				
	67	16,320	653				
	68	24,973	999				
1	69	25,972	1,039	226	1,265	1,513	248
2	70	25,724	1,029	"	1,255	1,639	384
3	71	25,340	1,014	"	1,240	1,771	531
4	72	24,809	992	"	1,218	1,907	689
5	73	24,120	965	"	1,191	2,046	855
6	74	23,265	931	"	1,157	2,192	1,035
7	75	22,230	889	"	1,115	2,343	1,228
9	77	19,568	783	"	1,009	2,666	1,657
10	78	17,911	716	"	942	2,837	1,895
11	79	16,016	641	"	867	3,023	2,156
12	80	13,860+2,650/2 = 15,185	607	280	887	3,217	2,330
13	81	12,855+1,325 = 14,180	567	"	847	3,422	2,575
14	82	11,605	464	"	744	3,641	2,897
15	83	8,708	348	"	628	3,884	3,256
16	84	5,452	218	"	498	4,143	3,645
17	85	1,807	72	"	352	4,429	4,077
18	86	+2,270					

According to the table above, the loan will be ammortized in approximately 16 years and 5 months beginning from the commencement of business. In case the construction is executed in one stage, it requires 17 years and 3 months. (the details omitted)

B. The redemption period shown above has been calculated according to the standard basis. We are of the opinion, however, that there exists a larger difference between the road user cost of the present Beyrouth-Damascus Road and that of the new tunnel route. It is considered that fuel consumption on the present road with many hairpin curves and steep slopes is greater than that on a straight road. It is also considered that tire fatigue due to sideslip at curves will become more large on the existing road.

Japan Highway Public Corporation's test data on the relation has been used as a basis for the calculation of the road user cost of our case and with its result we have calculated toll fee and redemption period as shown hereunder:

Table 36 Road user cost-3 a.

(Based on the Statistical Data of Japan Highway Public Corporation)

		Running Speed (km/h)	Gradient Class (%)	Fuel (P/km)	Tires (P/km)	Oil (P/km)	Maintenance and Repairs (P/km)	Depreciation (P/km)	Time Cost (P/km)	Comfort & Convenient (P/km)	Sub Total (P/km)	Special Conditions(snow,fog, frost)(P/km)	TOTAL P/km($)
Existing Rd.	P.Car	40	7-9	8.20	4.60	0.80	8.70	3.60	8.30	1.20	35.40	0;86	36.26(0.12)
	Bus	20	"	12.40	3.50	1.00	10.10	4.20	18.50	1.50	51.20	20;39	71.59(0.24)
	Truck	"	"	15.00	4.20	1.20	13.20	5.10	22.30	1.80	62.80	1;75	64.55(0.22)
New Rd.	P.Car	50	3-5	5.50	3.00	0.80	6.50	2.60	6.60	1.10	26.10	0;69	26.79(0.09)
	Bus	30	"	0.50	2.00	0.90	9.10	3.70	18.50	1.50	44.20	13.60	57.80(0.19)
	Truck	"	"	10.22	2.40	1.10	11.00	4.40	22.30	1.80	53.20	1.17	54.37(0.18)
Tunnel R.	P.Car	60	0-3	4.20	0.40	0.20	2.00	1.50	5.20	0.80	14.30	—	14;30(0.05)
	Bus.	50.	"	7.30	2.70	0.70	6.00	2.50	9.20	1.20	29.60	—	29.60(0.10)
	Truck	"	"	9.30	3.70	1.00	7.90	3.20	11.20	1.40	37.70	—	37.70(0.12)

b.

Route	Length	Road user cost $/Km			Cost $/car/day		
		P.Car	Bus	Truck	P.Car	Bus	Truck
Existing Rd.	10	0.12	0.24	0.22	1.20	2.40	2.20
New Rd.	9	0.09	0.19	0.18	0.81	1.71	1.62
Tunnel R.	7.85	0.05	0.10	0.12	0.39	0.79	0.94

Cost Difference in Kind of Vehicle between Existing Road and Tunnel Route

Passenger Car	1.20 - 0.39 = 0.81 cent.
Bus	2.4 - 0.79 = 1.61 "
Truck	2.2 - 0.94 = 1.26 "

As shown above, it is considered that the difference of bus and truck, even taking an average of $1.5, would not be so large. However, the $0.2 difference becomes a large factor as passenger cars number many. Cost difference of $0.7 of passenger car, being the mean value of the previous case and present case, and the same figure of bus and truck have been applied for the calculation of ammortization period shown below.

Business Revenue

	Passenger Car	Bus	Truck
Toll Rate per Vehicle	0.7 $	1.5 $	1.5 $
Vehicle Ratio	0.883	0.015	0.102

Table 37 Business Revenue Table-2

Period	Calendar Year	Traffic-volumo/day				Inome (unit:$1,000)			
		P	B	T	Total	P×0.7 x365	B×1.5 x365	T×1.5 x365	Total
1	69	5,099	99	624	5,822	1,303	54	342	1,699
2	70	5,528	106	676	6,310	1,412	58	370	1,840
3	71	5,974	115	731	6,820	1,526	63	400	1,989
4	72	6,421	124	791	8,336	1,641	68	433	2,142
5	73	6,900	133	844	7,877	1,763	73	462	2,298
6	74	7,392	143	904	8,439	1,889	78	495	2,462
7	75	7,905	152	967	9,024	2,020	83	529	2,632
8	76	8,433	163	1,031	9,627	2,155	89	564	2,808
9	77	8,991	174	1,100	10,265	2,297	95	602	2,994
10	78	9,565	184	1,170	10,919	2,444	101	641	3,186
11	79	10,192	197	1,247	11,636	2,604	108	683	3,395
12	80	10,850	209	1,327	12,386	2,772	114	727	3,613
13	81	11,541	223	1,412	13,176	2,949	122	773	3,844
14	82	12,280	237	1,502	14,019	3,138	130	822	4,090
15	83	13,095	253	1,601	14,949	3,346	139	877	4,362
16	84	13,970	270	1,709	15,949	3,569	148	936	4,653
17	85	14,935	289	1,827	17,051	3,816	158	1,000	4,974
18	86	16,046	310	1,963	18,319	4,100	170	1,075	5,345

Table-38 Redemption Plan-2

(Unit: $1,000)

Period	Calendar Year	Construction Cost or Remaining Redumption	Interest (A)	Expenses for Tunnel (B)	Total (A) (B) ≈ (C)	Business Revenue (D)	Amount to be allocated for Redumption (D) - (C)
	1966	8,000	320				
	67	16,320	653				
	68	24,973	999				
1	69	25,972	1,039	226	1,265	1,699	434
2	70	25,530	1,022	"	1,248	1,840	592
3	71	24,946	998	"	1,224	1,989	765
4	72	24,181	967	"	1,193	2,142	949
5	73	23,232	929	"	1,155	2,298	1,143
6	74	22,089	884	"	1,110	2,462	1,352
7	75	20,737	829	"	1,055	2,632	1,577
8	76	19,160	766	"	892	2,808	1,816
9	77	17,344	694	"	920	2,994	2,074
10	78	15,270	611	"	837	3,186	2,349
11	79	12,921	517	"	743	3,395	2,652
12	80	10,269+2,650/2 ≈ 11,594	464	280	744	3,613	2,869
13	81	8,725+1,325 ≈ 10,050	402	"	682	3,844	3,162
14	82	6,888	276	"	556	4,090	3,534
15	83	3,354	134	"	414	4,362	3,918
16	84	+ 564					

According to the above table, the loan will be ammortized in approximately 14 years and 10 months beginning from the commencement of business. That is, in Case A 16 years and 5 months and in Case B 14 years and 10 months which gives a difference of 19 months. This matter should be restudied in the next stage and be determined.

4. CONCLUSION

The direct and indirect benefits which may be obtained from this tunnel project are as mentioned in the foregoing. Though this tunnel project requires a considerable investiment, it is clear that this project will well be paid off.

As to the Toll fees, we would say that they are still conservative figures and they will be understood when road users recognize the benefit of this tunnel. The ammortization period of approximately 15 years is considered short when compared with the prevailing situations in other countries.

Lebanon will receive great benefits from the materialization of this tunnel project having a good economic feasibility. Further the materilization will play an important role to give great vitality to the activities in Lebanon.

VIII RECOMMENDATION

With the results of our field investigation and study based on various materials and data, it is concluded that this Project to construct Dahr El Baidar Tunnel including its operation will help to minimize road user cost and time, and that it will be a best mean to ease the traffic problem in consideration of the present situations in Lebanon. The materilization of this project further help to invite tourists to Lebanon and to develop transportation, traffic, and industrial development which in turn increase the national wealth.

The people of Lebanon will receive great benefits from the tunnel both materially and morally.

We hope that the Lebanese Government will make a detail review on our study and give approval on our plan, analyzing method, and their results and that the Government will execute the tunnel construction considering its good economic feasibility.

We shall always endevour to provide our best engineering services for further development of this project of your Government.

THE DAHR EL BAIDAR TUNNEL PROJECT LEBANON