The BEIRUT-DAMASCUS TURNPIKE

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SCHOOL OF ENGINEERING

PROJECT REPORT

AMERICAN UNIVERSITY OF BEIRUT

P R E F A C E

The Republic of Lebanon has been striving since its independence to develop its network of roads to a standard conforming its international function. Several improvements were made on the system, but on the whole Lebanon has failed so far to catch the spirit of modern highway design.

The project put forth in the following pages is aimed at giving an example on how can Lebanon ameliorate this aggrieving situation.

In the preparation of this project, the author has received many valuable consultations and desires to particularly acknowledge his indebtedness to Dean C. Ken. Weidner of the A.U.B. Division Of Engineering, and Professor N. E. Manasseh of the A.U.B. School Of Engineering.

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I N T R O D U C T I O N

Ever since the dawn of history the means of transportation and the extent to which they were developed has always governed the destiny of many a nation.

The invention of the wheel revolutionized the means of transportation thru its numerous by-products. One of its latest by-products is perhaps today's multi-wheeled vehicle which is capable of safe speeds that only twenty five years ago sounded fantastic.

In our rapidly developing world it is evident that suitable roads to match our modern means of transportation are a shear necessity. The efficiency of transportation has become more than ever the governing factor in a nation's economic growth.

The Republic of Lebanon holds presently the enviable position of the Middle East's " Grand Mediterranean Terminal". However, there seems to be no garantee that the Lebanese Republic will continue to hold this privileged position which plays a very delicate and decisive part in its national economy unless it satisfies certain basic requirements. These requirements are of prime importance to any area handling transit.

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Lebanon's outstanding function requires it to possess a modern, efficient and dependable system of transportation. This system of transportation should be coordinated with similar systems in other Middle Eastern Nations. The focal and conveyor points of the systems have to be conveniently located without sacrificing their unity and efficiency .

The assets of Lebanon presently can be boiled down to two major items ; namely the port of Beirut, and the Beirut International Airport. These two items are by no means comparable in condition. The Beirut port is being neglected and misused though it possesses the potentiality of becoming a source of wealth to Lebanon. Its condition requires further discussion which is outside the scope of this thesis . Beirut International Airport is a valuable asset in a good condition and ranks among the world's best equipped airports.

It is quite regrettable to see how loosely has Lebanon considered the question of providing ample connections between Beirut and other adjoining centers. The Lebanese system of roads connecting Beirut to Syria falls far below the requirements of any acceptable international standards. Their inadequacy is beyond question. Driving on them has lately become unbearable and hazardous. Beirut will eventually lose its privilege to other potential competitors if Lebanon overlooks the urgent need of ameliorating the inefficient

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and unreliable transit process which is being handled thru the port of Beirut and its connections to Syria. The failure to act immediately will undoubtedly encourage a pending economic crisis.

In the following pages, an attempt has been made to study the problem of providing an efficient and reliable connection between Beirut and Syria. The projected connection is by no means the only item on the remedy to the situation discussed previously, but it is the first step in many which would have to be carried out before the transit problem is solved.

The project to be considered will be confined to studying the possibilities of connecting Beirut to Damascus efficiently and reliably.

Primary Considerations

The necessity of linking Beirut to Damascus arises from the fact that no ample connection exists at present. The Beirut-Damascus road is narrow, winding and badly rutted. Its dependability is questionable. The need for another highway which conforms with our modern means of transportation stands out more than ever before.

Beirut can be linked to Damascus in three different ways - a highway, a railway and a skyway. In the analysis to follow an evaluation of all three systems will be considered.

A. Highway Versus Railway.

A railway cannot be operated economically for the relatively short Beirut-Damascus distance of sixty miles. Moreover, it would be a rather slow and inefficient mean of transportation due to the steep course which it will have to follow.

Railroads are subject to radical changes in design which would render them absolete in a matter of few years. A good example is the monorail railway which Germany is experimenting with.

The standardization of a railway system in Lebanon is very difficult to achieve because of the contrasts in its physical nature. Even if such a system is realized it can never be operated economically in such a relatively small area as that of Lebanon.

A railway binds the trains to it. This characteristic makes it vulnerable in case of war. Major arteries should be of such a flexible nature so as to eliminate any such vulnerability.

A highway is very flexible. Its operating cost falls well within the economical range for short distances. Strategically, it is by far much less vulnerable than a railway.

The trend in car design development is towards making them more comfortable and safe at high cruising speeds on standard roads and highway. This trend makes a highway a much more established and permanent mean of transportation than a railway. In case future cars require any changes in modern super-highways they can be realised at very reasonable costs.

A highway will incite an increase of vehicular transport in the country which is greatly desirable in the case of Lebanon. Tourist trade and other items requiring vehicular transport are sources of wealth to the Lebanese Republic.

B. Skyway ? ?

A - Skyway cannot be operated within a reasonably economical range between Beirut and Damascus. An airliner consumes most of its fuel taking off, climbing high enough before clearing the Lebanese range of mountains and circling the airport awaiting its turn to land. A routine forty minutes avarage time will elapse in a normal Beirut - Damascus flight. Only five or six minutes of the total forty minutes flight is actually required to cover the horizontal distance of fifty miles which seperates the two capital cities. It is obvious that this fact puts air transport completely out of question as a mean of linking Beirut to Damascus. Moreover, it would create an undesirably high traffic intensity between the two airports which might be greater than their maximum capacitive rating.

The most efficient and feasible of all three ways is thus the highway.

C. Why a highway at all ?

The choice of a highway as a mean of connecting Beirut to Damascus offers the following advantages.

1. The provision of a proper connection between the two cities.
2. Saving of the transicut business of Lebanon from dying out.

3. Tying the valley of Bekaa' which is probably the Middle East's most valuable strategic ground to both cities . Bekaa' is a natural air base which is not seriously vulnerable to sea or air raids. The road will make its supply from Beirut and adjoining areas easy and dependable.

4. The proposed road will put B.I.A. at a reasonably short driving time from Damascus and its suburbs. This will boost the business of B.I.A. by making it the natural choice of air traffic originating from Damascus and its suburbs . The projected road puts B.I.A. at only an hour's drive from Damascus under any prevailing weather conditions.

5. B.I.A. might be abandoned some day for one reason or another. A reconciliatory airport will then be located conveniently halfway between both cities. Obviously the site to suit such a requirement would be Bekaa' valley. This airport would also fall along the course of the projected highway which will then serve as its link to both cities.

6. If highway is not constructed, Syria will eventually build an International airport of its own to serve Damascus. This will drain off Syria's

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technical potential. Moreover it will cost it a precious capital which is more badly needed for other basic developments. The technicians that would then be needed to run the airport are much more vital to Syria's development along industrial and agricultural lines. Also, such an event will cause both airports' budgets to suffer from a sizeable yearly deficit. It is a serious and an undesirable affair to allow two strongly competing airports to be so closely located. The ultimate issue of such an enterprise will undoubtedly prove to be detrimental to both nations.

The intangible returns of the projected highway are also of mentionable value. Above all, the road will serve as an outstanding example on what can modern engineering achievements do towards accelerating the prosperity of a nation.

Today's automotive industry seems to be concentrating on developing and producing cars that make driving safer at high speeds. To provide this safety, manufacturers have equipped their high powered cars with such features as power steering and power brakes. Also, modern suspension design allows cars to take sharp curves at high speeds without dangerous sway . To obtain maximum economy at high speeds, the carburation of these cars was designed to yield maximum efficiency at speeds of forty miles per hour and above. This fact dictates that in order to operate these cars economically, they should be able to cruise steadily at high speeds on roads designed for such purposes.

L O C A T I O N

The major factors which governed the selection of the route were the topography between controlling points, the purpose of the road, and other prevailing physical conditions.

The projected highway originates at Hazmiyeh. It then follows a course which leads it past Faiyadiyeh, Jamhour, and Rjoum. From Rjoum, it tunnels thru Dahr-El-Wahsh and continues in a route which goes past Chouite, Aabadiyeh, Baalshmayeh and Ras-El-Harf. At Ras-El-Harf it tunnels for thirteen kilometers under the mountainous regions up to a point south of Kaissar in Bekaa'. A more exact outline of the course can be obtained by inspecting the location plan.

The maximum elevation which the road hits above mean sea level is 875 meters. This maximum elevation is safely below the 900 - 1100 meters snow line. The existing highway rises to a maximum height of 1550 meters above mean sea level making the saving in rise which the present highway offers quite sizeable. A rough estimate of this saving in rise alone would be an incredible $ 900,000 per 100 vehicles per day (1) . This estimate is based on a car's cost of operation in the United States of America and dates back many years. Referred to up to date Lebanese standards the saving will run up to quite a few million dollars. These savings represent the capitalized value in yearly operation.

The total distance which the proposed highway location saves is approximately eight miles. This saving in distance and thus yearly cost of operation amounts to a capitalized value of $ 584,000 (2) - referred to U.S. standards in 1927.

Avoiding bad snow conditions, flood areas, needless stream crossings, needless railroad grade crossings and slide or swamp formations is an outstanding characteristic

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1) Harger and Bonney, <u>Highway Engineers' Handbook</u>, P.80.

2) Ibid.

which the proposed road will achieve. Excessive rock work is necessary in tunnels and deep cuts, but in the long run it is more economical than carrying the road over the Kanissah Range by bridging repeatedly across valleys and deep ravines.

Maximum grades are reduced to reasonable standards by the proposed location. This reduction in grade is achieved by increasing the distance at certain places. Since a short distance is desirable and advantageous the increase in distance is limited to localities where it offers other valuable advantages. Between Jamhour and Abadiyeh the increase in length saves a tremendous expense which will be incurred if both points are to be connected in a shorter route whereby a lengthy suspension bridge will be necessarry. Moreover, the grade which is thus obtained will be higher than what is specified as maximum. However the proposed " detour " does not seriously increase the total length of the highway.

The alinement and grading design results in safe and desirable features. All sight distances are within safe limits for the design speed of sixty miles per hour. Extreme impracticable refinements and excessive expenditures are avoided without sacrifice of good alinement. Few major drainage structures are necessary for the location of the route avoids needless river crossings and water courses.

A major factor which influences the proposed location is traffic control. Most traffic whose intensity is unpredictable and fluctuates highly is kept off the course of the highway. This is necessary in order to increase the efficiency of the highway and make it serve its purpose more justly. Traffic interference whose intensity peaks for short periods is undesirable and uneconomical to accomodate for relatively short distances on a thru international highway such as the proposed one. There always exists certain limitations to the scope which a highway's versatility can cover.

ACCESS

Access to the proposed road is limited to a desirable minumum number of points. Only five access points are to be provided throughout the extent of the highway which lies between Beirut and Bekaa'. This restriction of accessibility releives overcongestion and permits a greater over all efficiency of the highway.

Hazmiyeh is the first access point on the proposed location. At this point the outbound traffic is fed into two major roads; one leading towards the port of Beirut and the other leads towards Beirut International Airport thru Chiyah. Both feeder roads are existing at present but both need basic improvements. A sketch for the suggested separation at Hazmiyeh is shown in figure I.

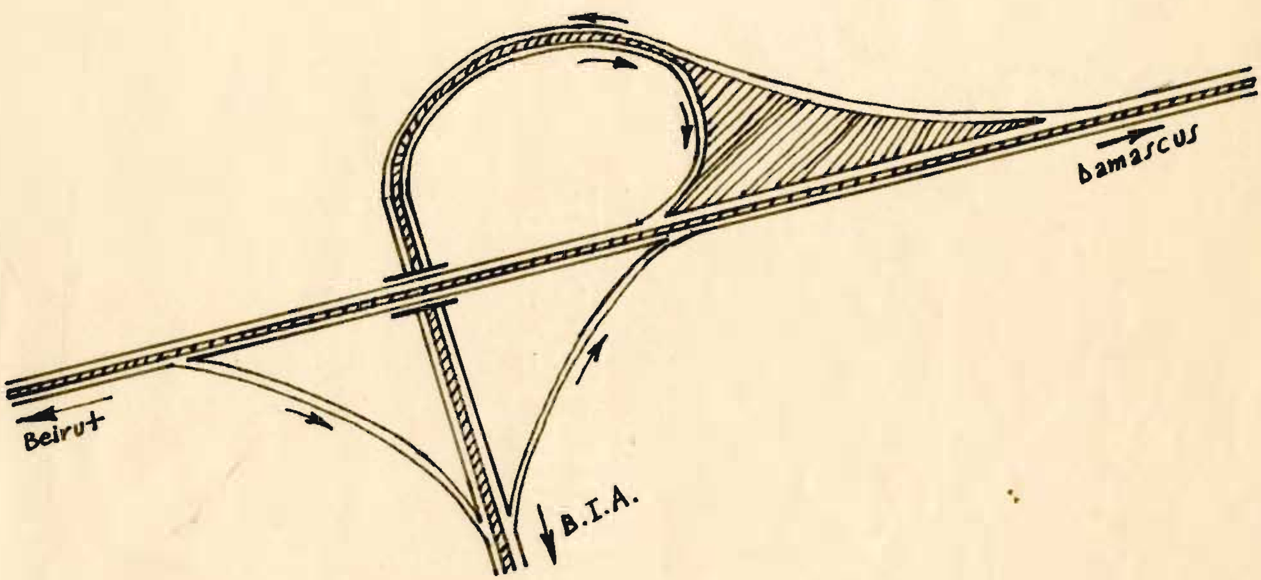

Fig. 1

The second point of access is located at the Baabda road junction with the existing Aley road at the start of the Jamhour hill. This point joins the proposed highway to the Baabda road thru a course which is indicated on the location plan. All Bsous-road bound traffic is fed thru this same junction. This is achieved by connecting the Bsous road and the Baabda road thru a short course which also appears on the location plan. Such a design permits a better control of traffic and avoids the overwhelming expenses which will result if a dual, multi-ramped intersection is attempted at Jamhour. Figure 2 shows a diagramatical representation of this second access point.

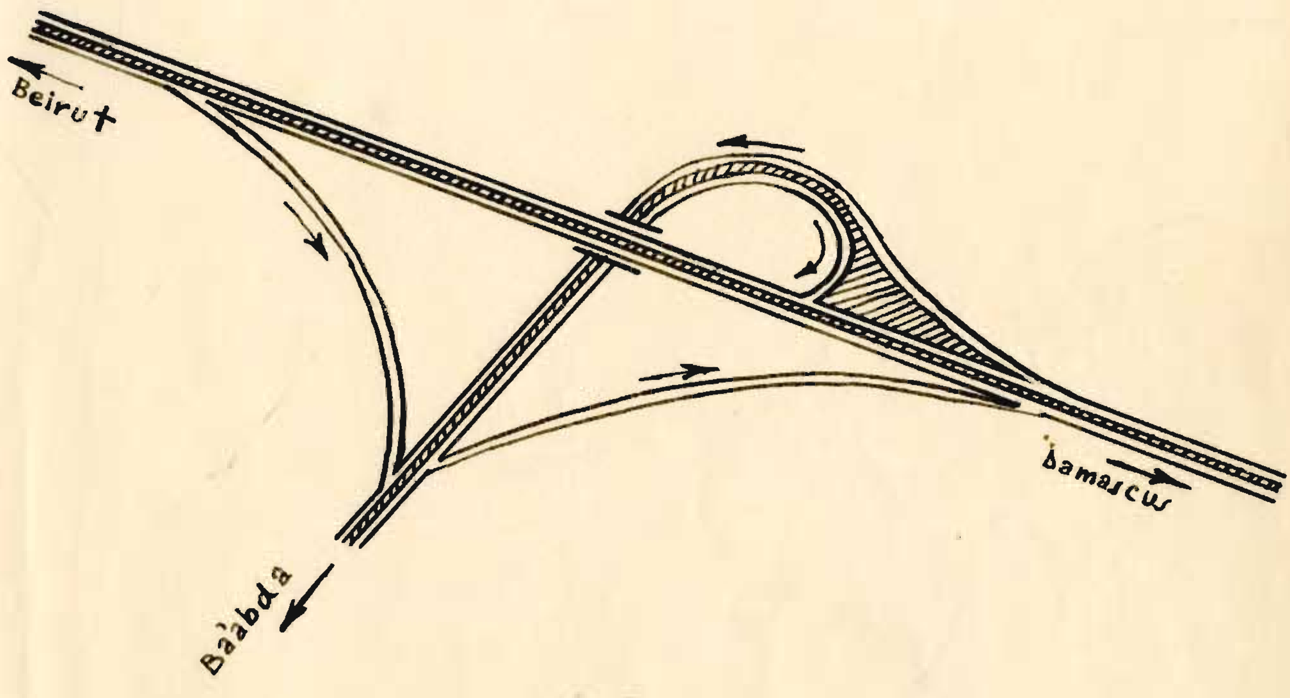

Fig. 2

At Sinndianneh are located the third access point on the highway and the first toll station. At this point the Aley road is separated from the main proposed highway. In figure 3 a suggested separation is shown roughly.

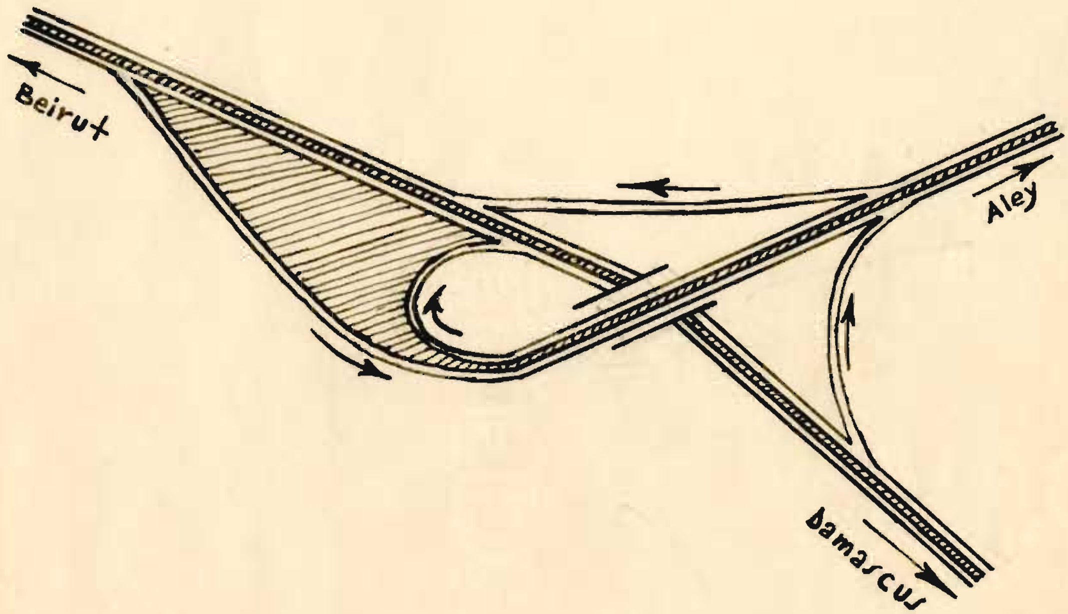

Fig.3

The fourth access point and second toll station are located at Ras-El-Harf. At this point the Chbaniyeh road meets the proposed highway thru an extension of the relocated Chouite - Abadiyeh - Qoubbey road. A rough representation of this intersection is shown in figure 4.

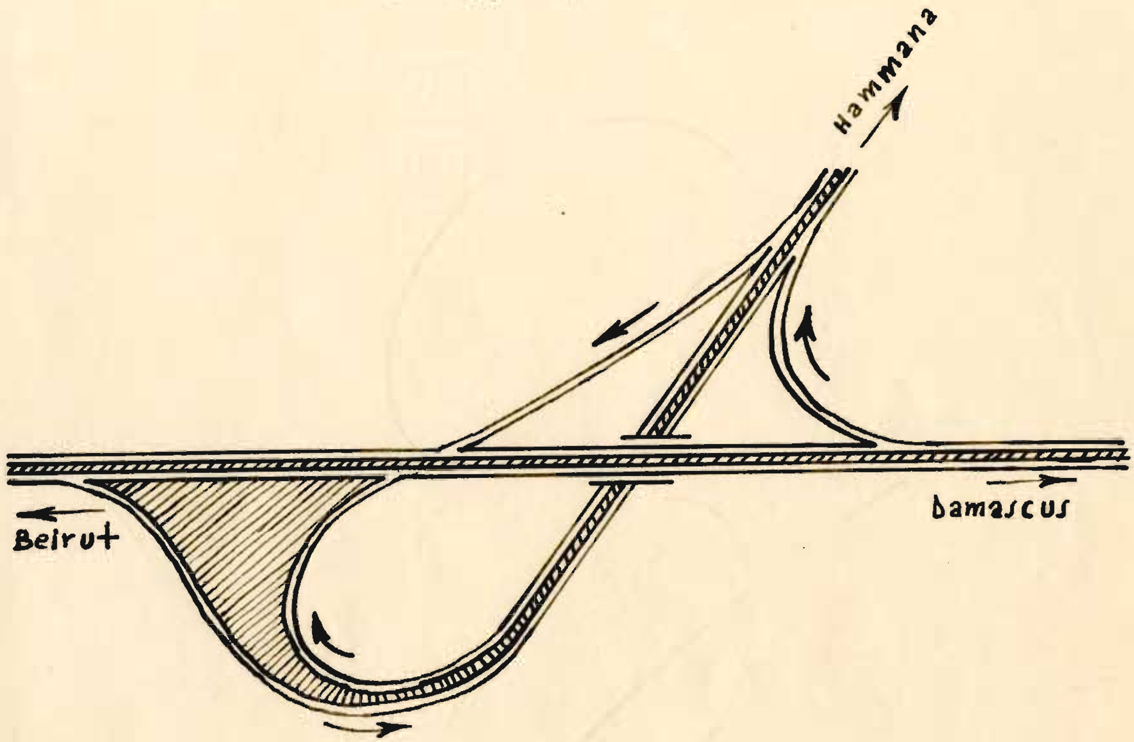

Fig. 4

South of Kaïssar - just before the portal of the proposed major tunnel - is located the fifth access point which also is the third toll station. Figure 5 shows a sketch which illustrates the suggested crossing at this point .

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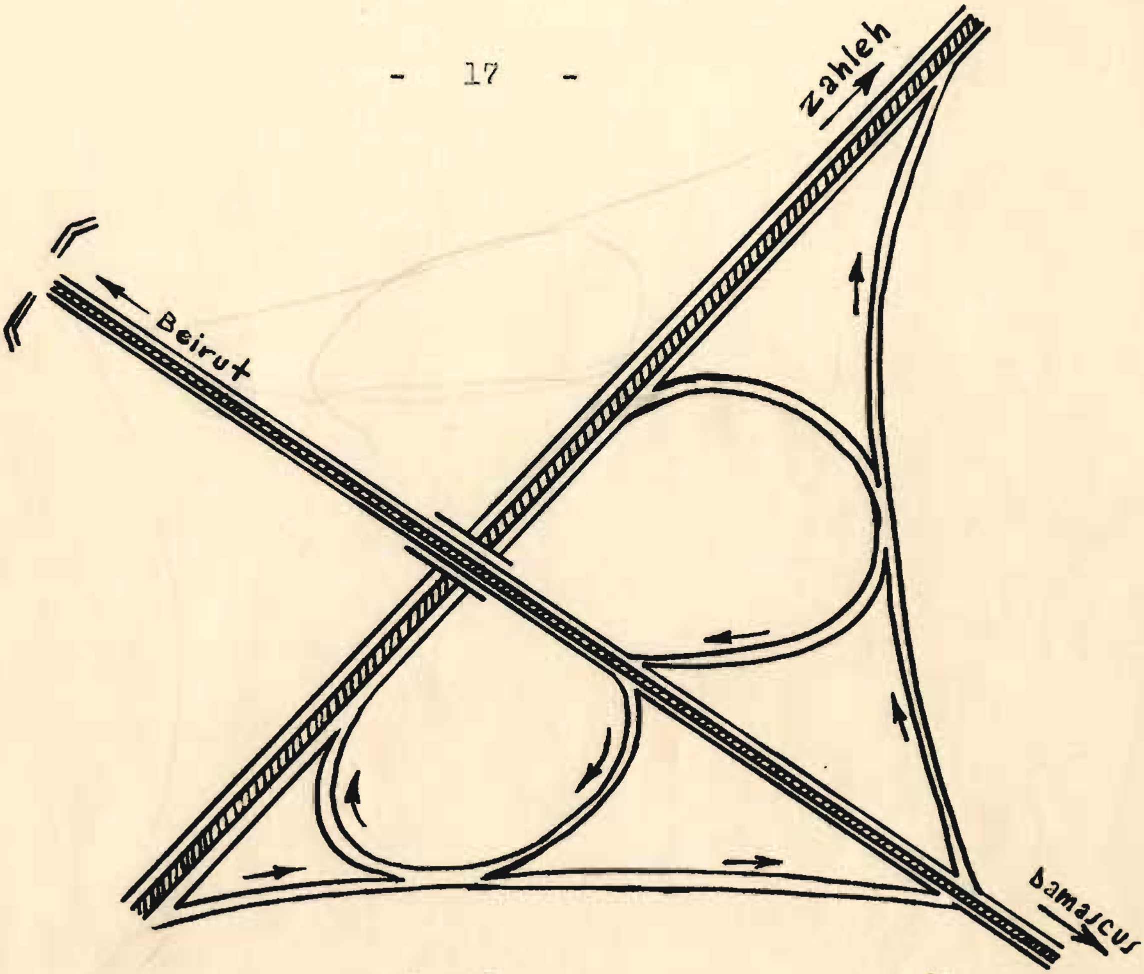

Fig. 5

The general policy which these grade separation designs adopts is the result of a basic consideration which involves both of two desirable features - economy and safety. Only at Kassar a two-ramp intersection is specified . All other intersections are of the T - trumpet type. Such designs are ample enough to feed the secondary roads from the proposed major highway and vice versa.

Geometric Standards Of Design

A. Design Speed

Various conditions have lead to the choice of 60 MPH as the ruling design speed. However the three factors that influenced this selection most of all were transfer time, vehicular operation economy and reasonable cost of construction.

Transfer time refers to the time which would be necessary for vehicular traffic originating from Damascus and its suburbs to reach B.I.A. and vice versa. This transfer time should not exceed certain desirable limits. It is estimated that such a transfer time should be short enough to allow B.I.A. bound passengers to cover the Damascus-Beirut distance within an hour and conversely. The assumed transfer time of one hour necessitates a design speed of approximately 60 MPH. B.I.A. requires presently an avarage 2 hrs. 15 min. transfer time from Damascus . The proposed time which would elapse in terrestrial transport will thus be comparable to most times which are required for transfer between other important cities and their airports. Table I lists up to date figures of the transfer times which separate major world cities from their airports.

TABLE I(1)

City	Airport	Transfer time
Amsterdam, Netherlands	Schiphol	45 Min.
Antofagasta, Chile	Cerro Moreno	40 Min.
Auckland, New Zealand	Whenuapai Field	45 Min.
Bangkok, Thailand	Don Muang	45 Min.
Bermuda	Kindley Field	45 Min.
Bueno Aires, Argentina	Ministro Pistarini	50 Min.
Calcutta, India	Dum Dum	45 Min.
Caracas, Venezuela	Maiquetia	75 Min.
Colon, Panama	Tocuman	75 Min.
Duesseldorf, Germany	Lohausen	50 Min.
Georgetown, B.G.	Atkinson Field	60 Min.
Glascow, Scotland	Prestwick	75 Min.
Honolulu, T.H.	Honolulu Inter.	40 Min.
Istanbul, Turkey	Yesikov	45 Min.
Johannesburg, U. of S. Africa	Palmietfontein	40 Min.
London, England	London Airport	60 Min.
Los Angeles, U.S.A.	L.A. International	45 Min.
Miami Beach, U.S.A.	Miami International	40 Min.
New York, U.S.A.	Idlewild	60 Min.
Oslo, Norway	Gardermoen	75 Min.
Paramaribo, Surinam	Zandery	60 Min.
Phildelphia, U.S.A.	International Airpt.	40 Min.

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City	Airport	Transfer time
Port of Spain, Trinidad	Piacco	45 Min.
Vienna, Austria	Tulln	45 Min.

1) Pan American World Airways System's time Table .

In the modern car, operation economy is strongly influenced by the engine's carburation efficiency . In the last few years, automobile manufacturers have acquired a tendency to design carburators which yield greater efficiencies at high speeds than ever before. Other engine and transmission design features have recently lead to satisfactory overall efficiencies at high speeds. Moreover, it can be justly said of the high-powered cars that it is most efficient and economical to operate them at comparatively high speed. High compression ratios and more perfected carburation processes are chiefly responsible for such an outstanding feat. Recent developments in the field of automotive industry give strong indications that in the next few years vehicular operation at high speeds will be well within a desirable range of economy.

The desire to reduce construction expenses without exposing the highway to the ultimate failure of achieving its basic aims, has led to the choice of 60 M.P.H. as the ruling design speed. Higher design speeds will undoubtedly necessitate many impracticable extreme refinements throughout the mountainous portion of the road. Such extreme refinements do not justify the expenses which will have to be undergone in order to provide these refinements. A ruling design speed of less than 60 mph. fails to secure the projected highway's high rating which its " raison d'être " dictates .

B. Alinement

Directness of alinement is an important consideration in the location of highways. This is because distance and transportation costs are related directly; However, there are two schools of thought in the matter of alinement details. The economist requires the straightest road which can possibly be secured with reasonable construction costs, whereas the land scaper demands winding alinement along the natural topographic contours with a minimum of cutting and filling. The economist has transportation costs in mind. The landscape engineer is chiefly concerned with appearances. It is the age-old controversy between science and art. Nevertheless, the highway engineer must, by intelligent compromise, develop alinement which will be reasonably direct but will include sufficient gentle curvature on natural contours to satisfy the demands of beauty on the part of highway users. This compromise should by no means interfere with the functional design of the road. The road should satisfy both requirements and still serve its purpose.

The science of highway design and construction alinement is chiefly influenced by safety, ease, speed, and hauling power of traffic and the cost of road construction. The proposed alinement satisfies remarkably all these requi-

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rements regardless of the fact that it is located in a mountainous region.

Wherever possible a radius of 10,000 ft. or greater will be given to obtain the flattest possible curvature. ~~The~~ Table II gives the suggested radii of curvature at the various design speeds.

TABLE II [1]

Design speed	Desirable minimum radius	Absolute minimum radius
75 MPH	5000 Ft.	5,000 Ft.
70 MPH	3000 Ft.	3,000 Ft.
60 MPH	3000 Ft.	3,000 Ft.
50[x] MPH	2500 Ft.	2,000 Ft.
40[x] MPH	2000 Ft.	1,800 Ft.

The minimum length of curves to be used including transitions is 600 ft. In rural areas the minimum distance between reversed curves shall be 1000 ft. and in urban areas 800 ft.[2]

1) Adopted from the geometric standards which were applied in designing the New-Jersey Turnpike.

2) Ibid.

Between curves which are in the same sense or direction the minimum distance shall be 2,500 ft. if the tangent and part of both curves can be seen by the driver. A flat curve shall connect curves in the same sense with an intervening tangent less than 2,500 ft. long unless no part of the far curve is visible to the driver while he is still on the near curve.[3]

Approaches to exit ramps from the main roadway are to be " spiraled " to a minimum radius of 200 ft. Minimum distance between reversed curves on ramps shall be designed to include runout distance for superelevation of both curves. [4]

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3) Ibid.

4) Ibid.

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x These speeds fall below the desirable ruling design speed of 60 MPH and might be encountered in a location such as the entrance to the first short tunnel at Rjoum.

These standards of design shall be utilized in order to give the highway maximum safety at the ruling design speed. They are also aimed at making driving on it easy if not a pleasure.

The purpose of spacing curves in the same sense or reversed ones is to enable cars to recover after taking a curve at the high speed of design . This space will act as an intermediary between two successive curves giving cars a chance to " adjust " themselves before going around the next curve.

C. Grades

In detailing the establishment of the grade line, there seems to exists two general tendencies. One tendency is to follow railroad practice as far as practicable, establishing long grades of low percent. Such grades are obtained by cutting down every hill and filling every valley, or bridging over it. The second tendency is to fit highway grades to the natural contours in gently rolling country as far as practicable in order to avoid heavy excavation and unstable subgrade conditions. This is based on the theory that highway economics is not governed by the same considerations as railroad economics. The first tendency of following railroad practice justifies large excavation quantities on the ground that lower unit costs result from large quantities, and that in any event the grading is but a relatively small part of the total cost of the complete highway construction.

On super-highway developments, between large cities the approach to railroad practice is undoubtedly justifiable, but on distinct rural road development the predominant trend is to avoid indiscriminate cutting at every rise in ground simply to reduce the grade by a negligible amount .

In establishing the grade line of the proposed highway both principles are satisfied by a clever choice of location . This is achieved without even sacrificing at any instant the advantages of one for the other. However, since the railroad practice theory is more applicable to the projected highway, it is emphasized more noticeably.

Theoretically, the most economical grade is one that will permit the vehicle to ascend in high gear at the most efficient engine speed and to descend without the use of brakes and without attaining too great a speed. On account of the wide difference in engine power of vehicles, driving habits of vehicle operators, vehicle loadings, gear ratios, wind resistance, rolling resistance, and braking power, and above all the continual changes in all these factor's, it is very difficult to design grades with any certainty that they will be the most economical ten or fifteen years from now.

It is a common practice in highway engineering to design main-line highway grades not exceeding 5 per cent in gently rolling country or 7 percent in rough country, but instead of resorting to sharp curvature it is permissible to use short 9 per cent grades . For modern traffic, a low gradient with numerous switch-back, or hairpin curves of short radius constitutes a great source of danger besides being impossible for a high design speed such as 60 MPH. Above all, a reasonably steeper gradient with flatter curvature will undoubtedly prove to be safer and more economical.

Grade has undoubtedly a great effect on motor operation cost. This was discussed previously under the topic of location. However, grade influences directly the fuel consumption of a vehicle. Figure 6 shows the results of a gasoline consumption test which was carried out on a private passenger automobile traveling at a constant speed on various grades.

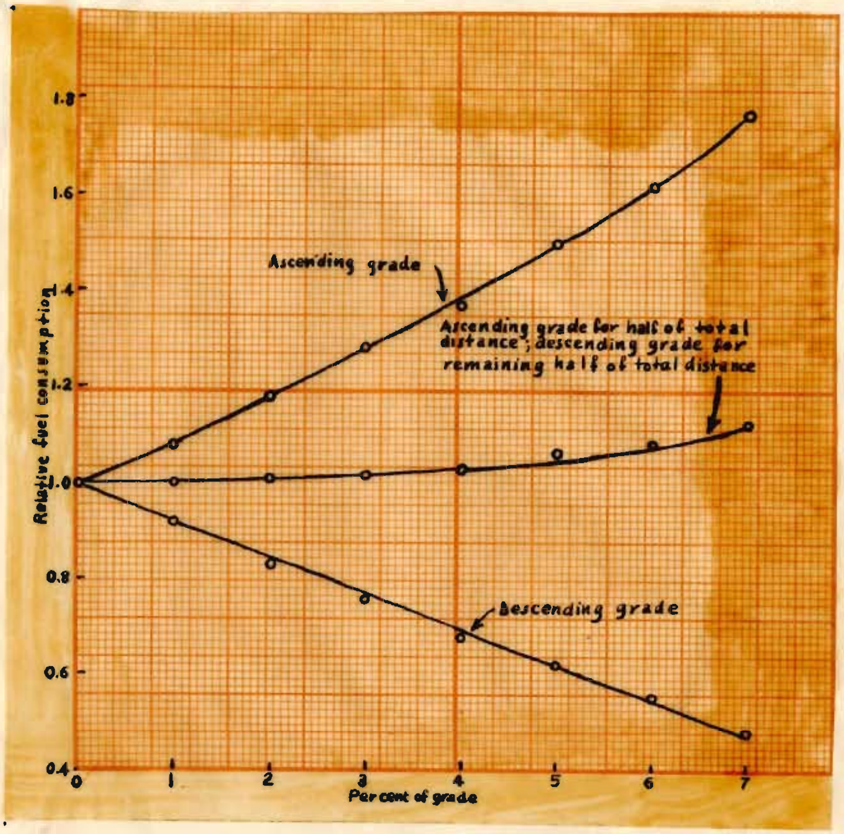

Figure 6 [1]

From a standpoint of convenience, safety, and economy of motor operation the choice of a 5 percent consistent grade is within desirable limits. A higher consistent grade would expose the vehicles utilizing the projected highway to excessive wear and tear due to fatigue and over heating besides being inconvenient. The safety in descending grades steeper than that in heavily loaded vehicles or ones equipped with uncontrollable

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1) Bateman, Highway Engineering , P. 467

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automatic transmissions becomes questionable.

Maximum grades for only short distances on main roadways are 9 percent, and the consistent maximum grade is 5 percent. The desired minimum grade is set at 0.5 percent, longitudinal drainage being provided. On ramps grades are set at a maximum of 9 percent for reasons of economy.

The grades selected offer reasonable safety, convenience, and economy to the vehicular traffic which is expected on the proposed highway, especially in a country with a mountainous nature such as that of Lebanon. Moreover, the relatively short distance for which they prevail dampens their overall undesirable and detrimental effects.

D. Vertical curves

Vertical curves are usually introduced in order to avoid abrupt changes in slope in passing from one grade to another. These curves are generally parabolic but sometimes circular. They should be introduced at the intersection of two grades having differences in rate of more than 0.5 percent. Parabolic curves are much more preferable to circular curves because of the convenience of their design and because they furnish a much more agreeable transition from a straight line grade to a curved grade than circular curves do.

Figure 7 shows a chart prepared by the U.S. Bureau of Public Roads for determining the required length of vertical curve for various sight distances and differences between the intersecting grades. This chart is based on the minimum passing sight distance on intersections of vertical curves assuming that the height of the driver's eye is 5 feet above the pavement.

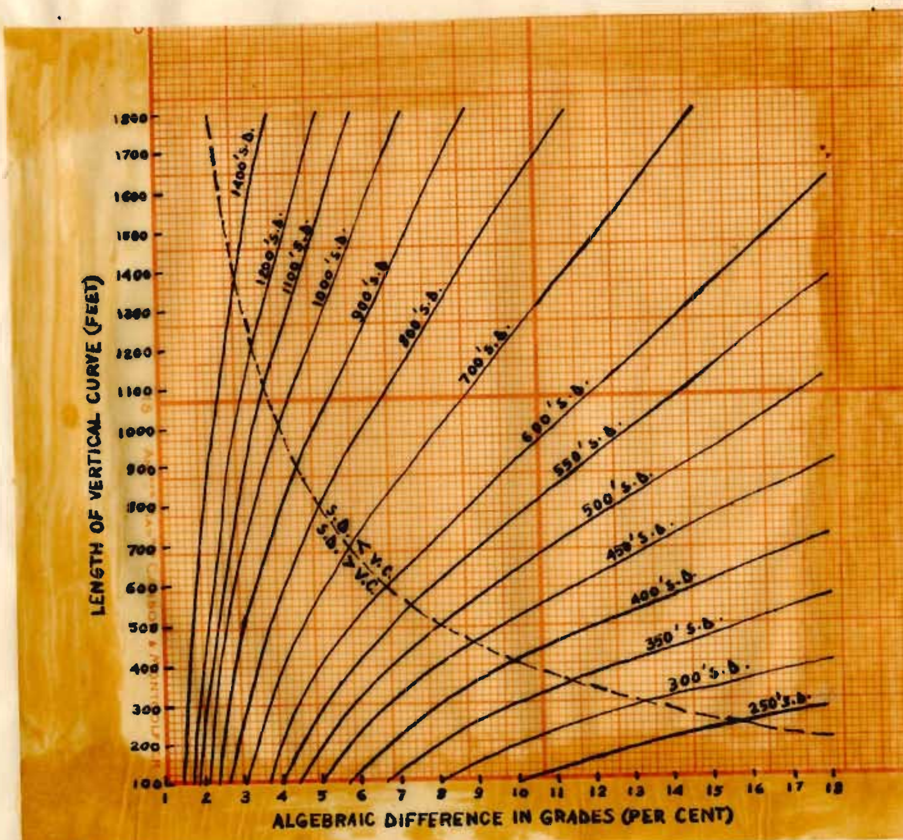

Figure 7

However, since the sight distances recommended for horizontal curves apply also to vertical curves, the minimum length of vertical curves at summits is generally governed by the safe stopping sight distance, i.e. the non-passing sight distance. Figure 8 represents a chart which gives the minimum lengths of vertical curves for non-passing sight distances at various algebraic differences in grades. The calculations are based on the assumption that the driver's eye is 4.5 feet above the pavement and the object's height is 4 inches.

Figure 8[1]

1. Bateman, Highway Engineering, p.110

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(G : algebraic difference in intersecting grades, in percentage, divided by 100.)-A.A.S.H.O. specifications.

On the projected highway, the minimum length of vertical curves on main roadways is 600 feet except when the algebraic difference in grades is 1.5 percent, the vertical curve is 500 feet; and when the algebraic difference is 1 percent, the curve is 400 feet long. These specifications are adopted in order to insure a desirable margin of safety for the relatively high speed of design. All vertical curves are parabolic. This feature is necessary in order to provide agreeable riding qualities at high speeds.

E. Superelevation

On curves having a degree of curvature greater than about 1°, it is advisable to counter balance the effect of centrifugal force by banking or superelevating the roadway, that is by making the outer edge higher than the inner edge. The safe maximum rate of superelevation in regions whose physical charactaristics are similar to those of Lebanon is 1.25 inches per foot or 10 percent.

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1) Bateman, Highway Engineering, P.110.

A uniform bank is selected for use all over the projected highway's curves rather than a variable bank pavement such as the one shown in figure 9. This is a result of the desire to obtain a uniform section, easy to construct, and above all safer and more convenient for the vehicular traffic which is expected on the highway.

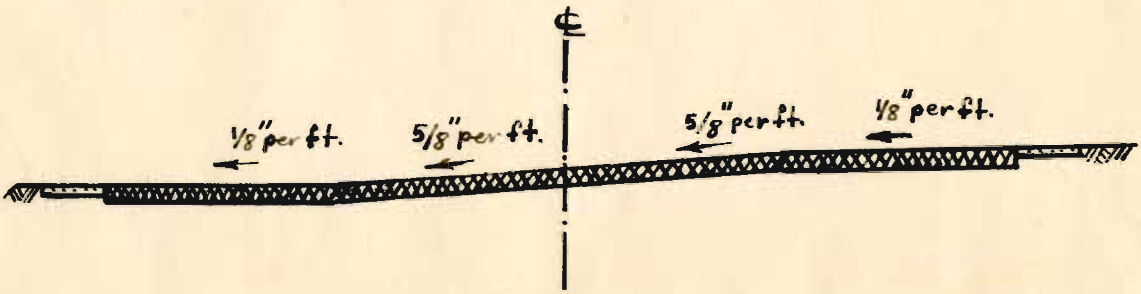

Figure 9

The superelevations which are adapted from the recommended New Jersey Turnpike's design standards to be used on the projected highway are listed in table III. These standards are selected because of the safety, economy and convenience they offer. Steeper banking of the highway would result in unstability of the heavy vehicles with high centers of gravity which are expected on the highway. Moreover, a tire creeping effect on the pavement will result in case of panic stops and eventually an inward sway might occur if a variable bank is used .

The moderate banking which is specified provides an ample counter balancing effect against the centrifugal force for all practical considerations and falls well within the requirements of safety and economy.

TABLE III [1]

Radius of curvature in feet	Superelevation in percent
1,800	4.2
2,000	4.0
3,000	3,0
3,200	3,0
3,400	2.8
3,500	2.8
3,600	2,6
3,800	2,4
4,000	2.2
4,500	1,8
5,000	1,5
5,500	1,3
6,000	1,2
6,500	1.0
7,000-10,000	1.0
Over 10,000	None

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Maximum superelevation in the design of ramps is 8 percent except for upgrade onbound ramps which are 6 percent. A 5 percent superelevation is specified as minimum on all 500 feet radius curves or sharper. Cross slope does not exceed a rate of change of 2 percent per second of time for the design speed . (2)

F. Transition curves

The introduction of an easement curve facilitates the transition from the normal crowned section to the banked section. A s full superelevation is required upon entering a circular curve while no superlevation is necessary on tangents, it is required to furnish a uniform transition from the normal tangent section to the full circular curve section. Easement curves thru which this transition can be attained may consist of compound circular curves, spiral transition curves - railroad type - , or parabolic curves. The most extensively used curve of all three is the spiral easement. Even though the parabolic curve furnishes its own easement it has been used but little in highway, design .On the approach to easement

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1) Adapted from the New Jersey Tunpike geometric standards of design.

2) Ibid.

curves the roadway surface's crown is gradually changed to a flat section and is banked until the full superelevation is attained where the full circular curve starts.

Table IV gives the standards of designing transition curves on the projected highway.

Table IV [1]

Radius in feet	Minimum length of transition curve In feet
1800 - 2000	350
3000 - 3200	250
3200 - 3500	200
Over 3500	None.

Transition curves will be omitted on ramps except for deceleration - lane turnouts.

1) Ibid.

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G. Sight distance

On highways, sight distance is the length of road ahead of the vehicle which is apparent to the driver.

A vehicle which is traveling at a certain speed should be able to stop within a safe distance. The total distance which the vehicle covers in making a safe stop from the assumed speed is specified as the minimum sight distance. In determining this distance many factors are involved. These factors include perception time, brake reaction time, friction factor between wheels and roadway surface, braking efficiency and techique, the total momentum which the car possesses at the instance the brakes are applied, and the external forces which are acting on the car. Experience has lead to the determination of the effects of all these factors. Table V gives the minimum sight distance or the non-passing minimum sight distance on the main roadway for various design speeds. This table is based on perception times and coefficients of friction which vary indirectly with the speed. A level grade was assumed.

Table V [1]

Assume design speed Miles per Hour	Non-Passing Minimum Sigh Distance, Feet
30	200
40	275
50	350
60	475
70	600
75	700

Sight distance should also be checked in profiles with head lamps to insure a sight distance of 1,000 ft. at 75 mph over peaks, and 800 ft. at 60 mph. (2)

Since the projected highway has a minimum number of traffic lanes of four no consideration of passing minimum sight distance is necessary.

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1) Bateman, Highway Engineering, p. 97 (A.A.S.H.O. Specifications).

2) From the New Jersey Turnpike geometric standards of design.

If feasible, the sight distance should be greater than the recommended minimum. Wherever possible, the sight distance on horizontal curves should be improved by removing obstructions to view on the inside of the curve.

Table VI gives the minimum sight distances on ramps. The values which the table lists are based on a perception time of 2 seconds, brake reaction time of 1 second and a coefficient of friction of 0.2. Minimum sight distance would then be equal to $\left(4.4 V + \frac{V^2}{6} \right)$; where V is the assumed design speed in mph. An eye height of 4.5 feet above the pavement is assumed. The height of the object to be viewed is supposed to be also 4.5 feet above the pavement.

TABLE VI[1]

Radius of Curvature In Feet	Design Speed of Ramp, MPH	Minimum Sight Distance, Feet
100	20	155
150	25	215
200	30	280
300	35	360
400	40	440
500	45	535

1) Ibid.

H. Acceleration and deceleration lanes

Relatively slow traffic joining the projected highway at points of interchange should be allowed to accelerate to the speed of the traffic on the highway or to a reasonably comparable value to it before being fed into the main lanes of the roadway. Conversly, out bound traffic should be allowed to slow down to a safe speed before attempting to veer away from the direction of traffic on the proposed highway. This is achieved - by furnishing extra lanes at points of interchange. These lanes are called acceleration and deceleration lanes.

Acceleration varies directy as the maximum torque output rating of a vehicle's engine and inversely as the total resistance to the vehicle's motion. Deceleration varies directly with the total resistance to the vehicle's motion, and the braking effect of both the engine - when the accelerator is released - and the mechanical brakes. Figure 10 represents the acceleration rates of ordinary passenger motor vehicles at various speeds.

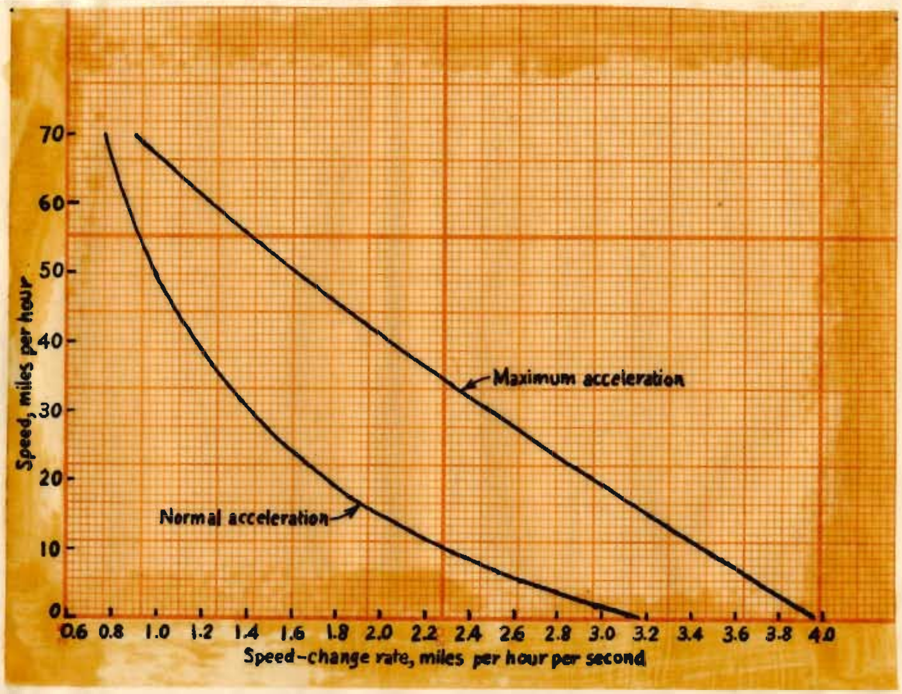

Figure 10[1]

The desirable length of acceleration and deceleration lanes is 1,200 feet. A greater length should be used whenever possible when a high grade occurs in the main roadway.

I. Right - of - way.

The right-of-way width is dependent on many indeterminable factors. The factors involved are cost of land to be expropriated, future developments of highway, and nature of surrounding terrain.

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1) Bateman, Highway Engineering , P.99

It is suggested that the right-of-way width be 300 feet (90 meters) wherever the number of traffic lanes is six, and 250 feet (75 meters) wherever there are only four traffic lanes. In heavily built up or expensive areas, the right-of-way width should be reduced as the situation requires. However, a wide right-of-way is preferable so as to insure good and permanent safe minimum sight distances in the mountainous nature of Lebanon. This extra width is also desirable in case future developments necessitate certain minor modifications in the highway's alinement.

J. Number of traffic lanes.

Between Hazmieh and Jamhour, initial construction provides six lanes, and ultimate construction six.

This decision was chiefly in fluenced by the nature of traffic which prevails on the highway and the basic aim of the highway rather than the intensity of traffic which fluctuates incredibly between these two points - i.e. Hazmieh and Jamhour.

The traffic which occurs predominantly between these two points of interchange falls generally under three categories. One consists of heavily loaded, slow moving vehicles cruising at 20 - 30 mph. The other includes vehicles moving at moderate speeds of 30 - 45 mph, such as low powered cars and fast busses and trucks. The last category covers all of the remaining vehicles which can attain with ease cruising speeds in excess of 45 mph. on the prevailing grade. This classification applies also to the opposing traffic.

It is evident that to serve its purpose efficiently the proposed highway should have a minimum number of six lanes of traffic, regardless of the traffic intensity between Jamhour and Hazmieh. However, since the future traffic intensity which the highway will eventually stimulate is unpredicable it is safer to provide a greater number of lanes than what seems to be necessary according to present traffic surveys.

Between Jamhour and the interchange at the Zahleh road in Bekaa' initial construction provides four lanes, and ultimate construction, four.

This reduction in number of traffic lanes from six to four after the interchange at Jamhour offers economy in the cost of construction, especially that the road bed from Jamhour onwards covers critical natural terrain. Above all, this reduction does not affect seriously the efficiency of the road since a great portion of the traffic deviates from the projected highway's course at the Jamhour interchange.

In tunnels, the four lanes of traffic are carried thru for the sake of consistency.

K. Bridge clearance vertically

All bridge clearances vertically from the surface of the projected highway's pavement to the underside of bridges passing over the highway are at least 15 feet (4.5 meters), which conforms with the specifications set by the Lebanese Department of Public Works.

L. Cross Roads

Intersecting roads, access roads, and relocated roads are designed according to geometric standards which are set as no less than those which existed previously on the road in question.

x x x

PAVEMENT DESIGN

The relative conditions of various roads in Lebanon stands as a good example of the cause and effect of a pavement's condition.

Well designed and built pavements have stood many years of service and are still in comparatively good condition. On the other hand , badly made pavements have deteriorated in the lapse of few years. Their yearly maintenance cost is extravagant; not to mention their detrimental effect on the vehicles which operate on them. Good pavement design and construction is indispensable to any first class highway. First class pavements always justify the expenses which are incurred in their construction.

Detailed typical sections of the proposed highway are shown on the map entitled " SECTIONS " .

Wherever physical charactaristics of the terrain permit the following general geometric standards are used :

Median width, 26 feet for six lane portion and 20 feet for the remaining, four lane portion whenever possible. This width includes inner shoulders. The minimum width of Median strips is 12 feet, including the inner shoulders whose minimum unit width is 4 feet.

.../...

Shoulders, outside 16 feet, of which 10 feet would be stabilized; inside 5 feet stabilized. Minimum shoulder widths are, outside 4 feet; inside 4 feet both stabilized. Wherever 4 feet outside shoulders are necessary, emergency parking strips will be provided.

Pavement lanes, 12 feet wide.

Vertical clearance, 15 feet (4,5 meters).

Maximum grade, 9 percent (absolute), and 5 percent (desirable) .

Design speed, 70-75 mph for level sections, 50 mph at entrance to tunnel at Rjoum, and 60 mph. for remaining portion.

Horizontal curves, minimum radius, 1,800-2,000 feet at curve in Rjoum; 3000 feet for all other curves.

Non-passing sight distance, to conform with design speed.

Right-of-way width, 300 feet for six-lane portion, 250 feet for remaining portion.

x x x

.../...

Two types of pavements are used ; The rigid, and the flexible. This is necessary in order to insure a greater versatility of the road.

The rigid type of pavement chosen is ordinary portland cement concrete. Lebanon, possesses at present first class equipment for the construction of such a pavement. This equipment is practically brand new and lies idle after having been used to pave the runways, taxiways, aprons, and terminal areas of Beirut International Airport.

Asphaltic concrete is the felxible type of pavement chosen . It is a most practical and economical pavement to use in a country such as Lebanon. Moreover, all the roadbuilders in the country are familiar with its use. Asphaltic concrete plants can be manufactured locally and set up at any convenient spot along the projected highway's course where the necessary aggregates are available.

Both types of pavements offer relatively low rolling resistances. Their life expectancies are high. The fact that they would stand up best under extremely heavy axle loads and insure good and economical service for the life of the projected highway's bonds lead to their ultimate selection.

Since heavy truck loads are anticipated a 36,000 lb. (18 tons) axle load is assumed. This is based on the New Jersey Turnpike Authority's recommendation for a similar compromise axle load and on the axle loads of the 25 - 30 ton trucks which are to be expected on the highway.

A. Rigid Pavement

The rigid type pavement will be used on all curves where the raidius of curvature is 3,000 feet or less. This is necessary due to the fact that on a sharp curve, asphaltic concrete pavements creep under the side thrust, which is brought on by a car taking the curve at high speeds. Centrifugal force causes this effect to be brought on by the car.

Use of the rigid type pavement will also be extended to all spots on the highway where soil tests reveal undesirable or critical subsoil conditions.

The rigid pavement will be of the standard type portland cement concrete pavement on a 6. in. pervious subbase and will have a thickness of 10 inches. This pavement is to be supported by a well compacted subgrade. The 6 in. pervious subbase will be two 3 in. layers of crushed stone.

Slab design details are as follows .

Control joints are to be spaced 78 1/2 ft. center to center and consist of treated, clear sound lumber 1/2 in. thich, extending from the bottom of the slab to within 3/4 in. of the top of the slab. Rubber latex joint filler is specified for watertightness. Round steel dowels 1.25 in. in diameter spaced on 12 - in. centers are used to transfer the loads accross the joints. These dowels are to be of a corrosion resistant metal or with equivalent protection, held firmly in a rigid frame(1)

Reinforcement is to avarage about 5.5 lb. per square yard of pavement - sufficient to prevent cracking of the slabs - and is to be placed 2 - 3 inches below the surface .More steel is to be used in the middle third of the slab length than near the ends .(2)

Construction will be in 12 ft. lanes, the lanes to be tied together by 0.5 in. round tie bars 30 in. in length, spaced 26 in. on centers. A Screw or lock type of tie bar of equal strength could be used . (3)

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1) Adapted from the New Jersey Turnpike design specifications.

2) Ibid.

3) Ibid.

.../...

The recommended mix is 6 bags of cement per cubic yard. A 1 - in. maximum slump is specified. Preliminary finishing should be kept at a minimum to prevent bringing excessive fines and mortar to the surface. Brooming is recommended to obtain a non-skid light-reflecting finish.(1)

x x x

B. Flexible Pavement

Asphaltic concrete is the type of flexible pavement chosen. It is by far much more economical than concrete- i.e. portland cement type concrete - in Lebanon. Moreover its versatility and other advantageous qualities make it much more practical to use than any other type in the case of the proposed highway. Asphaltic concrete is a highly non-skid and flexible type of pavement. Its relatively rough surface eliminates all the dangerous effects which characterize " glassy " type pavements.

The flexible pavement design consist of a - 12 in. previous subbase, three 2 - in. layers of penetration macadam base course; and 4,5 in. of asphaltic concrete. The 12 in. subbase consists of one 6 in. layer and two

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1) Ibid.

3 in. layers well compacted. This subbase should make use of local materials as much as possible. It should be of a material that could be compacted and still be sufficiently porous to drain well. Use of machine-crushed rock in 6 in. layer, and crushed rock, slag, or gravel of a durable and frost resistant character in remaining two layers is recommended. The base course consists of three 2 in. layers of penetration macadam. Crushed stone should be used with 1.6 - 1.8 gal. of asphalt per square yard (7.6 - 8.6 liters per square meter). Sufficient chips to fill the surface should be added while the bituminous binder is still liquid. A rubber tired roller with a wheel weight of 25,000 lb. (12 tons) is specified for compacting the top course, in addition to the conventional rolling of each individual layer. This is to insure excellent compaction.

The asphaltic concrete design consists of three 1.5. in. layers . The first layer is a leveling or binder course. It is to be layed after applying a tack coat to the base course. The other two courses are wearing or surface courses. They should be sealed by the application of a seal coat. All these courses are to be a plant mix and hot laid. Below is given a recommendation of an asphaltic concrete mix and a seal coat mix . The metric system is used :

Materials

A. Small chips - four types.

1) Passes 38 mm. and retained on 19 mm.
2) " 19 " " " " 12 "
3) " 12 " " " " 6.5 "
4) " 6.5" " " " 3.2 "

B. Sand (Grit) - passes 3 mm. and retained on seive 250

C. Flux

D. Butimen

E. Filler - e.g. powdered lime.

Asphaltic Concrete Mix

Each batch of 200 kg. (440 lb.) consists of :

168 kg. of chips.
1 " " Flux.
9 " " Bitumen.
2 " " Filler.
20 " " Sand or grit.
------
200 kg. total batch.

The chips are in the following proportion :

2 parts of (1)
2 " " (2)
1 " " (3)

x x x

Seal Coat

Each batch of 200 kg. (440 lb.) consists of :

190.00	Kgs. of	grit or sand.
1.50	" "	Flux.
6.25	" "	Bitumen.
2.25	" "	Filler
200.00	kg.	total batch.

This seal coal is to be used in a very small quantity and tightly rolled. Its purpose is to make the surface impermeable and to prevent the adhesion of foreign substances to the top of the wearing course before it dries up.

x x x

Asphaltic concrete will be the preferable type of pavement to use all over the projected road. The rigid portland cement type pavement will be used only where it is of utmost essentialness.

C. Shoulders

At the present time, a motor vehicle is less subject to breakdown or tire trouble than it was formerly; but with the increase in volume and speed of traffic,

.../...

a car parked on the pavement proper constitutes a greater source of danger and congestion. For this reason, modern highways should have shoulders at least 10 feet wide for emergency parking.

Shoulders sould be able to support, at infrequent intervals, the heaviest axle loads to which the projected highway might be subjected. They should furnish a seal to keep the water out from under the roadway pavement, and they should have a different appearance from the main roadway to discourage their use as a regular traffic lane.

Shoulder design consists of a compacted thickness of 10in. of subbase material with a double bituminous surface treatment as a seal. This recommended design is relatively inexpensive and satisfies the specified requirements.

All shoulders are 10 ft. wide except in mountainous and special areas where it is not feasible to provide this width along all the highway sections where the shoulders will be reduced to a 4 . ft. minimum width. Under such conditions, emergency parking strips will be provided.

.../...

Miscellaneous Structures

A. Retaining Walls

Standardized reinforced concrete retaining walls of the " cribbed " type will be used all along the course of the projected highway, wherever necessary .

The choice of cribbed retaining walls is a result of the desire to obtain maximum economy, flexibility, and simplicity. Cribbed retaining walls provide their own drainage, and are simple to construct and maintain. Achitecturally, they are functional and pleasant. For all practical purposes, they are by far more economical than all standard masonry retaining walls being used presently in Lebanon. In case of bad visibility, they serve as a good indicator of the roads' course and are less liable to be mistaken for other contemporary structures.

Figure 11 shows a section of a typical cribbed retaining wall made up of headers and strectchers.

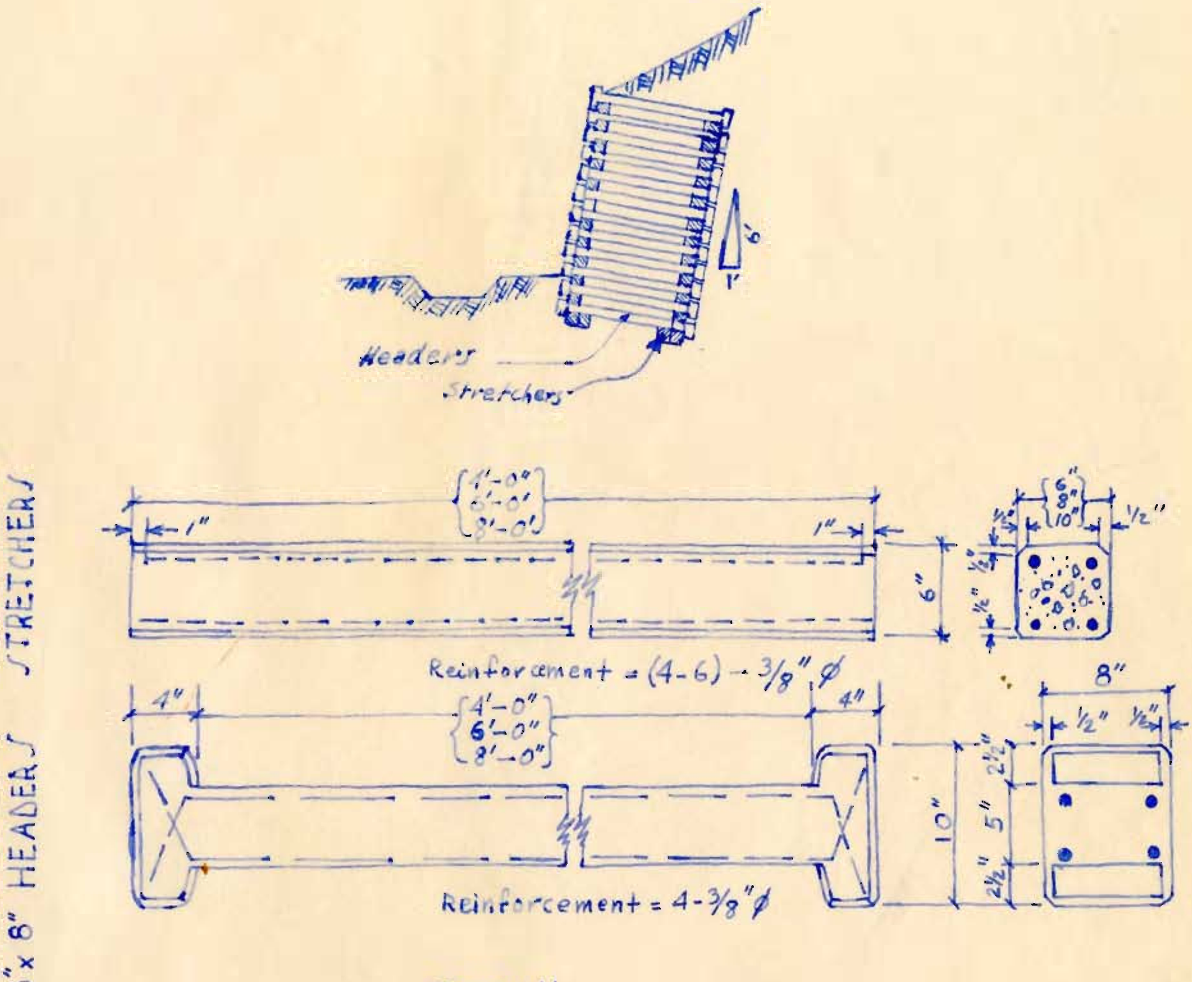


Figure II

B. Gard Rail

The use of guard rail will be restricted to the areas where its use is an absolute necessity. Gard rails will only be used whenever the side slopes on embankements are steeper than I vertical to 3 horizontal, or any other section of the highway where there is a need for protection, such as when the highway is split into two sections at different levels as shown on the " SECTIONS " sheet.

Gard rail design is in the form of a " bump-back" wall type which is sketched roughly below. This type was used successfully in Europe recently, especially Switzerland.

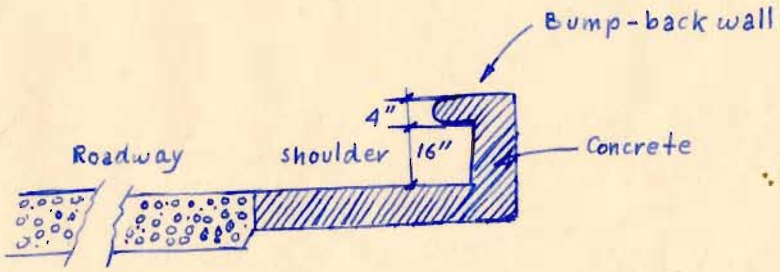


Figure 12

The above illustrated guard rail deflects the vehicle back toward the roadway rather than check its speed or stop it. Also, it does not entangle it but permits it to slide freely along its face. The fact that it comes in contact with the wheels or bumpers of the vehicle in case of accident makes it less harmful since these parts of the vehicle are best able to sustain the force of shock. It is highly visible and is to be painted with a luminous and bright color to secure a good outline of the course of the highway to accentuate visibility.

C. Signs and Markers

All highway signs and markers should be designed to be easily read at high speeds. They should be placed so as to give motorists ample warning of approaching exits. International design patterns will be used.

D. Lighting

The highway's function in its first stage of development does not justify its total illumination. Only tunnels will be illuminated. No recommendations for the over all system of illumination are specified since future developments in this field might render any premature prediction absolete.

x x x

C O N C L U S I O N

The alinement of the proposed highway is by no means an absolute final draft. Several refinements ought to be made on its final and more detailed version. Before realizing such a detailed final draft of the whole scheme more data is necessary . The data needed should include the following :

Soil studies and tests.

Geologic maps of the areas where tunnelling is necessary.

Extensive traffic surveys.

A precise, upto date, reliable and extensive survey of the belt thru which the project road passes; bearing in mind that maps should have countour intervals of 1 meter and a scale of 1 : 1000 at least and preferably 1 : 500.

The projected highway is not meant to be exclusive in its existence, but it is the first link in a chain which will enventually lead to a fully developed Pan-Arabian highway system, such as the scheme proposed by Mr. W. F. Moore in his booklet entitled ." The Arab States, Their Industrial Potential And The Proposed Pan-Arabian International Highway ."

It is evident that in the process of the projected road's construction, modern mechanized equipment should be utilized extensively in order to realize a closely controlled and consistent procedure.

Efficiency in operation will undoubtedly be one of the governing factors in the project's prosperity. In order to achieve a high operation efficiency, the road should be run by its own administrative body. This body or authority should concentrate on keeping the road running smoothly. It should control the policing of the highway and enforce all the necessary laws conforming with the highway's function.

No one can predict fully the indirect effect of the project's execution for many intangible factors are involved. However, it can be firmly said that the project, if carried out, will undoubtedly be an invaluable source of wealth to the Republic of Lebanon.

BIBLIOGRAPHY

Bateman, J. H., Highway Engineering, Fifth edition.

Civil Engineering Magazine, January 1952.

Harger And Bonney, Highway Engineers' Handbook.

APPENDIX

The practicing engineers in charge of the Beirut Damascus turnpike held a preliminary meeting on Tuesday May 5 to discuss the general financial patterns of their project. All unit prices were analysed and final figures were set as follows:-

	Unit cost per meter run
6 - Lane portion of road (Beirut-Bekaa')	1000.00 L.L.
4 - Lane portion of road (Beirut-Bekaa')	700.00 L.L.
4 - Lane bridge	10000.00 L.L.
4 - Lane tunnels	5000.00 L.L.
4- Lane portion of road (Bekaa'-Damascus	475.00 L.L.

These costs are average figures and include drainage structures, retaining walls, cost of expropriation, and all other standard items which the road design requires. They do not include engineering costs and other incidental items. These unit prices were arrived at after a careful breakdown of the assumed figures and are comparable to other similar projects' costs. However, no exact prices can be specified for many undeterminable factors are involved.

The total cost of the project based on the assumed costs is as follows:-

Item	Unit cost in L.L.	Quantity K.M.	Total cost in L.L.
6 - Lane portion (Hazmieh-Jamhour)	1,000.00	5.50	5,500,000.00
4 - Lane portion (Jamhour-Ras-el-Harf)	700.00	10.30	7,210,000.00
4 - Lane bridge at exit of first tunnel	10,000.00	0.20	2,000,000.00
4 - Lane tunnels (Khabbaz)	5,000.00	14.20	71,000,000.00
4-- Lane road (Bekaa'- Damascus	475.00	42.50	20,200,000.00
4 - Lane tunnels (Shabhar)	5,000.00	13.25	66,300,000.00
	TOTAL	L.L.	172,210,000.00

Engineering costs are estimated as being 10% of the total cost. They are to be added to the 172,210,000 L.L. total.

On the final meeting of practicing engineers Balabanian, Khabbaz, Khuri and Shabhar, which was held on May the 7 th., the financial study given a final consideration and the following decisions were unanimously arrived at:-

1 - The construction of the projected highway be a completely mechanized process. This will definetely cut down the total cost of the project.

2 - The total assumed cost of 190,000,000 L.L. renders the project unjustifiable economically with the present traffic intensity.

3 - Dependable and extensive traffic surveys are necessary before issuing a final tolling scheme.

Since the assumed tunneling costs render the project unfeasible, the practicing engineers find it necessary that they consult a tunneling specialist before arriving at a final decision. A revision of the tunneling costs by a consultant would clarify the pending economic problem further and put more light on the possibility of a more economical relocation.

The practicing engineers recommend the following schematic procedure to arrive at a satisfactory result.

1 - That the 5.50 kms. 6 - Lane portion of the proposed highway between Hazmieh and Jamhour be constructed at the expense of the Lebanese Public Works Department and supervised and maintained by the highway authority. Since it is justifiable due to the fact that this portion will be mainly used by summer resorts bound traffic such as Aley, Bhamdoun and adjoining areas.

2 - That the project be extended and carriet out as a Pan-Arabian International Highway System where the

Tunneling expenses of the projected road will be shared by all concerned countries.

3 - The tolling system be directly charged on the basis of kilometers covered by the vehicular traffic on the highway. Electronic and mechanical devices will be utilized to register the number of vehicles that enter and leave the highway at each access point.

4 - A bond issue of 190,000,000 L.L. will be floated as follows:-

a - 100,000,000 L.L. worth of stock will be issued by the highway authority as collateral paper and floated as series "A" bonds. These bonds will be sold to banking agencies and will received a guaranteed fixed interest of 3%. These bonds will mature in 30 years from the start of the highway's operation. This series will have priority until retirement against net revenues. If at any instant the acquired net revenues do not cover the service charges of this series the concerned states should make up the deficit from their national treasuries, or other national incomes since the project is a source of wealth to the concerned nations.

b - 90,000,000 L.L. worth of stock will be issued by the highway authority and floated as series "B" bonds. These bonds will be sold to the concerned states, private concerns, and individuals who wish to participate in the project. These bonds will participate in the returns of the project similar but subordinate to series "A" provided the net income is more than what is required to cover the series "A" service charges.

In case the returns are insufficient all income will be applied against the series "A", the deficit should be made up by the concerned states. However, if the returns exceed the total expenditures and requirements of the project, the surplus would proportionally be distributed between the concerned states and partly applied against the "A" series bonds expecting their retirement.

5 - An equivalent of 10,000 Beirut - Damascus vehicular movements have to be achieved daily in order to make the project economically feasible. This is based on the 190,000,000 L.L. cost.

6 - The average daily traffic of 10,000 Beirut-Damascus movements or their equivalent is based on a break - even yearly budget of 15,000,000 L.L. This budget's breakdown is as follows:-

Item	Cost in L.L.
Yearly depreciation for 30 years (sinking - fund)	2,800,000
Fixed interest on 100,000,000 L.L. bonds at 3%	3,000,000
Interest on 90,000,000 L.L. shares at 6%.	5,400,000
Maintenance and other incidental expenses (2% of total capital)	3,800,000
TOTAL	L.L. 15,000,000

All the estimates are subject to variations since they are very rough ones based on factors many of which are undeterminable. The suggestions do not recommend any particular administrative set up since this require much more estensive studies that fall outside the scope of this report. In this connection and other corporate matters, useful information is obtainable through studies of the organizational patterns of similar projects which have been executed such as the New Jersey Turnpike, and the Pennsylvania Turnpike.

SCALE

HORIZONTAL. 3 cm : 1000 meters   VERTICAL 3 cm : 100 meters

SCHOOL OF ENGINEERING _ A. U. B.

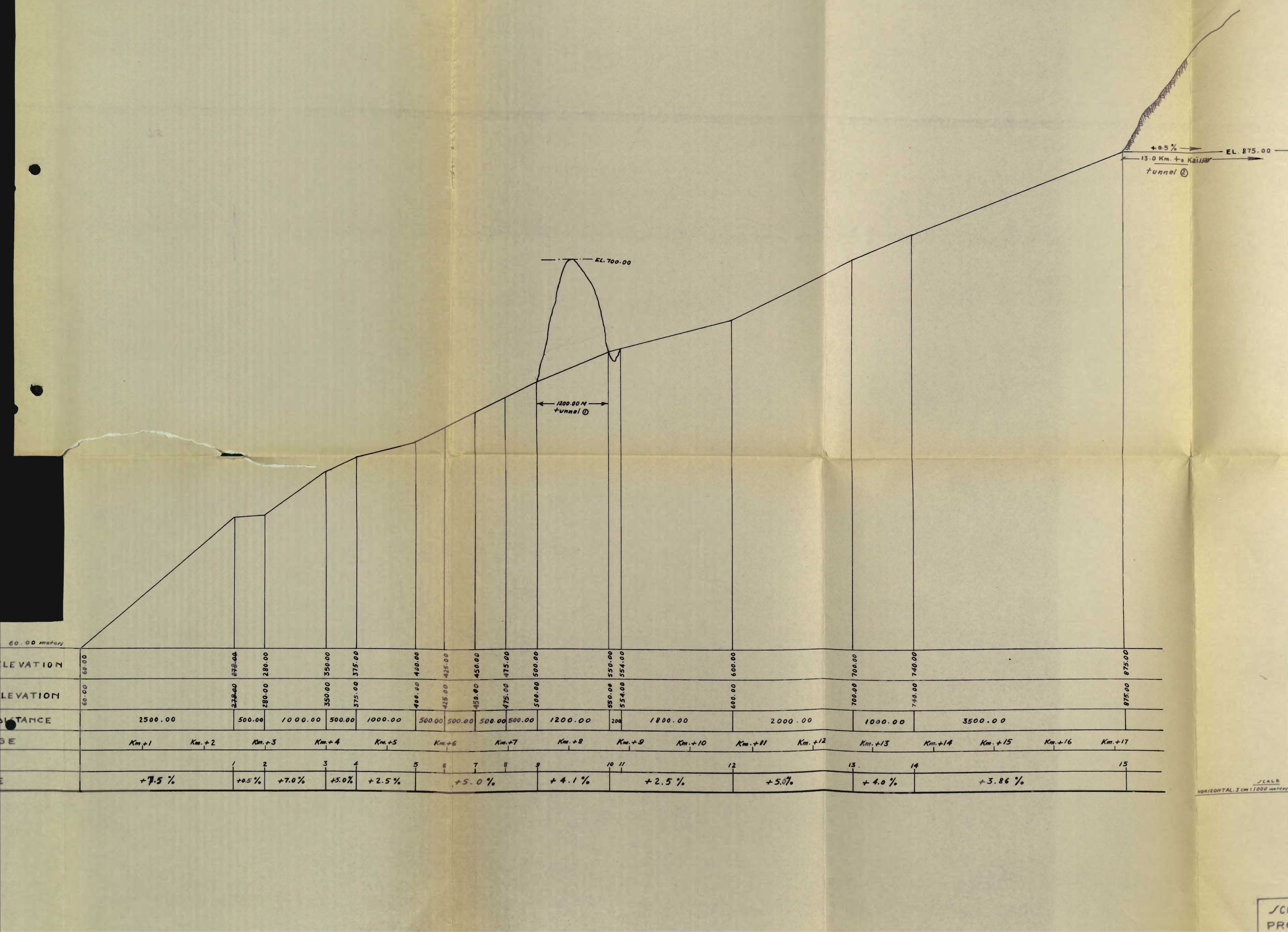
PROJECT : THE BEIRUT-DAMASCUS TURNPIKE

PROFILE

DESIGNED BY : K. KHURI

DATE : APRIL 27, 1953

SHEET 2 OF 3


EL. 700.00
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EL. 875.00
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ELEVATION
60.00 278.00 280.00 350.00 375.00 400.00 425.00 450.00 475.00 500.00 550.00 554.00 600.00 700.00 740.00 875.00
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HORIZONTAL: 3 cm : 1000 meters

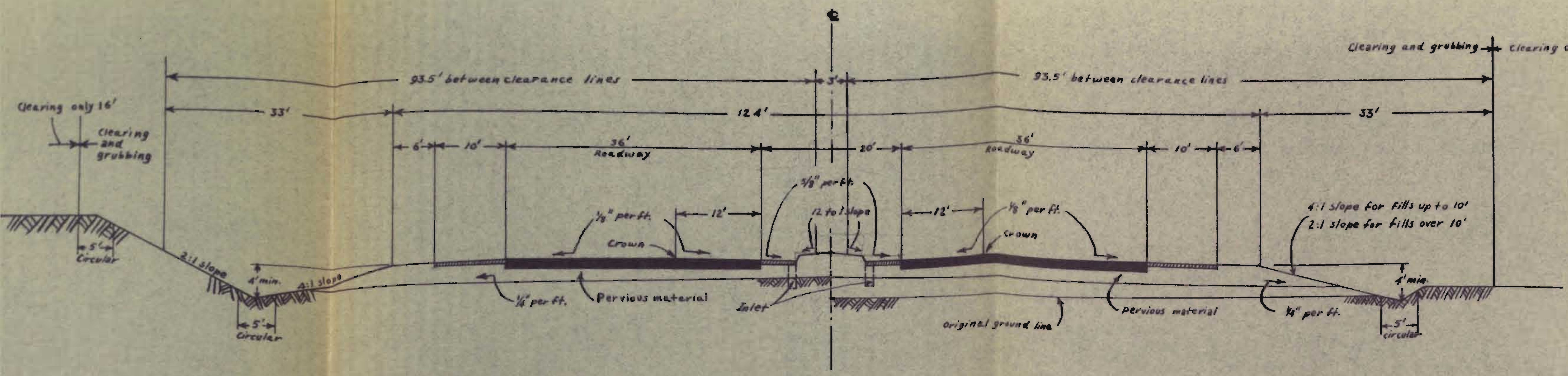
SCHOOL OF ENGINEERING — A.U.B.

PROJECT : THE BEIRUT-DAMASCUS TURNPIKE

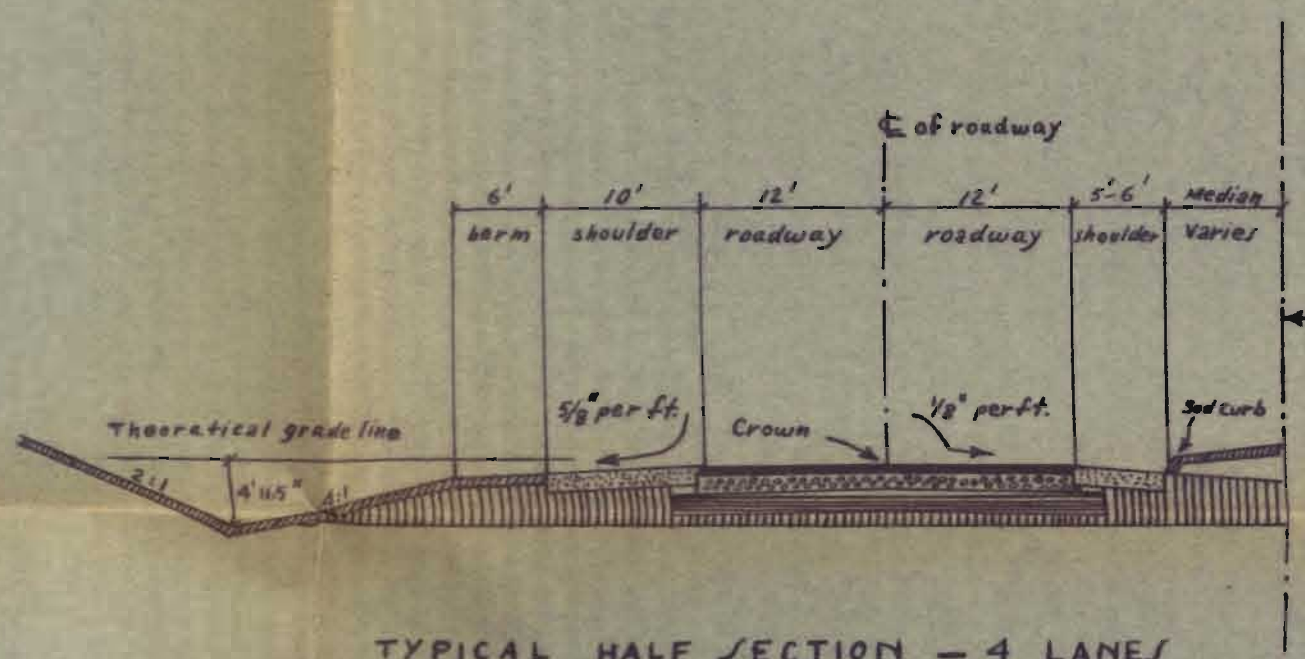
SECTIONS

DESIGNED BY : K. KHURI

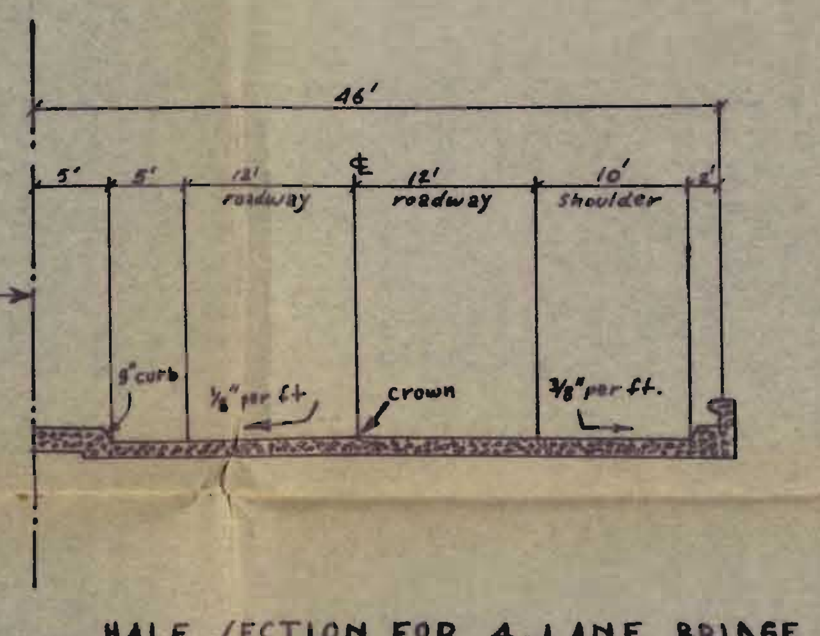
DATE: APRIL 27, 1953 SCALE: 1cm.:5ft. SHEET 3 OF 3



CUT SECTION — A TYPICAL 6-LANE SECTION — FILL SECTION



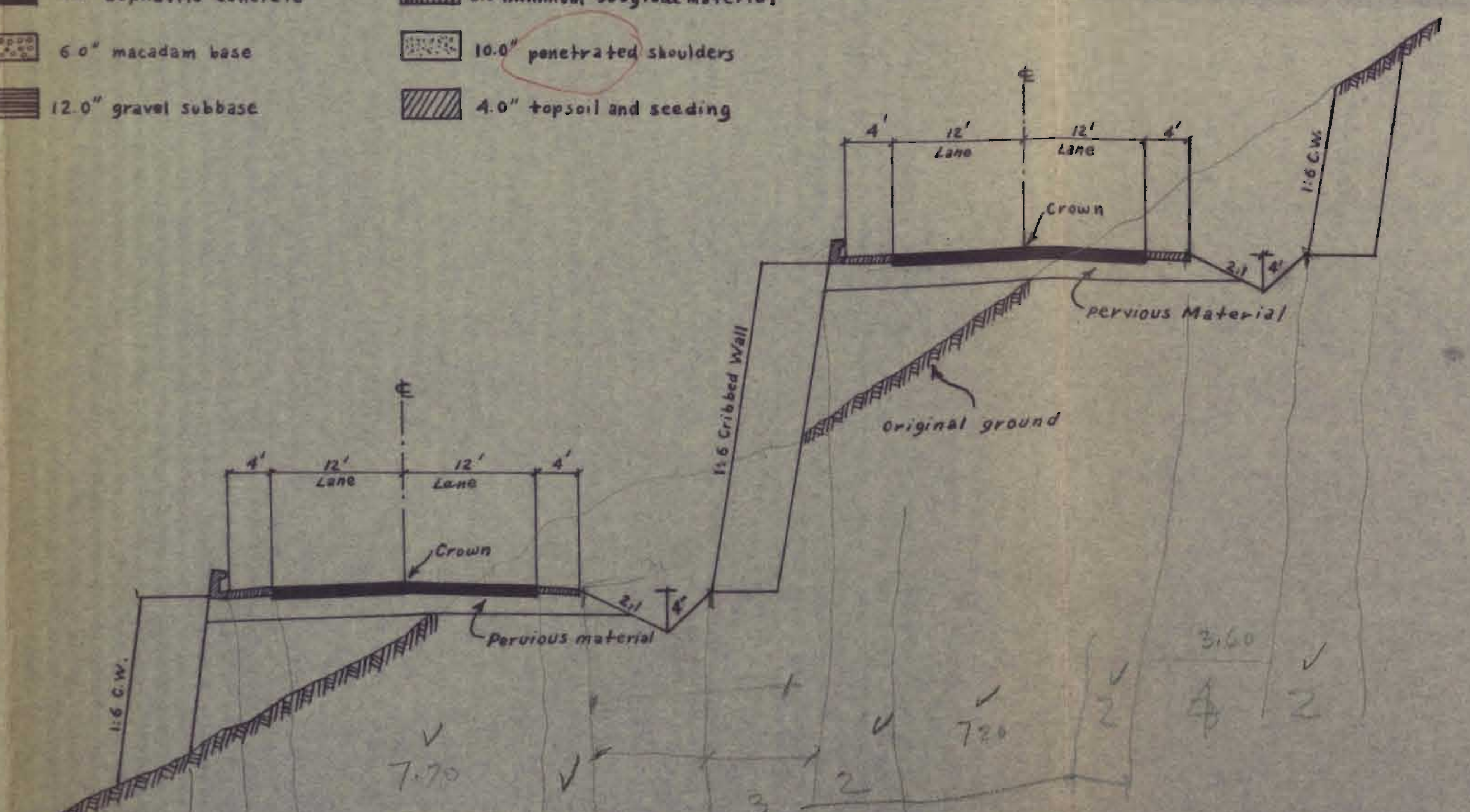
TYPICAL HALF SECTION — 4 LANES
ASPHALTIC CONCRETE PAVEMENT



HALF SECTION FOR 4-LANE BRIDGE AT CHOUITE

LEGEND

- 4.5" asphaltic concrete
- 6.0" macadam base
- 12.0" gravel subbase
- 8.0" minimum subgrade material
- 10.0" penetrated shoulders
- 4.0" topsoil and seeding



TYPICAL SPLIT 4-LANE SECTION

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PROJECT: THE BEIRUT-DAMASCUS TURNP
SECTIONS
DESIGNED BY: K. KHURI
DATE: APRIL 27, 1953 SCALE: 1cm.:5 ft. SHEET