

The geometric roadway design of Thaghert al-Jub and Idoun Bani Hassan Dr. Samir Juma'a Ahmad Farajallah

الملخص

شهدت مدن المملكة معدلات عالية من التنمية والتطور في كافة المجالات ومنها التنمية العمرانية. لذلك انطلقاً من التوجيهات السامية الكريمة إلى تطوير مسيرة التنمية الشاملة في المنطقة الشمالية الشرقية من المملكة الاردنية الهاشمية. سعينا لتصميم طريق بطول 5.5 كم يربط بين منطقتي ايدون بني حسن و ثغرة الجب. بحيث يربط هذا الطريق المنطقتين و يغطي احتياجات هذه المنطقة نظرا لعدم وجود طريق حيوي فعال يخدم سكان هذه المناطق.

Abstract

Never has there been an area so ignored in the field of safety as traffic management. Jordan, one among the countries that suffer from high road fatalities and road issues, stands as a grim example of what we could all face if we were to ignore traffic issues.

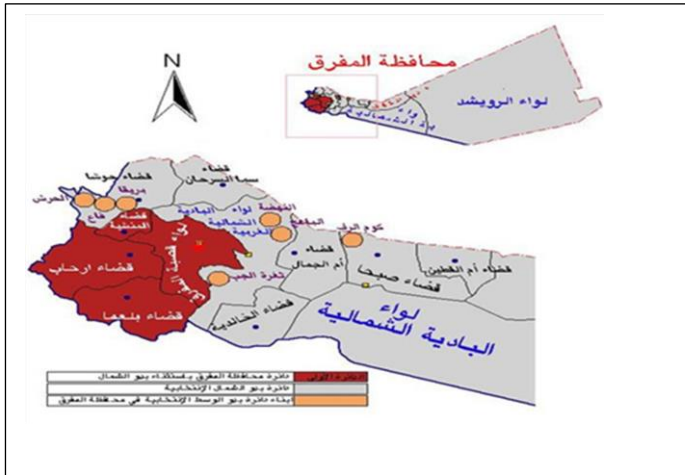
This study involves a design and planning of 5.5 km two way two lane highway to ensure safe and effective transportation of people and good between two small cities in northern part of Jordan within the branch of highway engineering standards.

In This study, the geometric roadway design can be broken into three main parts: alignment, profile, and cross-section. Combined, they provide a three-dimensional layout for a roadway.

1. Introduction

1.1 Introduction

Mafraq city: The capital city of Mafraq Governorate in Jordan, located 80 km to the north from the capital Amman in crossroad to Syria to the north and Iraq to the east .



The importance of the specialty of civil engineering can be understood through the definition of it. It is the engineering competence that humans can't live without. Humans need the homes that shelter them and make them safe and protect them from summer heat and cold winter ... Human beings need safety and transportation To move between cities with a lack of attention to the distances cut. As the population increases in a community and there was a problem for limited spaces, this problem will only be solved by the presence of civil engineers. This is a very simple definition of civil engineering.

1.2 Road Map

the geometric roadway design of Thaghtert al-Jub and Idoun Bani Hassan.



Figure 1. road planing

In this study we will study the construction of a road connecting the areas of Thaghert al-Jub and Idoun Bani Hassan.

This study includes the following:

1. Introduction and background of the project
2. Traffic studies.
3. The needed data and test to design.
4. The environmental and socio-economic impact.
5. Recommendations and conclusion.

There are many studies which should be done before highway design some of these studies:

1. design location studies
2. it shall consider the following
3. alignments and profuse design
4. soils investigation
5. alignments
6. all darnning facilities to determine all content that influence horizontal and vertical alignment.
7. used the topography photo to selected way.

There are certain considerations that must be properly addressed in the design process to successfully fit a highway to a site's topography and maintain its safety. Some of these design considerations include:

- 1-design speed
- 2-design traffic volume
- 3-level of service
- 4-cross section
- 5-horizantal and vertical clearance
- 6-lane width
- 7-sight distance.

1.3 Choosing alignment



Highway survey & plans

1.3.1 Field studies

It is important to study the location of the project, and this study include the following:

1. Topography of the area.
2. people centers.
3. Industrial centers.
4. Existing of valleys.
5. selected alternative

1.3.2 Alternative's locations.

When we want to select an alignment, we must consider the following

- 1-Avoid difficult areas such as deep valleys and very high mountains.
- 2-Avoid crossing water ways as possible.
- 3- Avoid grossing farms and buildings.
- 4- Choose the road so that to be as short as possible in order to reduce its cost.
- 5-Try not to gross the contour lines as possible.
- 6-Relative ratio between cut and fill quantities a reasonable.
- 7- Make the road to serve many populations center.
- 8- Minimum number of grossing bridges, culvers in alignment of the proposed road way.
- 9-The horizontal and vertical curves should be smooth as possible.

The selected alternative must consider the coordination between the horizontal and vertical alignment as follow:

1. The alignment is more natural and more pleasing in appearance if the horizontal and vertical alignments are combined.
2. The change on the horizontal alignment should preferably be made at a say curve, where the change in the direction is readily apparent to driver.
3. For economical consideration, since the optimum needs for cuts and fill with approximately equal amounts compared to other alternatives are achieved.
4. It satisfies the purpose of its construction by connecting all the required villages and passes through each one as possible.
5. Minimum number of crossed valleys.
6. Proper grades along the high way which increase safety, capacity smoothness of flow and decrease the consumption of the fuel.

The best design is accompanying in which safety, economics, and pleasing apparent are sensibly blended. Three alternatives were selected and we draw a plan and profile for each one considering the previous concepts. And then we select one of them, the best one which satisfy the previous concepts as possible.

1.3.3 Properties of alternatives:

Alternative Property	#1	#2	#3
Length of the route (Km)	5.750	5.500	5.750
NO. of H curves	3	2	2
NO. of V curves	2	2	2
Service population centers	3	3	2

1.3.4 Selected Alternative:

The selected alternative is alternative #2 because of many properties, the main advantages of this route are:

1. It serve the needed population centers.
2. It is the shortest one.
3. It has the easiest gradients and smooth curves.
4. the value of cut is smallest than the other

Alignment #1

station	Elevation	distance
0+00	676	0
1+00	695	250
2+00	684	500
3+00	685	750
4+00	691	1000
5+00	696	1250
6+00	680	1500
7+00	690	1750
8+00	690	2000
9+00	690	2250
10+00	712	2500
11+00	714	2750
12+00	711	3000
13+00	713	3250
14+00	714	3500
15+00	723	3750
16+00	729	4000
17+00	745	4250
18+00	750	4500
19+00	748	4750
20+00	753	5000
21+00	753	5250
22+00	745	5500
23+00	760	5750

Alignment #2

Station	Elevation	Distance
0+00	676	0
1+00	702	250
2+00	698	500
3+00	700	750
4+00	699	1000
5+00	703	1250
6+00	710	1500
7+00	714	1750
8+00	715	2000
9+00	719	2250
10+00	725	2500
11+00	737	2750
12+00	740	3000
13+00	746	3250
14+00	750	3500
15+00	746	3750
16+00	745	4000
17+00	752	4250
18+00	751	4500
19+00	745	4750
20+00	737	5000
21+00	742	5250
22+00	750	5500

Alignment#3

Station	Elevation	Distance
0+00	676	0
1+00	690	250
2+00	687	500
3+00	698	750
4+00	690	1000
5+00	698	1250
6+00	708	1500
7+00	705	1750
8+00	701	2000
9+00	714	2250
10+00	723	2500
11+00	712	2750
12+00	720	3000
13+00	719	3250
14+00	721	3500
15+00	723	3750
16+00	735	4000
17+00	739	4250
18+00	745	4500
19+00	750	4750
20+00	755	5000
21+00	758	5250
22+00	753	5500
23+00	757	5750

Chapter 2

2. Alignment design



Figure 2. plan (horizontal alignment)

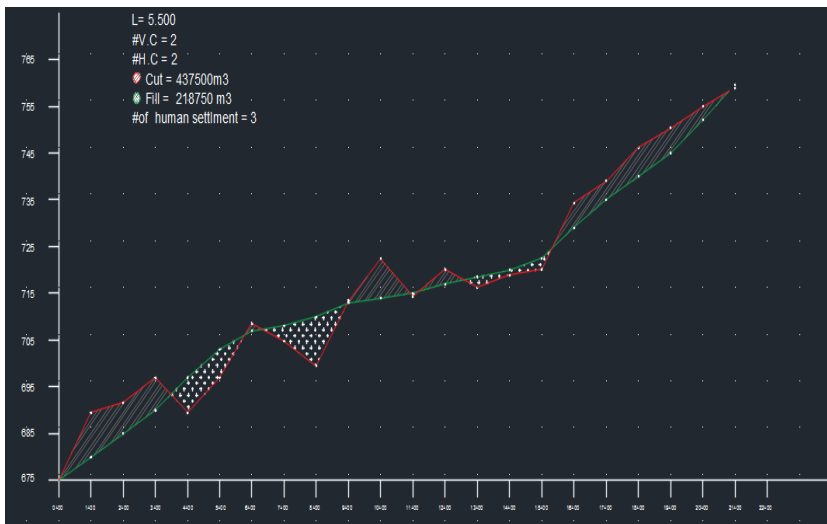


Figure 3. profile (vertical alignment)

2.1 Introduction

The alignment is defined as the combination of horizontal and vertical geometric elements giving the location of the road in the terrain. In alignment design should take care of road:

- 3) Select curve radius R min (Known from table 2-2).
- 4) Find the point of the intersection (P.I) of the tow tangents.
- 5) Calculate the elements of the circular curve:

Θ: Deflection angle

S: Design speed

R: Circular curve radius

L.c: Length of circular curve

T: Tangent length

Calculations:

Road type: collector

S = 100 km/hr

f=0.12 side friction force (from table 2-1)

e max= 0.06 cross fall of road for hilly area from AASHTO
to Determine value of radius (R min) use this formula:

$R \text{ min} = S^2 / 127(e+f)$

$= (100)^2 / 127(0.06+0.12) = 440 \text{ m} \dots\dots\dots$ or from table (2-2)

H.C #1

$\Theta = 18^\circ$

P.I = 3250 m (station 13+00)

We take Each 250m 1 station

$13 * 250 = 3250 \text{ m}$

Tangent length

$T = R \tan (\theta/2)$

$T = 440 \tan (18/2)$

$T = 70 \text{ m}$

Length of the curve between the BC, EC

$L = (\theta^2 * 3.14 * R) / 360$

$L = (18^2 * 3.14 * 440) / 360$

$L = 140 \text{ m}$

Long chord length between the BC, EC

$L_c = 2 R \sin(\theta/2)$

$= 2 * 440 \sin(18/2)$

$= 139 \text{ m}$

External distance from PI

$$E = R * (\sec(\theta / 2) - 1)$$

$$E = 440 * (\sec(18/2) - 1)$$

$$E = 5.5 \text{ m}$$

Middle ordinate (M)

$$M = R * (1 - \cos(\theta / 2))$$

$$M = 5.5 \text{ m}$$

Beginning of curve

$$BC = PI - T$$

$$BC = 3250 - 70$$

$$= 3180 \text{ m}$$

$$\text{Station of BC} \longrightarrow 12+72$$

End of curve EC

$$EC = BC + L$$

$$= 3180 + 139$$

$$= 3319 \text{ m}$$

$$\text{Station of EC} \longrightarrow 13+28$$

H.C #2

$$\Theta = 15^\circ$$

$$P.I = 4750 \text{ m (station } 19+00)$$

Tangent length

$$T = R \tan(\theta/2)$$

$$T = 440 \tan(15/2)$$

$$T = 58 \text{ m}$$

$$13+6 = 19 \text{ (No. of station)}$$

$$\text{Each } 250 \text{ m } 1 \text{ station}$$

$$19 * 250 = 4750 \text{ m}$$

Length of the curve between the BC, EC

$$L = (\theta^2 * 3.14 * R) / 360$$

$$L = (15^2 * 3.14 * 440) / 360$$

$$L = 115 \text{ m}$$

Long chord length between the BC, EC

$$L_c = 2 R \sin(\theta/2)$$

$$= 2 * 440 \sin(15/2)$$

$$= 114.8 \text{ m} \approx 115 \text{ m}$$

External distance from PI

$$E = R * (\sec(\theta / 2) - 1)$$

$$E = 440 * (\sec(15/2) - 1)$$

$$E = 3.8 \text{ m} \approx 4 \text{ m}$$

Middle ordinate (M)

$$M = R * (1 - \cos(\theta / 2))$$

$$M = 3.7 \text{ m} \approx 4 \text{ m}$$

Beginning of curve

$$BC = PI - T$$

$$= 4750 - 58$$

$$= 4692$$

Station of BC → 18+77

End of curve EC

$$EC = BC + L$$

$$= 4692 + 115$$

$$= 4807 \text{ m}$$

Station of EC → 19+22

2.2.2 Super elevation

Vehicles passing around circular curves are forced out of the curves by centrifugal forces. Super elevation is the raising of the edges of a road towards the centre of a horizontal curve in order to counteract centrifugal forces.

R=440m , v=100Km/hr , super ele. = 7.8% from table (2-3)

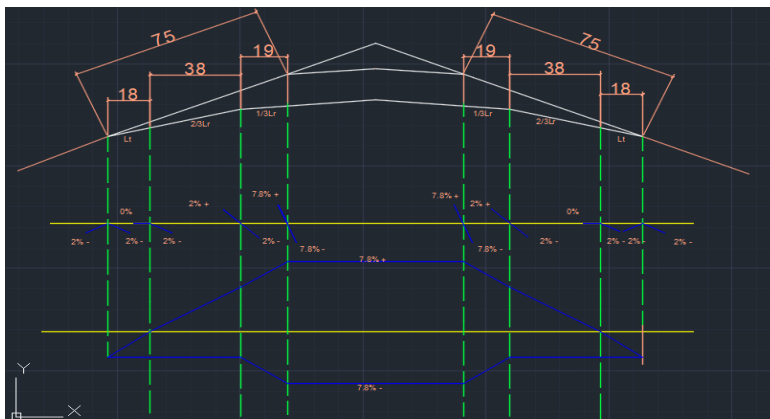


Figure 7.super elevation

2.2.3 Transition Curves

- To estimate the length of transition curve needed, three criteria are to be used and the higher value shall be adopted. These criteria are **driver's comfort, application of super elevation** and **Aesthetics** as described below:

a- Drivers Comfort:

the design speeds greater than 50 km/h so we take this equation:

$$L = \frac{VD^3}{23.3R}$$

Where:

VD: Design Speed (km/h).

R: Radius for the circular curve (m).

$$L = 100^3 / (23.3 * 440) = 98 \text{ m}$$

b- Super elevation run-off and run out to be contained within the transition:

$$L_r = \frac{w * n_1 * e_d * b_w}{\Delta s}$$

Where:

L_r = Length of super elevation runoff (**m**).

e_d = Value of design super elevation **in percent** **the value of e_d = 7.8%** from table

Δs = rate of change of super elevation (relative gradient) in percentage as given in Table 2-1

w = width of one traffic lane, **m**.

n₁ = number of lanes rotated.

b_w = adjustment factor for number of lanes rotated (**Table 2-4**) ... **the value of b_w = 1**

$$L_r = \frac{3.2 * 1 * 7.8\% * 1}{0.44\%}$$

$$= 57 \text{ m}$$

$$L_t = \frac{E_o}{E_d} * L_r$$

Where:

Lt = minimum length of tangent run out, **m**.

Lr = Length of super elevation runoff.

ed = Value of design super elevation in percent, %.

e0 = Normal Cross Slope in percent, % . (2 – 2.5)

$$L_t = \frac{2.5\%}{7.8\%} * 57$$

$$= 18 \text{ m}$$

$$L_s = L_r + L_t$$

$$= 57 + 18$$

$$= 75 \text{ m}$$

c- Aesthetics

$$L = R / 9$$

Where:

L: Length of transition curve.

R: Radius of the Circular curve.

$$L = 440/9 = 49 \text{ m}$$

- The three criteria described above are normally used to estimate **minimum length** of transition curves.
- In that case the **maximum value** of transition curve indicated in the equation below shall be considered.

$$L_s \text{ max} = \sqrt{24R}$$

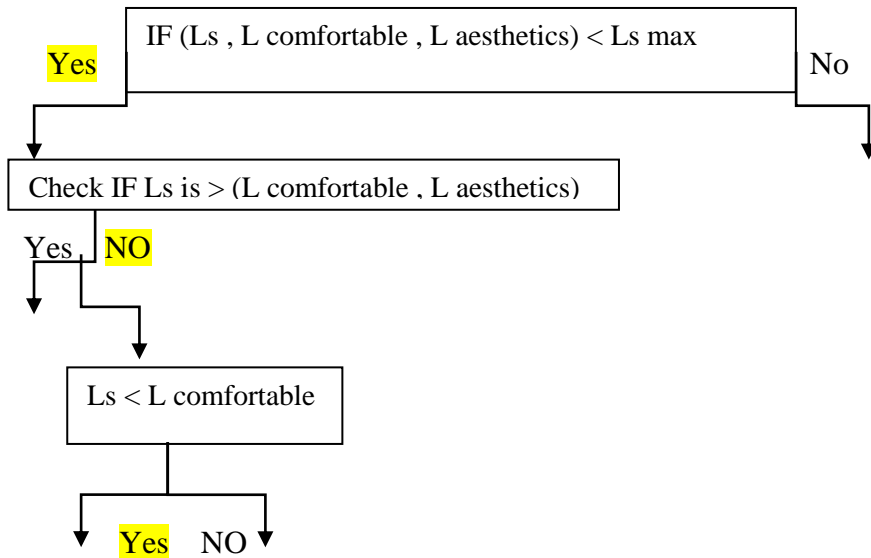
Where:

Ls max: maximum length of transition curve (m).

R: Curve radius (m).

$$L_s \text{ max} = \sqrt{24*440} = 103$$

This flow chart will describe the method of my solution



$$Lr \text{ new} = (Lr/Ls) * L \text{ com.}$$

$$Lt \text{ new} = (Lt/Ls)*L \text{ com.}$$

$$Lr \text{ new} = (57/75)*98 = 74\text{m}$$

$$Lt \text{ new} = (18/75)*98 = 23.5\text{m}$$

2.3 Widening on curves:

From AASHTO **IF R > 300 NO need** to widening.

2.4 Vertical alignments

2.4.1 Introduction

Vertical alignment consists of gradients (straight) connected to vertical curve which are normally parabolic. During the design of the vertical alignment, safety, comfort, and aesthetic factor need to be considered .

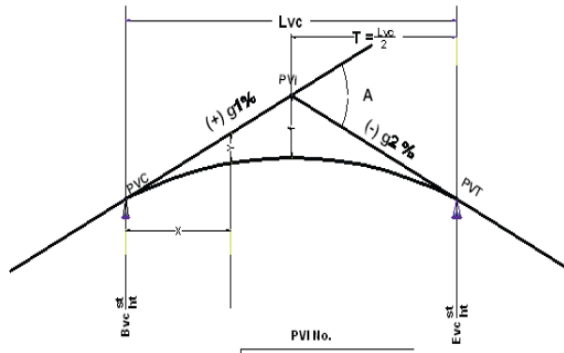


Figure 8. Vertical Curves in roads

*There are two types of vertical curves:

1. Crest curve: concave up.
2. Sag curve: concave down.

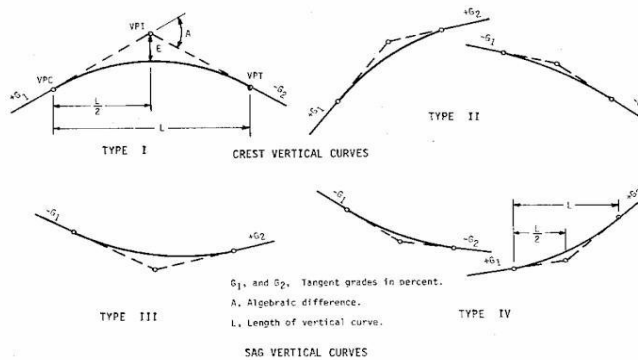


Figure 9. types of vertical curves

2.4.2 Design of vertical alignment

1-Vertical curve in highway are usually parabolic and the levels are computed using the formula:

$$LEV_x = LEV_{BVC} + G_1x + \frac{(G_2 - G_1)x^2}{2L_{vc}}$$

Where:

LEV_x=level at a point ,x meters from the beginning of vertical curve

LEV_{BVC}=level at the beginning of vertical curve

G₁=Slope of the first tangent in percentage

G2= slope of the second tangent in percentage
 X= distance from the beginning of the vertical curve
 LVC= length of vertical curve

2- Sight distance and minimum rate of curvature: Vertical curve are specified in terms of rate of curvature k and the Algebraic difference between gradients The vertical curve length are related to k by the formula:

$$L = K * A$$

Where:

K= rate of vertical curvature (the required length of crest/sag curve to a 1% change in gradient)

A= Algebraic difference between the gradient (g2-g1)

- Recommended minimum rate of curvature (K) for vertical curve are given table (2-6)

V.C #1

G1= 5.5% G2 = 1.5% if G2<G1 (sag vertical curve)

$$A = |G2 - G1|$$

$$= |0.015 - 0.055|$$

$$= 0.04$$

NO. of station	6+00
Level	→ 706
LEV(BVC)	→ 704

$$L = K * A$$

$$= 475 * 0.04$$

$$= 20 \text{ m}$$

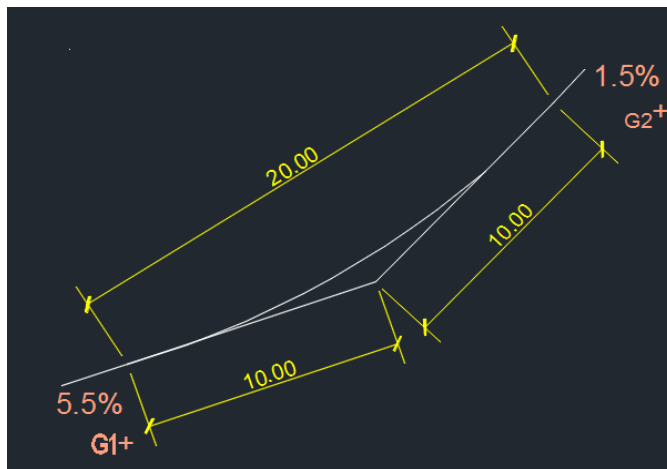


Figure 10.sag vertical curve

V.C #2

$G1 = 1.5\% \quad G2 = 6.5\%$

if $G2 > G1$ (crest vertical curve)

$$A = |G2 - G1|$$

$$= |0.065 - 0.015|$$

$$= 0.05$$

$$L = K * A$$

$$= 475 * 0.05$$

$$= 23.75 \text{ m} \approx 24 \text{ m}$$

NO. of station 10+00	
Level	→ 714
LEV(BVC)	→ 713

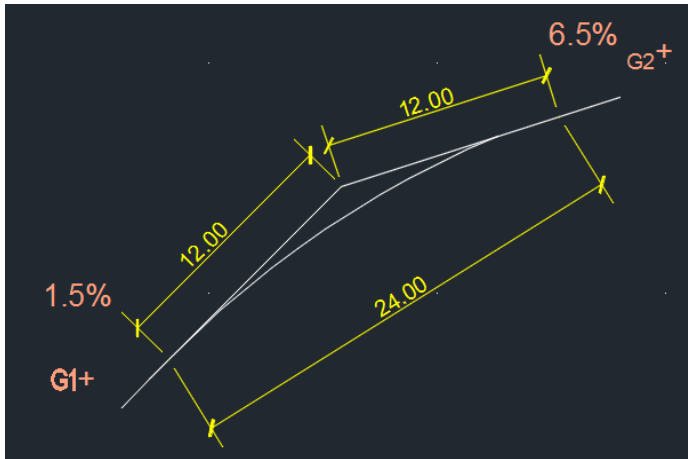


Figure 11.crest vertical curve

2.4.3 Climbing lane :

Check for climbing lane :

1. Directional flow rate on the upgrade ≥ 200 veh/h
2. Directional flow rate for trucks on the upgrade ≥ 20 veh/h and Speed reduction for trucks is 10 mi/h (20 km/hr) for a typical heavy Truck.
3. LOS is E or F on the grade.

(we do not need to climbing lane because we need 1 lane in each direction)

Chapter 3

3. Cross Section

3.1 Introduction

In geometric design there are some important controls and criteria should be considered: Design Vehicle and Vehicle Characteristics, Terrain , Driver Performance , Performance of Pedestrians and Other Road Users , Speed, Present and Future Traffic Volumes ,Capacity Safety and Design Criteria.

Road cross section will normally consist of the following: Roadway (shoulders, carriageway and median) , Drainage features (ditches),Earth work profiles (side and back slopes), Clear zones. The objective of this chapter is to get the cross section draw .

3.2 Number of lanes Determinations

The procedure to find the number of lanes:

1. Find present average annual daily traffic (AADTp).

- Traffic volume:

The general unit of measure for traffic on highway is annual average daily traffic volume , abbreviated as AADTp . which represent the total traffic for the year dividedly 365 or the average volume per day .

$$\text{AADTp} = 600 \text{ veh/day}$$

Design or (20) year : (n=20).

Population growth rate (i =5%).

2. Find future average annual daily traffic (AADTf) = AADTp (1+i)ⁿ.

$$\text{AADTf} = \text{AADTp} (1+i)^n$$

$$\text{AADTf} = 600(1+0.05)^{20} = 1591.9 = 1592 \text{ veh/day}$$

$$\text{Diverted} : 5\% * 1592 = 69.6 = 80 \rightarrow \text{AADT f} = 1592 + 80 = 1672 \text{ veh}$$

3. % directional = 50/50

$$\text{AADTf in each direction} = 1672 / 2 = 836 \text{ veh}$$

4. Hourly traffic flow DHV = 836 / 24 = 35 veh/hr.

5. Find peak hour factor PHF

$$\text{PHF} = 0.95 \text{ (The internal road)}$$

$$\text{DHV or SFi at peak} = 35 / 0.95 = 37 \text{ veh/hr}$$

6. Find the service flow

$$\text{SFi} = \text{MSFi} (N) (\text{fW})(\text{fHV}) (\text{fp})$$

Where:

SFi = service flow rate for level of service i under prevailing traffic and roadway conditions for N lanes in one direction (vph)

Find ER, ET, EB, FHV, Fp, Fw And MSF .

MSF = maximum service flow rate per hour per lane under ideal condition for level of service.

By use of table 3-2 while free flow speed =60mi/h and future level of service is D

MSF =1980 pc/lane /hr .

Fw= factor to adjust for the effect of restricted lane widths and /or lateral clearance.

By use of table 3-3 while lane width \geq 12 ft and distance from Travelled way to Obstruction \geq 6ft .

Fw = 1.00.

Fp = factor to adjust for the effect recreational or unfamiliar driver populations.

By use of table 3-4 (unfamiliar users).

Fp = 0.85

Find ER, ET,EB

By use of table 3-5 while type of terrain is Mountainous.

ET =8 , EB =5 , ER = 4

FHV= factor to adjust for the combined effect of heavy vehicles In traffic stream.

$$FHV = \frac{1}{(1+PB(EB-1) +PT(ET-1)+PR(ER-1))}$$

Where:

PB: % buses = 3%

PT: % trucks = 2%

PR: % recreational vehicles RV = 0

$$FHV = \frac{1}{(1+0.03(5-1) +0.02(8-1) +0)} \\ = 0.793 = 0.8$$

7. Calculate number of lanes.

$$SFi = 1980 (N) (1) (0.8) (0.85) = 37$$

$$N = 0.02 = 1$$

We need just 1 lane in each direction.

3.3 Width of Travel Lanes

- The selection of lane width is based on traffic volume and vehicle type and speed.
- In This study width of travel lanes (3.2m) and the slope of travel lanes is (2%) and this slope for drainage purposes.

3.4 Shoulder

- Shoulder is the portion of the roadway contiguous with the traveled way that Accommodates stopped vehicles, emergency use, and lateral support of sub base, base, and surface courses.
- In This study width of shoulder is 6ft (1.8m) and the slope of shoulder is (3%)for drainage purposes.

3.5 Side slopes

- Side slopes are provided on embankments and fills to provide stability for earthworks.
- They also serve as a safety feature by providing a recovery area for out-of-control vehicles.
- For suggested earth slopes for design, see table (3-6) and table (3-7).

3.6 Clear Zone :

- The clear zone is a safety zone adjacent to the traffic lanes. It is an unobstructed, relatively flat area provided beyond the edge of carriageway for the recovery of errant vehicles.
- The clear zone must be kept free of rigid objects and other hazards, such as steep embankment slopes, and steep-sided drainage ditches.
- If a hazard cannot be removed or relocated from the clear zone, it should be shielded by safety barrier.
- Clear Zone for design, see table (3-8).

Table 3-1.cross section elements

Station	Cut	Fill	Width Lanes	Width Shoulder	Side slope	Back slope	Drainage	Clear zone
1	10	-	3.2	1.8	1:4	1:15	0.6	Inside back slope
2	7	-	3.2	1.8	1:4	1:15	0.6	Inside back slope
3	7	-	3.2	1.8	1:4	1:15	0.6	Inside back slope
4	-	8	3.2	1.8	1:1.5	-	-	+ 2.7
5	-	5	3.2	1.8	1:1.5	-	-	+ 2.7
6	1	-	3.2	1.8	1:4	1:15	0.6	Inside back slope
7	-	3	3.2	1.8	1:1.5	-	-	+ 2.7

8	-	8	3.2	1.8	1:1.5	-	-	+ 2.7
9	2	-	3.2	1.8	1:4	1:15	0.6	Inside back slope
10	9	-	3.2	1.8	1:4	1:15	0.6	Inside back slope
11	-	2	3.2	1.8	1:2	-	-	+ 2.2
12	3	-	3.2	1.8	1:4	1:15	0.6	Inside back slope
13	-	-	3.2	1.8	1:4	1:15	-	+2.2
14	1	-	3.2	1.8	1:4	1:15	0.6	Inside back slope
15	1	-	3.2	1.8	1:4	1:15	0.6	Inside back slope
16	6	-	3.2	1.8	1:4	1:15	0.6	Inside back slope
17	5	-	3.2	1.8	1:4	1:15	0.6	Inside back slope
18	5	-	3.2	1.8	1:4	1:15	0.6	Inside back slope
19	4	-	3.2	1.8	1:4	1:15	0.6	Inside back slope
20	2	-	3.2	1.8	1:4	1:15	0.6	Inside back slope
21	-	-	3.2	1.8	1:4	1:15	-	+2.2

3.7 Cross Section Drawings

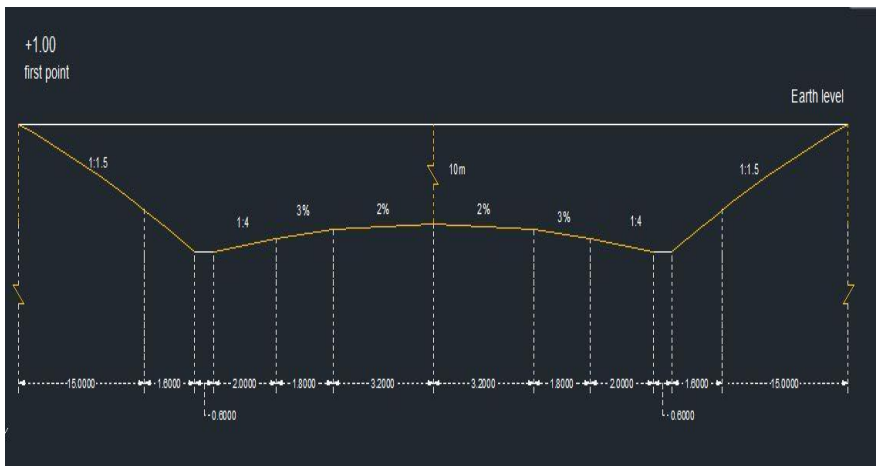


Figure 2. Cross sections draw for station +1.00

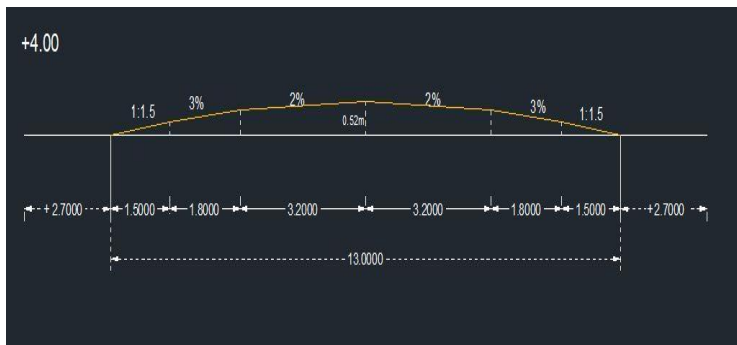


Figure 3. Cross sections draw for station +4.00

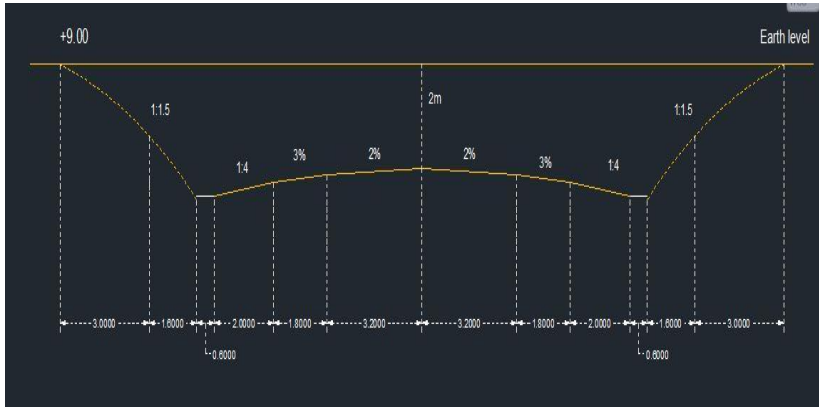


Figure 4. Cross sections draw for station +9.00

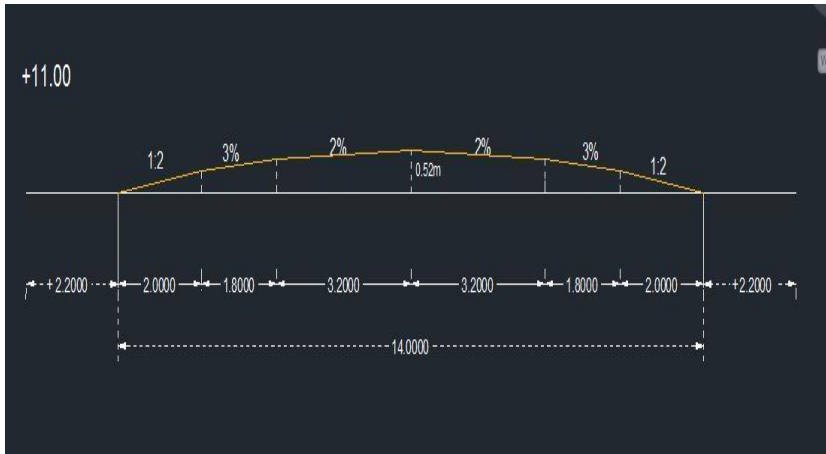


Figure 5. Cross sections draw for station +11.00

Chapter 4

4. Intersection Design

4.1 At Grade Intersections

An intersection, or junction, is the general area where two or more roads join, or cross, within which are included the carriageway(s) and roadside facilities for traffic movement in that area. An intersection is a critical part of a road because the efficiency, safety, speed, cost of roads operation, and capacity of the road depends on the intersection design.

The main objective of intersection design is to reduce the severity of potential conflicts between vehicles, bicycles, and pedestrians. In addition,

the intersection design should facilitate the convenience, ease, and comfort of people travelling through the intersection and, at the same time, assure ease of drivers in making the necessary maneuvers.

Although each intersection may have unique physical characteristics that distinguish from another intersection, Designers should adhere to uniform standards presented in **AASHTO** so as to avoid violation of driver expectancy.

Most of the intersection-accidents occur at the very lightly trafficked at-grade intersections and from a traffic-safety aspect these lightly trafficked intersections require as much attention as do those intersections where heavier conflicting traffic movements occur.

Good intersection design should allow transition from one route to another or through movement on the main route and intersecting route with minimum delay and maximum safety. The layout and operation of the intersection should be obvious to the driver, with good visibility between conflicting movements.

Crests, gradients and curves should be avoided and if absolutely inevitable, T-intersections on the outside of a curve will have much better visibility than those that are located on the inside of a curve. Furthermore, the number of intersections should be kept as low as possible consistent with traffic demands and their spacing should be as big as possible. Intersections should not be located where it is difficult or expensive to provide adequate visibility or driving comfort.

Locations which should be avoided are for example where earthworks are heavy, near bridges, on small radius curves, on the outside of super-elevated curves, on high embankments, steep grades (>3%) or on crests.

At – grade Intersection Types:

- Different At-grade intersection types will be appropriate under different circumstances depending on traffic flows, speed, and site limitations.

1. T intersection.

2. Four-leg intersection.

3. Multi – leg intersection.

- The type is determined by :

1. The number of legs.
2. The topography .
3. The Character of intersecting roads.

4. The traffic patterns and speed .
5. The desired type of operation .
 - Multi – leg intersection should be avoided .

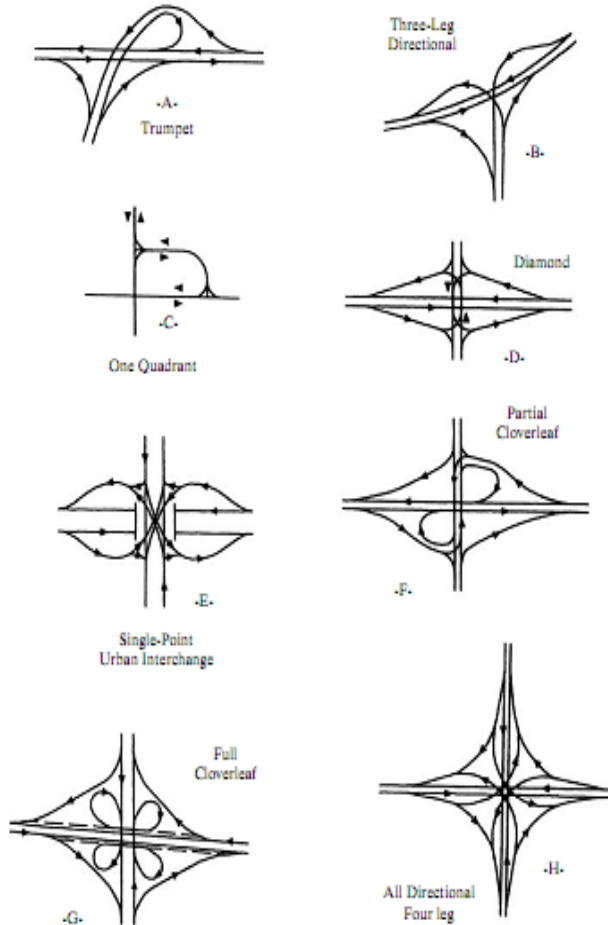


Figure 6.Examples of Grade Separated Interchanges

4.2 Intersection design procedure:

4.2.1 Select the intersection.

- Intersection 1: of the entrance to Thughrat al-Jib road.
- Intersection 2: of the entrance of Idoun Bani Hassan road.

1. Select the type of intersection.

In both intersections is T intersection.

2. Find the value of Angle of turn (Δ).

- For Intersection 1 :
 - $\Delta = 90$
 - $\Delta = 150$
 - $\Delta = 120$
- For Intersection 2 :
 - $\Delta = 120$
 - $\Delta = 180$
 - $\Delta = 60$

3. Find curve radius values (R) , offset , taper (L :T)

The angle of turn, turning speed, design vehicle, and traffic volume are the main factors governing the design of curves at at-grade intersections.

By using (table 4- 2) and (table 4-3) we can know the information we need for intersection and it is as follows .

Table 4-1. Minimum Edge of Pavement Design for Turns at Intersections.

Angle of turn	Design Vehicle	Simple Curve Radius (ft)	Simple Curve Radius with Taper		
			Radius (ft)	Offset (ft)	Taper L:T
- For Intersection 1 :					
90	P	30	20	2.5	10:1
150	P	-	18	2	10:1
120	P	-	20	2	10:1
For Intersection 2 :					
120	P	-	20	2	10:1
180	P	-	15	0.5	20:1
60	P	40	-	-	-

1ft= 3m

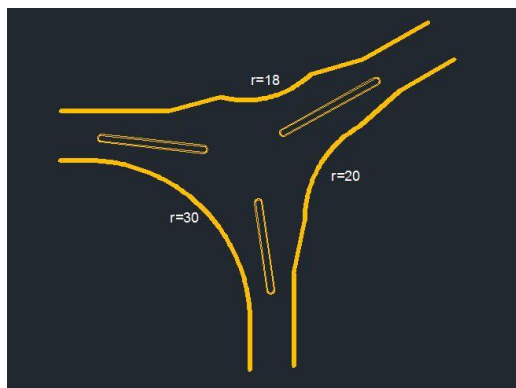


Figure 17 Intersection 1 (toThughrat al-Jib) .

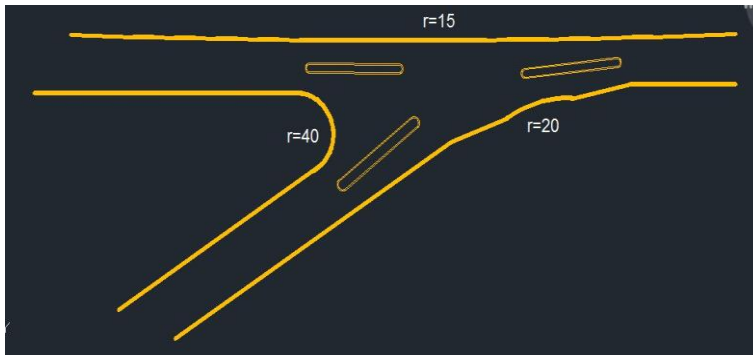


Figure 7.: Intersection 2 (to Idoun Bani Hassan).

Chapter 5

5. Pavement Layers Design .

5.1 Introduction:

The expected life of any proposed pavement structure is a function of various parameters. These parameters include the following:

Vehicle axle-loading.

1. Weights and repetitions.
2. Sub grade bearing capacity.
3. Pavements materials.
4. Construction specification and procedures.
5. Maintenance operations.
6. The number and areas of freeze-thaw cycle occurs.
7. Acceleration and deceleration of traffic.
8. Grades and curves.
9. Water flow through the pavement structure.
10. Initial serviceability index.
11. Maximum amount of roughness in pavement structure.
12. Time and climate.

The two general types of pavement used for highways are classified as :

- 1) Flexible pavement.
- 2) Rigid pavement.

Principally, the pavement design method centers around the investigation and evaluation of the soil sub grade and bearing capacity, the (18 kip) daily single axle load equivalent, and climatic condition.

The soil sub grade bearing capacity will be determined by the California bearing ratio (CBR), which is the percentage of the penetration resistance of material as related to the value of crushed stone .These value , referred to as CBR numbers, are determined in accordance with established standard procedure.

The existing soils to be used as the sub grade for the highway may be evaluated by the tests performed on soils taken from the project site during the soil investigation phase. if test not been performed, an approximate CBR value can be obtained from charts bases on the description of existing soils and bring blow counts recorded during the soil investigations .

The equivalent of 18 kip daily single axle load used in design is based upon the average daily traffic volume within the design period and major vehicle classifications.

The design period is usually defined as 20 years, beginning at the approximate date of completed constructions.

The number of cars and light trucks contribute very little to the total 18 kip load applications while the loaded trucks, and particularly heavily loaded single axle trucks, contribute greatly to the equivalent daily 18 kip load application . there for, it is important to obtained or estimate accurate truck volume data, and to make realistic projections from it .

* **AASHTO Design method:**

Design consideration:

The factors considered in the AASHTO procedure for the design of flexible pavement as presented in 1986 guide are:

- 1) Pavement performance.
- 2)Traffic (Σ ESAL).
- 3)Road bed soils(sub grade material).
- 4)Materials of construction.
- 5)Environment
- 6)Drainage.
- 7) Reliability.

5.2 Pavement performance:

- 1) The structural performance \rightarrow related to the physical condition of the pavement with respect to factors.
(Cracking, faulting, ravelling, ...)

2) The functional performance → indication of how effectively the Pavement serves the user with respect to factors.

(Riding comfort ... etc)

→ based on the previous, indicate PSI, present serviceability index,

PSI = f(roughness, distress). and it is range(0-5)

Initial serviceability index (Pi) → immediately after construction Pi

= 4.5

Terminal Serviceability index (Pt) → The minimum acceptable.

Value before resurfacing or reconstruction is necessary.

Pt = (2.5-3) → for major high way.

Pt = 2.5

⇒ $\Delta PSI = 4.5 - 2.5 = 2$

Traffic " \sum ESAL".

ESAL = (AADT) (T) (T_F) (G_{jt}) (D) (L) (y)

→ Type of pavement: Hot Mix Asphalt(HMA).

-Reliability(R%)=75%

=>for collectors/Rural (Table 5.1).

-standard deviation(S₀)=0.4

=> (Table 5.2)

- First year annual average daily

- traffic (AADT) =600 veh

-Truck(%)=2%

-Busses(%)=3%

-PC'S(%)=95%

-The percentage of truck in the ADT (T)

T→Busses → TB = 0.03

T→Trucks → TT = 0.02

-Truck Factor(T_f)=>Table (5.3)

=> for (Major/collectors/Rural)

T_f→Busses→2-axle, 4-trie→T_f=0.017

T_f→Trucks→3-axle, 6-trie→T_f=0.41

G_{jt}→ Growth Factor→ Table(5.4) → G_{jt}

=33.06 r =0.05

⇒ Where r : annual growth rate

-Design Period In Years (y) =20

-Direction Distance Factor (D) = 0.5

-Lane Distribution Factor→ from table (5.5) (L) =1

→Number of equivalent accumulated axle loads in the design lane

*Let

$ESAL_1$ =For single unit Truck/2-axle , 4-tire

$ESAL_2$ =For single unit Truck/3-axile , 6-tire

$$*ESAL_1 = (AADT) (T)(T_F)(G_{jt})(D)(L)(y) \\ = 600(0.03)(0.017)(33.06)(0.5)(1)(20)$$

$$ESAL_1 = 1626.552$$

$$*ESAL_2 = (AADT) (T)(T_F)(G_{jt})(D)(L)(y) \\ = 600(0.02)(0.41)(33.06)(0.5)(1)(20)$$

$$ESAL_2 = 101.163$$

$$\sum ESAL \ 1-2 = 1626.552 + 101.163 \\ = 1727.71$$

Road bed soils (sub grade materials)

Resilient modulus (MR) defines the property of the soil by conversion of the (CBR) or (R value) to (MR)

* For Resilient Modulus (Mr):

Surface layer

$$Mr_1 = E_2 = 40,000 \text{psi} = 40 \text{ksi}$$

- Base layer

$$Mr_2 = E_3 = 30,000 \text{psi} = 30 \text{ksi}$$

- Sub base layer

$$Mr_3 = Mr \text{ for sub grade} = 15,000 \text{psi} = 15 \text{ksi}$$

*Note: These values are taken from Ministry of public works & Housing.

***Materials of construction:**

Materials of surface construction (a_1) = 0.42

→ From fig (20)

Materials of base construction (a_2) = 0.07

Where (CBR2 = 20) → fig (21)

Materials of sub base construction (a_3) = 0.085

Where (CBR3 = 10) → fig (22)

*Note : California Bearing Ratio test (CBR) these values are taken from Ministry of public works & Housing .

* for structural number(SN):

- we can find it based on the given before:

1- Δ PSI

2-overall standard deviation (So)

- 3- ESAL for all truck
- 4- Resilient modulus (Mr) for each layer of pavement
- 5- Reliability(R)

Environment

Temperature and rainfall are the two main environmental factors Used in evaluating pavement performance in AASHTO method.

Drainage

Quality of drainage of (the saturation, excellent, less than 1 & water removed within 2 hours) → From tables (5.6 & 5.7)

$$m_2 = m_3 = 1.4$$

Structural Design:

- we can find it based on the given before:
 - 1- Δ PSI
 - 2-overall standard deviation (So)
 - 3- ESAL for all truck
 - 4- Resilient modulus (Mr) for each layer of pavement
 - 5- Reliability(R)

*Note: we can find (SN) from this book, Garber and Hoel-Traffic and Highway Engineering from figure (23) page(1049)

*we obtain that:

- (SN₃) for sub base (sub grade) =2.6
- (SN₂) for Base=2.3
- (SN₁) for surface=2.0

* D₁: Thickness of HMA

$$D_1 \geq \frac{SN_1}{a_1}$$

$$\geq 2 / 0.42$$

$$\geq 4.8 \text{ in}$$

$$D_1 \geq 12 \text{ cm}$$

D₂: Thickness of

$$\text{Base } D_2 \geq \left(\frac{SN_2 - a_1 * D_1}{a_2 - m_2} \right)$$

$$D_2 \geq \frac{2.3 - (0.42 * 4.8)}{(0.07 * 1.4)}$$

$$D_2 \geq 2.9 \text{ in}$$

$$D_2 \geq 8 \text{ cm}$$

*D₃:Thickness of Sub base larger
 $D_3 \geq (SN_{3-(a_1 * D_1)} - (a_2 * D_2 * m_2)) / (a_3 * m_3)$

$$D_3 \geq 2.55 \text{ in}$$

$$D_3 \geq 7 \text{ cm}$$

5.3 Conclusions & Recommendations:

*Thickness of layer:

1-HMA=12cm

2-Base=20 cm

3-SubBase=20 cm

6 We put D₂ = 20 cm and D₃ = 20 cm according to specifications of Ministry of public works and housing .

And we use Tack coat RC = 0.5 Kg /m² , Also primer coat

Mc = 2 Kg /m² .

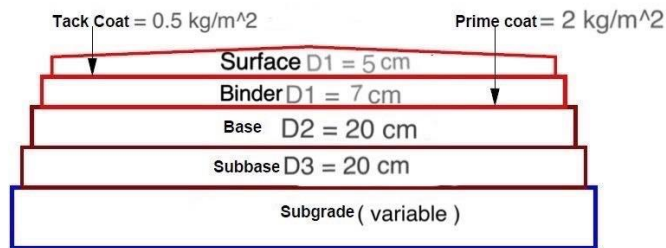


Figure 19. Typical Section for flexible pavement .

Chapter 6

6. Drainage and Water Service Design

6.1 Catchment Area:

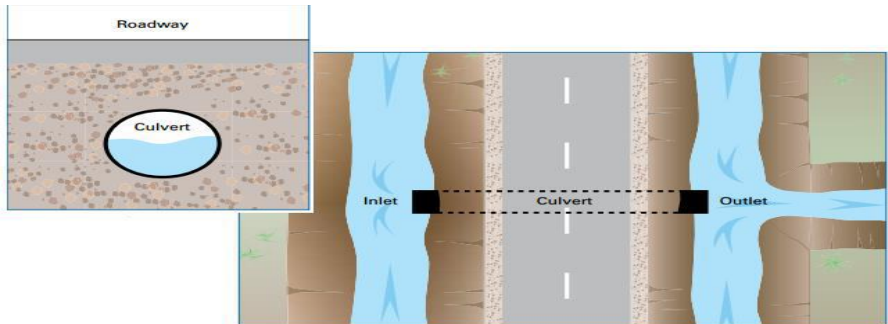
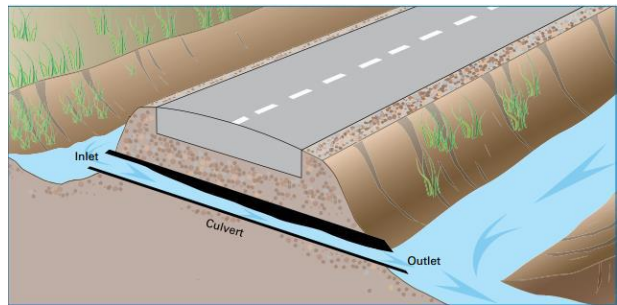
The drainage area is that are of Land that contributes to the run off (flow rate) of the point where the drainage system capacity is to be determined The drainage area determined by constructing the water divided Line on the contour map, this represent the separation of water that runs toward the point of interest from the water that runs away in the opposite direction This line is generally found at the top of mountainous crakes.

Starting from the point of interest (such as a culvert) which is usually located at a low elevation one should start inspecting the adjacent area and moving the direction of the rising elevation of ground starts decreasing, this pointer present the water divided line after doing so in all direction away from the point of interest the overall water divided line from the boundary of the drainage area, beyond this boundary the water will not contribute to the run off as it runs in the opposite direction .

Ditches:

Drainage ditches are used to move standing water from one location to another. Many home owners and gardeners use them to better control the amount of water that sits in one area of their yard. Low spots in a yard or garden tend to collect and hold water during heavy rain. These areas can create mosquito problems and damage the landscaping. Designing and using a drainage ditch can be a simple solution to a problem.

- Culvert:

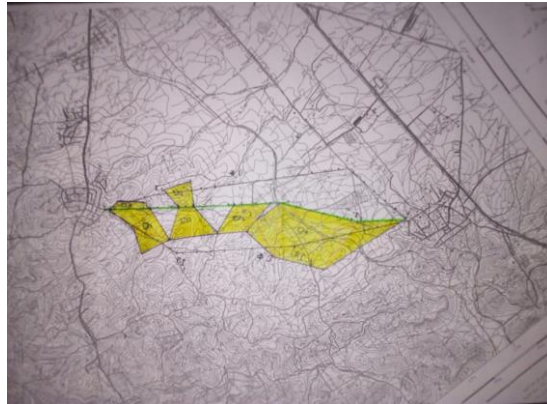


is a structure that allows water to flow under a road, railroad, trail, or similar obstruction from one side to the other side. Typically embedded so as to be surrounded by soil, a culvert may be made from a pipe, reinforced concrete or other material. In the United Kingdom the word can also be used for a longer artificially buried watercourse. A structure that carries water

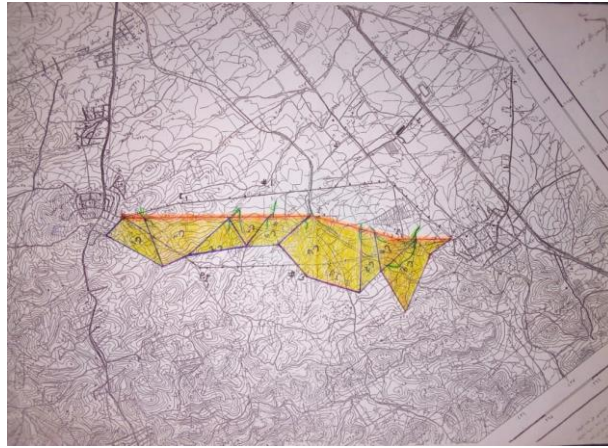
above land is known as an aqueduct. Culverts are commonly used both as cross-drains for ditch relief and to pass water under a road at natural drainage and stream crossings. A culvert may be a bridge-like structure designed to allow vehicle or pedestrian traffic to cross over the waterway while allowing adequate passage for the water. Culverts come in many sizes and shapes including round, elliptical, flat-bottomed, pear-shaped, and box-like constructions. The culvert type and shape selection is based on a number of factors including requirements for hydraulic performance, limitation on upstream water surface elevation, and roadway embankment height.

Culverts are classified by standards for their load capacities, water flow capacities, life spans, and installation requirements for bedding and backfill.

*After determining the boundary for each area , these areas are computed



NO of Ditches	Area (m ²)
D1	320937.5
D2	301562.5
D3	183750
D4	907812.5
D5	53750
D6	144375



NO. of Culverts	Area (m ²)
C1	226875
C2	555000
C3	130625
C4	131250
C5	259687.5
C6	726875
C7	153750
C8	138125
C9	2320468.75

6.2 Design of ditch

Procedure:

1. Determine the location of Ditch.
2. Find the catchment area of ditch.
3. Determine the highest point on catchment area (hh) .
4. Determine the lowest point on the route (hl).
5. Determine the distance between the highest farthest point (hh) and the lowest point on ditch (hl) , this distance called length of slope , Ls .
6. Determine G % , $G\% = (hh-hl)/Ls$
7. Determine the time of concentration , tc → of nomograph for overland flow time.
8. Determine the average rainfall intensity , I (mm/hr) from figure (rainfall intensity-duration-frequency) ,
 $I(\text{in/hr}) \rightarrow I^*(25.4) \rightarrow I(\text{mm/hr}) \rightarrow I/(3.6*10^6) \rightarrow I(\text{m/sec})$.
9. Determine the year storm /n, n=25year
10. Determine Run off coefficient, (c) , take C=0.5 .

11. Determine the available flow, Q_a (m^3/sec), $Q_a=CIA$
12. Assume depth of ditch below the sub base , d .
13. calculate the velocity of flow (V). of Manning equation
 $V=(1/n)(R)^{(2/3)}(S)^{(1/2)}$

Where:

n : roughness coefficient for manning equation → Table (3-5), assume " n " for the soil design of ditches =0.025

R :hydraulic radius , $R=A/P$

Where :

A : weted area , $A=(3d^2+0.6d)$

P :weted parameter , $P=(6.36d+0.6)$

► $R=A/P =(3d^2+0.6d)/(6.36d+0.6)$

S : the slope from profile .

14. If " V " calculated < 1m/sec → go to step "15"

If " V " calculated > 1m/sec → go to step "12"

Or set knew " n ", $n=0.014$ → go to step "15"

15. Calculate Q designed , $Q_d = V*A$.

16. If $Q_d > Q_a$ → ok , use the assumed " d "

17. $Q_d < Q_a$ → assume knew " d " → start from step "12"

# Ditch	(Sta- Sta) (M)	Area (M2)	Hh (M)	HI (M)	Ls (M)	G%	S%	Tc (Min)	I (Mm/hr)	Q_a (M3/Sec)	V_a (M/Sec)	Q_d (M3/Sec)	D (M)
1	4625-5500	32093 7.5	77 0	765	1050	1	5.5	34	88.9	4.0117	3.99	4.1895	0.5
2	3875-4125	30156 2.5	75 2	725	700	3.857	6.5	23.5	142.24	5.956	4.34	4.557	0.5
3	2500-3125	18375 0	75 0	723	1075	2.5116	6.5	29	116.84	2.9813	4.34	4.557	0.5
4	0-2312.5	90781 2.5	70 0	696	1850	1	6.5	49	86.36	10.885	4.34	4.557	0.5
5	3875-4125	53750	76 7	750	500	3.4	6.5	19.5	147.32	1.0997	4.34	4.557	0.5
6	4625-5500	14437 5	75 1	720	250	12.4	6.5	12	177.8	3.56462	4.34	4.557	0.5

To simplify the design process, use side ditch with 0.4m on both side along all road, and the surface of this ditches is concrete.

6.3 Design of culverts

Procedure:

- 1- Determine the location of culvert.
- 2- Find the catchment area of culvert.
- 3- Determine the highest point on catchment area, (hh).
- 4- Determine the Ground level (Gl) at the station of culvert .

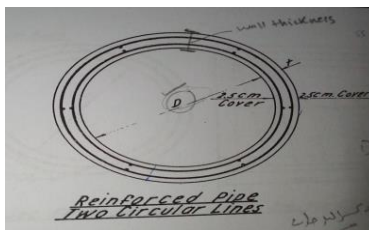
- 5- Determine the distance between the highest farthest point hh, and the culvert, this distance called length of slope, (Ls).
- 6- Determine G%, $G\% = (hh - Gl) / Ls$
- 7- Determine the time of concentration, $t_c \rightarrow$ from figure (3-5).
- 8- Determine "I" \rightarrow from figure (A-2).
- 9- calculate (Q), $Q = CIA$
- 10- assume the type and dimensions of culverts. depth of headwater (HW), diameter ($d = 90\text{cm} = 35.43\text{in}$).

# Culvert	Station (M)	Area (M2)	Hh (M)	Gl (M)	Ls (M)	G %	Tc (Min)	I (Mm/hr)	Qa (M3/Sec)	HW/D	Culvert used (M)
1	21+19	226875	789	765	450	5.33	16.5	152.4	47.463	6.5	Pipe1
2	16+00	555000	771	721	1400	3.57	29.6	106.68	8.22233	3.1	Pipe1
3	15+10	130625	756	722	525	6.48	18	149.86	2.727	2.45	Pipe1
4	13+25	131250	756	714	650	6.46	20	147.32	2.6854	2.41	Pipe1
5	10+40	259687.5	756	708	1200	4	27	127	4.5796	2.6	2 Pipe1
6	7+00	726875	727	706	1400	1.5	34	101.6	10.2563	3.4	2 Pipe1
7	6+10	153750	716	698	1050	1.7	31	109.22	2.3322	1.83	Pipe1
8	3+20	138125	712	687	800	3.125	24.3	124.46	2.3876	1.9	Pipe1
9	0+00	232046.875	725	685	1225	1	39	96.52	5.473	3.2	Pipe1

Design Requirement for Reinforced Conc Pipe
Concrete Strength 180 Kals/cm²

Inter Diam of Pipe	Wall Thickness	Min. Circular Reinforcement cal/m ²	Longitudinal Reinforcement	Ultimate load by Three edge Bearing test
50	7.50	3.71	-	888mm 8000
60	7.50	3.98	-	888mm 7000
75	8.50	5.09	-	888mm 8000
90	10	11.50	-	888mm 9000
90	10	5.03	3.71	1288mm 9500
Extra Strength Pipes				
60	7.50	5.40	-	888mm 8000
75	8.50	8.50	-	888mm 10000
90	10	18.50	-	888mm 11000
90	10	8.03	5.53	1288mm 11000

MINISTRY OF PUBLIC WORKS
BRIDGE SECTION
REINFORCE CONCRETE PIPES
SHEET No 23 11/1972



Bridge:

is a structure built to span physical obstacles without closing the way underneath such as a body of water, valley, or road, for the purpose of providing passage over the obstacle. There are many different designs that each serve a particular purpose and apply to different situations. Designs of bridges vary depending on the function of the bridge, the nature of the terrain where the bridge is constructed and anchored, the material used to make it, and the funds available to build it.

Design of bridges not required in This study since the following reasons:

- 1.the topography is not mountainous.
- 2.the quantity of water or rains are small.

Chapter 7**7. Earth work quantities****Measurements of area of cut and fill :**

By knowing the cross section of the highway and the side slop and the elevation of cut or fill (differences in elevations from profile between the ground level and road level) , and the slop of the neutral ground , the area of each section can be calculated using referent method .

These method such as using a mechanical integration by plan meter or mathematically .

***Volume calculations :**

There are many method used to find the volume from cross-section "average End-area method" , and "Prismoidal Formula " .

Prismoidal Formula is more accurate than the average End-area method . but we used average End-area method for a simplicity .

$$V = D * (A1 + A2) / 2$$

V: volume between cut and cut or fill and fill section (m³)

D : distance between two successive section (m)

= 100 m ... constant in this project

A1 , A2 : area of first and next station (m²)

*** Mass haul diagram (MHD) Calculations :**

In work were large the volume of the earth work have to be handled . Especially large works such as railway and highway , a mass haul diagram is of great value both in planning and construction .

MASS HAUL DIAGRAM**Table 71-.MASS HAUL DIAGRAM**

Station	Cut + (m2)	Fill – (m2)	Cut +(m3)	Fill – (m3)	Cumulative (m3)
0+00	0	0	0	0	0
1+00	10	0	25000	0	25000
2+00	7	0	17500	0	42500
3+00	7	0	17500	0	60000
4+00	0	8	0	20000	40000
5+00	0	5	0	12500	27500
6+00	1	0	2500	0	30000
7+00	0	3	0	7500	22500
8+00	0	8	0	20000	500
9+00	2	0	5000	0	5500
10+00	9	0	22500	0	28000
11+00	0	2	0	5000	23000
12+00	3	0	7500	0	30500
13+00	0	0	0	0	30500
14+00	1	0	2500	0	33000
15+00	1	0	2500	0	60500
16+00	6	0	15000	0	75500
17+00	5	0	12500	0	88000
18+00	5	0	12500	0	100500
19+00	4	0	10000	0	110500
20+00	2	0	5000	0	115500
21+00	0	0	0	0	115500

Chapter 8**8. Traffic engineering**

Signs size depends mainly on the type and size of message it is to convey.

Regulatory and warning signs should be reflectorized or illuminated to show the same shape and color both day and night.

In general, signs are usually located on the right-hand side of roadway for easy viewing by drivers. They are placed at an angle to reflect beams back to the driver at night

Traffic Markings :

It is used on the surface of Route for the following purposes

1. Indicates the edge of lanes and the center line.
2. Indicates The passing and no-passing Zones.
3. Indicates the crossing walk for pedestrian... etc

***Traffic signs:**



A traffic signs are a device mounted on a fixed or portable support where by a specific message is conveyed means of words or symbols officially evicted for the purpose of regulating warning or guiding traffic.







Signs can be either permanent, temporary, or variable messages.

They should be used only when justified by common sense, judgment and engineering studies. A conservative use of regulating and warning signs is particularly a devisable so as to avoid a tendency on the part of motorists to disarrayed too many signs. Guide signs, however, can be used liberally without losing their value as traffic control devices since they help guide motorists to their destinations.

Signs are standardized by shape:

- 1)The diamond shape: to warn drivers of road way hazard
- 2)The vertical rectangle: for most regulatory signs.
- 3) The horizontal rectangle: for guide signs and giving directions, locations, and destinations.

station	sign
0+00	
2+00	

4+00	
7+00	
9+00	
14+00	
18+00	
22+00	

Chapter 9

9. Cost analysis for the project.

Total	Price (JD)	Quantity.	Unit	Labor
14987.5	5.45	2750	m ³	HMA with 5cm thickness
30800	8.00	3850	m ³	HMA with 7cm thickness
11792.4	600	19.654	Ton	MC Prime Coat
44057.08	0.90	55000	m ²	Seal Coat
75876.08	15.50	4895.2314	m ³	Base Coarse
35490.43	14.50	2447.6157	m ³	Sub base Coarse
1749200	4.00	437300	m ³	Cut works
765625	3.50	218750	m ³	Fill works
152	9.50	16	Number	Reflectors
334.75	9.5	352.185	m ²	Hotpoint various colors for roads Yellow (solid)
3881.25	27	143.75	m ²	white Painting of walkways
784.7	9.5	82.6	m ²	Hotpoint various colors for roads white Painting of lane line
2827.49	9.5	279.63	m ²	Hotpoint various colors for roads Yellow (broken)

Chapter 10

10. The Environmental Impact of the Road

Roads are increasingly common in today's world as human development expands and people increasingly rely on cars for transportation on a daily basis. Forest roads are the base infrastructure foundation of forestry operations. These roads entail a complex engineering effort because they can cause substantial environmental damage to forests and include a high-cost construction.

Forest roads are the most costly structures in forestry. Inadequately constructed forest roads can cause severe environmental impacts including road surface erosion and sediment yield, pollution of off-site waters, slope failures and mass movement direct loss of habitat (by the conversion of the original land cover into an artificial surface) and indirect loss of habitat (by the fragmentation of an ecosystem into smaller and more isolated patches).

Therefore, forest road managers should design forest roads by considering not only cost efficiency but also sustainable management of the forest environment.

Potential negative environmental impacts:

- increased noise, air and dust pollution during construction;
- consequences of excavating and transporting road building materials
- cutting through unstable geological formations likely to result in landslides and soil erosion
- effect on drainage that restricts water channels used for agricultural irrigation

During the construction project of a forest road, the standard design must be carried out on the ground to achieve the desired road with minimal impact on environment. Sometimes the standard design cannot be useful for determining the clearing limit of forest roads.

Forest road construction often results in the most environmental impact to adjacent ecosystems because earth movement and other activities can disturb whole watersheds. An enumeration of road effects on ecosystem goods and services is marginally addressed in this report. The effects of roads on those ecological structures and processes that are of direct and indirect use to humans are, however, discussed in detail. Ecosystem structure and functioning can be translated into ecosystem goods and services, as described in subsequent sections. Roads can also be a conduit for pollutants into the environment. The debris from tires on the road can decrease the time to metamorphosis of wood frogs

11. Conclusion

As mentioned before This study is a full design for a Two way-Two lane Road that connect between two small cities in northern part of Jordan within the branch of highway engineering standards. On the other hand, The impacts of this road were studied.

12. Appendix

Chapter 1

Table 2:1

Alternative Property	#1	#2	#3
Length of the route (Km)	5.750	5.500	5.750
NO. of H curves	3	2	2
NO. of V curves	2	2	2
Service population centers	3	3	2
Cut +	583730+	437500+	468900+
Fill -	399820-	218750-	286500-

(Table 2:2) Alignment#1

Station	Elevation	Distance
0+00	676	0
1+00	695	250
2+00	684	500
3+00	685	750
4+00	691	1000
5+00	696	1250
6+00	680	1500
7+00	690	1750
8+00	690	2000
9+00	690	2250
10+00	712	2500
11+00	714	2750
12+00	711	3000
13+00	713	3250
14+00	714	3500
15+00	723	3750
16+00	729	4000
17+00	745	4250
18+00	750	4500
19+00	748	4750
20+00	753	5000
21+00	753	5250
22+00	745	5500
23+00	760	5750

(Table 2:3) Alignment #2









Station	Elevation	Distance
0+00	676	0
1+00	702	250
2+00	698	500
3+00	700	750
4+00	699	1000

5+00	703	1250
6+00	710	1500
7+00	714	1750
8+00	715	2000
9+00	719	2250
10+00	725	2500
11+00	737	2750
12+00	740	3000
13+00	746	3250
14+00	750	3500
15+00	746	3750
16+00	745	4000
17+00	752	4250
18+00	751	4500
19+00	745	4750
20+00	737	5000
21+00	742	5250
22+00	750	5500

(Table 2:4) Alignment #3

Station	Elevation	Distance
0+00	676	0
1+00	690	250
2+00	687	500
3+00	698	750
4+00	690	1000
5+00	698	1250
6+00	708	1500
7+00	705	1750
8+00	701	2000
9+00	714	2250
10+00	723	2500
11+00	712	2750
12+00	720	3000
13+00	719	3250
14+00	721	3500
15+00	723	3750
16+00	735	4000
17+00	739	4250
18+00	745	4500
19+00	750	4750
20+00	755	5000
21+00	758	5250
22+00	753	5500
23+00	757	5750

(Table 8:1)

station	sign
0+00	
2+00	
4+00	
7+00	
9+00	
14+00	
18+00	
22+00	

Chapter 2

Table 2-1 Side friction factors for different design speeds

Design Speed (km/h)	Limiting value of (f)
30	0.17
40	0.17
50	0.16
60	0.15
70	0.14
80	0.14
90	0.13
100	0.12
110	0.11
120	0.09

Table 2-2 : Minimum radii for design of roads for most common design speeds for bituminous surfaced roads

Design Speed (km/h)	Minimum Radii of Curves (m)		
	Desirable	Absolute (Calculated)	
		$e_{max} = 0.08$	$e_{max} = 0.06$
30	50	28	31
40	75	50	55
50	100	82	90
60	150	123	135
70	200	175	193
80	300	229	252
90	350	304	336
100	450	394	440
110	600	501	560
120	780	667	760

Table 12-3. Super elevation rates % related to design speed (Vd)

R(m)	Vd 30 km/h	Vd 40 km/h	Vd 50 km/h	Vd 60 km/h	Vd 70 km/h	Vd 80 km/h	Vd 90 km/h	Vd 100 km/h	Vd 110 km/h	Vd 120 km/h
7000	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
5000	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
3000	NC	NC	NC	NC	NC	NC	NC	RC	RC	RC
2500	NC	NC	NC	NC	NC	NC	RC	RC	RC	2.9
2000	NC	NC	NC	NC	NC	RC	RC	2.6	3.0	3.5
1500	NC	NC	NC	NC	RC	RC	2.8	3.4	3.9	4.6
1400	NC	NC	NC	RC	RC	2.5	3.0	3.6	4.1	4.9
1300	NC	NC	NC	RC	RC	2.7	3.2	3.8	4.4	5.2
1200	NC	NC	NC	RC	RC	2.9	3.4	4.1	4.7	5.6
1000	NC	NC	RC	RC	2.8	3.4	4.0	4.8	5.5	6.5
900	NC	NC	RC	RC	3.1	3.7	4.4	5.2	6.0	7.1
800	NC	NC	RC	2.7	3.4	4.1	4.8	5.7	6.6	7.6
700	NC	RC	RC	3.0	3.8	4.5	5.3	6.3	7.2	8.0
600	NC	RC	2.6	3.4	4.3	5.1	6.0	6.9	7.7	
500	NC	RC	3.0	3.9	4.9	5.8	6.7	7.6	8.0	
400	RC	2.7	3.6	4.7	5.7	6.6	7.5	8.0		
300	RC	3.5	4.5	5.6	6.7	6.7	8.0			
250	RC	4.0	5.1	6.2	7.4	7.9				
200	3.0	4.6	5.8	7.0	7.9	8.0				
175	3.4	5.0	6.2	7.4	8.0					
150	3.8	5.4	6.7	7.8						
140	4.0	5.6	6.9	7.9						
130	4.2	5.8	7.1	8.0						
120	4.4	6.0	7.4							
119	4.4	6.0	7.4							
110	4.7	6.3	7.6							
100	5.0	6.6	7.8							
90	5.2	6.9	8.0							
80	5.5	7.2	8.0							
70	5.9	7.5								
60	6.4	7.9								
50	6.9	8.0								
40	7.5									
30	8.0									

Table 2-4. Maximum and minimum rate of change of super elevation

Design Speed Km/h	30	40	50	60	70	80	90	100	110	120
Max. Δs (%)	0.75	0.70	0.65	0.60	0.55	0.50	0.47	0.44	0.41	0.38
Min. Δs (%)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3

Table 2-5 Adjustment Factors for Number of Lanes Rotated

Number of lanes Rotated	Adjustment Factor	Length Increase Relative to One-Lane Rotated (=n1bw)
1	1.00	1.0
2	0.75	1.5
3	0.67	2.0

Table 2-6 minimum rate of curvature (K) for vertical curve

Design Speed km/h	K-Values to Satisfy stopping sight distances (m / % of g)		K-Values to satisfy passing sight distances (m / % of g)
	Crest	Sag	
30	3	4	50
40	5	8	86
50	10	12	126
60	18	18	176
70	22	25	246
80	49	32	310
90	71	41	387
100	105	51	475
110	151	62	561
120	201	74	664

Chapter 3

Table 3-1.cross section elements

Station	Cut	Fill	Width Lanes	Width Shoulder	Side slope	Back slope	Drainage	Clear zone
1	10	-	3.2	1.8	1:4	1:15	0.6	Inside back slope
2	7	-	3.2	1.8	1:4	1:15	0.6	Inside back slope
3	7	-	3.2	1.8	1:4	1:15	0.6	Inside back slope
4	-	8	3.2	1.8	1:1.5	-	-	+ 2.7
5	-	5	3.2	1.8	1:1.5	-	-	+ 2.7
6	1	-	3.2	1.8	1:4	1:15	0.6	Inside back slope
7	-	3	3.2	1.8	1:1.5	-	-	+ 2.7
8	-	8	3.2	1.8	1:1.5	-	-	+ 2.7
9	2	-	3.2	1.8	1:4	1:15	0.6	Inside back slope
10	9	-	3.2	1.8	1:4	1:15	0.6	Inside back slope
11	-	2	3.2	1.8	1:2	-	-	+ 2.2
12	3	-	3.2	1.8	1:4	1:15	0.6	Inside back slope
13	-	-	3.2	1.8	1:4	1:15	-	+2.2
14	1	-	3.2	1.8	1:4	1:15	0.6	Inside back slope
15	1	-	3.2	1.8	1:4	1:15	0.6	Inside back slope
16	6	-	3.2	1.8	1:4	1:15	0.6	Inside back slope
17	5	-	3.2	1.8	1:4	1:15	0.6	Inside back slope
18	5	-	3.2	1.8	1:4	1:15	0.6	Inside back slope
19	4	-	3.2	1.8	1:4	1:15	0.6	Inside back slope
20	2	-	3.2	1.8	1:4	1:15	0.6	Inside back slope
21	-	-	3.2	1.8	1:4	1:15	-	+2.2

Table 3-2. Level of Service Criteria for Multilane Highways

Criteria	Level of Service				
	A	B	C	D	E
Free-Flow Speed = 60 mi/h					
Maximum density (pc/mi/ln)	11	18	26	35	40
Minimum speed (mi/h)	60.0	60.0	59.4	56.7	55.0
Maximum v/c	0.30	0.49	0.70	0.90	1.00
Maximum service flow rate (pc/h/ln)	660	1,080	1,550	1,980	2,200
Free-Flow Speed = 55 mi/h					
Maximum density (pc/mi/ln)	11	18	26	35	41
Minimum speed (mi/h)	55.0	55.0	54.9	52.9	51.2
Maximum v/c	0.29	0.47	0.68	0.88	1.00
Maximum service flow rate (pc/h/ln)	600	990	1,430	1,850	2,100
Free-Flow Speed = 50 mi/h					
Maximum density (pc/mi/ln)	11	18	26	35	43
Minimum speed (mi/h)	50.0	50.0	50.0	48.9	47.5
Maximum v/c	0.28	0.65	0.65	0.86	1.00
Maximum service flow rate (pc/h/ln)	550	900	1,300	1,710	2,000
Free-Flow Speed = 45 mi/h					
Maximum density (pc/mi/ln)	11	18	26	35	45
Minimum speed (mi/h)	45.0	45.0	45.0	44.4	42.2
Maximum v/c	0.26	0.43	0.62	0.82	1.00
Maximum service flow rate (pc/h/ln)	490	810	1,170	1,550	1,900

Table3-3. .Restricted Lane Width and Lateral Clearance Factor, (fw)

Distance from Traveled Way to Obstruction ¹ (ft)	Adjustment Factor					
	Obstructions on One Side			Obstructions on Two Sides		
	Lane Width ¹ (ft)					
	≥12	11	10	≥12	11	10
≥6	1.00	0.95	0.90	1.00	0.95	0.90
4	0.99	0.94	0.89	0.98	0.93	0.88
2	0.97	0.92	0.88	0.95	0.90	0.86
0	0.92	0.88	0.84	0.86	0.82	0.78

Table3-4. Adjustment Factor for Driver Population

Traffic Stream Type	Adjustment Factor (f_p)
Weekday, commuter (familiar users)	1.00
Recreational or other	0.75-0.99

Table3-5. Passenger-Car Equivalents for Trucks, Buses, and RVs on Extended General Terrain Sections of Freeways or Multilane Highways.

FACTOR	TYPE OF TERRAIN		
	LEVEL	ROLLING	MOUNTINOUS
E_T	1.7	4	8
E_B	1.5	3	5
E_R	1.6	3	4

Table3-6. Recommended maximum rates of side slopes for embankment (fills)

Embankment height (m)	Slope (Vertical : Horizontal)
≤ 1.0	1:4
1.0 - 3.0	1:2
≥ 3.0	1:1.5

Table3-7. Recommended maximum rates for back slope

Type of material	Slope (Vertical : Horizontal)
Hard Rock	1:1 to 4:1
Decomposed Rock and/Compact soils	1:2 to 1:1
Ordinary soils	1:2 to 1:1.5

Table 3-8. Clear zone widths.

Speed Limit km/hr	Standard	
	Desired(m)	Minimum(m)
70	5	3
80	6	4
100	9	6

Chapter 4

Table4-1. Minimum Edge of Pavement Design for Turns at Intersections.

1ft= 3m

Angle of turn	Design Vehicle	Simple Curve Radius (ft)	Simple Curve Radius with Taper		
			Radius (ft)	Offset (ft)	Taper L:T
- For Intersection 1 :					
90	P	30	20	2.5	10:1
150	P	-	18	2	10:1
120	P	-	20	2	10:1
For Intersection 2 :					
120	P	-	20	2	10:1
180	P	-	15	0.5	20:1
60	P	40	-	-	-

Table4-2. Minimum Edge of Pavement Design for Turns at Intersections: Simple Curves and Simple Curves with Taper

Angle of Turn (degree)	Design Vehicle	Simple Curve Radius (ft)	Simple Curve Radius with Taper		
			Radius (ft)	Offset (ft)	Taper L:T
30	P	60	-	-	-
	SU	100	-	-	-
	WB-40	150	-	-	-
	WB-50	200	-	-	-
	WB-62	360	220	3.0	15:1
	WB-67	380	220	3.0	15:1
	WB-100T	260	125	3.0	15:1
45	P	50	-	-	-
	SU	75	-	-	-
	WB-40	120	-	-	-
	WB-50	175	120	2.0	15:1
	WB-62	230	145	4.0	15:1
	WB-67	250	145	4.5	15:1
	WB-100T	200	115	2.5	15:1
60	P	40	-	-	-
	SU	60	-	-	-
	WB-40	90	-	-	-
	WB-50	150	120	3.0	15:1
	WB-62	170	140	4.0	15:1
	WB-67	200	140	4.5	15:1
	WB-100T	150	95	2.5	15:1
75	P	35	25	2.0	10:1
	SU	55	45	2.0	10:1
	WB-40	-	60	2.0	15:1
	WB-50	-	65	3.0	15:1
	WB-62	-	145	4.0	20:1
	WB-67	-	145	4.5	20:1
	WB-100T	-	85	3.0	15:1
90	P	30	20	2.5	10:1
	SU	50	40	2.0	10:1
	WB-40	-	45	4.0	10:1
	WB-50	-	60	4.0	15:1
	WB-62	-	120	4.5	30:1
	WB-67	-	125	4.5	30:1
	WB-100T	-	85	2.5	15:1
WB-109D	-	115	2.9	15:1	

(Continued)

Table4-3. Minimum Edge of Pavement Design for Turns at Intersections: Simple Curves and Simple Curves with Taper(continued)

Angle of Turn (degree)	Design Vehicle	Simple Curve Radius (ft)	Simple Curve Radius with Taper		
			Radius (ft)	Offset (ft)	Taper L:T
105	P	—	20	2.5	8:1
	SU	—	35	3.0	10:1
	WB-40	—	40	4.0	10:1
	WB-50	—	55	4.0	15:1
	WB-62	—	115	3.0	15:1
	WB-67	—	115	3.0	15:1
	WB-100T	—	75	3.0	15:1
	WB-109D	—	90	9.2	20:1
120	P	—	20	2.0	10:1
	SU	—	30	3.0	10:1
	WB-40	—	35	5.0	8:1
	WB-50	—	45	4.0	15:1
	WB-62	—	100	5.0	15:1
	WB-67	—	105	5.2	15:1
	WB-100T	—	65	3.5	15:1
	WB-109D	—	85	9.2	20:1
135	P	—	20	1.5	10:1
	SU	—	30	4.0	10:1
	WB-40	—	30	8.0	15:1
	WB-50	—	40	6.0	15:1
	WB-62	—	80	5.0	20:1
	WB-67	—	85	5.2	20:1
	WB-100T	—	65	5.5	15:1
	WB-109D	—	85	8.5	20:1
150	P	—	18	2.0	10:1
	SU	—	30	4.0	8:1
	WB-40	—	30	6.0	8:1
	WB-50	—	35	7.0	6:1
	WB-62	—	60	10.0	10:1
	WB-67	—	65	10.2	10:1
	WB-100T	—	65	7.3	10:1
	WB-109D	—	65	15.1	10:1
180	P	—	15	0.5	20:1
	SU	—	30	1.5	10:1
	WB-40	—	20	9.5	5:1
	WB-50	—	25	9.5	5:1
	WB-62	—	55	10.0	15:1
	WB-67	—	55	13.8	10:1
	WB-100T	—	55	10.2	10:1
	WB-109D	—	55	20.0	10:1

Chapter 5

Recommended Level of Reliability		
Functional Classification	Urban	Rural
Interstate and other freeways	85–99.9	80–99.9
Other principal arterials	80–99	75–95
Collectors	80–95	75–95
Local	50–80	50–80

Table 12-1.Suggested Levels of Reliability For Various Functional

Table 12-2. Standard Deviation

	Standard Deviation, S_o
Flexible pavements	0.40-0.50
Rigid pavements	0.30-0.40

Table 12-3. Distribution of Tuck Factors for Different Classes of Highways and Vehicles in the United States :

Vehicle type	Truck factors											
	Rural systems					Urban systems						
	Interstate	Other Principal	Collectors			Range	Interstate	Other Freeways	Other Principal	Minor Arterial	Collectors	Range
			Arterial	Major	Minor							
Single-unit trucks												
2-axle, 4-tire	0.003	0.003	0.003	0.017	0.003	0.003-0.017	0.002	0.015	0.002	0.006	—	0.006-0.015
2-axle, 6-tire	0.21	0.25	0.28	0.41	0.19	0.19-0.41	0.17	0.13	0.24	0.23	0.13	0.13-0.24
3-axle or more	0.61	0.86	1.06	1.26	0.45	0.45-1.26	0.61	0.74	1.02	0.76	0.72	0.61-1.02
All single units	0.06	0.08	0.08	0.12	0.03	0.03-0.12	0.05	0.06	0.09	0.04	0.16	0.04-0.16
Tractor semitrailers												
4-axle or less	0.62	0.92	0.62	0.37	0.91	0.37-0.91	0.98	0.48	0.71	0.46	0.40	0.40-0.98
5-axle ^b	1.09	1.25	1.05	1.67	1.11	1.05-1.67	1.07	1.17	0.97	0.77	0.63	0.63-1.17
6-axle or more ^b	1.23	1.54	1.04	2.21	1.35	1.04-2.21	1.05	1.19	0.90	0.64	—	0.64-1.19
All multiple units	1.04	1.21	0.97	1.52	1.08	0.97-1.52	1.05	0.96	0.91	0.67	0.53	0.53-1.05
All trucks	0.52	0.38	0.21	0.30	0.12	0.12-0.52	0.39	0.23	0.21	0.07	0.24	0.07-0.39

Table 12-4. Growth Factor :

Design Period, Years (n)	Annual Growth Rate, Percent (r)								
	No Growth	2	4	5	6	7	8	10	
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
2	2.0	2.02	2.04	2.05	2.06	2.07	2.08	2.10	
3	3.0	3.06	3.12	3.15	3.18	3.21	3.25	3.31	
4	4.0	4.12	4.25	4.31	4.37	4.44	4.51	4.64	
5	5.0	5.20	5.42	5.53	5.64	5.75	5.87	6.11	
6	6.0	6.31	6.63	6.80	6.98	7.15	7.34	7.72	
7	7.0	7.43	7.90	8.14	8.39	8.65	8.92	9.49	
8	8.0	8.58	9.21	9.55	9.90	10.26	10.64	11.44	
9	9.0	9.75	10.58	11.03	11.49	11.98	12.49	13.58	
10	10.0	10.95	12.01	12.58	13.18	13.82	14.49	15.94	
11	11.0	12.17	13.49	14.21	14.97	15.78	16.65	18.53	
12	12.0	13.41	15.03	15.92	16.87	17.89	18.98	21.38	
13	13.0	14.68	16.63	17.71	18.88	20.14	21.50	24.52	
14	14.0	15.97	18.29	19.16	21.01	22.55	24.21	27.97	
15	15.0	17.29	20.02	21.58	23.28	25.13	27.15	31.77	
16	16.0	18.64	21.82	23.66	25.67	27.89	30.32	35.95	
17	17.0	20.01	23.70	25.84	28.21	30.84	33.75	40.55	
18	18.0	21.41	25.65	28.13	30.91	34.00	37.45	45.60	
19	19.0	22.84	27.67	30.54	33.76	37.38	41.45	51.16	
20	20.0	24.30	29.78	33.06	36.79	41.00	45.76	57.28	
25	25.0	32.03	41.65	47.73	54.86	63.25	73.11	98.35	
30	30.0	40.57	56.08	66.44	79.06	94.46	113.28	164.49	
35	35.0	49.99	73.65	90.32	111.43	138.24	172.32	271.02	

Table 12-5. Lane Distribution Factor :

No. of lanes in each direction	Percentage of 18-kip ESAL in design lane
1	100
2	80-100
3	60-80
4	50-75

Table 12-6.: Definition of Drainage Quality .

Quality of Drainage	Water Removed Within*
Excellent	2 hours
Good	1 day
Fair	1 week
Poor	1 month
Very poor	(water will not drain)

Table 12-7. Recommended Drainage Coefficients for Untreated Bases and Sub bases in flexible Pavements

Quality of Drainage	Percent of Time Pavement Structure Is Exposed to Moisture Levels Approaching Saturation			
	Less Than 1%	1 to 5%	5 to 25%	Greater Than 25%
Excellent	1.40-1.35	1.35-1.30	1.30-1.20	1.20
Good	1.35-1.25	1.25-1.15	1.15-1.00	1.00
Fair	1.25-1.15	1.15-1.05	1.00-0.80	0.80
Poor	1.15-1.05	1.05-0.80	0.80-0.60	0.60
Very poor	1.05-0.95	0.95-0.75	0.75-0.40	0.40

SOURCE: Adapted with permission from AASHTO Guide for Design of Pavement Structures, American Association of State Highway and Transportation Officials, Washington, D.C., 1993.

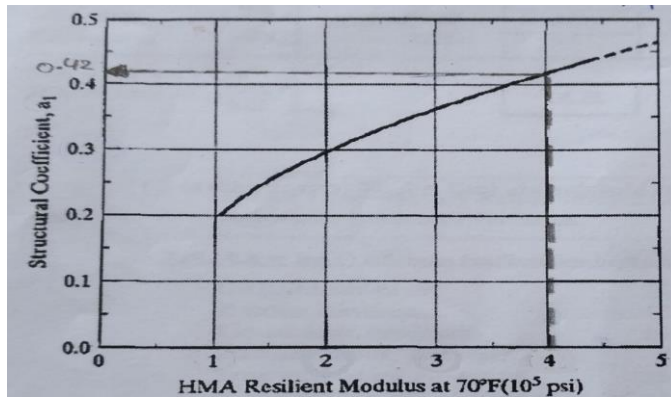


Figure 20. Chart for estimating layer coefficient of dense-graded asphalt concrete based on elastic modulus (1psi = 6.9 kPa).

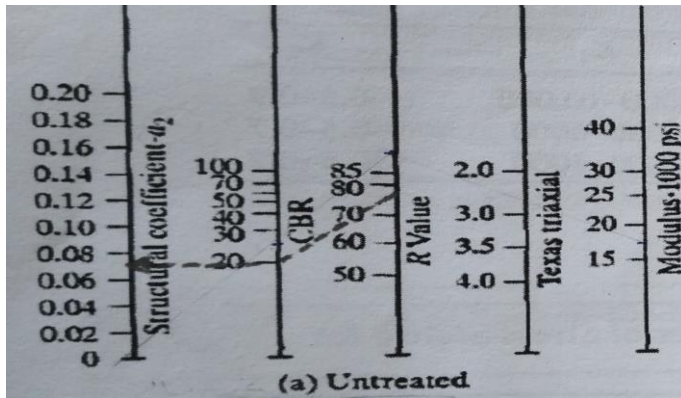


Figure 21. Correlation Chart for estimating resilient modulus of base (1lb = 1psi = 6.9 kPa).

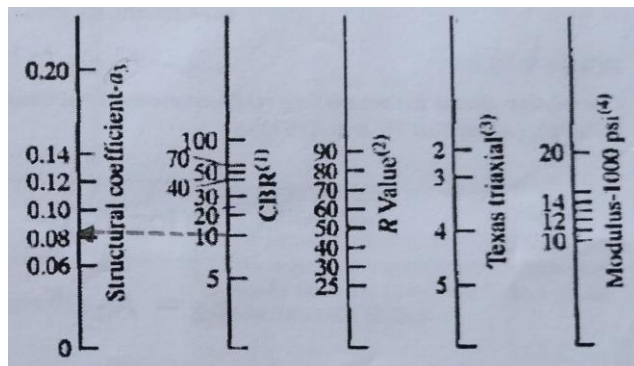


Figure 8. Correlation Chart for estimating resilient modulus of Sub base (1lb = 1psi = 6.9 kPa).

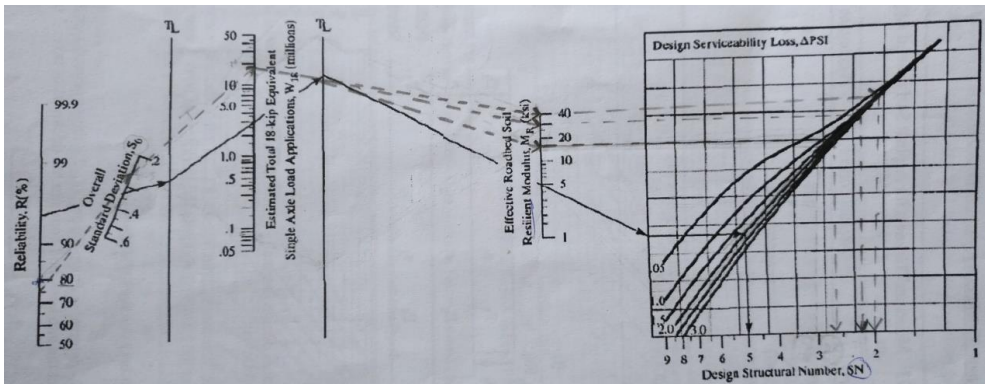


Figure 23. Design chart for flexible pavements based on mean values for each input (1Ksi = 6.9 MPa) From AASHTO Guide Structures Copyright 1986 . American Association of state highway and Transportation officials .

Chapter 6

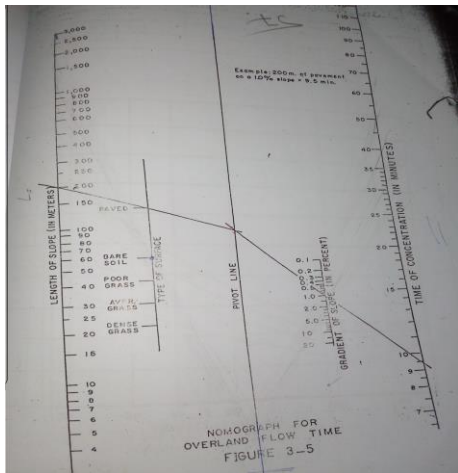


Figure 9.fig(6-1)

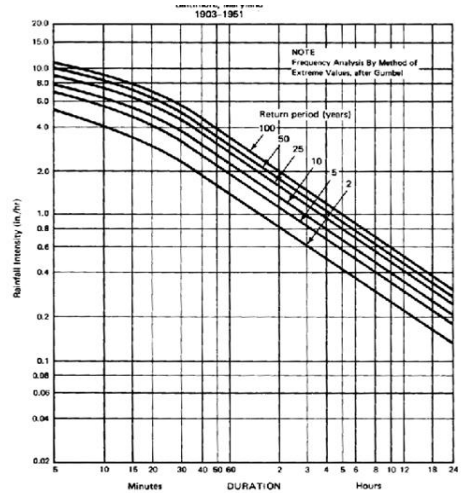


Figure 25(6-2)

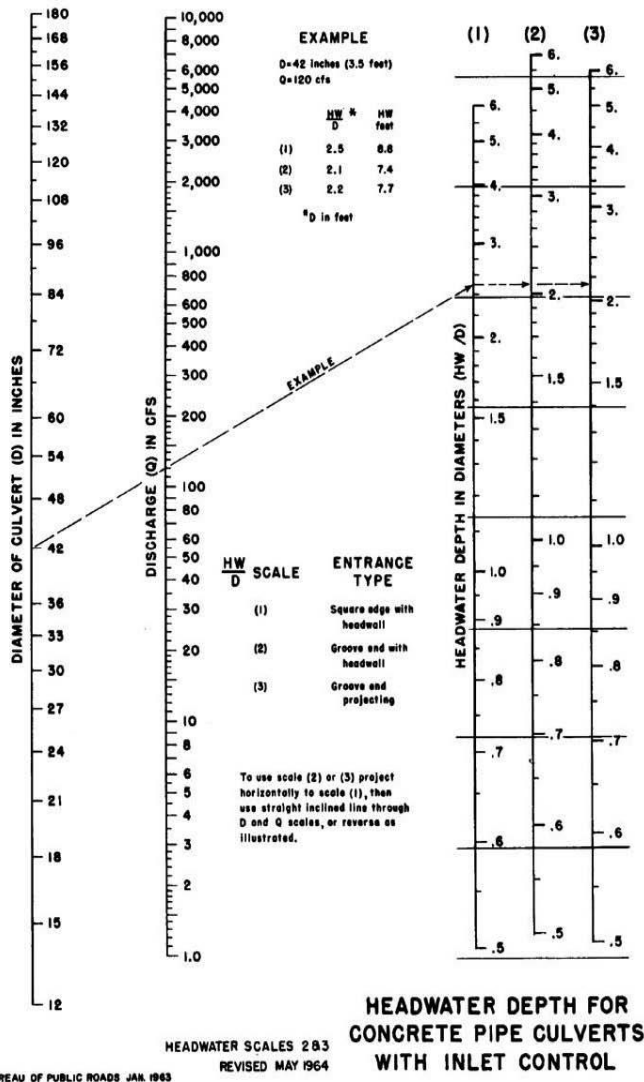


Figure 26.(6-3)depth of headwater (HW), dimeter($d=90\text{cm}=35.43\text{in}$).

Chapter 7**MASS HAUL DIAGRAM**

Station	Cut + (m2)	Fill – (m2)	Cut +(m3)	Fill – (m3)	Cumulative (m3)
0+00	0	0	0	0	0
1+00	10	0	25000	0	25000
2+00	7	0	17500	0	42500
3+00	7	0	17500	0	60000
4+00	0	8	0	20000	40000
5+00	0	5	0	12500	27500
6+00	1	0	2500	0	30000
7+00	0	3	0	7500	22500
8+00	0	8	0	20000	500
9+00	2	0	5000	0	5500
10+00	9	0	22500	0	28000
11+00	0	2	0	5000	23000
12+00	3	0	7500	0	30500
13+00	0	0	0	0	30500
14+00	1	0	2500	0	33000
15+00	1	0	2500	0	60500
16+00	6	0	15000	0	75500
17+00	5	0	12500	0	88000
18+00	5	0	12500	0	100500
19+00	4	0	10000	0	110500
20+00	2	0	5000	0	115500
21+00	0	0	0	0	115500

Chapter 9

Total	Price (JD)	Quantity.	Unit	Labor
266790.11	5.45	48952.314	m ²	HMA with 5cm thickness
391618.51	8.00	48952.314	m ²	HMA with 7cm thickness
14685.6	600	24.476	Ton	MC Prime Coat
44057.08	0.90	48952.314	m ²	Seal Coat
75876.08	15.50	4895.2314	M ³	Base Coarse
35490.43	14.50	2447.6157	M ³	Sub base Coarse
54545.92	4.00	13636.488	M ³	Cut works
137881.46	3.50	39394.70	M ³	Fill works
3866.5	9.50	407	Number	Reflectors
550	275	2	Longitude Meter	Bumps
334.75	9.5	352.185	m ²	Hotpoint various colors for roads Yellow (solid)
3881.25	27	143.75	m ²	white Painting of walkways
784.7	9.5	82.6	M ²	Hotpoint various colors for roads white Painting of lane line
225	75	3	Number	Mandatory signs U-turn signs
2827.49	9.5	279.63	m ²	Hotpoint various colors for roads Yellow (broken)

