College of Engineering
Department of Civil Engineering

Spring 2020 – Learning Outcome Assessment III

(Final Presentation)

<u>Design Of Abuma'an-Halfmoon Bay Highway In Eastern Province</u>

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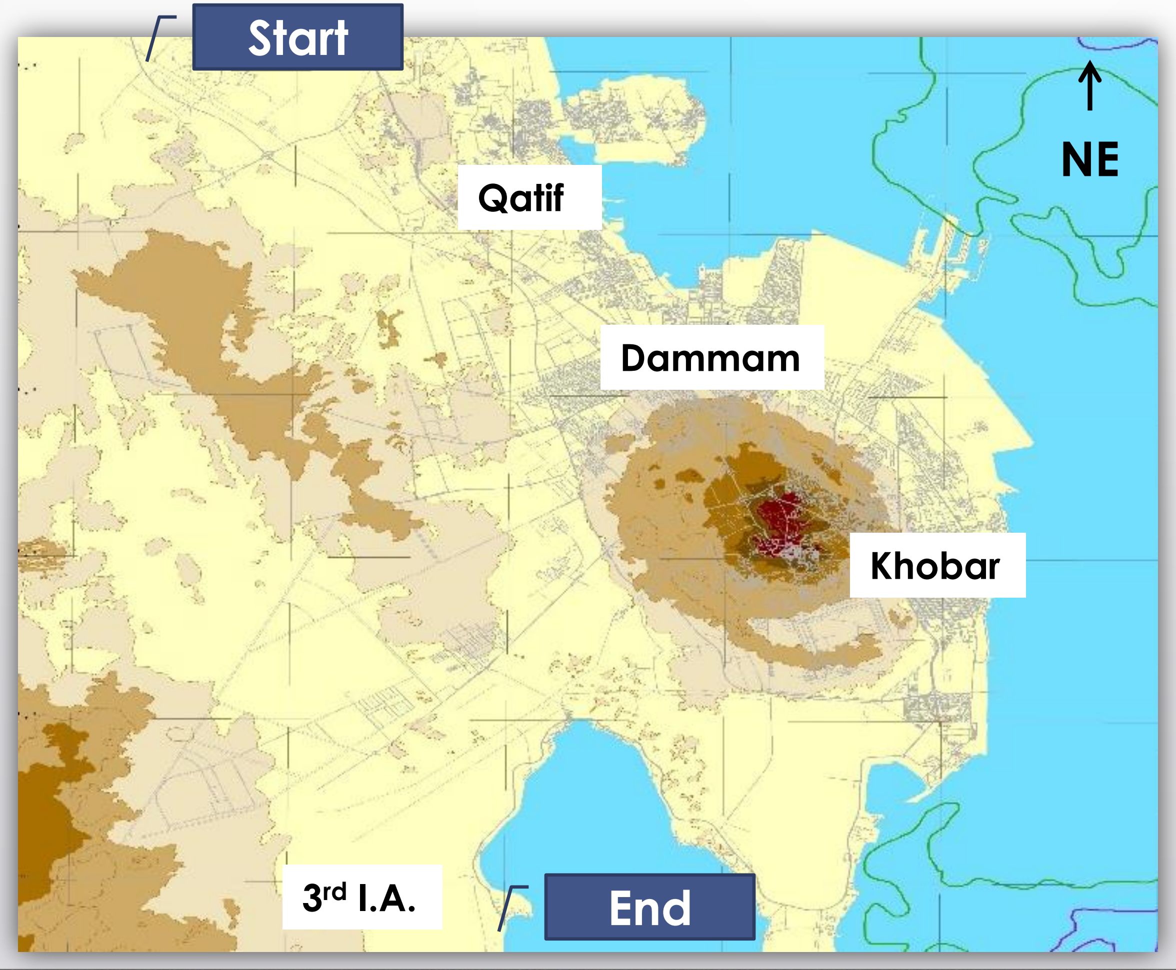
Outlines

- Introduction
- Objectives
- Methodology
- Constrains
- Traffic Analysis
- (Profile/Mass Haul) Diagram
- Geometric Design
- Soil study
- Pavement Structural Design
- Drainage system
- Road intersection
- Road services
- Cost estimation
- Time-Line

Introduction



Project Area

The project starts from Abu-Maan, heading to the third industrial area, by passing Dammam.

Figure [1] - Topographic map of the project

(Source: Geographic Information Systems Department, Eastern Eamana, Kingdom of Saudi Arabia)

Alternatives

Alternative #	Road length (Km)	# Of V.C.	# Of H.C.	Max. cut Height (m)	Max. Fill Height (m)
A	58.16	12	6	2.4	2.65
B	65.5	21	12	8.2	7.95
C	71.6	27	15	16.7	17.5

Table[1] – Alternative Selection

Selected road

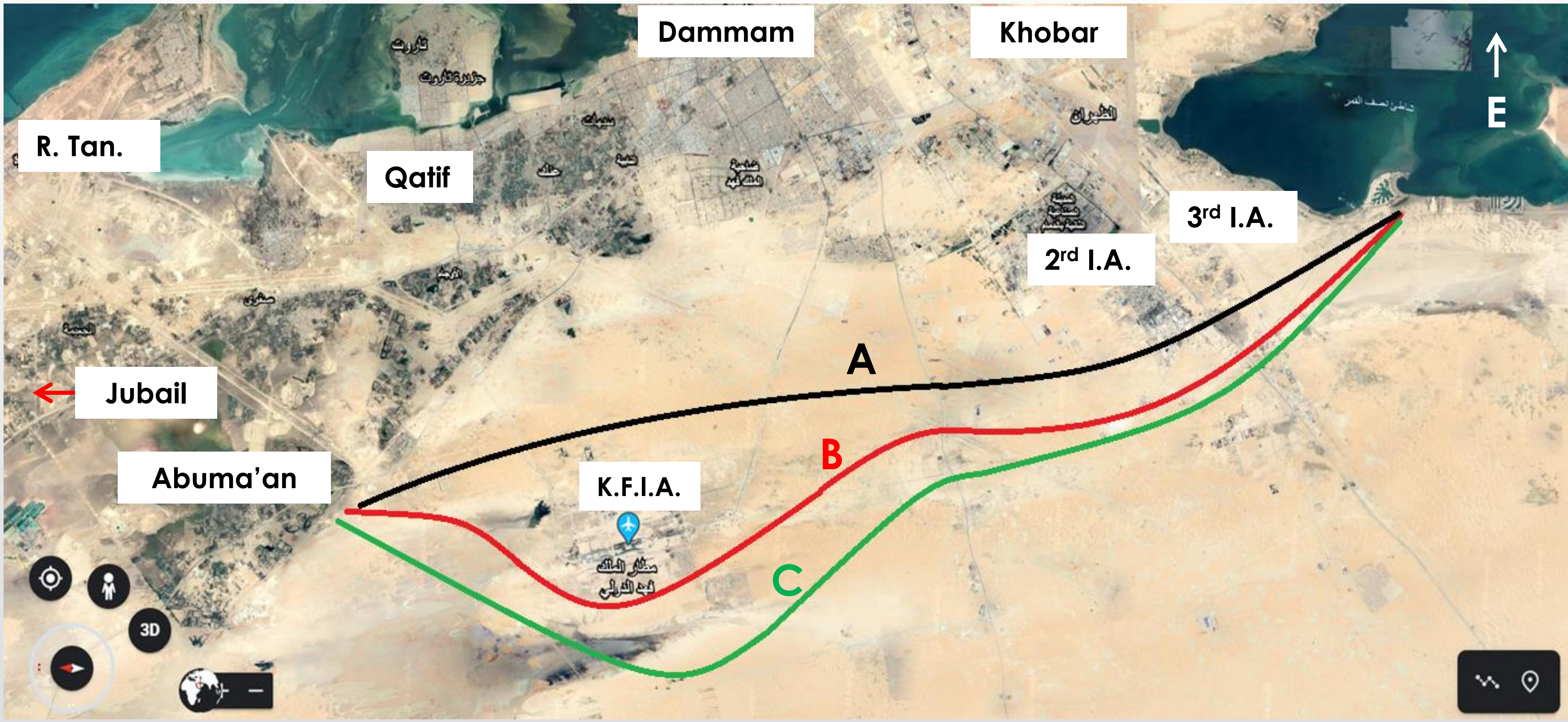


Figure [2] - Selected road

(Source: Google Earth)

Objectives

- Support the industrialists.
- Decrease the crowded of Abu-Hadryia and Jubail-Dhahran highways.
- Serving the motion of Dammam airport visitors.
- Increase in the number of citizens and residents who are experienced in the industrial field.
- Serving the west areas of Dammam.

Methodology

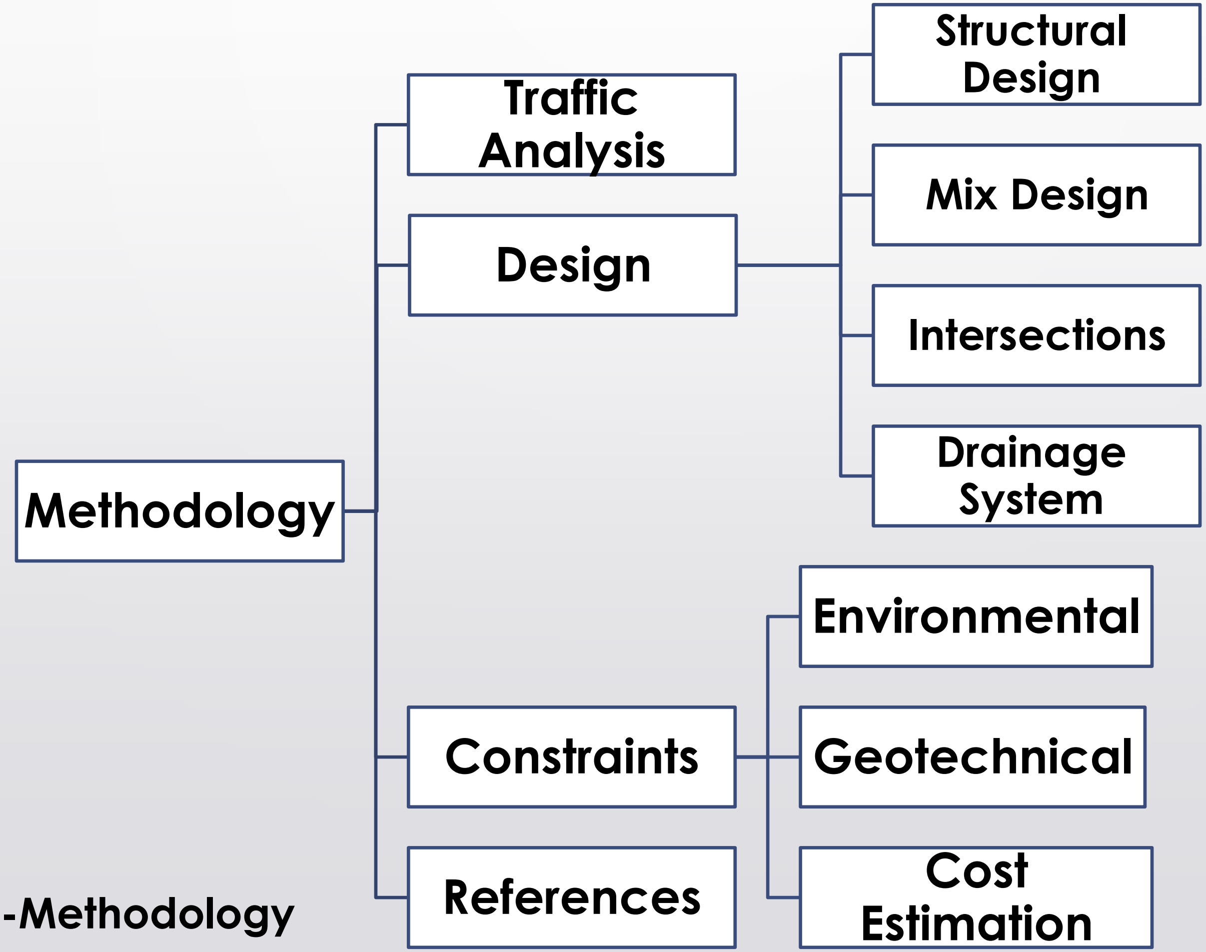


Figure [3]-Methodology

Constraints

Structural:

- Soil bearing test
- Soil compaction test
- Pavements design

Environmental:

- Rainfall Rate

Design Components:

- Asphalt mix design

Geotechnical:

- Subgrade treatment

Cost Analysis:

- Collecting prices

Traffic Analysis

Counting method:

- The manual count method was used.
- counting period for three days:

1. Monday (for 24 hours).
2. Thursday for 16 hours (from 6 AM to 10 PM).
3. Friday for 12 hours (from 6 AM to 6 PM).

Heavy traffic on Monday

- The following charts show the daily traffic volume during the counting period:-

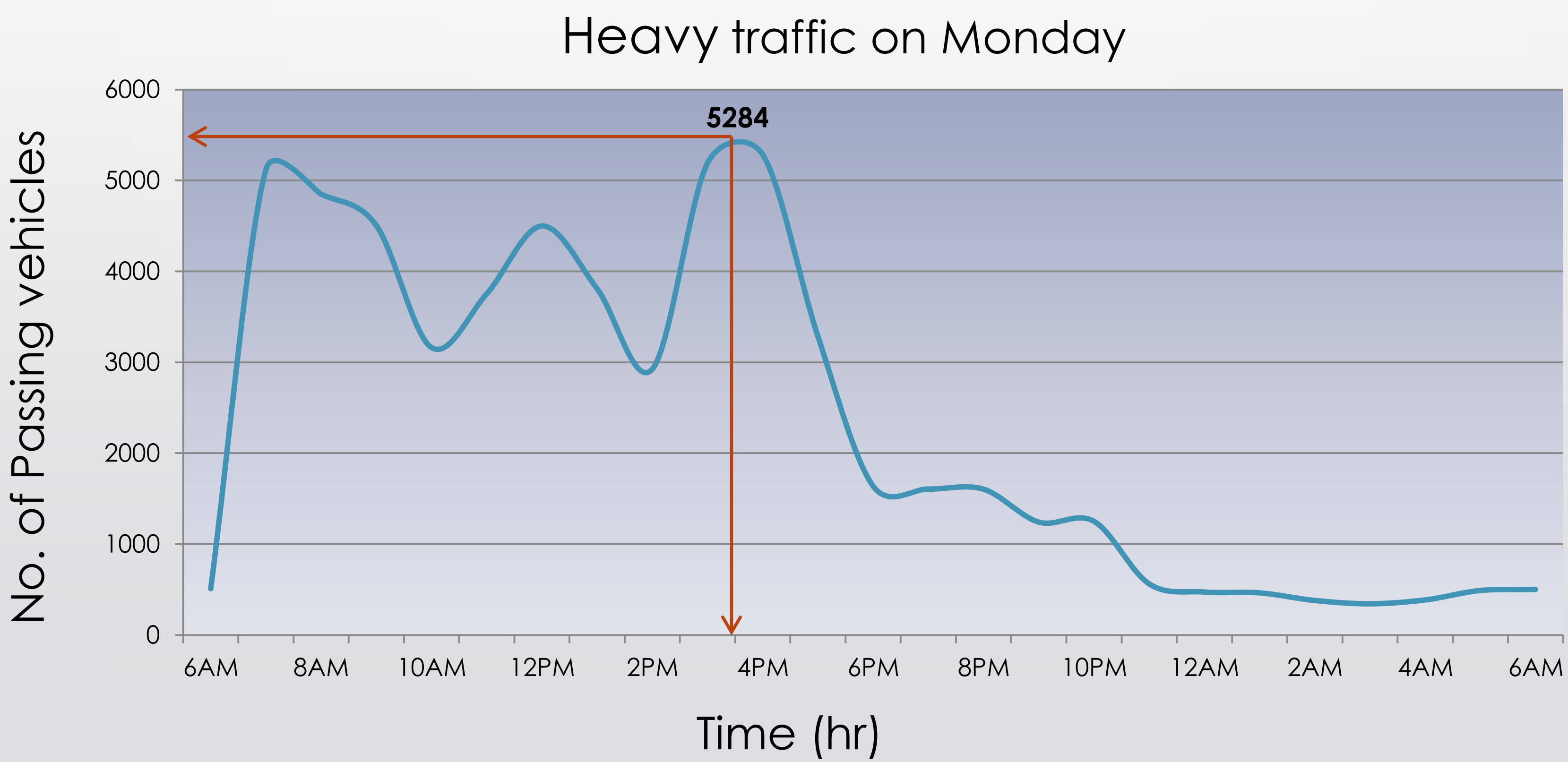


Figure [4]-Heavy traffic on Monday

Heavy traffic on Thursday

- The following charts show the daily traffic volume during the counting period:-

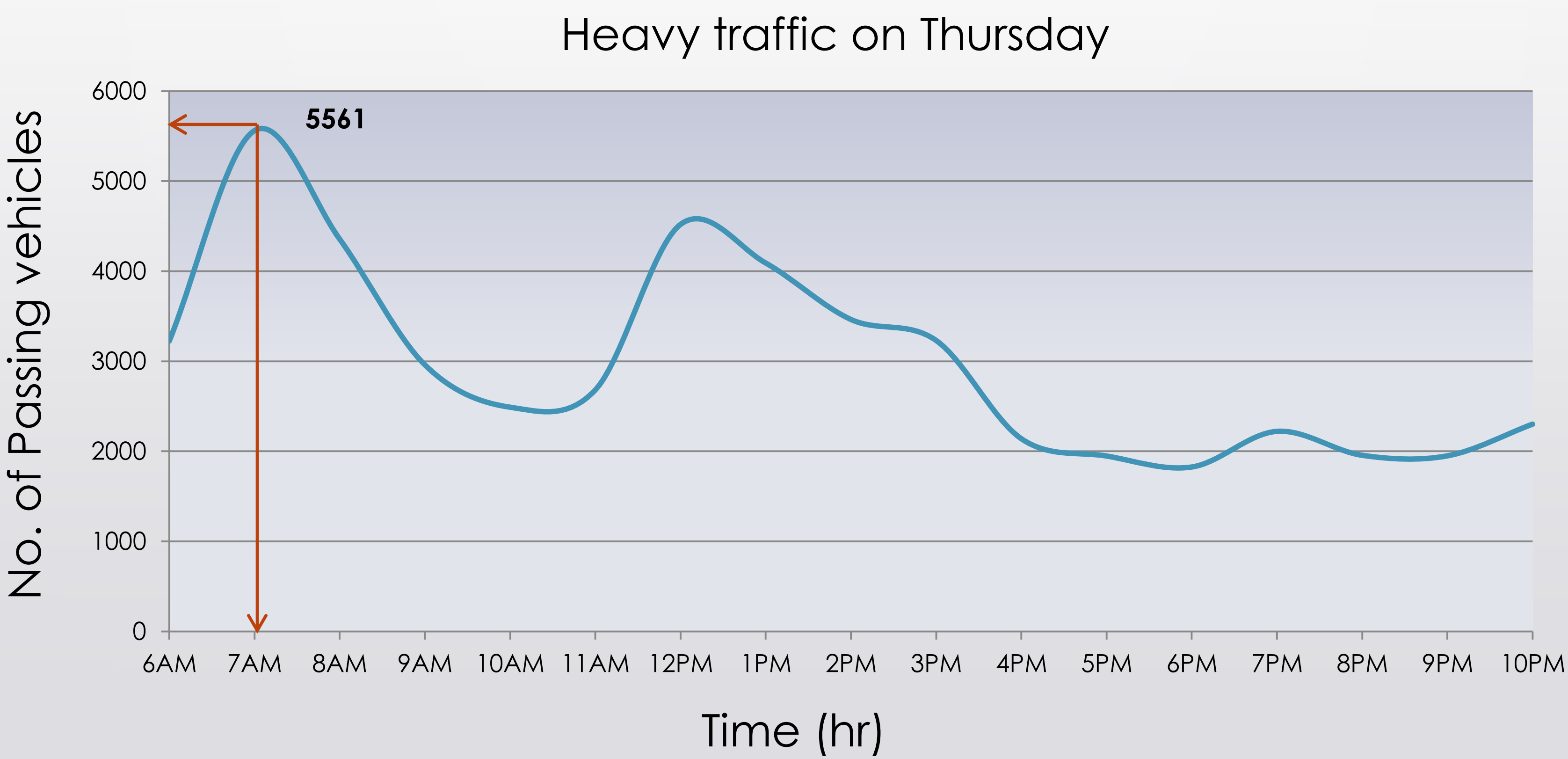


Figure [5]-Heavy traffic on Thursday

Heavy traffic on Friday

- The following charts show the daily traffic volume during the counting period:-

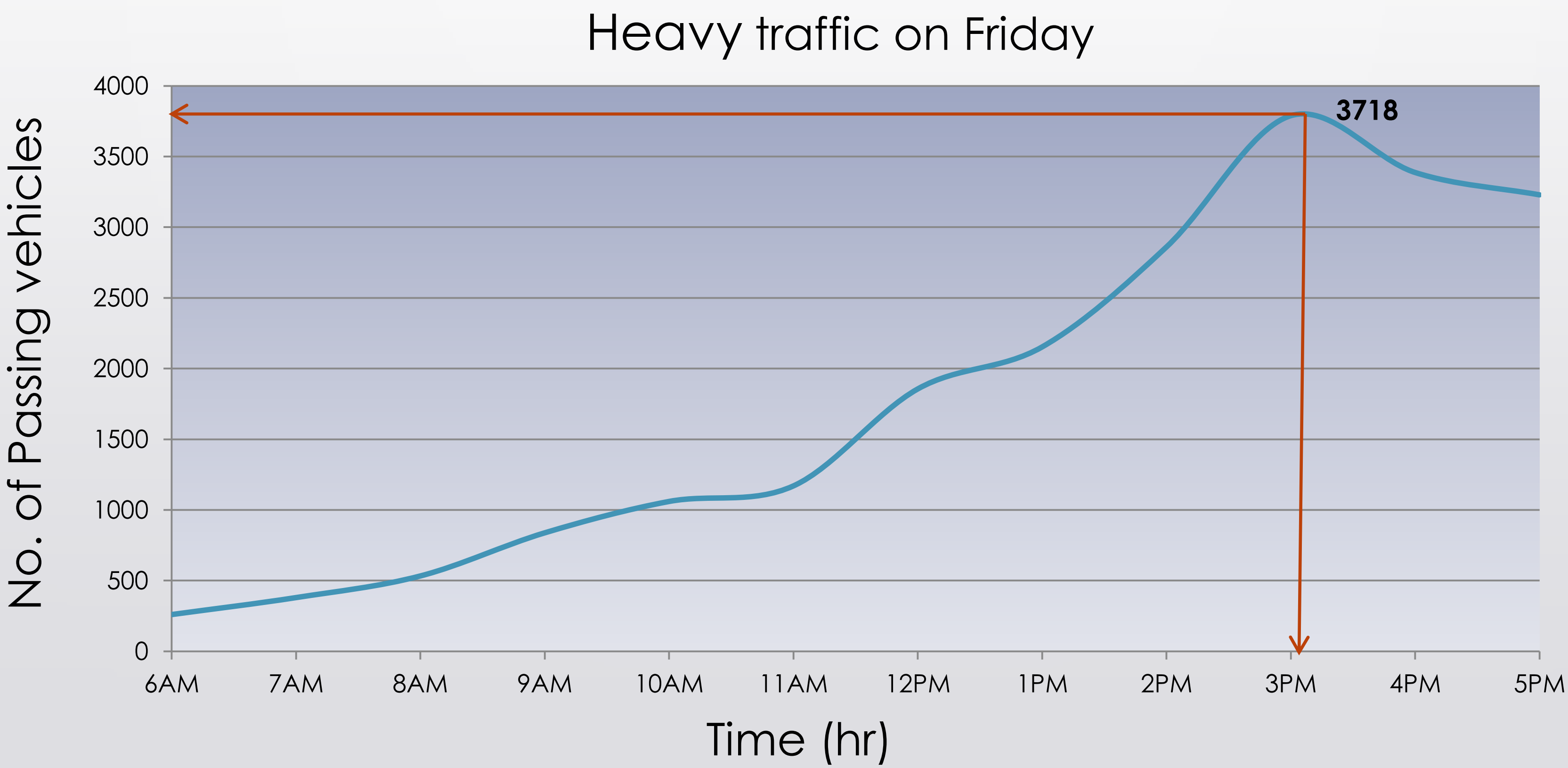


Figure [6]-Heavy traffic on Friday

The number of lanes

- The size of the designed hourly traffic:

$$(DHV) = Kx(ADT)F$$

- The value of the ratio (K) $\rightarrow$ ($K = \frac{DHV}{(ADT)F}$)
- K-is the proportion of daily traffic occurring during the

peak hour

- We will depend on the value of (K) recommended by (AASHTO) as follows:

$K = (0.08 \sim 0.12) for\ Urban\ Road$

$K = (0.12 \sim 0.18) for\ Rural\ Road$

" Highway Capacity Manual ,2010" Transportation Research Board, Washington D.C.1965

The number of lanes

- The size of the design hourly traffic as follows:

$$(DHV) = Kx(ADT)F = 0.08x126681 = 10134\ Pc/hr$$

- The prevailing traffic volume in one direction:

$$(DDHV) = Df\ x\ (DHV)$$

- Df = directional factor = (50%~70%)

- The coefficient will be taken equal to (50%):

$$(DDHV) = 0.5\ x\ 10134 = 5067\ Pc/hr/dir.$$

" Highway Capacity Manual ,2010" Transportation Research Board, Washington D.C.1965

The number of lanes

Road degree	Lower speed (Km/hr.)	Higher speed (Km/hr.)
Local	30	50
Collector	50	60
Arterial Highway	80	100
Less disorder	70	90
High disturbance	50	60
Expressway	90	120

Table [2]- Low & High speeds on road degrees

Nature of the region	Speed (Km/hr.)		
	Urban Road	Secondary road	Rural Road
Plain area	120	100	80
Rolling area	100	80	60

Table [3]-Speed based on nature of region

" Highway Capacity Manual ,2010" Transportation Research Board, Washington D.C.1965

The number of lanes

- Design speed = 120 Km/hr.
- Design capacity = 1664 Pc/hr/lane. (From AASHTO)
- Practical capacity = design capacity x (V/C) x fw
- Practical capacity = 1664 x 0.65 x 0.98 = 1059 Pc/hr/lane.

$$N = \frac{SF}{Cj \ x \left(\frac{V}{C}\right) \ x \ fw}$$

$$N = \frac{5076}{1664 \ x \ 0.65 \ x \ 0.98} = 4.78 \approx 5 \ lanes/dir.$$

" Highway Capacity Manual ,2010" Transportation Research Board, Washington D.C.1965

Civil 3D

- What is Civil 3D?
- What is the purpose of using Civil 3D?
- Features of Civil 3D:

➢Pipe sizing and analysis.

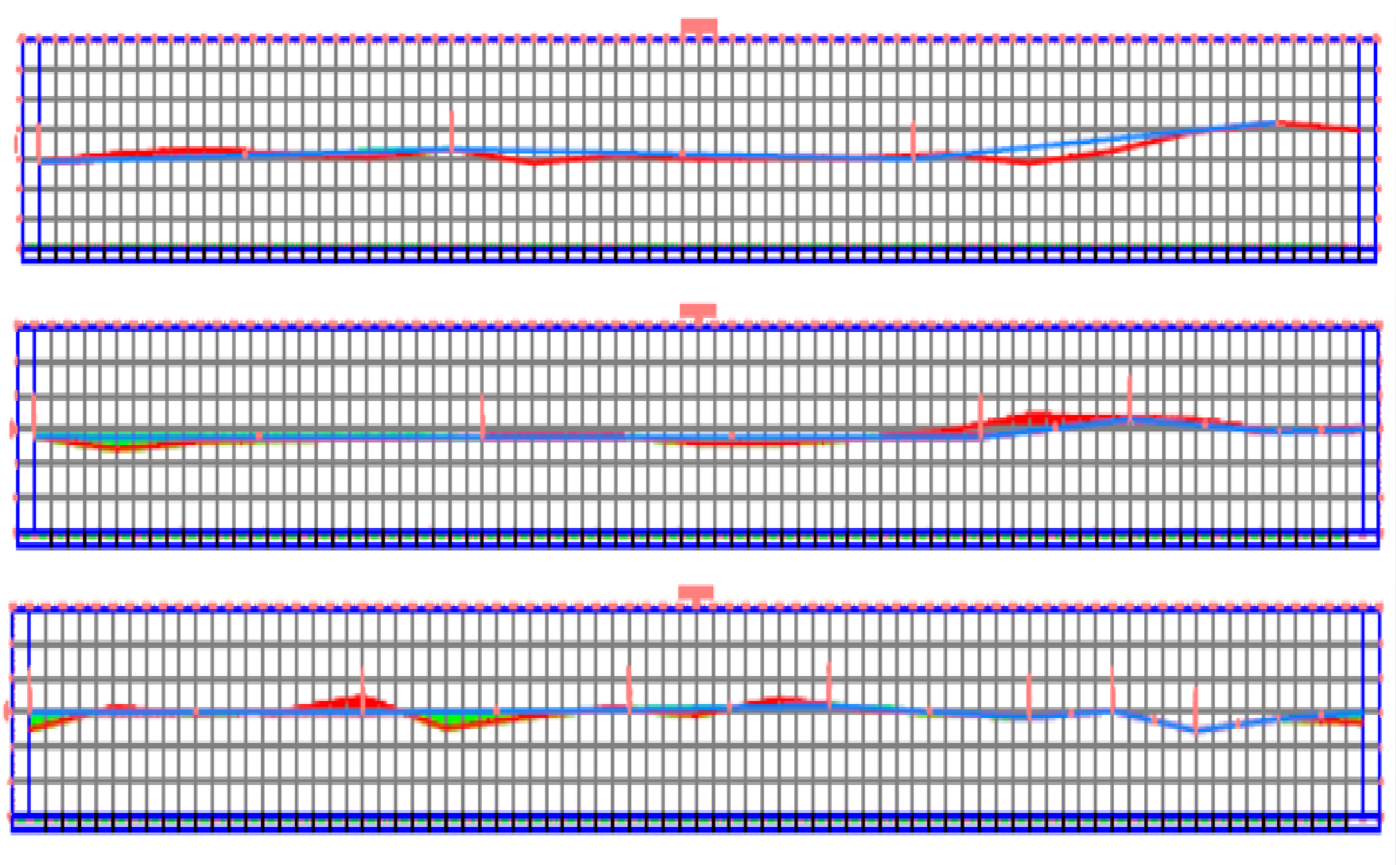
➢Connected alignments.

➢Dynamic offset profile.

➢Corridor design.

Figure [7]-AUTIDESK CIVIL 3D Logo

Civil 3D



Part 1

Part 2

Part 3

Figure [8]-Civil 3D Results

Civil 3D

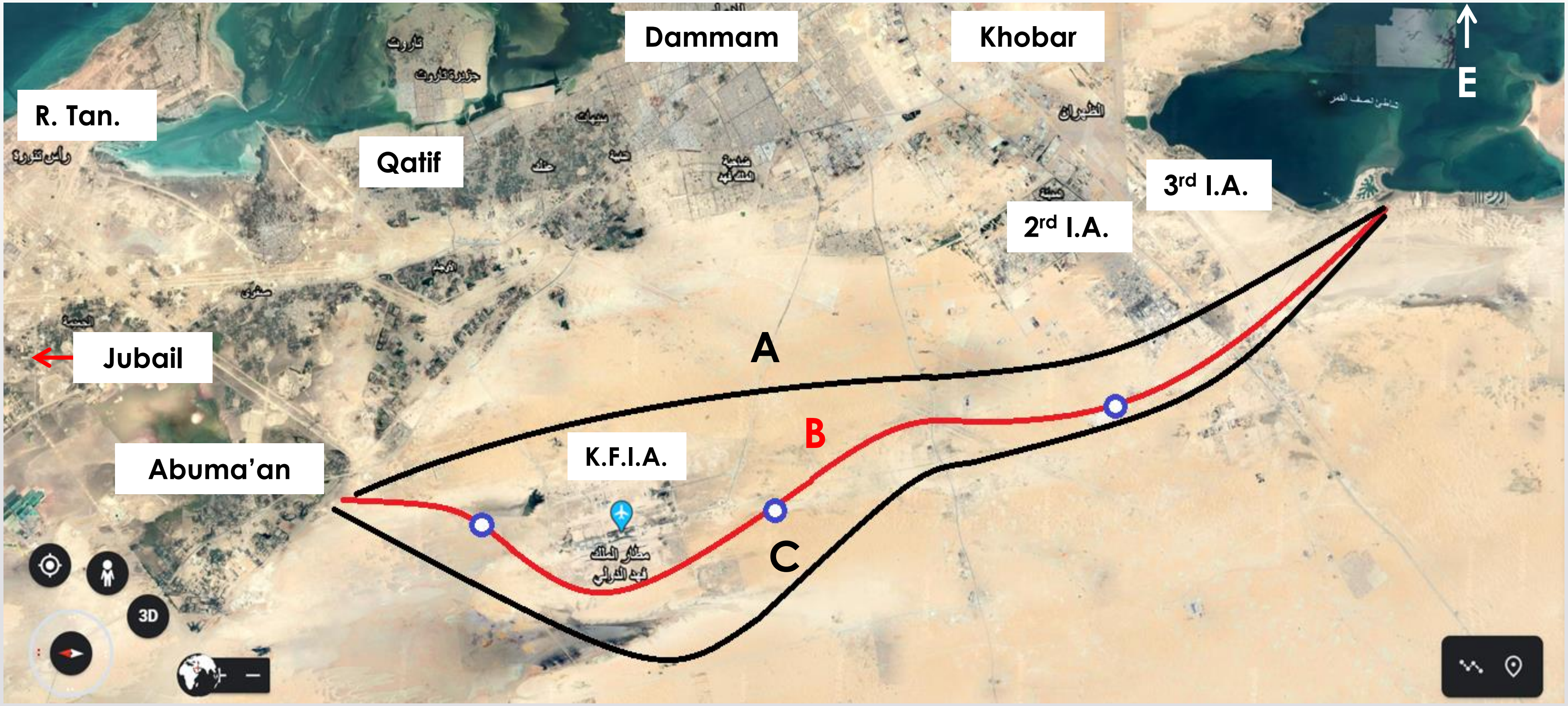


Figure [9]-Three parts used in Civil 3D

Two Horizontal Alignments

- What is Horizontal Alignment?

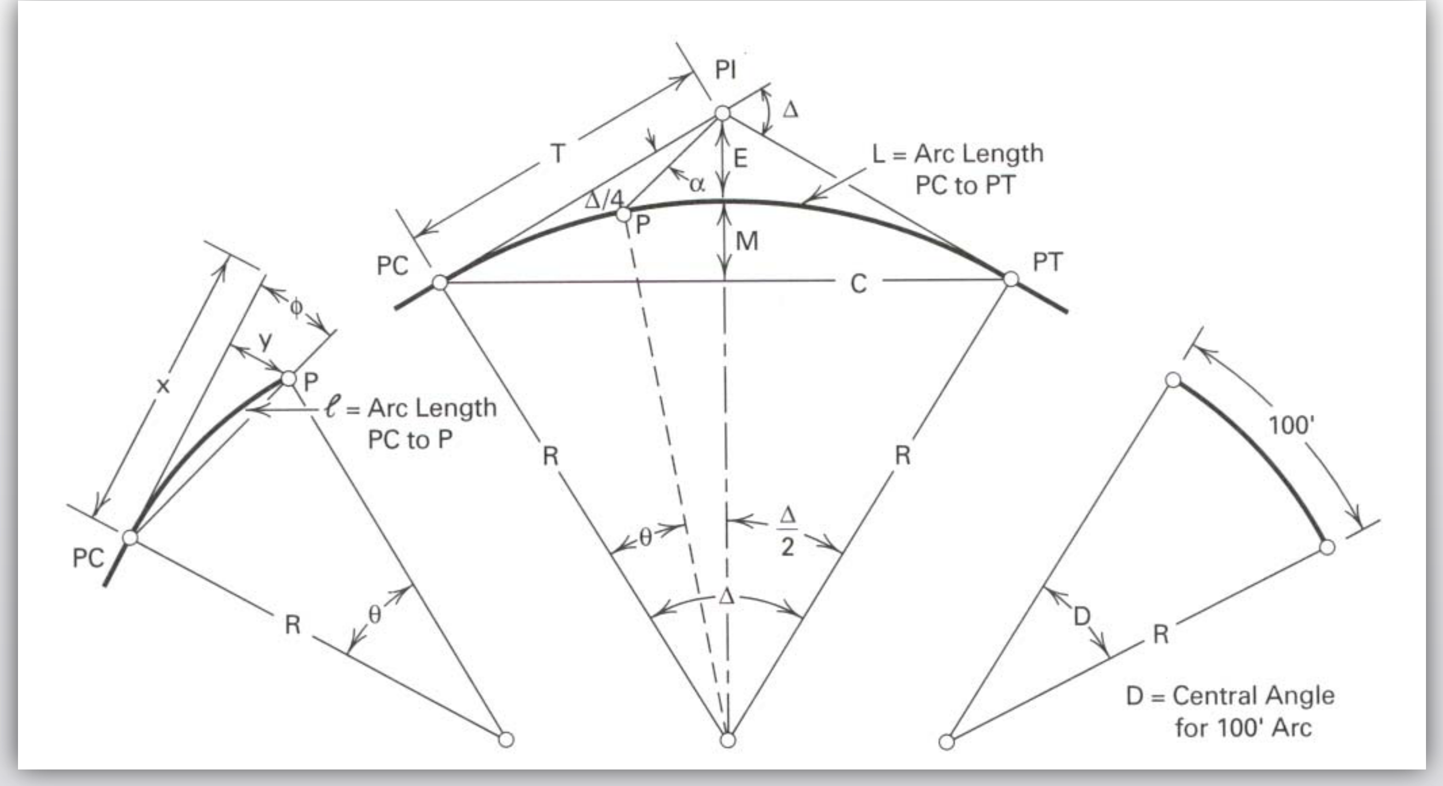


Figure [10]-Horizontal alignment details

Example of Horizontal Alignments

Figure [11]-Horizontal alignment example

Two Horizontal Alignments

- Stopping Sight Distance (SSD):

$$SSD = 0.278 * v * t + \frac{v^2}{254 * (0.04 \pm 0.01G)}$$

- Where:

V= Designed speed.

T= Absorption and Response Time.

F= Coefficient of friction

between tires and road surface.

G= Longitudinal inclination.

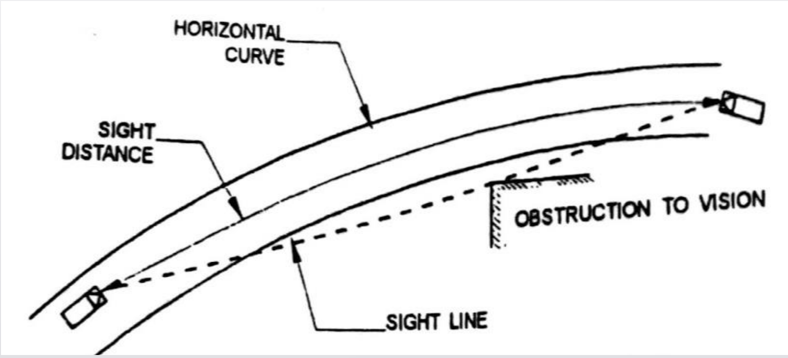


Figure [12]-SSD

Two Horizontal Alignments

- **For design: (G=0.0%)**

Design speed (km/h)	Brake reaction distance (m)	Braking distance on level (m)	Stopping sight distance Calculated (m)	Stopping sight distance Design (m)
		Metric		
20	13.9	4.6	18.5	20
30	20.9	10.3	31.2	35
40	27.8	18.4	46.2	50
50	34.8	28.7	63.5	65
60	41.7	41.3	83.0	85
70	48.7	56.2	104.9	105
80	55.6	73.4	129.0	130
90	62.6	92.9	155.5	160
100	69.5	114.7	184.2	185
110	76.5	138.8	215.3	220
→ 120	83.4	165.2	248.6	250
130	90.4	193.8	284.2	285

Table [4]-SSD (Matric)

$$SSDdesign > SSDrequired$$

- *Based on our calculation, we get result:*

$$SSD = 0.278 * 120 * 2.5 + \frac{120^2}{254 * (0.28)}$$

$$SSD = 285.87m$$

285.87 m > 248.6 m ✔

Horizontal Alignment Design

- By using these materials to design the **First** horizontal alignment:

$$\textbf{Tangent dist. } (X) = R\sin\theta \quad , \quad \textbf{Tangent offset } (y) = R[1 - \cos\theta],$$

$$\textbf{Lenght of Arc } (l) = \frac{100\ \theta}{D}$$

Station (0+00)	Θ (deg)	X (m)	Y (m)	L (m)
32+00	0°	0	0	0
32+20	2.329°	49.98	1.016	100
32+40	4.658°	99.88	4.062	200
32+60	6.987°	149.622	9.134	300
32+80	9.316°	199.11	16.223	400
32+94.75	11.03°	253.32	22.72	473.79

Table [5]-First horizontal alignment design

Cont. Horizontal Alignment Design

- By using these data to design the **Second** horizontal alignment:

Station (0+00)	Θ (deg)	X (m)	Y (m)	L (m)
82+60	0°	0	0	0
82+80	2.018°	50	0.88	100
83+00	4.036°	99.94	3.52	200
83+20	6.055°	149.78	7.92	300
83+40	8.073°	199.417	14.07	400
83+60	10.092°	248.82	21.97	500
83+80	12.11°	297.9	31.6	600
84+00	14.12°	346.41	42.9	700
84+20	16.14°	394.739	55.96	800
84+40	18.16°	442.57	70.73	900
84+57.73	19.95°	484.5	85.213	988.62

Table [6]- Second horizontal alignment design

Two Vertical Alignments

- What is Vertical Alignment?

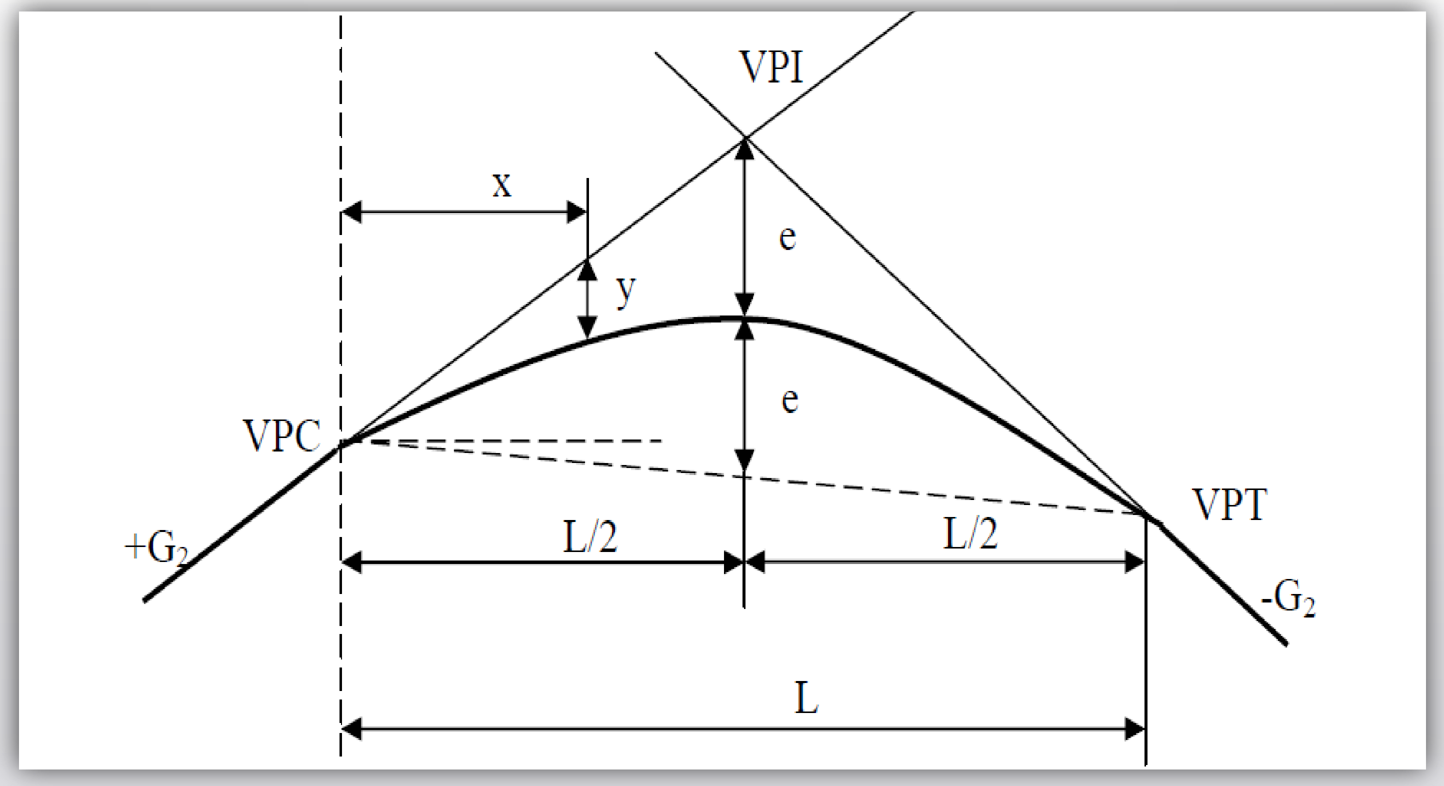


Figure [13]-Vertical alignment details

Example of Vertical Alignments

Figure [14]-Horizontal alignment example

Vertical Alignment Design

By using **Civil 3D** for **First** vertical alignment we got that LVC= 150m, and K=58.

- For Checking the design:
- When S < L:

$$L = \frac{AS^2}{658} = \frac{2.58\ x\ S^2}{658} \quad , therefore\ \boldsymbol{S = 195.6m}.$$

- When S > L:

$$L = 2S - \frac{658}{A} = \quad , therefore\ \boldsymbol{L = 136.14m.}$$

- The ratio of curvature (K): $K = \frac{L}{A} = \frac{136.14}{2.58} = 52.76$

Vertical Alignment Design

- Regardig for PSD (Passing Sight Distance):
- $when\ S < L,$

$$L = \frac{AS^2}{864} \quad \rightarrow \quad 209 = \frac{2.58\ x\ S^2}{864}, therefore\ \boldsymbol{S} = \boldsymbol{266.3m}$$

- $when\ S > L,$

$$L = \ 2S - \frac{864}{A} = 198.38m$$

So, **L = 200m.**

Vertical Alignment Design

- **First** vertical alignment data:

Point	X	Station	Y	Elevation
PVC	0	$429+80$	0	12.815
1	25	$429+85$	0.040	13.060
2	50	$429+90$	0.161	13.386
3	75	$429+95$	0.362	13.792
4	100	$430+00$	0.645	14.280
5	125	$430+05$	1.007	13.067
6	150	$430+10$	1.451	13.063
7	175	$430+15$	1.975	12.979
PVT	200	$430+20$	2.58	11.875

Table [7]-First vertical alignment design

Vertical Alignment Design

By using **Civil 3D** for **Second** vertical alignment we get that LVC= 150m, and K=130.21

- Checking the design:
- When S < L:

$$L = \frac{AS^2}{658} = \frac{1.16xS^2}{658} \quad , therefore\ S = 291.7m.$$

- When S > L:

$$L = 2S - \frac{685}{A} = \quad , therefore\ L = 16.2m.$$

- The ratio of curvature (K):

$$K = \frac{L}{A} = \frac{291.7}{1.16} = 251.5$$

Vertical Alignment Design

- Regardig for PSD (Passing Sight Distance):
- $when\ S < L$:

$$L = \frac{AS^2}{864} \rightarrow \quad 251.5 = \frac{1.16xS^2}{864}, Therefore\ S = 432.78m$$

- $when\ S > L$:

$$L = 2S - \frac{864}{A} = 120m$$

Vertical Alignment Design

- **Second** vertical alignment data:

Point	X	Station	Y	Elevation
PVC	0	$269 + 88$	0	13.480
1	20	$269 + 92$	0.0002	13.670
2	40	$269 + 96$	0.0008	13.862
3	60	$270 + 00$	0.0017	14.051
4	80	$270 + 04$	0.0031	13.311
5	100	$270 + 08$	0.0048	13.268
6	120	$270 + 12$	0.0069	13.224

Table [8]-Second vertical alignment design

Soil Study

- What is Soil classification?
- What is the Purpose of soil classification?
- Engineering classification systems
- AASHTO Classification Table

Engineering classification systems

- Textural Classification.
- AASHTO. ✓
- Unified Soil Classification.
- The International Soil Classification.
- American Society of Testing Material.

AASHTO Classification Table

General Classification	Granular materials (35% or less passing No. 200 Sieve (0.075 mm))							Silt-clay Materials More than 35% passing No. 200 Sieve (0.075 mm)			
Group Classification	A—1		A—3	A—2				A—4	A—5	A—6	A—7
	A—1—a	A—1—b		A—2—4	A—2—5	A—2—6	A—2—7				A—7—5 A—7—6
(*a*) Sieve Analysis: Percent Passing											
(*i*) 2.00 mm (No. 10)	50 max										
(*ii*) 0.425 mm (No. 40)	30 max	50 max	51 min								
(*iii*) 0.075 mm (No. 200)	15 max	25 max	10 max	35 max	35 max	35 max	35 max	36 min	36 min	36 min	36 min
(*b*) Characteristics of fraction passing 0.425 mm (No. 40)											
(*i*) Liquid limit				40 max	41 min	40 max	41 min	40 max	41 min	40 max	41 min
(*ii*) Plasticity index	6 max		N.P.	10 max	10 max	11 min	11 min	10 max	10 max	11 min	11 min*
(*c*) Usual types of significant Constituent materials	Stone Fragments Gravel and sand		Fine Sand	Silty or Clayey Gravel Sand				Silty Soils		Clayey Soils	
(*d*) General rating as subgrade.	Excellent to Good							Fair to Poor			

* If plasticity index is equal to or less than (liquid Limit—30), the soil is A—7—5 (*i.e.* PL > 30%)
If plasticity index is greater than (Liquid Limit—30), the soil is A—7—6 (*i.e.* PL < 30%)

Table [9]-AASHTO classification

Group Index

- The group index is given according to the formula:

$$G.I = (F - 35)[0.2 + 0.005(LL - 40)] + 0.01(F - 15)(P.I - 10)$$

- Where:

F: The percentage of passed soil on sieve No. 200

L.L: Liquid limit.

P.I: Plasticity index.

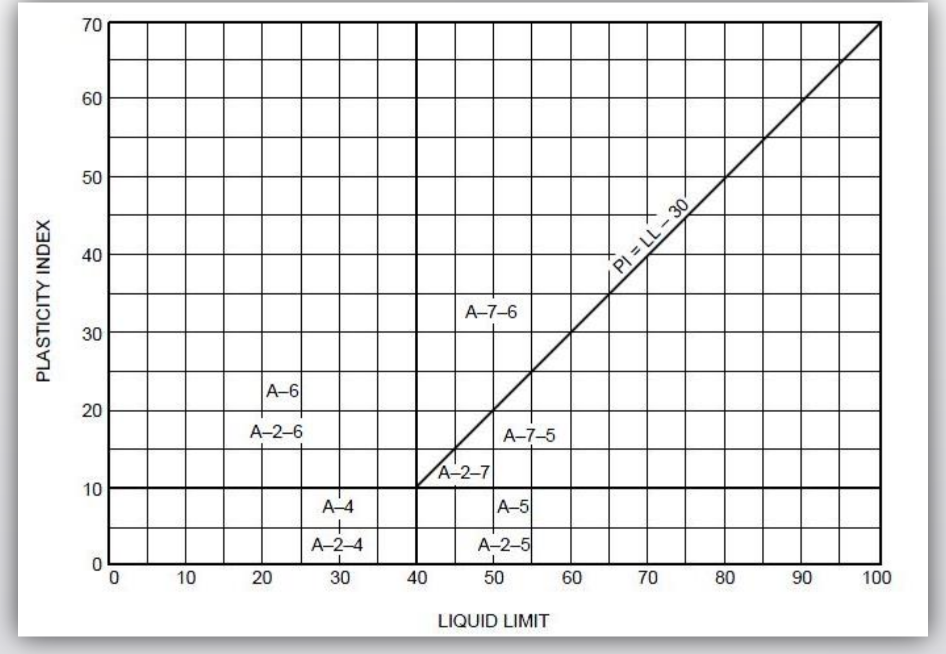


Figure [15]-Group index chart

AASHTO standard Specification for Transportation Materials and Methods of Sampling and Testing. Copyright 1990 by American Association of State Highway and Transportation Officials, Washington, D.C. Used by permission)

Unified Soil Classification

- Based on our calculation results for **First** soil sample:

Unified Classification

Pass No.200	1.13 % < 50 %	Coarse grained soils
Pass No.4	50 %>56.46 %	Sand
Cu	24 Greeter than 4	SP
Cc	0.4267	
Final Classification	Poorly-graded sand gravely sands	

AASHTO Classification

Pass No.200	1.13 % < 50 %	Granular Materials
Pass No.4	50 %>56.46 %	Sand
Pass No.40	50 %<19.52 %	A-1
Pass No. 10	50 %<48.22 %	A-1-b
Final Classification		A-1-b

Sample#1

Unified Soil Classification

- Based on our calculation results for **Second** soil sample:

Unified Classification			
	Pass No.200	4.72 % < 50 %	Coarse grained soils
	Pass No.4	70.08 % > 50%	Sand
	Cu	6.71 Greeter than 6	SW
	Cc	0.14	
	Final Classification	Well-graded Sand	

Sample#2

AASHTO Classification			
	Pass No.200	4.72 % < 50 %	Granular Materials
	Pass No.40	26.6 % > 19.87%	A-1
	Pass No.200	60.54 > 34.61 % %	A-1-b
	Final Classification		A-1-b

Unified Soil Classification

- Based on our calculation results for **Third** soil sample:

Unified Classification

Pass No.200	10.07 % < 50 %	Course grained soils
Pass No.4	85.9 % > 50 %	Sands
Cu	33.33 Greeter than 4	SP
Cc	0.024	
Final Classification	Poor-graded Sands with Clayey sands	

Sample#3

AASHTO Classification

Pass No.200	10.00 % < 35 %	Granular Materials
Pass No.40	85.9 % > 51 %	Fine Sands
Pass No.200	Equal 10.00%	A-3
Liquid Limit Plasticity Index	NP	A-3
Final Classification		A-3

The weakest

CBR Test (ASTM 1883)

- CBR (California Bearing Ratio).
- We got **CBR % = 10.67**
- CBR value are usually calculated

  for penetration of 2.5 mm & 5.0 mm.

CBR value	Subgrade strength
3% & less.	Poor
3% - 5%	Normal
5% - 15%	Good

Table [10]-Subgrade strength

Figure [16]-CBR machine test

Flexible Pavement Design Methods

- **Highway Pavements:**

- AASHTO guide method. ✓

- The Asphalt Institute (T. A. I. Method).

- Portland cement Association (PCA).

- N. C. S. A. (National Crushed Stone Association).

- MEPDG (Mechanistic-Empirical (Pavement Design).

Equivalent Single Axle Load (ESAL)

- During the first year of service, the following is observed.
- Assuming an annual growth rate of 4% and design factor 0.45 .
- Then,

$$\boldsymbol{ESAL = N * AADT * 365 * Fd * Grn}$$

$$\boldsymbol{ESAL = 15,867,588.1}$$

Road bed soil

- Obtaining the resilience factor (Mr) of the path soil.
- Taking the weakest soil with the following characteristics:

✓Soil classification (ASHTOO method) = (A-3).

✓CBR > 10%

✓ $Mr = 15000\,psi$

Pavement coefficients

- To find pavement coefficients (A1,A2,A3) and (Mr) for Base-course and Sub-base:
- The base layer and the auxiliary foundation:

Layer	B.C	Sub.B	(AC)
CBR%	85%	40%	Marshall (Stability) (1900 lb)
Mr(psi)	28500	16500	Flexibility (40000 psi)
A	0.135	0.12	0.42

Table [11]-Pavement coefficients

The coefficient of layer discharge for B.C (m2) and Sub. B (m3) soil

- Project area.
- The properties.

Layer	Base Course	Sub-base
Water removed from 100%-50% saturation	1 day	1 day
Quality of Drainage	Good	Good
m2,m3	1.15	1.15

Table [12]- The discharge coefficients

Structural Number

- Two ways to calculate the structural number:

1- Monograph.

2- AASTO Design Equation:

$$\log_{10}(W18) = ZRSo + 9.36\log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left[\frac{\Delta PSI}{2.7}\right]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32\log_{10}(M\,R) - 8.07$$

- The value of reliability, R=85% , and reasonable value for the total standard deviation, S=0.45. Our results:

SN	SN1	SN2	SN3
Value	**3.2**	**3.8**	**3.9**

Table [13]- Structural numbers

AASHTO Guide for Design of Pavement Structures. American Association of State Highway and Transportation Officials. Washington, D.C.

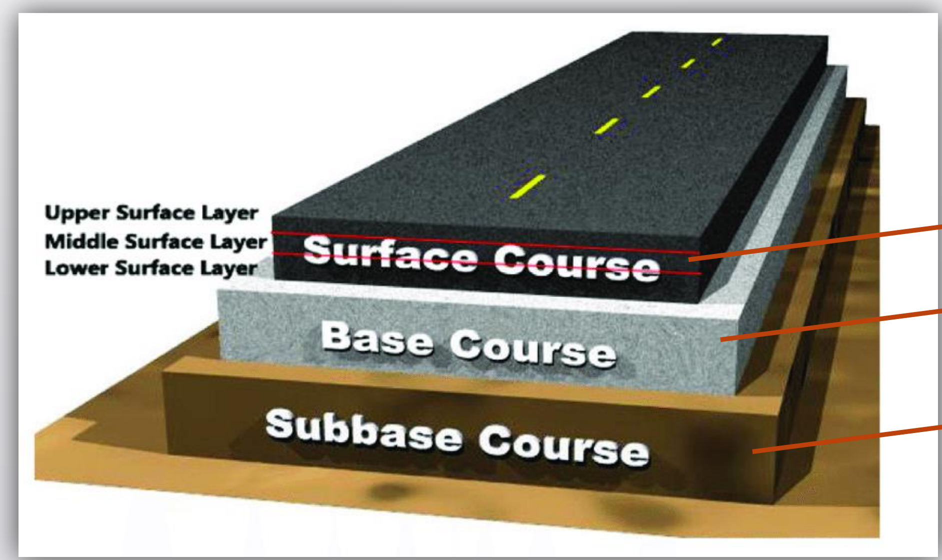
Layers thicknesses

- To calculate the layers thickness (tn):

$$SN1 = A1 \times t1 \quad \rightarrow \quad t1 = \frac{SN1}{A1}$$

$$SN3 = (a1 \times t1) + (a2 \times t2 \times m2) + (a3 \times t3 \times m3)$$

We got, **t1= 12 cm** , **t2= 20 cm** and **t3= 20 cm**



t1= 12 cm

t2= 20 cm

t3= 20 cm

Figure [17]- Layers thicknesses summery

Drainage System

ID	Station	Area (m2)	Lowest Elevation (m)	Highest Elevation (m)	Length (m)	Slope
1	432+28	1820	2.88	17.99	357	0.04

Table[14]- Characteristics of the casting basins

- Repeat period: The design period (50) years.
- **Mean Intensity (i) mm/hr.** For duration of 2Hr, and 10 year return period,

$$XT = \bar{X} + KT \times S = 33.17 + 1.035 * 15.9 = 53.9\ mm/hr$$

Drainage System

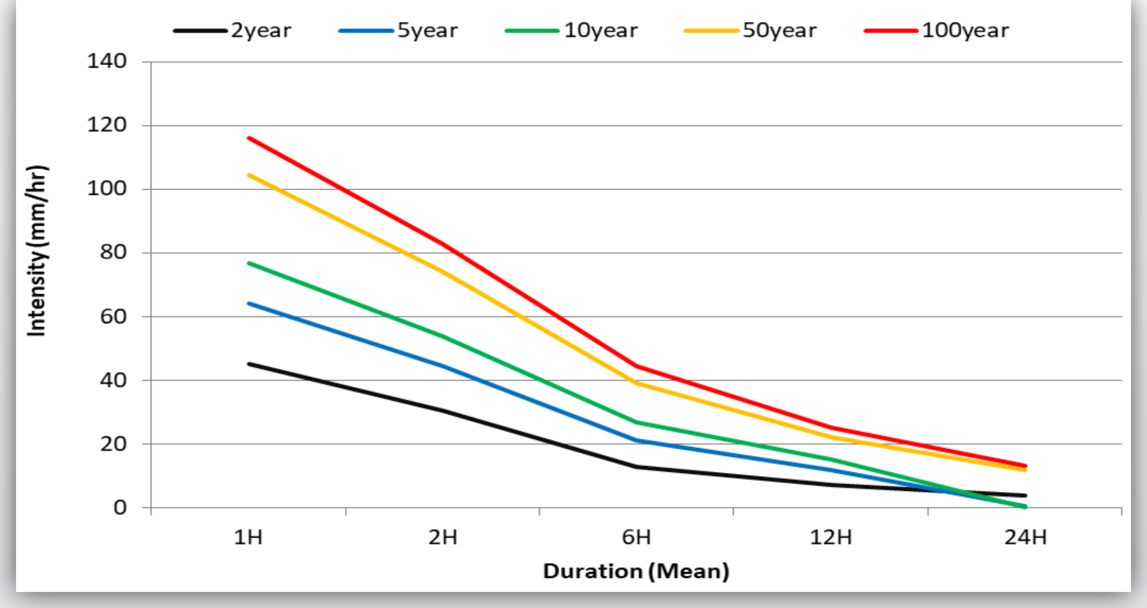


Figure [18]- Intensity-Duration-Frequency curve (IDF curve)

- The design intensity for 50 years period and 1hr duration is 112.3mm/hr.

Drainage System

- Hydraulic Design:

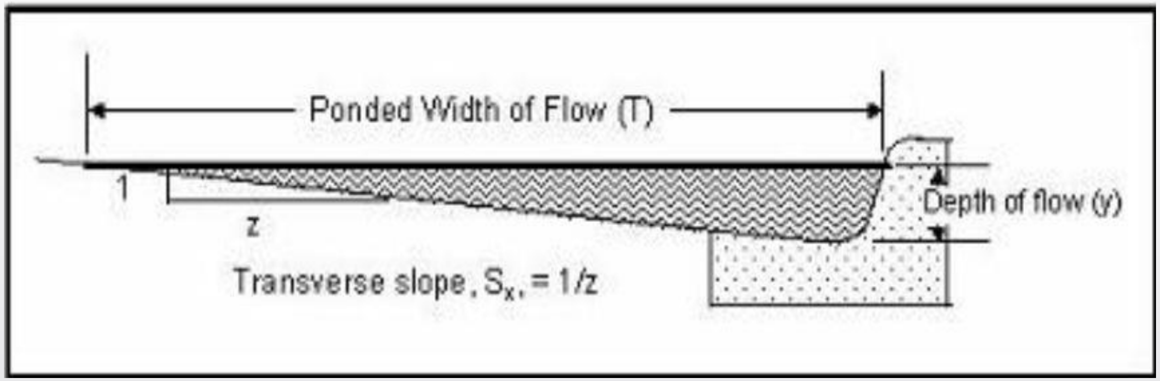


Figure [19]-Hydraulic design details

- The max. Gutter Flow Equation :

$$Q = K(z/n)s^{1/2}y^{8/3} \quad \rightarrow \quad 25.5 = 0.38\ x\ (66.67/0.016)s^{1/2}\ (0.225)^{3/8}$$

$$s = 0.54\% \quad \rightarrow \quad Let\ s = 0.8\%$$

Road Intersection

- **Types of Intersections:**

1. At-grade Intersection.
2. Grade Separation intersection.

- **Intersection Requirements.**
- **Intersections with our future road:**

Intersection	Name of road
1	Jubail-Dhahran Rd.
2	Abo-Hadryia Rd.
3	Al-Riyadh Rd.
4	Al-Ahsa Rd.
5	Half Moon Rd.

Table [15]- Intersections

Road Intersection

Figure [19]-At-grade intersection

Figure [20]-Grade separation intersection

Road Intersection

- Suggested intersection paths:

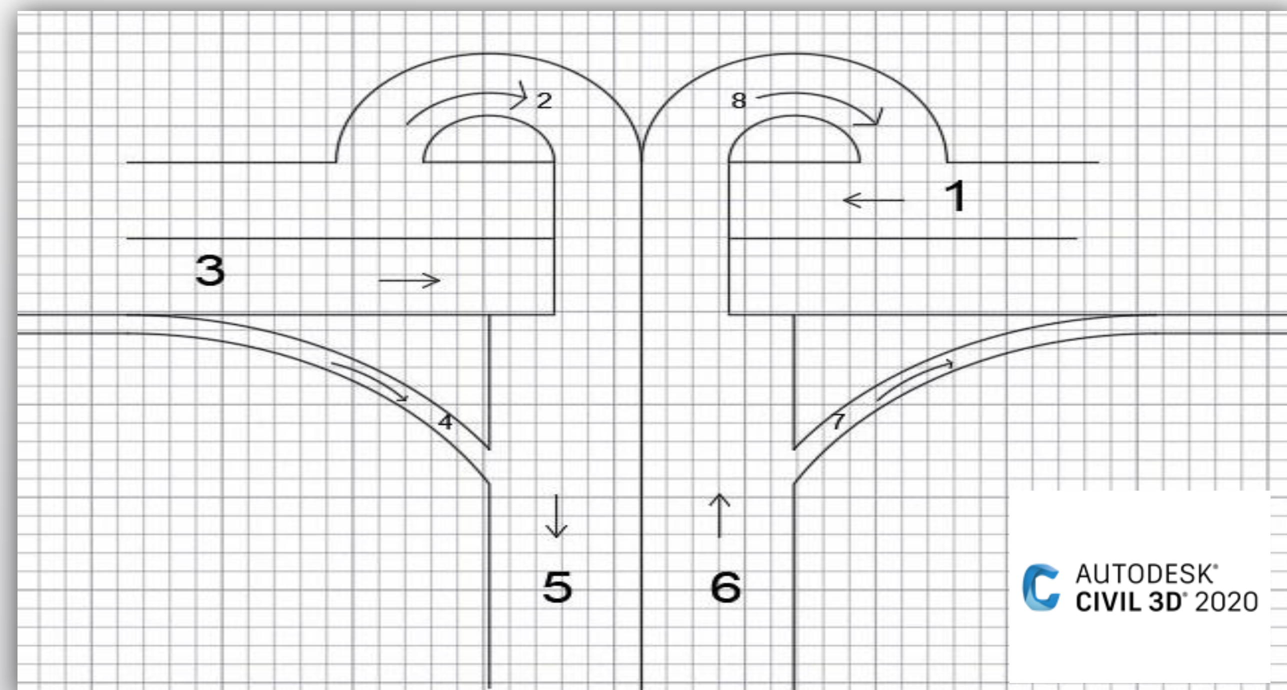


Figure [21]-Suggested intersection path

- With number of lanes: $\mathbf{N} = \frac{PCE}{SF} = \frac{793}{608} = 1.30 \approx 2\ lanes$

Road services

The main points of road services that we worked on:

- Drainage of layers
- Shoulders
- Curb Stone
- Barriers (Mountable Curbs)
- Islands separating the two directions (Median)
- Episodic tendencies of the central island
- Variation of pavements and central islands
- The middle islands curb stone
- Lateral tendencies

Road services

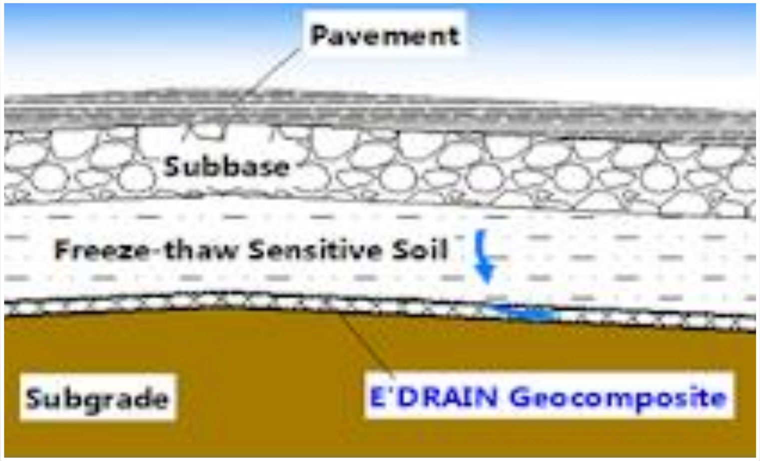


Figure [22]-Drainage of layer

Drainage of layers

Drainage channels at 3m to 5m intervals should be cut through the shoulder to a depth of 50 mm below sub-base level .

Shoulder materials

- It is recommended to make shoulders whose width ranges between 1.25 meters as a minimum and 3.6 meters as a maximum.
- We use 2.8m width.

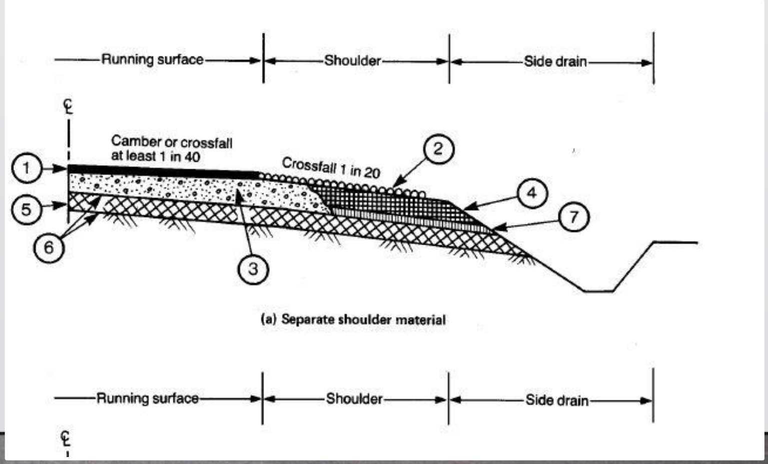


Figure [23]-Shoulder materials

Road services

Figure [24]-Lateral tendencies

Lateral tendencies

The lateral inclinations are designed to ensure the stability and stability of the road, to give the opportunity to secure external cars from control.

Islands separating the two directions (Median)

In almost all modern roads designed with four lanes or more, the central islands are used, and the central islands are broad enough to achieve what we want from non-overlapping opposing traffic.

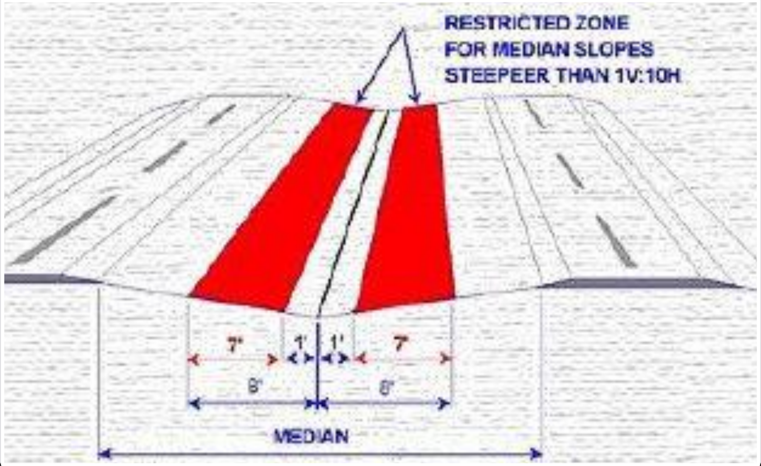


Figure [25]-Median Islands

Road services

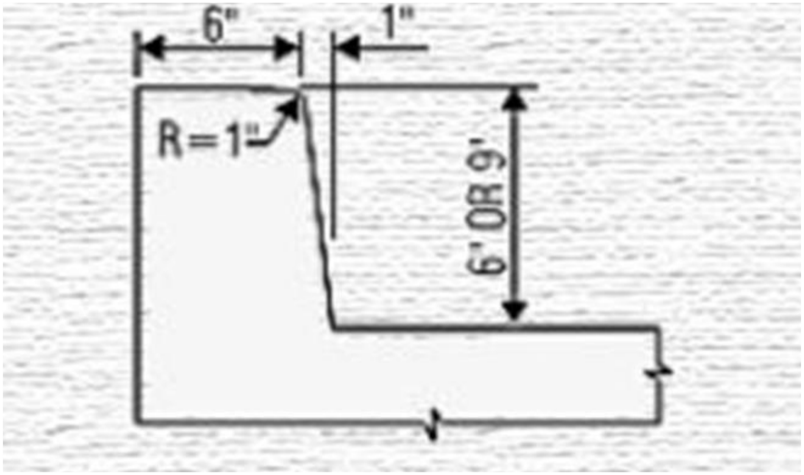


Figure [26]-Middle island curb stone

The middle islands curb stone

It has a sharp side face and is relatively high, and it is designed to prevent cars or at least distract them from trying to get off the pavement, the height of which varies between (15 ~ 22.5) cm approximately.

Sidewalk curb Stone

Curbs determine the width of the sidewalk, and in doing so, they help the driver to drive safely.

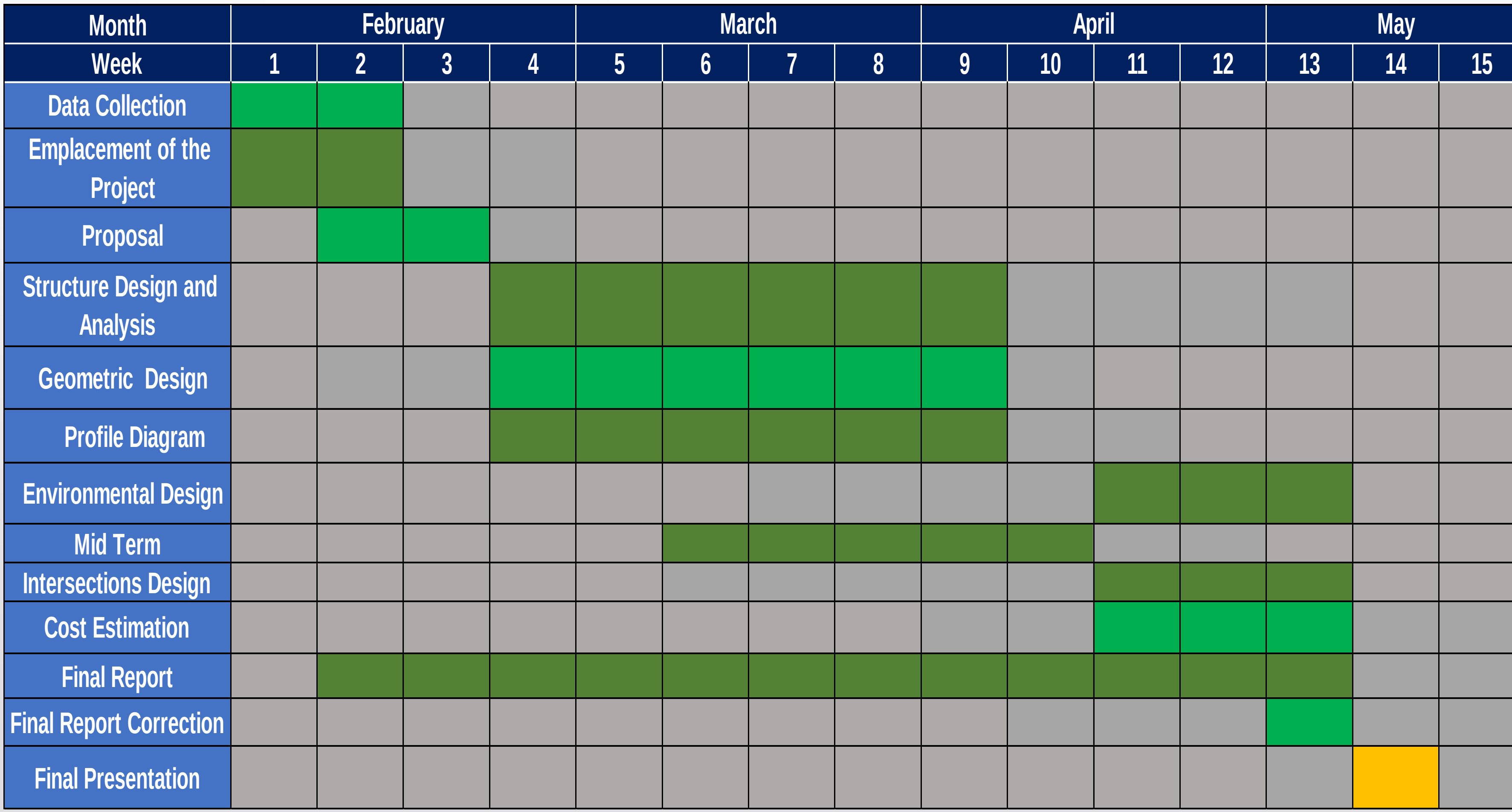
Figure [27]-Curb stone

Cost Estimation

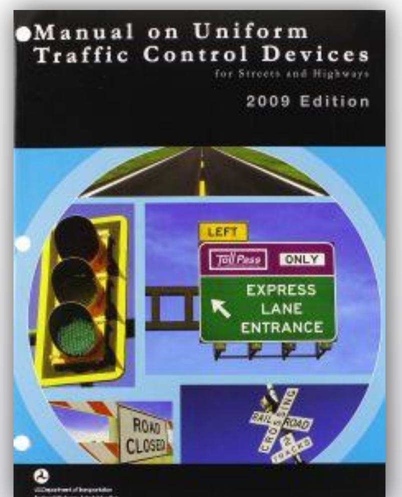
Main items								
Item	Quantity	Unit price (SR)	Item	Quantity	Unit price (SR)	Item	Quantity	Unit price (SR)
Cutting and back filling the natural land.	2751000	187,068,000	Supply and install of Sub-grade layer.	962850	21,182,700	Supply and install sub-base layer, 20cm thickness.	550200	25,309,200
Supply and install sub-base layer, 20cm thickness.	550200	25,309,200	Supply and install asphalt layer, 7 cm thickness.	2751000	60,522,000	Supply and install RC2 layer.	2751000	9,628,500
Supply and install MC1 layer.	2751000	9,628,500	Supply and install asphalt layer, 5cm thickness.	2751000	49,518,000	Staff costs and the consulting office.	An assumption were equivalent to 10%	38,816,610
Total cost = 426,982,710 SR								

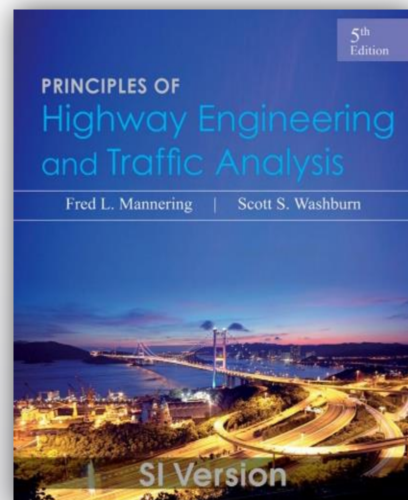
Table [16]-Cost estimation (Main items)

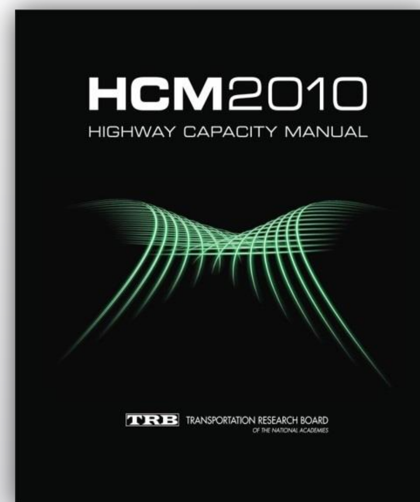
Time line


Month
February
March
April
May
Week
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Data Collection
Emplacement of the Project
Proposal
Structure Design and Analysis
Geometric Design
Profile Diagram
Environmental Design
Mid Term
Intersections Design
Cost Estimation
Final Report
Final Report Correction
Final Presentation

References







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ANY QUESTIONS?

Thank You