"FEASIBILITY STUDY OF R111; UPGRADATION FROM 4-LANE TO 6-LANE"

A Project Report Submitted

In Partial Fulfillment of the Requirements for the Degree of Bachelor of Science in Civil Engineering

CAPSTONE DESIGN PROJECT

SUPERVITION UNDR

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On Behalf of Group Members,

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ABSTRACT

A developed transportation system is mandatory for a modern city/country and for a developed transportation system; a perfect highway design must be needed. For designing a perfect highway, it must be needed to analyze its various types of impact. We have selected the Sing Board to Chashara highway for design of its pavement and analysis of its impact on the environment.

Since Narayanganj is one of the most important cities in Bangladesh, It plays a vital role in the perspective of Bangladesh. For this reasonNarayanganj is connected with the Dhaka by this Regional highway. So every day a huge amount of traffic volume moves on by using this road. So, it's necessary to determine the pavement design and analyze different types of impact on this road, which will give it long-term durability and give better service for transportation. For long term durability and for better service of this road, we analyze its pavement type and design, analyze its growth factors, analyze transportation costs and economic efficiency, determine its noise impact and energy emission on this highway at various times of the day, and analyze the importance of noise barrier, determine its air impact and land use impact, of this road. The purpose of the study is to gauge, evaluate and suggest which type of pavement is best for the highway and how to mitigate its bad impact. Hopefully, our judgment and evaluation will be helpful for this highway's long term duration.

For analyzing and evaluating all things, we organized our total project work into 12 chapters. Firstly, we discuss some introductory topics and the purpose of the study and study framework. Then we give literature review and methodology by giving the statement of data collection and limitations. After this, we analyze and compare pavement design and growth factors and cost estimation. Then, step by step, we analyzed different impacts like economic efficiency, noise,

air, land use, wetland and other ecosystems, and finally concluded it by giving our evaluation and recommendation.

Key Word:

Narayanganj, Chashara, Sing Board, highway, pavement, durability, Regional highway, design, analyze, growth factors, analyze transportation costs, economic efficiency, noise impact, energy emission, noise barrier, mitigate, gauge, evaluate.

Contents

CHAPTER-1

Introduction

1.1Background

For country development the transportation system plays a vital role because how much a country will develop depends on the economic system of that country. A Regional highway can connect a large amount of population from one region to another by improving road network. Utilize of Regional highways will influence essentially each financial movement of the environment. Regional Highway makes life superior in different ways as lessening travel time for: Inhabitants; workers; students; getting to well-being; traveler centers and advertise places. Narayanganj is one the main city of Bangladesh and for many reasons every day a large amount of population and traffic volume enter into the city from different parts of the country.

1.2 Objectives of the Study

*Measuring traffic volume for our selected location

*For design its pavement and cost analysis

*To determine its economic efficiency impact

*To determine its noise impact

*To determine its air impact

*To determine its land use impact

1.3 Study Frame Work

This study is organized by step by step. Firstly, introduction is pointed is briefly discuss and Objective of the study. After this given Literature review in which a review of the relevant research like related about pavement design and different type of impact and methodology is related about the statement of data collection process and talk about limitations. Then we briefly discuss about pavement design and analysis and compare with flexible and rigid pavement and recommended pavement type and analysis growth factor from registered vehicles. Economic efficiency analysis for comparison and analysis for cost estimation. And then, discuss about noise and analysis its impact with and without noise barrier and noise barrier cost. After this chapter we discuss about air pollution and analysis impact and discuss about the mitigation process. Lastly, discuss about different type of ecosystem, there elements and mechanisms and impact and land use impact are analysis for find out the mitigation process. Finally, we give a final conclusion.

CHAPTER-2

LiteratureAnd Review

2.1 General

About 1.5 million people live in Narayanganj. They are increasing in number every day. As a result of bad traffic signals, insufficient personnel, inadequate road space, and the tendency of cars to overtake one another, a significant amount of time is spent on the roads, which has a negative influence on the economy. Heavy environmental contamination from noise and air pollution motorized and non-motorized means of transportation are available in Dhaka. Difficulty in operating the present transportation system is a result of this. So here we have selected a busy road. Our goal is to analyze the pavement design for that road and many other things as well, which we will discuss below. This Road connected the two major cities and less the traffic jam. It is also use as a bypass of N1 and N8 road. Narayanganj is the fast growing cities in Bangladesh and this road make the transit easier.

Source: Feasibility Study EXECUTIVE SUMMARY Dhaka East West (Middle/ Outer Ring Road) Elevated Expressway August 2017

2.2 Pavement Design Analysis

We shall conduct analysis based on various pavement kinds in this chapter. We shall choose five pavements because this is a group effort. In this manner, we will be able to evaluate these five pavements in comparison and draw our own conclusions. Since we lack sufficient information, we will work based merely on the pavement's thickness. Analysis of Growth Factors We obtained information on registered automobiles during the previous years from the Bangladesh Road Transport Authority. We shall now display the anticipated automobiles for Bangladesh in the years to come.

2.3 Economic Efficiency Analysis

The quickest route from Dhaka to Narayanganj is by this road. We will analyze the cost for the five different types of designs we created in accordance with BRTA.A road's construction not only makes it possible for us to move more quickly, but it also affects a number of other variables, including economic production, gross regional product, value added, personal income, employment, capital investment, and public spending. We'll attempt to evaluate that. The number of automobiles grows along with noise pollution. We classify a car's horn as sound pollution when it goes beyond a specific volume. We must be careful of the sound emissions from our chosen route because it is a multilane highway so that it won't harm our health. Our climate is becoming worse every day.

2.4 Travel Demand Forecasting

2.4.1 Land use and Census

Land use data forms the basis for the amount and type of activity in a region. This demographic information is available from several sources. The Census is a nationwide survey conducted every ten years and provides a detailed population profile of Connecticut. Existing statistics are available from the Bangladesh Roads & Highways Department (RHD).

2.4.2 Trip Generation

Trip generation provides the connection between land use and travel. It uses known relationships between trip making and demographics to predict the number of person trips, or 'trip ends', starting and ending in particular geographic areas.

The road R111 is a regional highway. This road was a two-lane, two-way road. Now it is being six-lanes, two-way road. Two-way trip is generated here each day. One is from Signboard to Chashara; another is from Chashara to Signboard. This road is the gateway to Narayanganj; which is a very big economic zone. For this a large number of trips is generated here.

2.4.3 Trip Distribution

Trip distribution uses characteristics of the transportation network and regional demographics to distribute the trip ends from the generation model to specific origins and destinations amongst the places.

The road R111 is an access-controlled highway. So, no new trip distribution will occur in between the trip origin and trip ending.

2.4.4 Mode Choice

The allocation of person and vehicle trips to a particular travel mode occurs in the mode choice model. Using Level of Service characteristics of each available transportation system, the model 'chooses' a mode of travel for each trip based on the relative attractiveness of each competing mode.

The road R111 had a level of service "E". Now, it is being upgraded to a level of service "C". For this reason, non-motorized vehicles will not be able to use this road. A new service lane is being constructed along the side of the road for the other types of vehicles. Only motorized vehicle will be allowed on the road.

2.4.5 Travel Assignment

Travel assignment or trip assignment is the process in which the volumes on the transportation system are estimated. These can be present-day volumes on an existing network or forecasted volumes on alternative future systems. Assignment volumes may be expressed as vehicles on a highway network or persons on a transit system.

CHAPTER-3

Method of Counting

3.1 Two types of traffic counting:

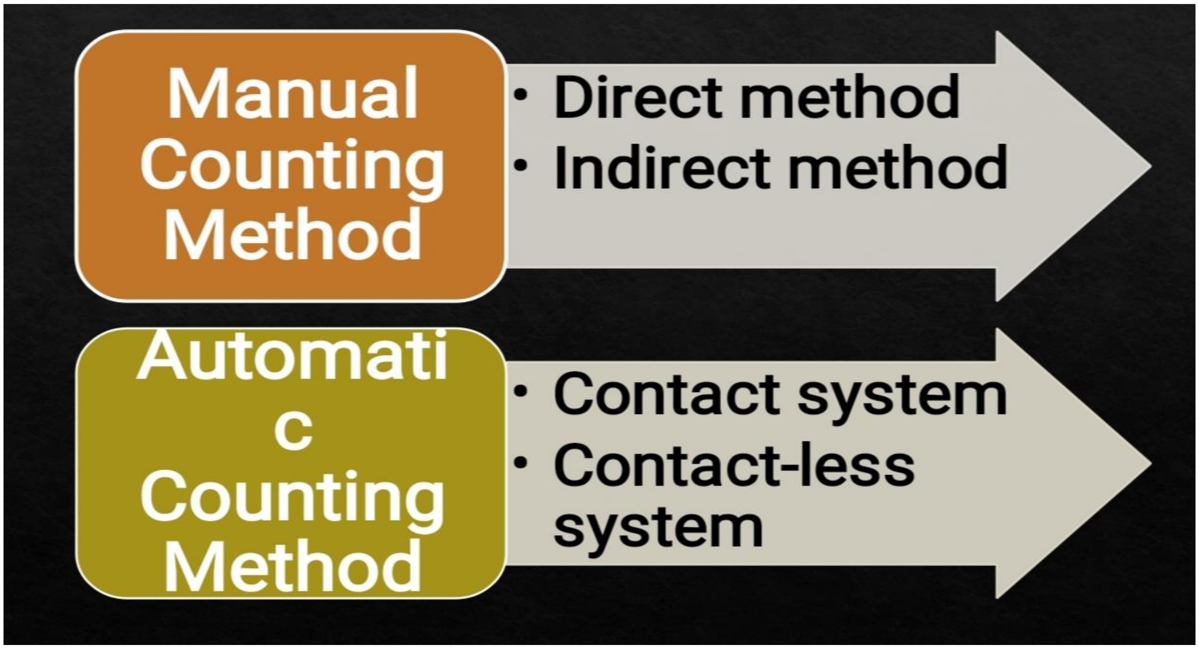


Figure 3.1 types of traffic counting

[Source: Slide Share.net (www.slideshare.net/tanviralam31337/traffic-volume-studies)]

3.2 Method of Counting (cont.)

Manual counting method is conducted.

When automated equipment is unavailable, manual count is needed.

Used to determine data of vehicle classification, movements & travel direction.

It requires small samples of data at any given location.

We conducted manual counting for 15 minutes.

Counting was conducted for both directions.

Figure 3.2 Data collection

CHAPTER-4

Geometric Design

Geometric design also affects an emerging fifth objective called «livability,» which is defined as designing roads to foster broader community goals, including providing access to employment, schools, businesses and residences, accommodate a range of travel modes such as walking, bicycling, transit, and automobiles, and minimizing fuel use, emissions and environmental damage

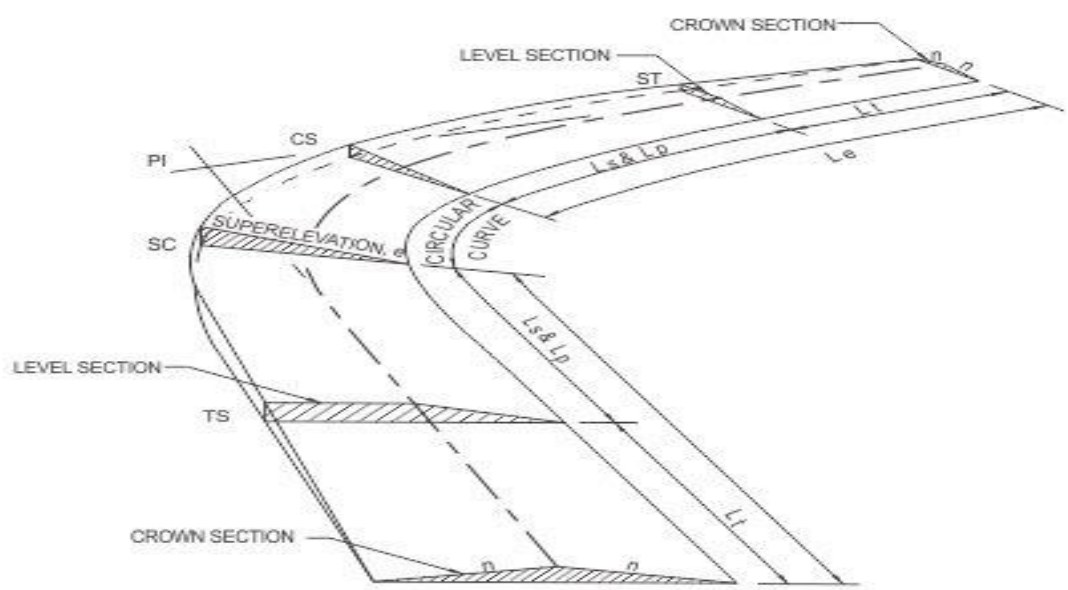


Figure: 4.1 drawing of super elevation

[Source: civil jungle (https://civiljungle.com/superelevation/)]

From RHD manual,

Design type 4- 6.2m Wide Carriageway.

Use type for low cost and economic zone.

Crest = 15.2m

Carriage way = 6.2m

Shoulder paved = 1.5m

Verge = 3m

Design Capacity

Max. Capacity= 1600Pcu/hr

NMT/MV Ratio= 0.005

Considering,

Bicycle=2

Rickshaw=2

Cart=4

Here our counting Non-Motorize Vehicle is all

(Bicycle + Rickshaw)

Nmt= (non-motorize*2.5)

= (132*2.5)

= 330Pcu/hr<400pcu/hr

Here,

Nmt is 330 pcu/hr<400 pcu/hr

So Extra Nmt lane not needed.

Geometric Curve,

Assumed,

Design Speed=80km/hr

For tow lane single Carriage Road (6.2m Carriage)

Curve Radius = 500m/2000m/8000m (table 5.1)

Design Speed (km/h)	Single Lane Roads (3.7m carriageway	Two Lane Single Carriageway Roads (6.2 and 7.3m carriageway)			Dual Carriageway Roads (2 x 7.3)
	ISD	SSD	ISD	OSD	ISD
30	120	35	120	500	-
40	250	65	250	1000	-
50	500	120	500	2000	500
65	1000	250	1000	4000	1000
80	-	500	2000	8000	2000
100	-	1000	4000	-	4000

Table 4.1- Minimum Curve Radius (M)

[Source: Geometric Design Standard Manual]

Table 5.2,

Design Speed (km/h)	Sight Distance (m)								
	25	30	45	60	90	120	180	250	360
	Curve Radii (m)								
	20	35	65	120	250	500	1000	2000	4000
	Minimum Super-elevation Requirement (%)								
30	7	5	3	Nil	Nil	-	-	-	-
40	-	7	5	3	Nil	Nil	-	-	-
50	-	-	7	5	3	Nil	Nil	-	-
65	-	-	-	7	5	3	Nil	Nil	-
80	-	-	-	-	7	5	3	Nil	Nil
100	-	-	-	-	-	7	3	3	Nil

Table 4.2- Minimum Super elevation required (%)

[Source: Geometric Design Standard Manual]

For Curve Radius = 500m- 120m (SSD)

Design Speed = 80km/hr

Minimum super elevation = 5%

Table 5.3,

L_p =45m, L_c = 25m

Table 5.4,

Extra Carriage way Width on Curve for 500m and 6.2m Wide two-lane load = 0.6(both lane) 0.3 for one side

Vertical Curves,

Parabolic vertical Curve, k = L/A,

Here, L= Length of vertical Curve, A= Change Of grade (%)

From, Table 6.1,

Design Speed =80km/hr

K= 35, Length required for a 1 % change (K)

Let,

L_1 % = 6% &

Amp; L_2 % = -4%

A=6%-(-4%) = 10%

L = 350m

Gradients,

All design type, All the design Speeds Plain (0-3%) (Max. Gradients %)

Stopping Sight Distance,

T_r = 2.53,

V=80km'hr

D_r = 0.278*80*2.5= 55.6m

A= 3.4m/s^2

Breaking Distance,

B_D= 0.039*(80) 2 /3.4 = 73.4m

Stopping Sight Distance, SSD = 55.6+73.4 = 129m

Stopping Distance on grades,

D= 0.278*t*v+ = 122.51m (For downgrade) 123m

And 135.19 (For Upgrade) 136m

Horizontal Alignment

Max Side Friction F=

$$\frac{v^2}{9.81127R} - \frac{e}{100}$$

$$\frac{(80)\text{^}2}{127*500} - \frac{6}{100}$$

= 0.04

Now,

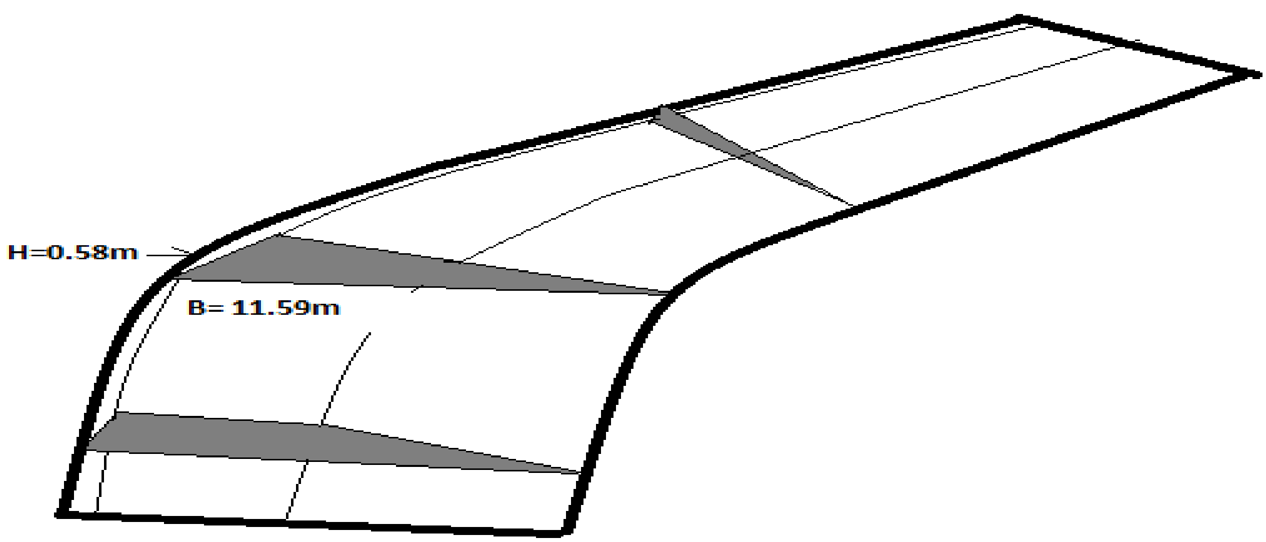
R= 500m, SSD= 129m, Design Speed= 80km/hr

4.1 Super Elevation

The road is frequently tilted or banked at an angle while a motive force passes thru a curve, making it easier to barter the curve at a safe velocity without sliding or tipping. That is a excellent elevation at paintings. On curved roads, superb elevation aids drivers in preserving each safety and the quality speeds. In moist or slippery circumstances, or at excessive speeds, many vehicles could slide or skid thru curves—or even tip and roll over—without high-quality elevation. Moreover, it enables some degree of curve velocity upkeep, avoiding giant slowdowns at every bend in the road.

From RHD manual, Design speed= 80km/hr.

H=11.59m * 5% = 0.58m



So, 5% super elevation will be provided.

Figure: 4.2 drawing of super elevation

CHAPTER-5

Pavement Design

5.1 Introduction:

A road pavement structure is constructed of many layers of processed and compacted materials in varying thicknesses and in both bound and unbound forms. These layers work together to create a structure that primarily sustains vehicle weights and offers a pleasant ride.

5.2 Types of pavement:

There are two types of pavement.

1) Flexible pavement
2) Rigid Pavement.

5.3 Design in flexible Pavement

Roads or pavements that are flexible bend or deflect under the weight of traffic, making them less prone to damage and necessitating repairs over time. Multiple layers of various materials make up a flexible pavement structure, which collectively allow the road to accommodate this flexing.

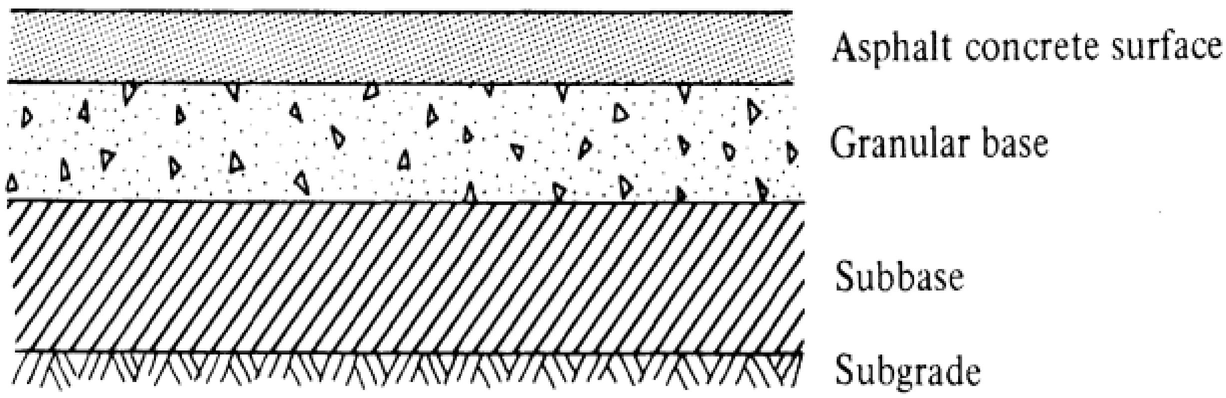


Figure 5.1: Schematic of a Flexible Pavement
[Source: Traffic and Highway Engineering (Nicholson J. Garber)]

5.4 Sub-grade:

Sub grade is the area of the earthen roadbed that receives the foundation or surface material after being built in pretty close compliance with the lines, grades, and cross-sections shown on the drawings. The sub grade in a fill section is the summit of the embankment or fills.

5.5 Sub Base:

A sub base is a layer of gravel or soil that comes over the sub grade. Over the sub base comes the base course layer. Sub base is considered the main load bearing layer of a pavement. Some of the sub base material used for construction is recycled concrete, granular fill. Manufactured aggregate, lean concrete, recycled materials like brick or concrete materials, and crushed rock.

5.6 Granular Base

Crushed stone makes up more than 50% of the coarse aggregate particles in most granular base materials. There should be few flat or thin and elongated particles and many cubical ones. Usually, the granular basis is densely graded, with the number of fines kept to a minimum to aid in drainage.

5.7 Asphalt Concrete Surface:

One of the most popular forms of pavement surface materials utilized worldwide is asphalt concrete. It is a porous substance generated at a very high temperature of roughly 180 °C and is composed of a mixture of aggregate pieces, air spaces, and asphalt binder (bitumen).

5.8 1993 AASHTO Flexible Pavement Structural Design

Flexible pavement,

Highway type = 6 lane

Design year = 20 yrs.

Uniform growth rate = 7%

AADT = 59,000

Assumed,

SN = 6

$P_T = 2.5$

$B = \{(1+g)^n\}/g$

Design year, n=20

Growth rate, g=7/100 = 0.07

B = 55.28

Table 1 Axle Load Equivalency Factors for Flexible Pavements Single Axles (Pt = 2.5)

Axle Load	Pavement Structural Number (SN)					
(kips)	1	2	3	4	5	6
2	0.0004	0.0004	0.0003	0.0002	0.0002	0.0002
4	0.003	0.004	0.004	0.003	0.002	0.002
6	0.011	0.017	0.017	0.013	0.01	0.009
8	0.032	0.047	0.051	0.041	0.034	0.031
10	0.078	0.102	0.118	0.102	0.088	0.08
12	0.168	0.198	0.229	0.213	0.189	0.175
14	0.328	0.358	0.399	0.388	0.36	0.342
16	0.591	0.613	0.656	0.645	0.623	0.606
18	1	1	1	1	1	1
20	1.61	1.57	1.49	1.47	1.51	1.55
22	2.48	2.38	2.17	2.09	2.18	2.3
24	3.69	3.49	3.09	2.89	3.03	3.27
26	5.33	4.99	4.31	3.91	4.09	4.48
28	7.49	6.98	5.9	5.21	5.39	5.98
30	10.3	9.5	7.9	6.8	7	7.8
32	13.9	12.8	10.5	8.8	8.9	10
34	18.4	16.9	13.7	11.3	11.2	12.5
36	24	22	17.7	14.4	13.9	15.5
38	30.9	28.3	22.6	18.1	17.2	19
40	39.3	35.9	28.5	22.5	21.1	23
42	49.3	45	35.6	27.8	25.6	27.7
44	61.3	55.9	44	34	31	33.1
46	75.5	68.8	54	41.4	37.2	39.3
48	92.2	83.9	65.7	50.1	44.5	46.5
50	112	102	79	60	53	55

Vehicle Types	Current AADT (A)	Growth Factors (B)	Forecasted Traffic (C)	ESAL Factor* (D)	Forecasted ESAL (E)
Car	10646	55.28	578449.9	0.0008	462.76
Pick up	4992	55.28	275957.8	0.0122	3366.69
Covert Van	15264	55.28	843793.9	0.6560	553528.8
Bus	11808	55.28	652746.2	0.0021	1370.76
Truck	8928	55.28	493539.8	0.8646	426714.5
Total pcu = 51456				Total Esal =985443.6	

Table 5.1 Determine total PCU and total ESAL

Directional Distribution = 0.5

Lane distributions = 0.9 (table 1)

Therefore,

Design Esal = 985443.6*0.5*0.9

= 443449.6pcu/hr

W_{18} kip equivalent single axle load

R= 95% (Interstate)

S = 0.45 (Flexible)

Del Psi = P_o-P_T

P_o = Initial serviceability = 4.6 (assumed)

P_T = Terminal serviceability = 2.5 (assumed)

Del Psi = 4.6-2.5 = 2.1

Growth rate g= 7%

Design time = 20 years

Initial service life of the pavement =20 years

AASTHO work sheet for flexible pavement Design

Pavement layer	Material used	Resilient Modulus M_R(psi)		Layer Coefficient	Drainage Coefficient	Required SN above the layer	Layer Thickness calculation	Thickness (D) inches
Surface Course	Asphalt Concrete	E_{AC}	$4x10^5$	$a_1 = 0.42$	M_1=1		D_1=4.76 SN_1^*=2.73	5.00
Base Course	Granular	E_{BC}	$3x10^3$	$A_2 = 0.14$	M_2=1.2	SN_1=2	D_2 = 4.2 SN_2^*=0.756	4.5
Sub base Course	Granular	E_{SB}	$1.1x10^3$	$A_3 = 0.08$	M_3=1.2	SN_2=2.8	D_3 = 10.88	11.00
Roadbed Course	Compacted Soil	E_{RB}	$5.7x10^3$			SN_3=3.9		

Table 5.2 AASTHO work sheet

5.8.1 Layer co-efficient,

$a_1 = 0.169\ln(E_{Ac}) - 1.764$

E_{Ac}= Resilient Modulus M_R Asphalt Concrete (psi)

$a_2 = 0.249 \log_{10}(E_{BS}) - 0.977$

E_{BS}= Resilient Modulus M_R Base Course (psi)

$a_3 = 0.227 \log_{10}(E_{SB}) - 0.839$

E_{SB}= Resilient Modulus M_R Sub base Course (psi)

Resilient Modulus M_R (psi) is assumed.

5.8.2 Layer Thickness calculation

$D_1 = SN_1/a_1{*}m_1$

$= 4.76$ in

$SN_1^* = a_1 \times D_1^* \times m_1 = 2.1$ in

$D2 = SN_2\text{-}SN_1^*/a_2 \times m_2 = 3.99$in

$SN_2^* = a_2 \times D_2^* \times m_2 = 0.756$ in

$D_3 = SN_3 - SN_2^* - SN_1^*/a_3m_3 = 11.00$ in.

5.8.3 Cheek,

$SN_3 = 0.42 \times 1 \times 5 + 0.14 \times 1.2 \times 4.5 + 0.08 \times 1.2 \times 11$

$= 3.9$ in ≈ 3.9 in

SN_3 (from the graph) = SN_3 (From Calculation)

5.8.4 Result:

Surface Course: 5”

Base Course: 4.5”

Sub Base Course: 11”

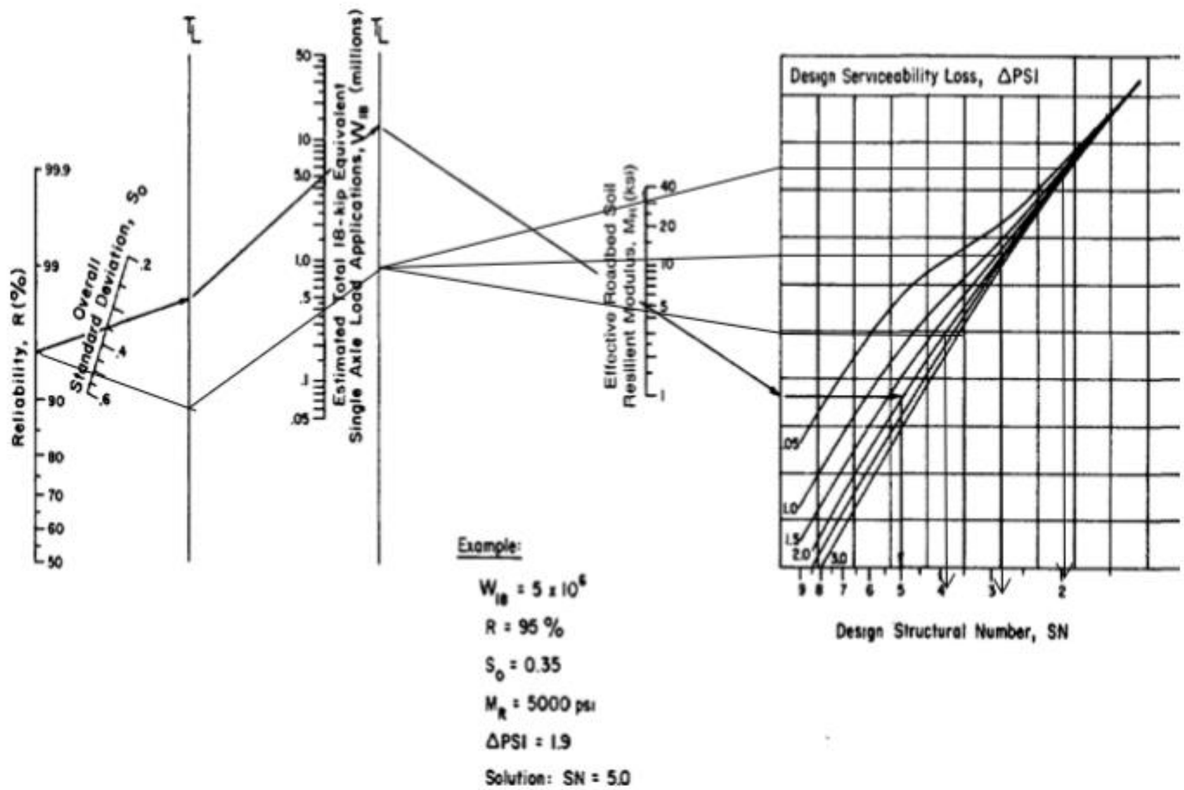


Figure5.1: Design Chart Flexible Pavements Based on Mean values for each Inputs

5.9 PCA Design Method

Design Traffic Volume

$$V = 365\,(ADT)\,(T)\,(D)\,(L)\,(G)\,(Y)$$

where, ADT = Average Daily Traffic (two-way)
T = Percent Trucks
D = Direction Distribution Factor
L = Lane Distribution Factor
G = Traffic Growth Multiplier
Y = Design Life (Years)

Traffic Growth Multiplier

$G = (1 + r)^{Y/2}$ where, r = Annual Growth Rate

Adt = 59,000 (two-way)

T = 0.42% ($\frac{93}{59000} * 100$)

R= 7%

D= 0.5(assumed)

Y= 20years

G= $(1+0.07)^{10}$

= 1.97

Clay Sub-grade K=100psi/in

Concrete M_R = 650psi (assumed)

Use Sub base = 4” (Untreated)

Use Doweled JPCP & Asphalt Shoulders

Lane distribution factor,

ADT x D x G

= 57820

Design traffic volume= ADT*365*D*G*T*L*Y

= 95729104.8 trucks

For lane distribution factor we use the graph.

Here, L=0.54 (3 lane in one Direction)

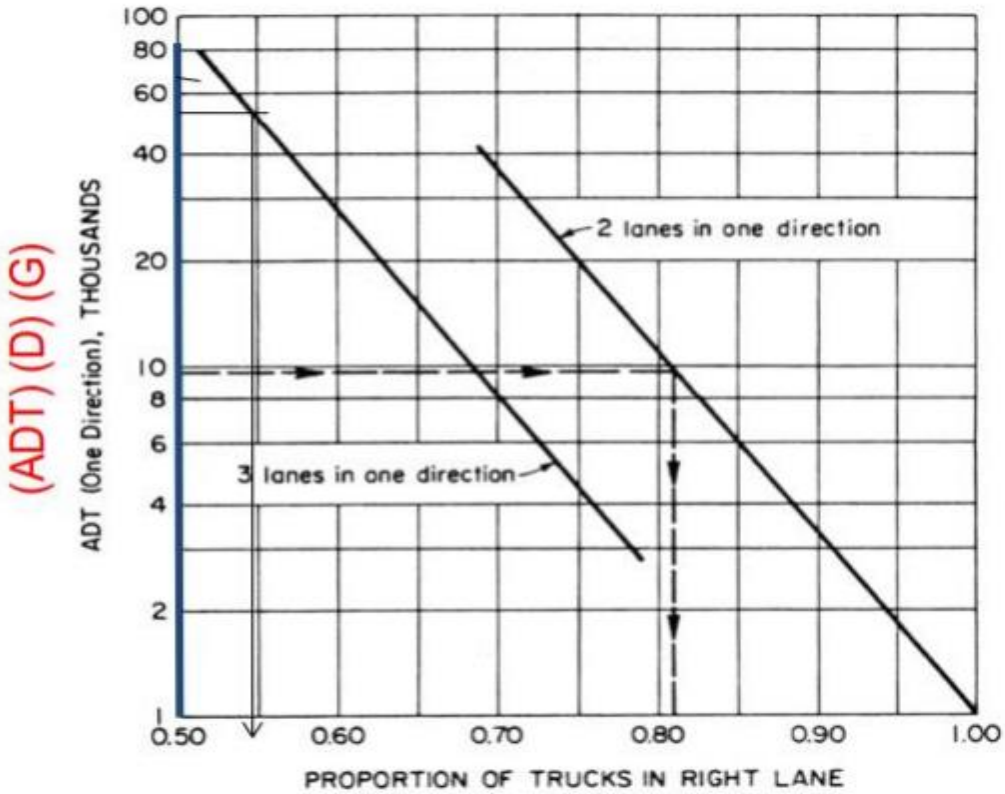


Figure 5.2: Lane Direction Graph

Load Safety Factor (Multiplication factor for axle loads)

Traffic Volume	LSF
High (interstates, multilane highways)	1.2
Moderate (highways and arterials)	1.1
Low (collectors, residential streets)	1.0

For Load Safety Factor we use this table. Our road is Moderate (highway and arteials)

so, Lsf = 1.1

There is a doweled joint and no concrete shoulder.

For slab thickness= 9”

K for Sub grade – Sub base = 130

Modulus of Subgrade Reaction

Design *k* Values for Untreated Subbases

Subgrade *k* value, pci	Subbase *k* value, pci			
	4 in.	6 in.	9 in.	12 in.
50	65	75	85	110
100	130	140	160	190
200	220	230	270	320
300	320	330	370	430

Design *k* Values for Cement-Treated Subbases

Subgrade *k* value, pci	Subbase *k* value, pci			
	4 in.	6 in.	8 in.	10 in.
50	170	230	310	390
100	280	400	520	640
200	470	640	830	—

Equivalent Stress – No Concrete Shoulder (Single Axle / Tandem Axle)

Slab thickness, in.	k of subgrade-subbase, pci						
	50	100	150	200	300	500	700
4	825/679	726/585	671/542	634/516	584/486	523/457	484/443
4.5	699/586	616/500	571/460	540/435	498/406	448/378	417/363
5	602/516	531/436	493/399	467/376	432/349	390/321	363/307
5.5	526/461	464/387	431/353	409/331	379/305	343/278	320/264
6	465/416	411/348	382/316	362/296	336/271	304/246	285/232
6.5	417/380	367/317	341/286	324/267	300/244	273/220	256/207
7	375/349	331/290	307/262	292/244	271/222	246/199	231/186
7.5	340/323	300/268	279/241	265/224	246/203	224/181	210/169
8	311/300	274/249	255/223	242/208	225/188	205/167	192/155
8.5	285/281	252/232	234/208	222/193	206/174	188/154	177/143
9	264/264	232/218	216/195	205/181	190/163	174/144	163/133
9.5	245/248	215/205	200/183	190/170	176/153	161/134	151/124
10	228/235	200/193	186/173	177/160	164/144	150/126	141/117
10.5	213/222	187/183	174/164	165/151	153/136	140/119	132/110
11	200/211	175/174	163/155	154/143	144/129	131/113	123/104
11.5	188/201	165/165	153/148	145/136	135/122	123/107	116/98
12	177/192	155/158	144/141	137/130	127/116	116/102	109/93
12.5	168/183	147/151	136/135	129/124	120/111	109/97	103/89
13	159/176	139/144	129/129	122/119	113/106	103/93	97/85
13.5	152/168	132/138	122/123	116/114	107/102	98/89	92/81
14	144/162	125/133	116/118	110/109	102/98	93/85	88/78

From This table we calculate the equivalent stress ratio

For, Slab thickness = 9”

And K=130

We have to interpolated for k=130 value.

Equivalent stress = $232-\frac{16}{50}$ *30

=222.4

Ratio Factor,

222.4/650 = 0.34 (Single Axle)

Again,

$$\text{Equivalent stress} = 218 - \frac{23}{50} * 30$$

$$= 204.2$$

Ratio Factor,

204.2/650 = 0.31 (Tandem Axle)

Erosion Factor – Doweled Joints, No Concrete Shoulder (Single Axle / Tandem Axle)

Slab thickness, in.	k of subgrade-subbase, pci					
	50	100	200	300	500	700
4	3.74/3.83	3.73/3.79	3.72/3.75	3.71/3.73	3.70/3.70	3.68/3.67
4.5	3.59/3.70	3.57/3.65	3.56/3.61	3.55/3.58	3.54/3.55	3.52/3.53
5	3.45/3.58	3.43/3.52	3.42/3.48	3.41/3.45	3.40/3.42	3.38/3.40
5.5	3.33/3.47	3.31/3.41	3.29/3.36	3.28/3.33	3.27/3.30	3.26/3.28
6	3.22/3.38	3.19/3.31	3.18/3.26	3.17/3.23	3.15/3.20	3.14/3.17
6.5	3.11/3.29	3.09/3.22	3.07/3.16	3.06/3.13	3.05/3.10	3.03/3.07
7	3.02/3.21	2.99/3.14	2.97/3.08	2.96/3.05	2.95/3.01	2.94/2.98
7.5	2.93/3.14	2.91/3.06	2.88/3.00	2.87/2.97	2.86/2.93	2.84/2.90
8	2.85/3.07	2.82/2.99	2.80/2.93	2.79/2.89	2.77/2.85	2.76/2.82
8.5	2.77/3.01	2.74/2.93	2.72/2.86	2.71/2.82	2.69/2.78	2.68/2.75
9	2.70/2.96	2.67/2.87	2.65/2.80	2.63/2.76	2.62/2.71	2.61/2.68
9.5	2.63/2.90	2.60/2.81	2.58/2.74	2.56/2.70	2.55/2.65	2.54/2.62
10	2.56/2.85	2.54/2.76	2.51/2.68	2.50/2.64	2.48/2.59	2.47/2.56
10.5	2.50/2.81	2.47/2.71	2.45/2.63	2.44/2.59	2.42/2.54	2.41/2.51
11	2.44/2.76	2.42/2.67	2.39/2.58	2.38/2.54	2.36/2.49	2.35/2.45
11.5	2.38/2.72	2.36/2.62	2.33/2.54	2.32/2.49	2.30/2.44	2.29/2.40
12	2.33/2.68	2.30/2.58	2.28/2.49	2.26/2.44	2.25/2.39	2.23/2.36
12.5	2.28/2.64	2.25/2.54	2.23/2.45	2.21/2.40	2.19/2.35	2.18/2.31
13	2.23/2.61	2.20/2.50	2.18/2.41	2.16/2.36	2.14/2.30	2.13/2.27
13.5	2.18/2.57	2.15/2.47	2.13/2.37	2.11/2.32	2.09/2.26	2.08/2.23
14	2.13/2.54	2.11/2.43	2.08/2.34	2.07/2.29	2.05/2.23	2.03/2.19

Erosion Factor

$$2.67-\frac{0.002}{100} *30$$

= 2.66 (Single Axle)

Again,

$$2.87 -\frac{0.007}{100} *30$$

= 2.86 (Tandem Axle)

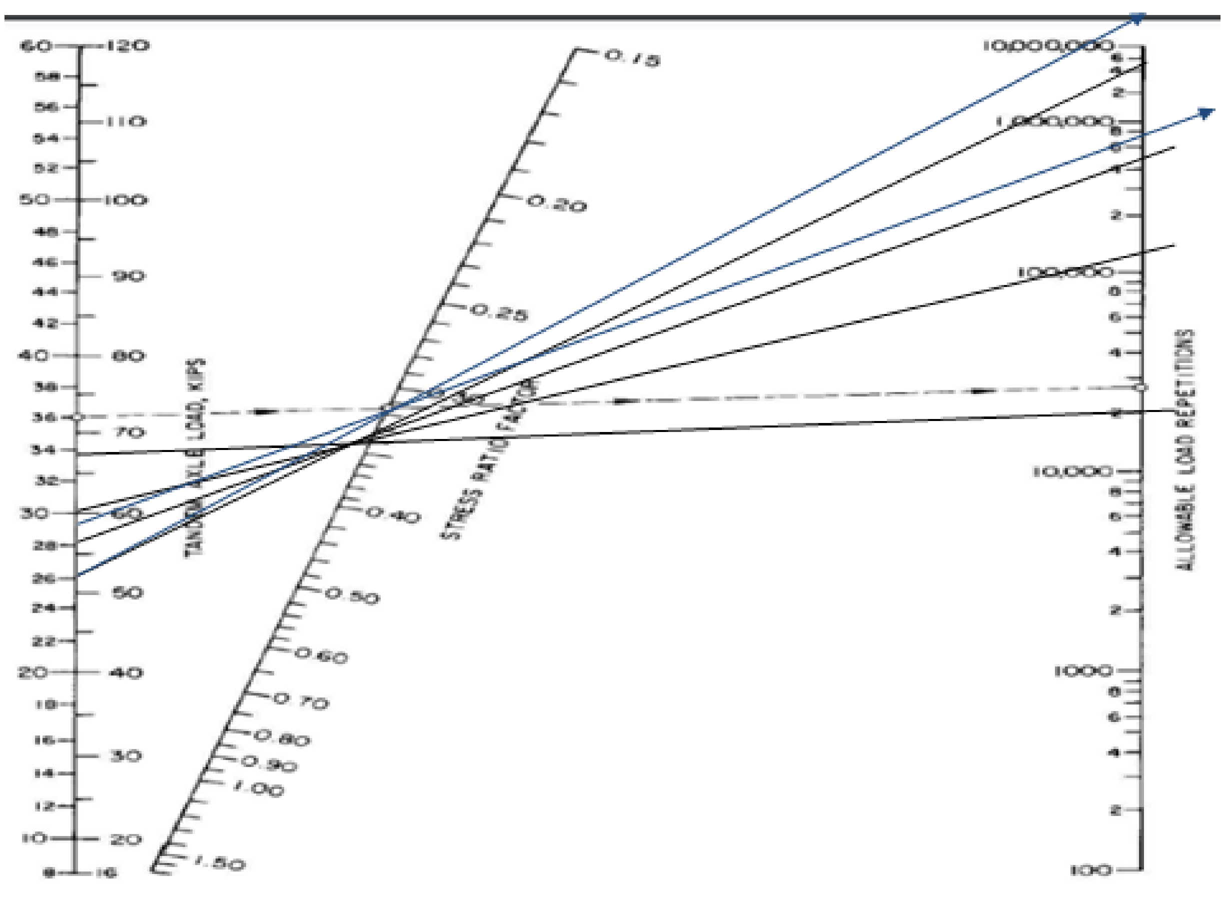


Figure: 5.4 NOMO Graph

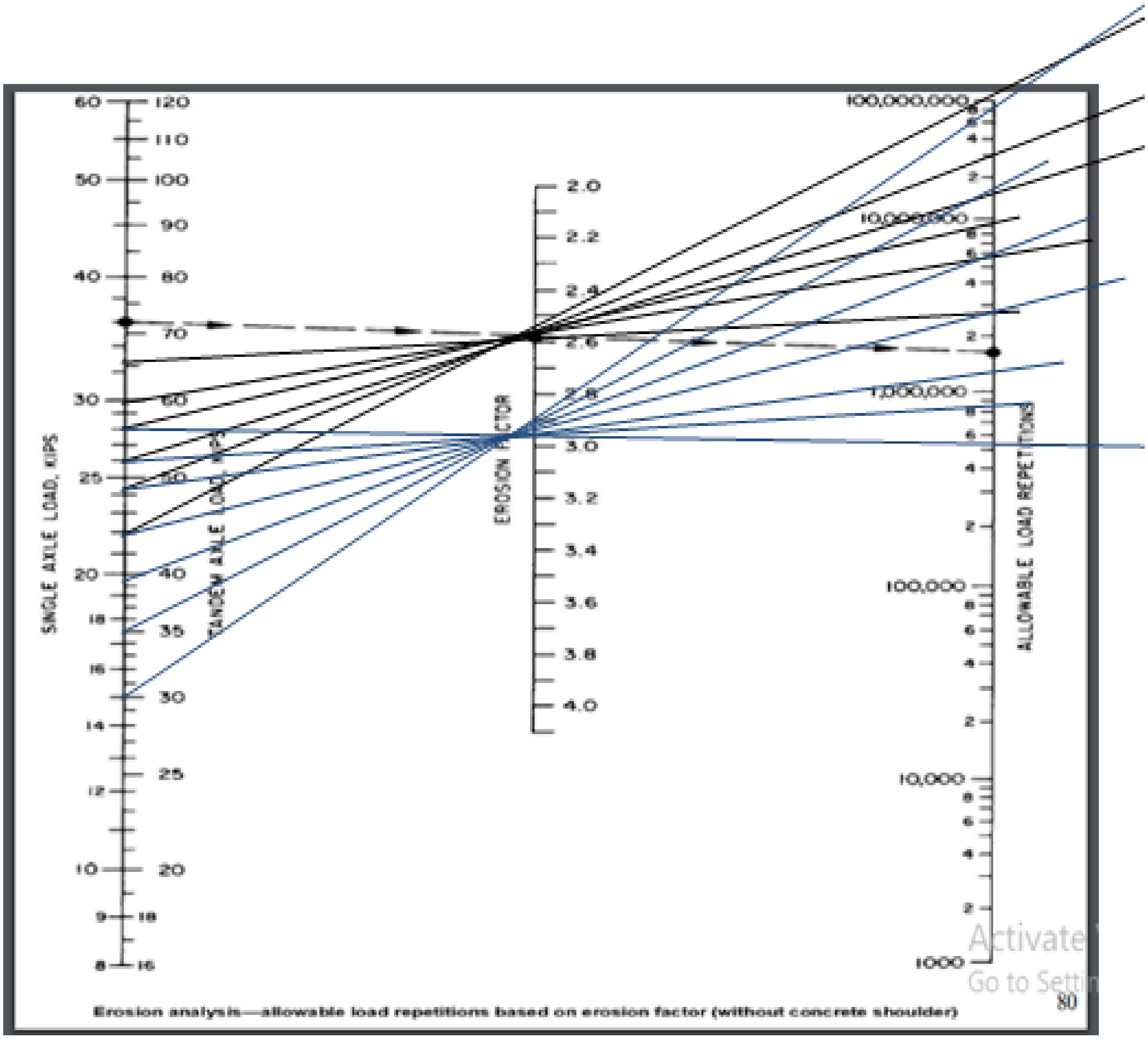


Figure: 5.5 NOMO Graph

5.11 Calculation of pavement Thickness

Trial thickness: 9” Doweled joints: yes

K= 130Pci Concrete Shoulder: No

M_R = 650 Psi Design period: 20 years

Lsf = 1.2

Axle Load, kips	Multiplied by LSF	Expected Repetition	Fatigue analysis		Erosion analysis	
			Allowable Repetitions	Fatigue %	Allowable Repetitions	Damage %
1	2	3	4	5	6	7

Equivalent stress: 222.4

Erosion factor: 2.66

Stress Ratio: 0.34

Single Axle

30	33	6310	20000	29.6	290000	2.2
20	30.8	14690	120000	10.24	500000	2.94
26	28.6	30140	500000	5.03	900000	3.35
24	26.4	64410	41,00000	1.6	30,000,000	2.15
22	24.2	106900	Unlinked	0.0	Unlinked	0.0
				∑= 46.47	∑ = 10.64	

5.12 Calculation of pavement Thickness

Trial thickness: 9”　　　　　Doweled joints: yes

K= 130Pci　　　　　Concrete Shoulder: No

M_R = 650 Psi　　　　　Design period: 20 years

Lsf = 1.2

Axle Load, kips	Multiplied by LSF	Expected Repetition	Fatigue analysis		Erosion analysis	
			Allowable Repetitions	Fatigue %	Allowable Repetitions	Damage %
1	2	3	4	5	6	7

Equivalent stress: 204.2

Erosion factor: 2.86

Stress Ratio: 0.31

Single Axle

52	57.2	21320	6000000	0.36	520000	4.1
48	52.8	42870	Unlinked		820000	5.23
44	48.4	124900			14000000	7.9
40	44	372900			29000000	10.86
36	39.6	885800			60000000	12.8
32	35.2	930700			10800000	0.86
28	30.8	1656000			100000000	0.17
24	28.4	984900			Unlinked	0.0
				∑ = 0.36		∑ = 41.92

Comments

Total Fatigue & Damage = Fatigue % + Damage %

= 46.83 + 52.56

= 99.39%;

Which is acceptable Therefore, design Thickness, t = 9.0”

• Notes:

– If total fatigue and damage was << 100%; which would have implied that the assumed thickness was overestimated. As such, 2nd trial would have been needed with reduced thickness. OR,

– If total fatigue and damage was >>100%; which wild have implied that the assumed thickness was under-estimated. As such, 2nd trial would have been needed with increased thickness.

5.13 Flexible Pavement Design Using RHD Manual

5.13.1 California Bearing Ratio (CBR)

Every layer's strength is described in terms of the California Bearing ratio (CBR), and each layer must employ the appropriate materials and achieve the necessary compaction to meet the (CBR) specifications. Even if the top layers of a road surface must be built properly, they can fail if the bottom layers do not have the required (CBR). The RHD Specification contains the CBR requirements for the various pavement layers, which are outlined as follows:

Pavement Layer		CBR	RHD Specification Clause
Aggregate Base	Type I	>= 80%	3.3.2
	Type II	>= 50%	3.3.2
Sub-base		>= 25%	3.2.2
Improved Sub-grade		>= 8%	2.8.2
Sub-grade		>= 5%	2.7.2
Embankment fill/natural ground		>= 3%	2.6.2

Source: RHD Pavement Design Manual

5.13.2 Design Life and Traffic Growth Rate

Table 4.2: Pavement Design Life and Traffic Growth Rates

	Pavement Design Life	Traffic Growth Rate
National Road	20 years	10% pa
Regional Road	20 years	7% pa

Source: RHD Pavement Design manual

Determining Cumulative ESAs over the Pavement Design Life

Table 4.3: Vehicle Equivalence Factors

Vehicle Category	Equivalence Factor
Large Truck (dual axle)	4.8
Medium Truck (Single axle)	4.62
Small Truck	1.0
Large Bus	1.0
Mini Bus	0.5

Source: RHD Pavement Design Manual

To obtain the additive ESA loading over the planning lifetime of the road, the present annual ESA loading ought to be increased by one of the subsequent factors.

Table 4.4: Cumulative Growth Factors

Road Type	Factor
National Road	57.3
Regional Road	41.0

Source: RHD Pavement Design Manual

The above factors have been derived from the following compound growth formula: Cumulative

ESA = (1 + r)/n – 1

Where,

r = annual traffic growth rate

n = design life in years

(Note: For National Roads r = 10% and n = 20 years; For Regional Roads r = 7% and n = 20 years)

5.13.3 Calculating total ESA

Vehicle types	Existing Flow/ day(0.5 x Two-way)	ESA factors	Existing ESAS/day	Annual ESAs
Bus	1968	1	1968	718320
Pick up	2496	1	2496	911040
Cover Van	1644	4.62	11753	2772278
Truck	1488	4.8	7142	2606830
			Total = 7008468	

Table 5.3 Calculation of Annual ESAS

Cumulative ESA = 7008468*41.0

= 287347188

=28.7 million ESAs

5.13.4 Determine the Pavement Thickness

The estimated cumulative ESAs are then used to determine the various pavement layers from the following design chart.

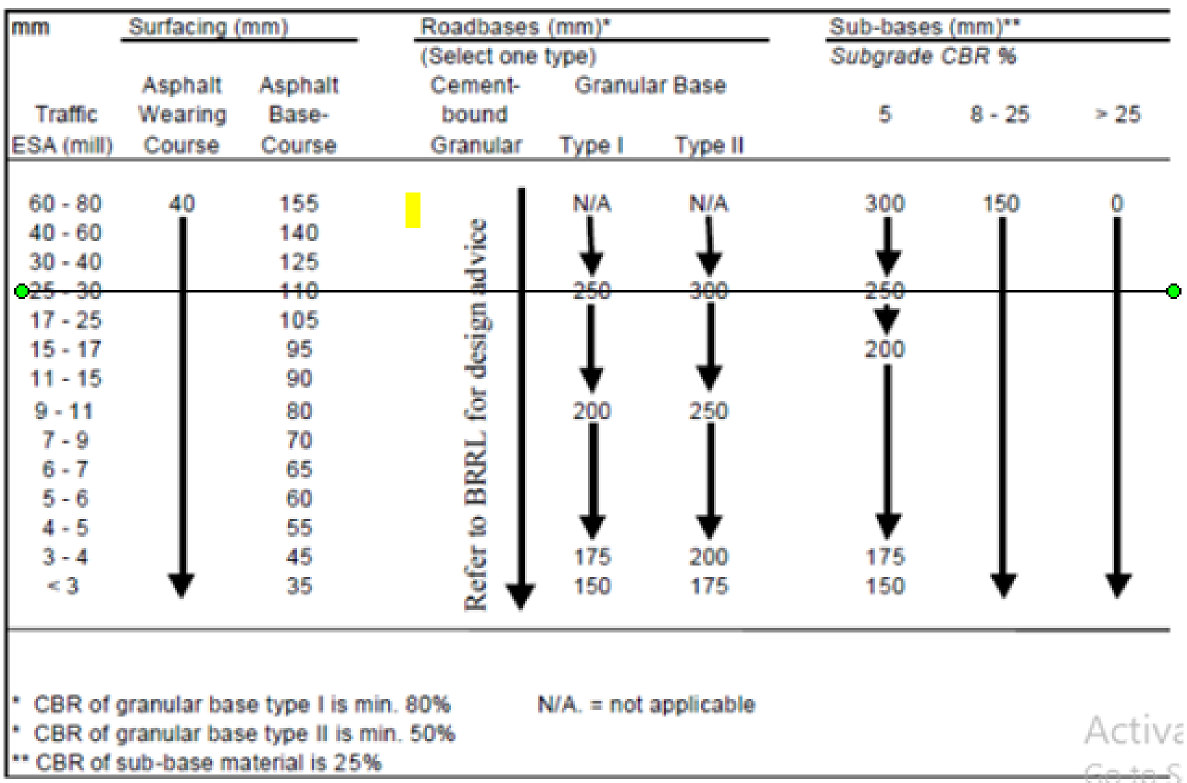


Figure5.6: RHD Manual Graph
Source: RHD Pavement design Manual

By reference to Table 6 an improved sub-grade will be required to achieve a sub grade Strength of 5% CBR and by reference to the design chart in Table 5 the required pavement layers will be:

150 mm DBS (40mm wearing course + 110mm base course)

250 mm Base Types 1

250 mm Sub-Base

Improved sub-grade - 300mm

5.13.5 Catalogue of Pavement Structures

Calculating annual ESAs

vehicle types	AADT	ESA factors	Existing ESAs/day
CNG	176	0.5	88
Auto	214	0.5	107
Car	109	1	109
Micro Bus	28	1	28
Pick up	52	2	104
Cover van	43	3	129
Bus	41	3	123
Truck	31	4	124
Bike	109	1	109
Non motorize	30	2	60
			Total = 981

Table 5.4 Existing ESAs/day

Table 1: PCU Factors for Rural Road

Vehicle Types	PCU Factors
Large Truck	3.0
Small Truck	2.0
Large Bus	2.5
Small Bus	1.5
Car/Tempo	1.0
Autorickshaw	0.5
Motor Cycle	0.3
Bicycle	0.3
Rickshaw	2.0
Cart	4.0

Table 5.5: RHD Manual Chart.

Forecasted Design flow in 2042(after 20 years)

$= 981 * (1+r)^{n}$

Here,

r = 7%

n = 20 years

Forecasted Design flow in 2042(after 20 years)

=8000 pcu/day (plus)

According to this Chart,

Regional Roads-Cross-Section Design Capacities

Cross-Section	Optimum Maximum Design Capacity (PCU/Hour)	Design year Optimum Demand Flow (PCU/Hour)	Application	
			New Construction	Widening w.r.t RHD
RHD 5.5 m	750 (Daily 8300) (Note 1)	1 to 750	Not applicable New 6.2m standard already has a better overall economic performance	No widen necessary of demand flows less than 750 PCU/Hour
6.2 m Pre-widening of embankment to 7.4m standard	1700 (Daily = 18,500)	1 to 1700 (New Const.) 751 to 1700 (Widening)	The standard new minimum width for Regional roads	If traffic demand above 750 PCU/Hour widening can be easily carried out by re-arranging the road layout on the existing embankment width
7.4m + pre-widening of embankment to 11m standard.	(1900)	(1700-1900) But, optimal flow range too narrow to be useful	Not applicable as a find design standard but useful part of stage construction on way to the top cross-section of 11 m.	Not applicable due to various optimal flow range and due to practical difficulties of widening 5.5m to 7km under traffic.
11m	2500 (Daily = 28,000)	1701-2500	Not likely that many completely new roads would need to adopt this standard at the out set.	An economical widening choice for the bu, ie Regional roads in Bangladesh.

Table 5.6: RHD Manual Chart

From the manual of geometric Design Standards

Road Class = Regional highway

Road width = 6.2m

Shoulder width = 1.2m (total)

Vehicle types	Existing Flow/ day(0.5 x Two-way)	ESA factors	Existing ESAS/day	Annual ESAs
Bus	1968	1	1968	718320
Pick up	2496	1	2496	911040
Cover Van	1644	4.62	11753	2772278
Truck	1488	4.8	7142	2606830
			Total = 7008468	

Table 5.7 Annual ESAs

Cumulative ESAL in both direction =7008468

Total Cumulative ESAL in one direction,

=3504234

The proportion of non motorized traffic to heavy vehicle,

P = 46/375

= 0.12 < 0.5

From table 3

Channelization factor = 2- (1/1.2)*0.6 = 1.5

Table 3: Channelisation Factor

Road Width		Channelisation Factor depending on the ratio of NMV to be applied to 1-way flow	
m	ft	Low(<0.5)	High (>=0.5)
5.6	18.4	2.0	2.0
6.8	22.3	1.0	1.8
7.3	23.9	1.0	1.6

Table 5.8 Channelization factor

Design cumulative traffic,

= Total Cumulative ESAL in one direction x Channelization factor

= 3504234 x 1.5 = 5256351Esa = 5.3Msa

Table 4: Traffic Definition

Class	MSA
T0	<0.5
T1	0.5 - 1.5
T2	1.5 - 3.0
T3	3.0 - 7.5
T4	7.5 - 20.0
T5	20 - 30

Table 5: Subgrade Definition

Class	CBR
S1	3 - 5
S2	5 - 7
S3	7 - 10
S4	10 - 15
S5	>15

Table 5.9 traffic definition

From table, traffic definition

= Class T3

Sub grade definition = S2 (CBR 5%)

TRAFFIC DEFINITION		
T_1	=	MAX 1.5 MILLION ESA
T_2	=	MAX 3.0 MILLION ESA
T_3	=	MAX 7.5 MILLION ESA
T_4	=	MAX 20.0 MILLION ESA
T_5	=	MAX 30.0 MILLION ESA

SUBGRADE DEFINITION		
S_1	=	MIN 3 % CBR
S_2	=	MIN 5 % CBR
S_3	=	MIN 7 % CBR
S_4	=	MIN 10 % CBR
S_5	=	MIN 15 % CBR

PAVEMENT CATALOGUE

MATERIAL DEFINITION

- SURFACE TREATMENT
- ASPHALT CONCRETE
- GRAVEL ASPHALT
- SAND BITUMEN
- HAND CRUSHED BRICKS WITH 0 – 20 % LOCAL SAND
- WELL GRADED PLANT CRUSHED BRICKS (0/37mm)
- HAND/PLANT CRUSHED BRICKS WITH 50 % LOCAL SAND
- MIXTURE OF CRUSHED BOULDER, SHINGLES, PEA-GRAVELS & SAND (30:30:20:20)
- MIXTURE OF COARSE SAND & LOCAL SAND (40:60)
- HAND CRUSHED BOULDERS, PEA-GRAVELS & SAND(60:20:20)
- WELL GRADED PLANT CRUSHED BOULDERS (0/37mm)
- HAND/PLANT CRUSHED BOULDERS WITH 50 % LOCAL SAND
- WELL GRADED PLANT CRUSHED BRICK/BOULDERS (0/37mm)
- HAND CRUSHED BRICKS WITH 0 – 20 % LOCAL SAND OR MIXTURE OF CRUSHED BOULDER, SHINGLES, PEA-GRAVELS & SAND (30:30:20:20)
- SOIL STABILISED WITH 4 % LIME
- LOCAL FINE RIVER SAND / MECHANICALLY STAB. SAND CLAY MIXTURE / SANDY SILT WITH PI 5 – 8

CATALOGUE FOR PAVEMENT TYPE - 1

(BRICKS)

	S1	S2	S3	S4	S5
T1	ST 150 275 225	ST 150 275 175	ST 150 275 150	ST 150 275 100	ST 150 275
T2	ST 150 325 250	ST 150 325 200	ST 150 325 150	ST 150 325 100	ST 150 325
T3	ST 200 275 275	ST 200 275 200	ST 200 275 150	ST 200 275 125	ST 200 275
T4	60 175 250 250	60 175 200 250	60 175 200 225	60 175 275 100	60 175 275
T5	60 200 250 250	60 200 200 250	60 200 200 225	60 200 250 125	60 200 250

CATALOGUE FOR PAVEMENT TYPE - 2

(GRAVELS & STONE)

	S1	S2	S3	S4	S5
T1	ST 150 250 225	ST 150 250 175	ST 150 250 150	ST 150 250 100	ST 150 250
T2	ST 150 300 250	ST 150 300 200	ST 150 300 150	ST 150 300 100	ST 150 300
T3	ST 200 225 250	ST 200 225 175	ST 200 225 125	ST 200 225 100	ST 200 225
T4	60 175 250 250	60 175 200 250	60 175 200 225	60 175 275 100	60 175 275
T5	60 200 250 250	60 200 200 250	60 200 200 225	60 200 250 125	60 200 250

CATALOGUE FOR PAVEMENT TYPE - 3

(GRAVEL ASPHALT BASE)

	S1	S2	S3	S4	S5
T1					
T2					
T3					
T4	40 120 175 250	40 120 150 250	40 120 150 200	40 120 175 100	40 120 175
T5	50 120 200 250	50 120 175 250	50 120 150 250	50 120 200 100	50 120 200

CATALOGUE FOR PAVEMENT TYPE - 4

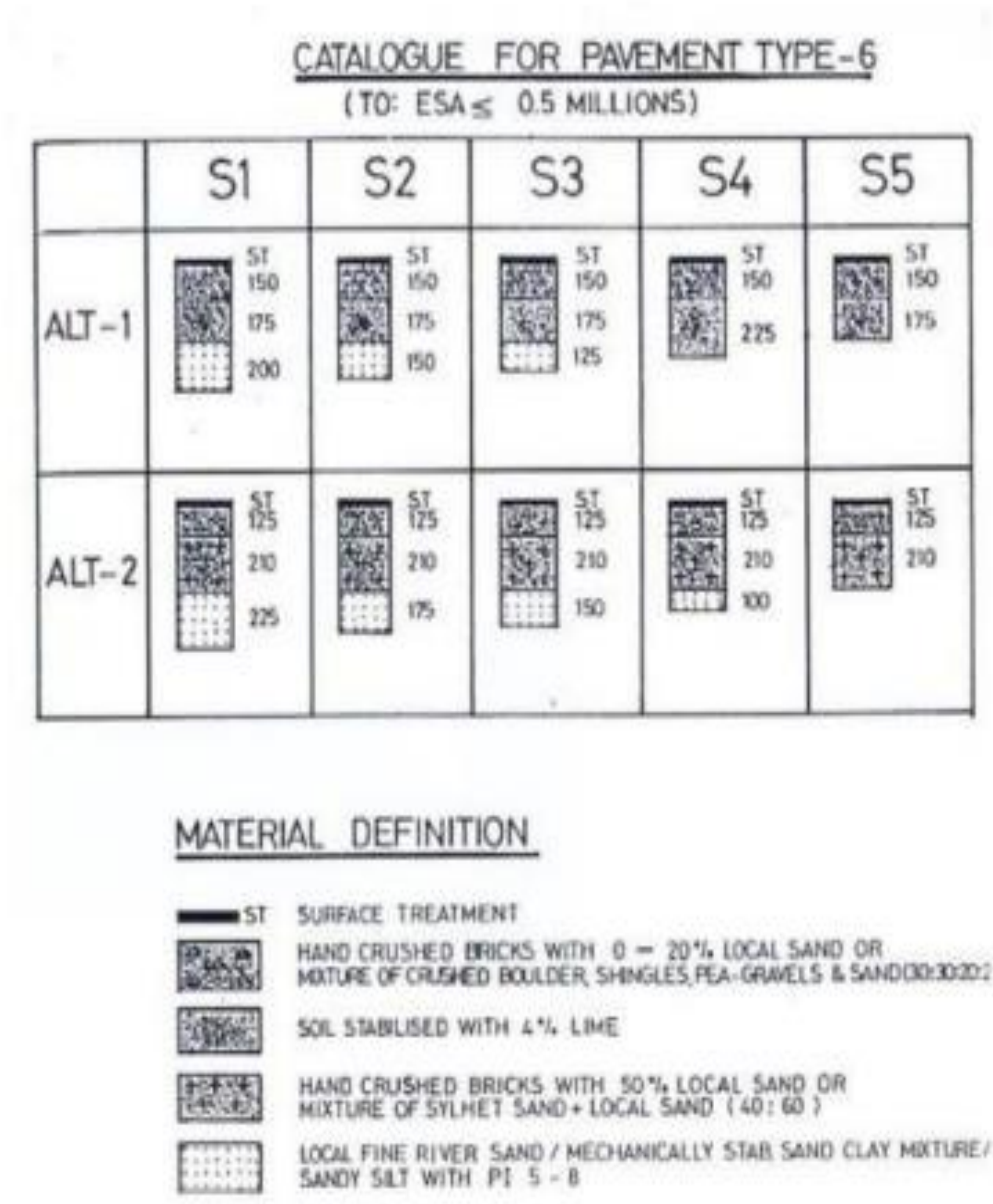
(SAND BITUMEN BASE)

	S1	S2	S3	S4	S5
T1					
T2					
T3					
T4	50 115 200 250	50 115 175 250	50 115 150 250	50 115 200 100	50 115 200
T5	50 120 225 250	50 120 200 250	50 120 175 250	50 120 225 100	50 120 225

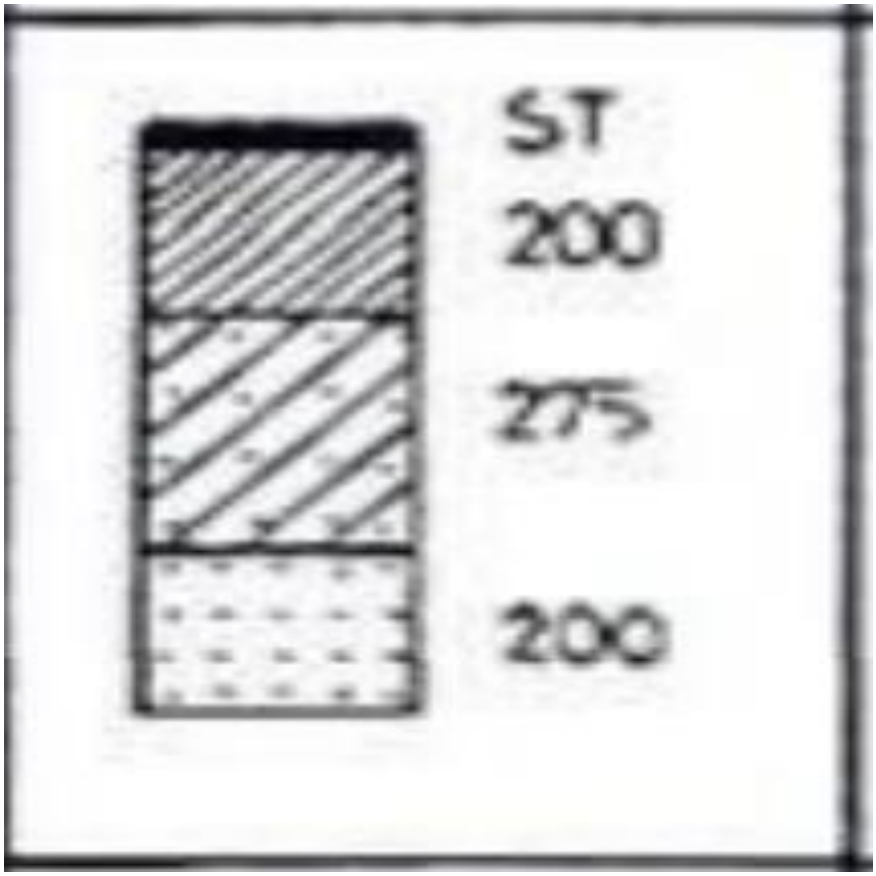
CATALOGUE FOR PAVEMENT TYPE - 5

(LIME STABILISED SUB-BASE)

	S1	S2	S3	S4	S5
T1	ST 150 275 200	ST 150 250 175	ST 150 250 125	ST 150 325	ST 150 250
T2	ST 150 300 225	ST 150 300 175	ST 150 300 125	ST 150 375	ST 150 300
T3	ST 200 300 175	ST 200 275 175	ST 200 250 150	ST 200 325	ST 200 250
T4					
T5					



We know that CBR 5 percent than Traffic definition 5.3Msa. We use catalogue for pavement type-1



Than we define material First layer, well ganged plant crushed bricks Second layer, Mixture of crush Boulder Last layer, Local fine river sand.

5.14 AASHTO Rigid Pavement Design

$$\log_{10} W_{18} = Z_R S_o + 7.35\left[\log_{10}(D+1)\right] - 0.06 + \frac{\log_{10}\left[\Delta \mathrm{PSI}/3.0\right]}{1+\left[1.624\times 10^{7}/(D+1)^{8.46}\right]} + (4.22 - 0.32\mathrm{TSI})\log_{10}\left(\frac{S_c' C_d\left[D^{0.75} - 1.132\right]}{215.63 J\left\{D^{0.75} - \left[18.42/(E_c/k)^{0.25}\right]\right\}}\right) \tag{4.4}$$

where

W_{18} = 18-kip–equivalent single-axle loads,

Z_r = Reliability (z-statistic from the standard normal curve),

S_o = Overall standard deviation of traffic,

D = PCC slab thickness in inches

TSI = Pavement's terminal serviceability index,

ΔPSI = Loss in serviceability from the time when the pavement is new until it reaches its TSI,

S_c' = Concrete modulus of rupture in lb/in^2

C_d = Drainage coefficient,

J = Load transfer coefficient,

E_c = Concrete modulus of elasticity in lb/ in^2, and

k = Modulus of subgrade reaction in lb/in^3.

Table 4.9 Relationship Between California Bearing Ratio (CBR) and Modulus of Subgrade Reaction, *k*

CBR	*k*, lb/in^3
2	100
10	200
20	250
25	290
40	420
50	500
75	680
100	800

The CBR value is 5% only so the Modulus of sub grade reaction, K = 200 lb/in^3

Now, $E_c = 57000\sqrt{f'_c}$ = 3604997.6 lb/ in^2 = 3.6 x 10^6lb/in^2

s'_c = 650 lb/in^2

S_o 0= 0.29

R = (95%)

Z_R = -1.610"

J = 3.2

C_d = 1.0

Del Psi = 4.5 – 2.5 = 2.1

$W_{18} = 3.5 \times 10^6$ (18 kip ESAL)

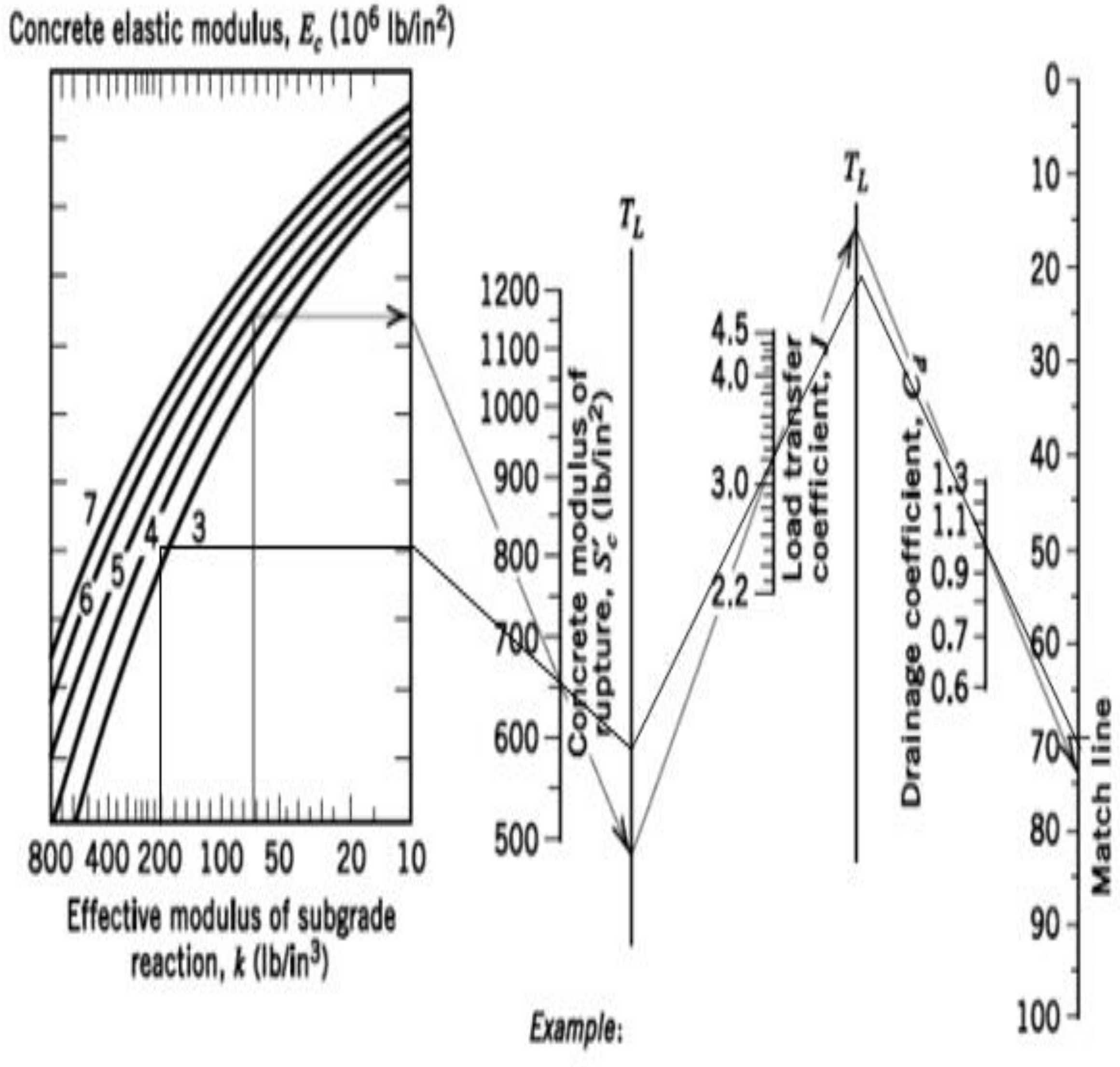


Figure 5.7 Concrete Elastic Modulus

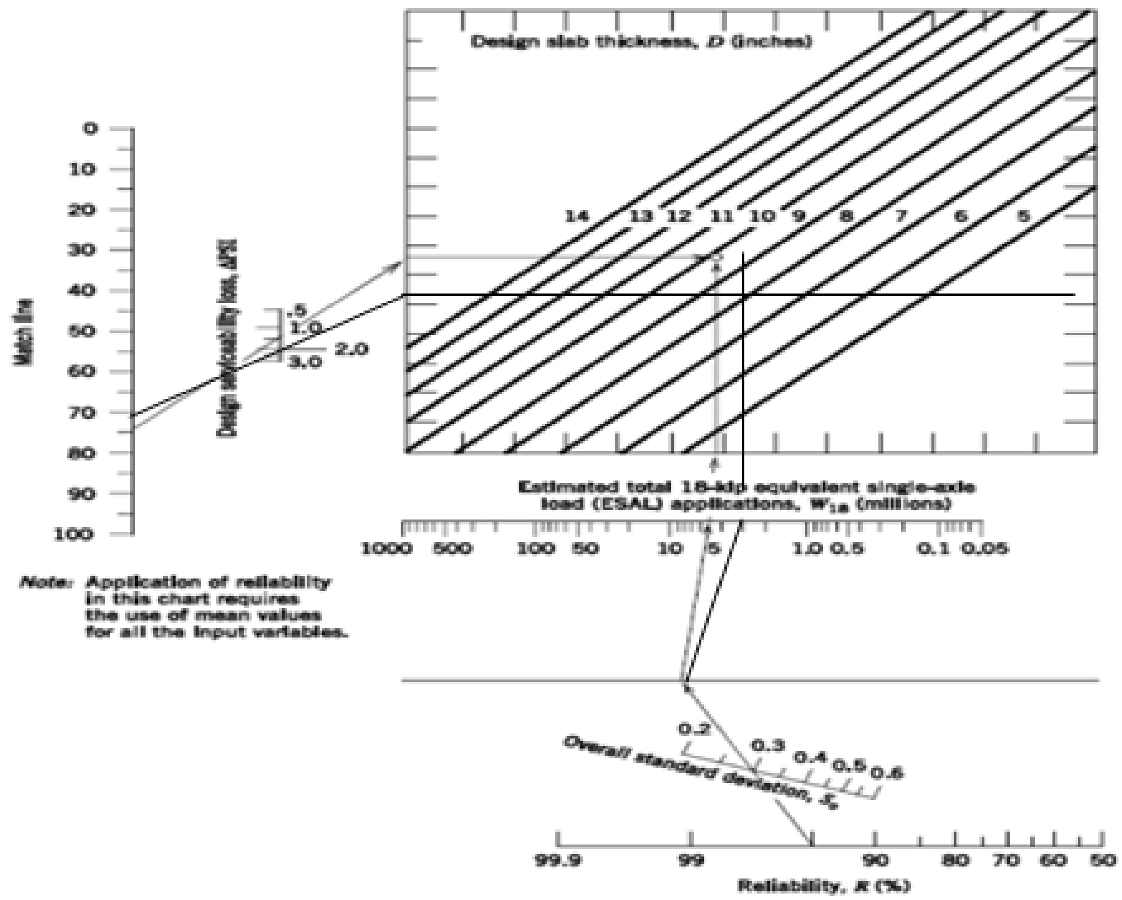


Figure 5.8 Concrete Elastic Modulus

Source: AASTO Manual

From this graph we got the thickness,

D= 8.2” or 8.5”

5.15 Flexible Pavement Design for Raising Part.

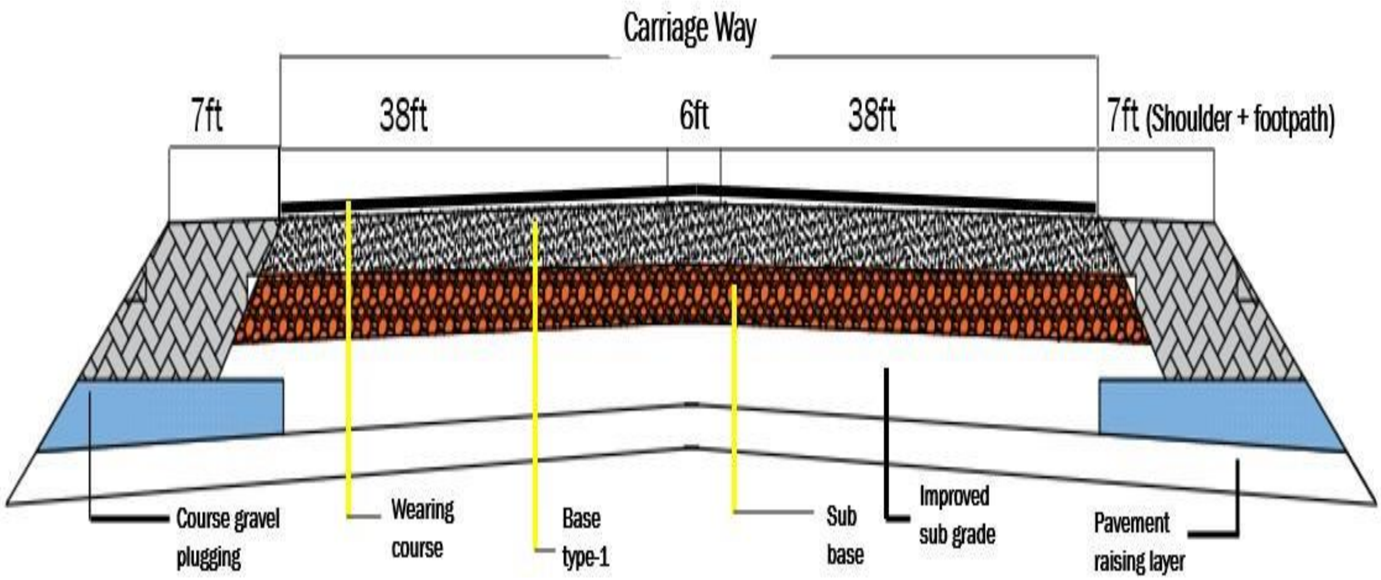


Figure 5.9FlexiblePavementDesign

*WearingCourse=150mm

*BaseType= 250mm

*SubBase=250mm

*ImprovedSubGrade=300mm

5.16 Level of Service

Singboard to Chasara (7.9km) or 4.9 miles

Ffs = Sfm +0.00776* V_f/F_{Hv}

S fm = 40km/hr or 24.85mi/hr

Estimation FFS:

FFS: BFFS – FLS – FA … … … … (Eq 1)

One lane = 11'≥ (11≤12)

Shoulder width 2' (≥ 2 > 4)

Reduction factor F_{LS}=3.0

EXHIBIT 20-5. ADJUSTMENT (f_{LS}) FOR LANE WIDTH AND SHOULDER WIDTH

	Reduction in FFS (mi/h)			
	Shoulder Width (ft)			
Lane Width (ft)	≥ 0 < 2	≥ 2 < 4	≥ 4 < 6	≥ 6
9 < 10	6.4	4.8	3.5	2.2
≥ 10 < 11	5.3	3.7	2.4	1.1
≥ 11 < 12	4.7	3.0	1.7	0.4
≥ 12	4.2	2.6	1.3	0.0

Source: HCM 2000 Manual

Adjustment for lane width and shoulder width F_{LS} = 3.0

EXHIBIT 20-6. ADJUSTMENT (f_A) FOR ACCESS-POINT DENSITY

Access Points per mi	Reduction in FFS (mi/h)
0	0.0
10	2.5
20	5.0
30	7.5
40	10.0

Source: HCM 2000 Manual

Assumed, Total access point per meter = 10

Total road length =4.9 mile

Access point per mile = 10/4.9 = 2<10

Adjustment F_A = for access point density = 2.5 mi/Hr

Base FFS, BFFS = 24.85 mi/hr

From Eq1,

$$FFS = BFFS - F_{LS} - F_A$$

$$= 24.85 - 3 - 2.5 \text{ mi/hr}$$

$$= 19.34 \text{ mi/hr}$$

Demand Flow rate,

Demand Flow rate, $V_P = V/P_{HF} * F_G * F_{HV}$

Peak hour factor, P_{HF} = 0.95

Passenger car per hour = 9042/24 = 377<600

Car = 9042pcu/day

EXHIBIT 20-7. GRADE ADJUSTMENT FACTOR (f_G) TO DETERMINE SPEEDS ON TWO-WAY AND DIRECTIONAL SEGMENTS

Range of Two-Way Flow Rates (pc/h)	Range of Directional Flow Rates (pc/h)	Type of Terrain	
		Level	Rolling
0–600	0–300	1.00	0.71
> 600–1200	> 300–600	1.00	0.93
> 1200	> 600	1.00	0.99

EXHIBIT 20-8. GRADE ADJUSTMENT FACTOR (f_G) TO DETERMINE PERCENT TIME-SPENT-FOLLOWING ON TWO-WAY AND DIRECTIONAL SEGMENTS

Range of Two-Way Flow Rates (pc/h)	Range of Directional Flow Rates (pc/h)	Type of Terrain	
		Level	Rolling
0–600	0–300	1.00	0.77
> 600–1200	> 300–600	1.00	0.94
> 1200	> 600	1.00	1.00

Source: HCM 2000 Manual

Range of directional flow = 0-300pcu/hr

Terrain level = level

F_G to determine speed = 1

F_G to determine percent time spent following =1

For heavy vehicle 31106/24 = 1296 pcu/hr> 1200 pcu/hr

Terrain type = level

-

EXHIBIT 20-9. PASSENGER-CAR EQUIVALENTS FOR TRUCKS AND RVS TO DETERMINE SPEEDS ON TWO-WAY AND DIRECTIONAL SEGMENTS

Vehicle Type	Range of Two-Way Flow Rates (pc/h)	Range of Directional Flow Rates (pc/h)	Type of Terrain	
			Level	Rolling
Trucks, E_T	0–600	0–300	1.7	2.5
	> 600–1,200	> 300–600	1.2	1.9
	> 1,200	> 600	1.1	1.5
RVs, E_R	0–600	0–300	1.0	1.1
	> 600–1,200	> 300–600	1.0	1.1
	> 1,200	> 600	1.0	1.1

EXHIBIT 20-10. PASSENGER-CAR EQUIVALENTS FOR TRUCKS AND RVS TO DETERMINE PERCENT TIME-SPENT-FOLLOWING ON TWO-WAY AND DIRECTIONAL SEGMENTS

Vehicle Type	Range of Two-Way Flow Rates (pc/h)	Range of Directional Flow Rates (pc/h)	Type of Terrain	
			Level	Rolling
Trucks, E_T	0–600	0–300	1.1	1.8
	> 600–1,200	> 300–600	1.1	1.5
	> 1,200	> 600	1.0	1.0
RVs, E_R	0–600	0–300	1.0	1.0
	> 600–1,200	> 300–600	1.0	1.0
	> 1,200	> 600	1.0	1.0

Source: HCM 2000 Manual

E_T =1.1

For R_{vs} ,

Range of two-way flow rates = (310*2)/24

= 26pcu/hr<600pcu/hr

Range of directional flow rate = 0-300

Type of terrain type = level

R_{vs}, E_R to determine speed = 1

Trucks, E_T to determine percent time spent following = 1.1

R_{vs} , E_R to determine percent time spent following = 1.0

(E_T =1.0)

Heavy vehicle adjustment factor,

$F_{HV} = 1/1+P_T (E_T -1) + P_R(E_R -1)$

Here, Proportion of truck in the traffic stream

$P_T = 31106/59,000$

$= 0.53$

Proportion of R_{vs} in the traffic stream $P_R = 310/59,000 = 0.005$

Using Eq3,

For determining speed, $F_{HV} = 0.95$

For determining percent time spent following, $F_{HV} = 1$

Flow rate (one way)

V= 2000veh/hr

$P_{HF} = 0.95$

Demand flow rate $V_P = V/P_{HF} *F_G *F_{HV}$

=2216.06veh/hr

As the value of V_p is greater than the flow rate range (600-1200),

So, V_p = 2216.06 veh/ hr

Should not be used

Two-way flow rate = $0.5V_p$

= 0.5*2216.06 = 1108.03 veh/hr

Trial 2,

Using upper range, = 1108.03 Pcu/hr

F_{HV} = 1

V p = 2216.06 is within the flow rate range, so acceptable

Average travel speed, ATS = FFS – $0.00776V_p$ - Fv p

Adjustment for percent of no passing F np =0

ATS = (19.36 – 0.0076*2216.06)-0

= 2.16mi/hr

Percent time spent following, PTSF = BPTSF + F d/VP

BPTSF = 100(1 – e -0.000879*VP)

= 86%

No passing zone 0%

Vp≥ 1400

Fd/np= 0

PTSF = 86+0 = 86%

Determining, LOS

Percent time spent following is almost 86%

From the table 20-4,

Los is E

EXHIBIT 20-4. LOS CRITERIA FOR TWO-LANE HIGHWAYS IN CLASS II

LOS	Percent Time-Spent-Following
A	≤ 40
B	> 40–55
C	> 55–70
D	> 70–85
E	> 85

Note:
LOS F applies whenever the flow rate exceeds the segment capacity.

Source: HCM 2000 Manual

After all the calculation we have to fill up the worksheet.

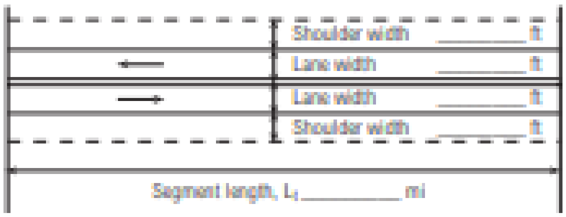
EXHIBIT 20-28. TWO-WAY TWO-LANE HIGHWAY SEGMENT WORKSHEET

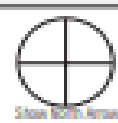
TWO-WAY TWO-LANE HIGHWAY SEGMENT WORKSHEET

General Information		***Site Information***	
Analyst	________	Highway	________
Agency or Company	________	From/To	________
Date Performed	________	Jurisdiction	________
Analysis Time Period	________	Analysis Year	________

❑ Operational (LOS) ❑ Design (v_p) ❑ Planning (LOS) ❑ Planning (v_p)

Input Data





❑ Class I highway ❑ Class II highway
Terrain ❑ Level ❑ Rolling
Two-way hourly volume ________ veh/h
Directional split ______ / ______
Peak-hour factor, PHF ________
% Trucks and buses, P_T ________ %
% Recreational vehicles, P_R ________ %
% No-passing zone ________ %
Access points/mi ________ /mi

Average Travel Speed	
Grade adjustment factor, f_G (Exhibit 20-7)	
Passenger-car equivalents for trucks, E_T (Exhibit 20-9)	
Passenger-car equivalents for RVs, E_R (Exhibit 20-9)	
Heavy-vehicle adjustment factor, f_{HV} $f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$	
Two-way flow rate,[1] v_p (pc/h) $v_p = \frac{V}{PHF * f_G * f_{HV}}$	
v_p * highest directional split proportion[2] (pc/h)	
Free-Flow Speed from Field Measurement	Estimated Free-Flow Speed
Field measured speed, S_{FM} ________ mi/h Observed volume, V_f ________ veh/h Free-flow speed, FFS ________ mi/h $FFS = S_{FM} + 0.00776\left(\frac{V_f}{f_{HV}}\right)$	Base free-flow speed, BFFS ________ mi/h Adj. for lane width and shoulder width, f_{LS} (Exhibit 20-5) ______ mi/h Adj. for access points, f_A (Exhibit 20-6) ________ mi/h Free-flow speed, FFS ________ mi/h $FFS = BFFS - f_{LS} - f_A$
Adj. for no-passing zones, f_{np} (mi/h) (Exhibit 20-11)	
Average travel speed, ATS (mi/h) $ATS = FFS - 0.00776v_p - f_{np}$	
Percent Time-Spent-Following	
Grade adjustment factor, f_G (Exhibit 20-8)	
Passenger-car equivalents for trucks, E_T (Exhibit 20-10)	
Passenger-car equivalents for RVs, E_R (Exhibit 20-10)	
Heavy-vehicle adjustment factor, f_{HV} $f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$	
Two-way flow rate,[1] v_p (pc/h) $v_p = \frac{V}{PHF * f_G * f_{HV}}$	
v_p * highest directional split proportion[2] (pc/h)	
Base percent time-spent-following, BPTSF (%) $BPTSF = 100(1 - e^{-0.000879v_p})$	
Adj. for directional distribution and no-passing zone, $f_{d/np}$ (%) (Exhibit 20-12)	
Percent time-spent-following, PTSF (%) $PTSF = BPTSF + f_{d/np}$	
Level of Service and Other Performance Measures	
Level of service, LOS (Exhibit 20-3 for Class I or 20-4 for Class II)	
Volume to capacity ratio, v/c $v/c = \frac{V_p}{3,200}$	
Peak 15-min vehicle-miles of travel, VMT_{15} (veh-mi) $VMT_{15} = 0.25L_t\left(\frac{V}{PHF}\right)$	
Peak-hour vehicle-miles of travel, VMT_{60} (veh-mi) $VMT_{60} = V * L_t$	
Peak 15-min total travel time, TT_{15} (veh-h) $TT_{15} = \frac{VMT_{15}}{ATS}$	

Notes

1. If $v_p \geq 3{,}200$ pc/h, terminate analysis—the LOS is F.
2. If highest directional split $v_p \geq 1{,}700$ pc/h, terminate analysis—the LOS is F.

5.17 Multilane Highway

New speed = 80km/hr = 50 mi/hr

Assume, Base FFS to be 5mi/hr

= 50 + 5 = 55 mile/ hr

DDHV (Convert AADT to design hour volume AADT*k*D)

Here,

k=0.10 (assumed)

D = 0.55 (”)

For one way,

= (29500*0.10*0.55)

= 1622 Veh/ hr

$F_{HV} = 1/1+P_T (E_T -1) + P_R (E_R -1)$

Here,

$P_T = 0.53$

$P_R = 0.005$

$E_T = 1.5$

$E_R = 1.2$

$F_{HV} = 1/1+0.53(1.5-1) + 0.005(1.2-1)$

$= 0.66$

Type terrain = level

Use 21-4, 21-5, 21-6, and 21-7

Lane width = 12 ft

FFS= 0.0

Total lateral clearance,

12ft Reduction in FFS (mi/hr)

Adjustment for median type divided highway FFS reduction (0.0)

Access point per mile reduction FFS (mile/hr)

10’ ---- 2.5

$FFS = BFFS – F_{LW} – F_{LC} – F_{A} - F_{A}$

$= 55 – 0 – 0 – 2.5 – 0$

$= 52.5$ mile/hr

$P_{HF} = 0.95$

$N= V/P_{HF} *V_{P} *F_{P} *F_{HV}$

$= 1622/0.95*1*0.66*2000$

$= 1.2$ (use 2)

$V_{P} = 1622/0.95*2*0.66*1.00$

$= 1293.5$ Pc/hr/ln

Medan width = 12ft

Lane width = 12ft

Lateral clearance (Shoulder) = 6ft

Total required width = 12+72+12 = 96 ft

(Determine if base conditions will fit width in available right of way with a – 12 ft median of accommodate left turn bays in the future)

Assume different design to ft available right of way, use 6 ft median and do not use Shoulder at median.

Medan width = 12ft

Lane width = 12ft

Lateral clearance = 6ft

Total required width = 6+72+12 = 90 ft

FFS = 55-0-2.5-0

= 52.5 mi/hr

EXHIBIT 21-4. ADJUSTMENT FOR LANE WIDTH

Lane Width (ft)	Reduction in FFS (mi/h)
12	0.0
11	1.9
10	6.6

Source: HCM 2000 Manual

EXHIBIT 21-5. ADJUSTMENT FOR LATERAL CLEARANCE

Four-Lane Highways		Six-Lane Highways	
Total Lateral Clearance[a] (ft)	Reduction in FFS (mi/h)	Total Lateral Clearance[a] (ft)	Reduction in FFS (mi/h)
12	0.0	12	0.0
10	0.4	10	0.4
8	0.9	8	0.9
6	1.3	6	1.3
4	1.8	4	1.7
2	3.6	2	2.8
0	5.4	0	3.9

Note:
a. Total lateral clearance is the sum of the lateral clearances of the median (if greater than 6 ft, use 6 ft) and shoulder (if greater than 6 ft, use 6 ft). Therefore, for purposes of analysis, total lateral clearance cannot exceed 12 ft.

EXHIBIT 21-6. ADJUSTMENT FOR MEDIAN TYPE

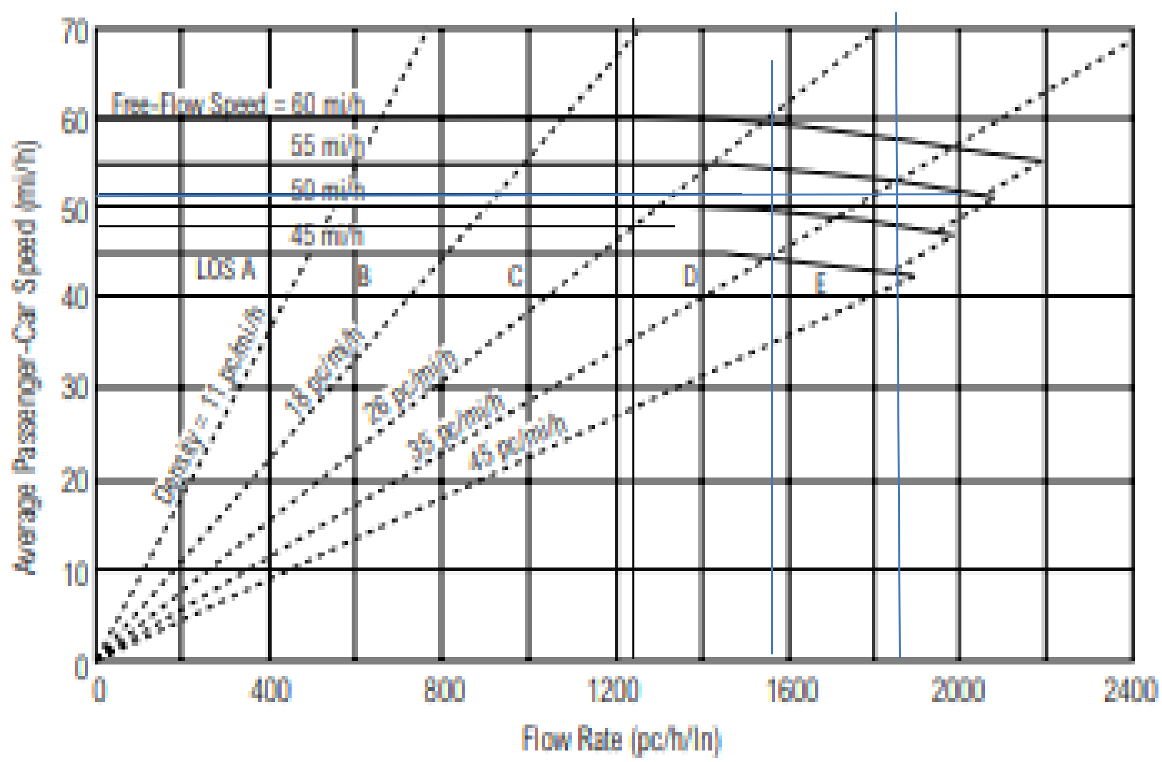
Median Type	Reduction in FFS (mi/h)
Undivided highways	1.6
Divided highways (including TWLTLs)	0.0

Source: HCM 2000 Manual

EXHIBIT 21-7. ACCESS-POINT DENSITY ADJUSTMENT

Access Points/Mile	Reduction in FFS (mi/h)
0	0.0
10	2.5
20	5.0
30	7.5
≥ 40	10.0

EXHIBIT 21-3. SPEED-FLOW CURVES WITH LOS CRITERIA



Note:

Figure 5.10 Speed-Flow Curves with Los Criteria
Source: HCM 2000 Manual

By using the graph … … … 21.3

LOS C (Upgrade)

After 10 years

V=1586 Pc/hr/ln

LOS D

After 20 years

V=1872 Pc/hr/ln

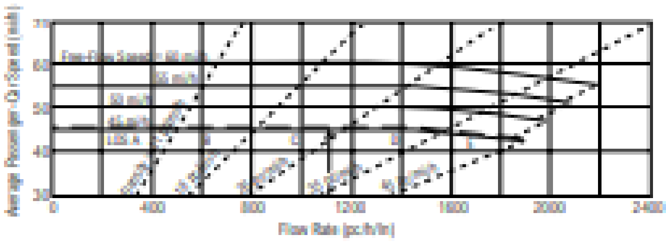
LOS E

We see that Design speed is = 80km/hr

Safety speed is 70km/hr in this limit vehicles can easily passing without delay.

We have filled this worksheet also,

MULTILANE HIGHWAYS WORKSHEET



Application	Input	Output
Operational (LOS)	FFS, N, v_p	LOS, S, D
Design (N)	FFS, LOS, v_p	N, S, D
Design (v_p)	FFS, LOS, N	v_p, S, D
Planning (LOS)	FFS, N, AADT	LOS, S, D
Planning (N)	FFS, LOS, AADT	N, S, D
Planning (v_p)	FFS, LOS, N	v_p, S, D

General Information		Site Information	
Analyst	JMYE	Highway/Direction of Travel	US 80 (East)
Agency or Company	EHI	From/To	MP 17 - MP 20
Date Performed	5/16/99	Jurisdiction	M. County
Analysis Time Period	AM	Analysis Year	1999

☒ Operational (LOS) ☐ Design (N) ☐ Design (v_p) ☐ Planning (LOS) ☐ Planning (N) ☐ Planning (v_p)

Flow Inputs

Volume, V	1,900 veh/h	Peak-hour factor, PHF	0.90
Annual avg. daily traffic, AADT	veh/day	% Trucks and buses, P_T	13
Peak-hour proportion of AADT, K		% RVs, P_R	2
Peak-hour direction proportion, D		General terrain	
DDHV = AADT * K * D	veh/h	☒ Level ☐ Rolling ☐ Mountainous	
Driver type		Grade: Length ____ mi	Up/Down ____ %
☒ Commuter/Weekday ☐ Recreational/Weekend		Number of lanes	2

Calculate Flow Adjustments

f_p	1.00	E_R	1.2
E_T	1.5	$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$	0.936

Speed Inputs		Calculate Speed Adjustments and FFS	
Lane width, LW	11 ft	f_{LW}	mi/h
Total lateral clearance, TLC	ft	f_{LC}	mi/h
Access points, A	A/mi	f_A	mi/h
Median type, M ☒ Undivided ☐ Divided		f_M	mi/h
FFS (measured)	46.0 mi/h	FFS = BFFS – f_{LW} – f_{LC} – f_A – f_M	mi/h
Base free-flow speed, BFFS	mi/h		

Operational, Planning (LOS); Design, Planning (v_p)

Operational (LOS) or Planning (LOS)

$v_p = \frac{V \text{ or } DDHV}{PHF * N * f_{HV} * f_p}$	1129 pc/h/ln
S	46.0 mi/h
$D = v_p/S$	24.5 pc/mi/ln
LOS	C

Design (v_p) or Planning (v_p)

LOS	
v_p	pc/h/ln
$V = v_p * PHF * N * f_{HV} * f_p$	veh/h
S	mi/h
$D = v_p/S$	pc/mi/ln

Design, Planning (N)

Design (N) or Planning (N) 1st Iteration

N	assumed
$v_p = \frac{V \text{ or } DDHV}{PHF * N * f_{HV} * f_p}$	pc/h/ln
LOS	

Design (N) or Planning (N) 2nd Iteration

N	assumed
$v_p = \frac{V \text{ or } DDHV}{PHF * N * f_{HV} * f_p}$	pc/h/ln
LOS	
S	mi/h
$D = v_p/S$	pc/mi/ln

Glossary

- N - Number of lanes
- V - Hourly volume
- v_p - Flow rate
- LOS - Level of service
- DDHV - Directional design-hour volume
- S - Speed
- D - Density
- FFS - Free-flow speed
- BFFS - Base free-flow speed

Factor Location

- E_T - Exhibit 21-8, 21-9, 21-11
- E_R - Exhibit 21-8, 21-10
- f_p - Page 21-11
- LOS, S, FFS, v_p - Exhibit 21-2, 21-3
- f_{LW} - Exhibit 21-4
- f_{LC} - Exhibit 21-5
- f_M - Exhibit 21-6
- f_A - Exhibit 21-7

CHAPTER 6

Concepts of Economic Analysis

Roadway engineers, economists, and statisticians all take part within side the multifaceted assignment of engaging infinancial analyses of road projects. While the overallpopulacemakes use of the roads, the authoritiescan payfor his or herproduction and upkeep. Costs are borne by the authorities, even asthe overall public benefits.

6.1 Total Transportation Cost:

The total transportation cost is composed of:

1. Initial cost of construction

2. Periodic maintenance cost over the design life.

3. Road-user cost.

6.2 Initial Construction Cost of Rigid and Flexible pavement chart are shown below

Item No.		Description	Amount (BDT)	Amount (Million BDT)
Civil Cost	1	DIVISION 1 : GENERAL & SITE FACILITIES	1741153	1.74
	2	DIVISION 2 : EARTHWORK	23008	0.023
	3	DIVISION 3 : PAVEMENT WORK	1495755	1.49
	4	DIVISION 4 : FOUNDATION WORKS	4022079	4.02
	5	DIVISION 5 : STRUCTURE WORKS	3224043	3.22
	6	DIVISION 6 : INCIDENTALS	388656	0.38
A		**Sub Total**	**10894694**	**10.87**
B		Physical Contingency @ 3 % of (A)	326840.82	0.32
C		**Sub Total (A + B)**	**11221534.82**	**11.19**
D		Price Contingency @ 6 % of (C)	673292.1	0.67
E		**Engineer's Estimate = (C+D)**	**11894826.92**	**11.86**
F		Detailed Design Cost @ 3 % of (A)	326840.82	0.32
G		Supervision Fees @ 2 % of (A)	217893.88	0.217
H		**Cost per Km = (E+F+G)**	**12439562**	**12.397**

Table 6.1 for rigid pavement
[Source: RHD SCHEDULE OF RATE-2018]

Item No.		Description	Amount	
			(BDT)	(Million BDT)
Civil Cost	1	Division 1: General & Site Facilities	1741153	1.74
	2	Division 2: Earthwork	23008	0.023
	3	Division 3: Pavement Work	498585	0.5
	4	Division 4: Foundation Works	1340693	1.34
	5	Division 5: Structure Works	1074681	1.07
	6	Division 6: Incidentals	129552	0.13
A	***Sub Total***		**4807672**	**4.803**
B	Physical Contingency @ 3 % of (A)		144230.16	0.144
C	***Sub Total (A + B)***		**4951902.16**	**4.947**
D	Price Contingency @ 6 % of (C)		297114.12	0.29
E	***Engineer's Estimate = (C+D)***		**5249016.28**	**5.237**
F	Detailed Design Cost @ 3 % of (A)		144230.16	0.144
G	Supervision Fees @ 2 % of (A)		96153.44	0.096
H	***Cost per Km = (E+F+G)***		**5489400**	**5.477**

Table 6.2 for Flexible pavement
[Source: RHD SCHEDULE OF RATE-2018]

6.3 Periodic maintenance cost over the design life

Pavement type	Periodic maintenance cost (tk.)	Interval (3years)	Remarks
Flexible pavement	2095019	3	Once every 3 years before the rainy season
	2095019	6	
	2095019	9	
	2095019	12	
	2095019	15	
	2095019	18	
Total	12570114		

Table 6.3 for Flexible pavement
[Source:https://www.researchgate.net/publication/317644727_Cost_and_Benefit_Analysis_of_Rigid_and_Flexible_Pavement_A_Case_Study_at_Chancho_-Derba-Becho_Road_Project]

6.4 Road-user cost

These three are interdependent, and we have to choose that alternative which makes the sum of these three a minimum.

(i) Vehicle operating cost

(ii) Time cost

(iii) Accident cost.

6.4.1 VEHICLEOPERATINGCOST

Through an elaborate method, the Vehicle Operating Cost (VOC) for the RHD community is calculated. Costs of foremost additives are derived the usage of a questionnaire survey of approximately 1020 vehicles. Other fee elements, which includes the rate of the auto itself, the fee of gas and lubricants, the fee of customs duties, etc., are accrued from diverse sellers and pertinent government organizations.

Before new road construction

Financial VOC

Name of vehicle	VOC (Tk/km)	Number of vehicles	Total amount
CNG	15.10	76	1147.6
Auto rickshaw	8.77	120	1052.4
Car	43.85	66	2894.1
Micro	35.97	12	431.64
Pickup	31.35	28	877.8
Covered van	40.46	31	1254.26
Bus	49.52	17	841.84
Truck	64.24	10	642.4
Motorcycle	5.46	56	305.76
			9447.8

Table 6.4 for Financial VOC

[Source: “Review of existing Road User Cost (RUC) estimationprocedureusedinRHDandupdatethesameunderBRRLduringtheyear2016-2017”]

Economical VOC

Name of vehicle	VOC (Tk/km)	Number of vehicles	Total amount (Tk)
CNG	12.76	76	969.76
Auto rickshaw	7.09	120	850.8
Car	25.41	66	1677.06
Micro	23.50	12	282
Pickup	25.01	28	700.28
Covered van	31.70	31	982.7
Bus	41.23	17	700.91
Truck	53.67	10	536.7
Motorcycle	4.38	56	245.28
			6945.49

Table 6.5 for Economical VOC

3*[Source: “Review of existing Road User Cost (RUC) estimationprocedureusedinRHDandupdatethesameunderBRRLduringtheyear2016-2017”]

After new road construction

Financial VOC

Name of vehicle	VOC (Tk/km)	Number of vehicles	Total amount
CNG	11.99	76	911.24
Auto rickshaw	6.98	120	837.6
Car	36.78	66	2427.48
Micro	34.01	12	408.12
Pickup	28.82	28	806.96
Covered van	37.57	31	1164.67
Bus	45.8	17	778.6
Truck	55.49	10	554.9
Motorcycle	3.96	56	221.76
			8111.33

Table 6.6 for Financial VOC

[Source: "Review of existing Road User Cost (RUC) estimationprocedureusedinRHDandupdatethesameunderBRRLduringtheyear2016-2017"]

Economical VOC

Name of vehicle	VOC (Tk/km)	Number of vehicles	Total amount
CNG	9.82	76	746.32
Auto rickshaw	5.51	120	661.2
Car	20.43	66	1348.38
Micro	20.8	12	249.6
Pickup	22.33	28	625.24
Covered van	28.63	31	887.53
Bus	37.03	17	629.51
Truck	45.27	10	452.7
Motorcycle	3.15	56	176.4
			5776.88

Table 6.7 for Financial VOC

[Source: "Review of existing Road User Cost (RUC) estimationprocedureusedinRHDandupdatethesameunderBRRLduringtheyear2016-2017"]

So, comparing before and after economical and financial vehicle operating cost we can clearly see that a large number of money is saved.

6.4.2 TRAVELTIMECOST

General

Travel Time Cost (TTC) is a significant part of RUC. It is otherwise called 'Worth of Time (WOT)'. Travel time cost is characterized by the idea that time spent in voyaging has an 'opportunity cost'. This time could be utilized in an elective movement which can possibly deliver critical 'utility' known as 'benefit'. On the off chance that the elective action can have a financial worth relegated to it, this can be utilized as a piece of RUC in the monetary examination of ventures, especially of the vehicle projects having connection with utilization of time in the utilization of their result.

In a nation like Bangladesh, the pay design between the clients of profoundly costly mechanized vehicles, for example, vehicles and jeeps and those of utilizing public minibuses is fundamentally unique and they might try and address two distinct monetary classes in the general public. Consequently, rather than the uniform TTC approach, the TTC ought to be assessed by isolated vehicle type. Travel Time Cost in this study is surveyed both for cargo and travelers named as TTC Cargo and TTC Traveler. The procedure and aftereffects of the two kinds of TTC review is introduced in the accompanying segments.

Before new road construction TTC

VehicleCategory	Occupancy Number	Financial		Economic	
		TTC perPassenger Taka/hr.	TTC per Vehicle Taka/hr.	TTC perPassenger Taka/hr.	TTC perVehicle Taka/hr.
Truck	3	142	426	91	273
Covered Van	3	95	285	73	219
Ordinary Bus	47	62	2914	35	1645
Pickup	2	67	134	35	70
Micro Bus	9	110	990	104	936
Car	5	135	675	125	625
CNG	4	72	288	46	184
Auto Rickshaw	6	78	468	53	318
Motor Cycle	2	99	198	73	146
Total			**6378**		**4416**

Table 6.8 for Before Travel Time Cost

[Source: “Review of existing Road User Cost (RUC) estimationprocedureusedinRHDandupdatethesameunderBRRLduringtheyear2016-2017”]

After new road construction TTC

VehicleCategory	Occupancy Number	Financial		Economic	
		TTC perPassenger Taka/hr.	TTC perVehicle Taka/hr.	TTC perPassenger Taka/hr.	TTC perVehicle Taka/hr.
Truck	3	117	351	93	279
Covered Van	3	84	252	67	201
Ordinary Bus	47	49	2303	39	1833
Pickup	2	52	104	41	82
Micro Bus	9	107	963	86	774
Car	5	130	650	104	520
CNG	4	59	236	47	188
Auto Rickshaw	6	66	396	52	312
Motor Cycle	2	86	172	69	138
Total			**5427**		**4327**

Table 6.9 for After Travel Time Cost

[Source: “Review of existing Road User Cost (RUC) estimationprocedureusedinRHDandupdatethesameunderBRRLduringtheyear2016-2017”]

6.4.3 CALCULATION OF TOTAL ACCIDENT COST

Street car crashes become a significant reason for untimely fatalities and handicaps in from one side of the planet to the other. It is a significant danger to the human existence and it influences on the world monetary status. Because of street mishaps many individuals kick the bucket and get wounds. In Bangladesh, the street mishap turns into an issue of worry because of the rising pace of fatalities and wounds. A colossal measure of monetary misfortune brought about by these mishaps for casualties as well as legislatures. The elements answerable for street mishaps in Bangladesh are surpassing propensity, over speeding, keep away from wellbeing gears like safety belt and head protector, unfortunate street characteristics, dangerous streets, medication and liquor, over-burdening, inadequacy of the driver, disregarding regulations and so on

A. Cost of all fatalities and injuries:

Average fatalities per year= 3,500

Average injuries per year= 2,650

Average age of accident= 30 years

Average age of retirement= 65 years

Expectation of life= 73 years

GDP per capita (2022) = 2520 USD

Total GDP (2022) = 416 billion USD

If a person dies at 30 years,

The years of life lost= 35

Lost output= w= Average years of wages of fatal crash casualty.

r= discount rate (10%)

n= average number of years of cost output per fatal casualty

If a person dies at 30 years, the years of life lost= 35 years for both fatal and injury cases,

Income lost= 98576.4USD

Economic cost of all fatalities = 159.95million USD

Economic cost of all injuries= 8.48 million USD

Considering underreporting, Cost of fatal is 12 times of reported value and cost of injuries is 8.2 times of fatal of reported value,

Economic cost of all fatalities considering underreporting= 1919.43 million USD

Economic cost of all injuries considering underreporting= 1311.61 million USD

Total Economic cost of all fatalities and injuries= 3399.49 million USD

B. Economic Cost Considering Pain, Grief, Sufferings

Economic cost of Pain, grief, sufferings= 20% of fatal + 50% of injury Total Economic cost of all fatalities and injuries= 1039.69 million USD

C. Economic Cost of Disabilities

Percentage of serious injuries that lead to permanent disability or fatality= 7 Total economic cost of all disabilities (including underreporting) = 111.96 million USD

D. Hospital and Medicine Cost (Govt. Medical) For fatal case,

Average cost per person= 11.17 USD for injury case,

Average cost per person= 173.23 USD for minor injury case,

Average cost per person= 5.59 USD

Economic cost of Hospital and Medicine (including Underreporting): 4.76 million USD

E. Vehicle Damage Cost

Average registered vehicle involved in accidents per year= 4582.35

Per vehicle damage cost (average) = 55.88 USD

And if 10% of the registered vehicles have been damaged permanently then Economic cost of vehicle damage= 2.98 million USD

F. Administrative Expenses

Average expense per accident = 16.76 USD

Economic cost of administrative expense= 0.13 million USD

G. Travel Delay Cost

Average cost per hour= 20.11 USD

Economic cost of Average delay= 42.75 million USD

H. Road Damage Cost

Average 10% accident occurs in Bridge. It is assumed that about 5m3 RCC works need to be repaired (railing, pedestal, pavement and divider) after an accident. Cost of railing per cum 296.17 USD and for pedestal 158.70 USD. Labor cost per day is 5.14 USD. [PWDB rate schedule 2018]. Economic cost of road damage 0.49 million USD reveals that the total 4602.24 million USD (BDT 43721.28 Crore) that constituted 1.3% of the GDP of Bangladesh.

Total Accident Costs in Bangladesh (2022) (1 USD= 95 BDT)

Accident Cost Item	Cost in USD (million)	Cost in BDT (crore)
Cost of all fatalities & injuries	3399.49	32295.155
Cost considering pain, grief & Sufferings	1039.69	9877.055
Cost of disabilities	111.96	1063.62
Cost of Hospital & medicine (Govt. medical)	4.76	45.22
Vehicle damage cost	2.98	28.31
Administrative cost	0.13	1.235
Travel delay cost	42.75	406.125
Road damage cost	0.49	4.655
Total	4602.24	43721.28

Table 6.10 Accident Cost

[Source “ANIN-DEPTHESTIMATIONOFROADTRAFFICACCIDENTCOSTINBANGLADESH” By Md.JamilAhsan[1],SouravRoy[2]andArmanaSabihaHuq[3*1]DepartmentofCivilEngineering,Bangladesh(UniversityofEngineeringandTechnology(BUET)]

CHAPTER-7

Safety

Alongside all the social and economic benefits obtained from the transport system, a serious cost that the society pays in terms of the crashes and loss of life that are connected with the movement of people and goods. Majority of the population know that no transportation system is free of risks. So, lots of safety measures can and should be taken in order to reduce the number of accidents, severity of crashes and injuries on roads.

7.1 Road Accidents in Bangladesh

Accidents on the roads in Bangladesh are always increasing. Every year the number of accidents is crossing the number of the previous year. A study on the road accidents inBangladeshfortheperiod1982-2000 shows that,

(i) Thenumber ofaccidentsincreased43%.
(ii) The numberoffatalities increased400%.
(iii) The numberofinjuriesincreased5%.
(iv) The numberofcasualties(fatalitiesplusinjuries)increased100%;and
(v) Thefatalityrateincreasedfrom126to163fatalitiesper10,000vehicles.

By the data shown above, we can surely say that the severities and the casualties of the road accidents has increased in an alarming rate. Through road accident the maximum number of injuries is occurred between ages 21 and 30 while the maximum number of deaths is occurred between ages 11 and 30.

ROAD ACCIDENTS, DEATHS

TIME	ACCIDENT	DEATHS
Jan-Jul 2021	**3,259** (42.25% rise)	**3,095** (39.98% rise)
Jan-Jul 2020	**2,291**	**2,211**

SOURCE: BANGLADESH POLICE

Figure 7.1 Road Accidents Deaths

A report from Bangladesh police shows that, in the year of 2020 number of accidents were 2291 and number of deaths were 2211. In 2021 the number of accidents increased to 3259 with a rise of 42.25% and the number of deaths increased to 3095 with a rise of 39.98%.

Another survey from the year 2017 shows that Dhaka has the highest percentage of road accidents and Barisal has the lowest.

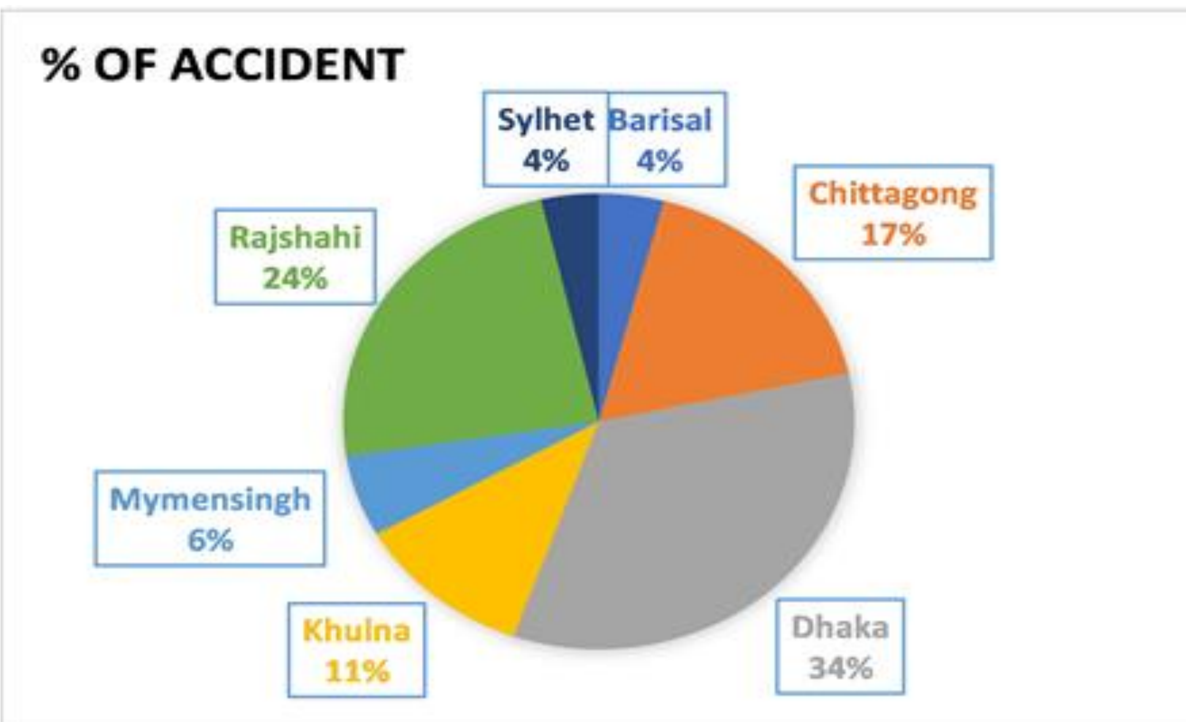


Figure 7.2 % of Road Accidents

In terms of death through road accidents, Dhaka is also at the top. The pie chart below shows the %of deaths in different parts of Bangladesh.

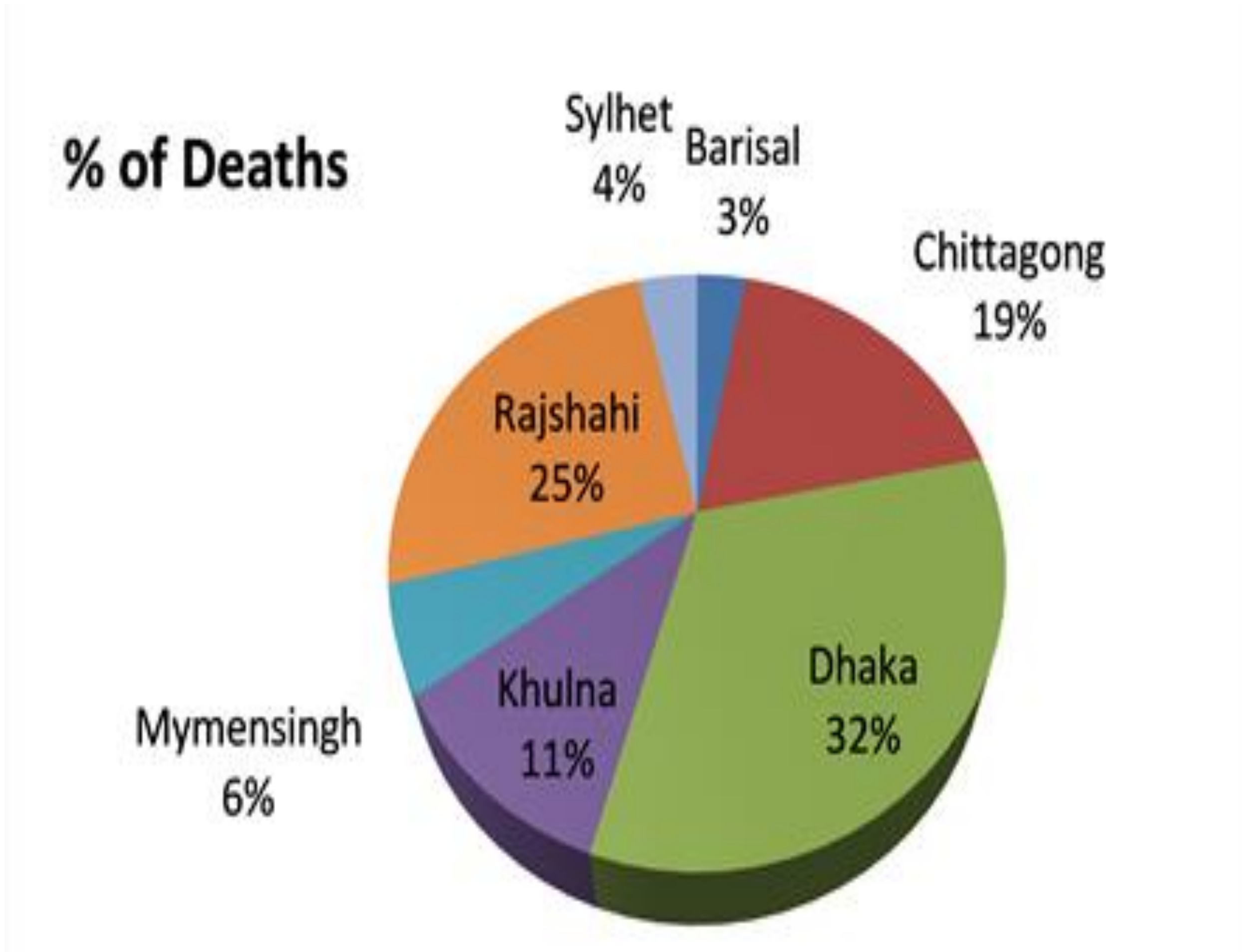


Figure 7.3 % of Road Accidents Deaths

The amount of traffic accidents, injuries, and deaths, as well as the corresponding economic loss from property damage, medical expenditures, and missed productivity, is much too great. According to reports, traffic accidents in Bangladesh have resulted in around 4,000 deaths and 2,300 injuries.

7.2 Safety Improvements

Improved safety necessitates a multifaceted comprehensive approach that addresses issues such as road conditions, regulations, enforcement, driver training, vehicles, public education, awareness, incident response, and information, all of which should be implemented in a systematic manner over time and with adequate funding.

A) RoadSafetyInitiatives

Effective road safety action necessitates the participation of many different disciplines as well as the cooperation of a diverse range of government, corporate, and public groups. The development of a multi-sector strategy is a basic necessity for improving road safety. To coordinateroadsafetyactivities, theNationalRoadSafetyCouncil (**NRSC**) wasestablishedinJuly1995.Secretarial a service to NRSC, NRSC Secretariat (NRSCS) was established in September1997with in BRTA.NRSCS was converted to the Road Safety Cell in March2001.

Among the national-level actions made in Bangladesh to address concerns about accidents and safety are:

- CreationofNationalRoadSafetyCouncil(NRSC)
- EstablishmentNRSCSecretariat(RoadSafetyCell)
- Establishmentofoperational systemsforaNational Road AccidentDatabase at BRTA
- AdoptionofNational RoadSafetyActionPlans
- AdoptionofNationalLandTransportPolicy
- Creation ofRoadSafetyDesign UnitwithinRHD
- EstablishmentofAccidentResearchCenterinBUET
- AdoptionofroadsafetyDesignStandardsManualfor RHD
- Adoption of Traffic SignsManual byBRTA
- AdoptionofRoad SafetyAuditpolicybyRHD
- RoadsafetyimprovementprojectsbyRHD
- Establishmentof MetropolitanRoadSafetyCommittees

- EstablishmentofDistrictRoadSafetyCommittees
- Establishmentof UpazilaRoadSafetyCommittees

While such efforts to establish institutional frameworks and technical standards appear to be significant, their overall success appears to be limited. One critical issue that has yet to be addressed is the absence of necessary financing for road safety.

B) Traffic LawEnforcement

To promote safer road use and orderly traffic flow, traffic law enforcement is required. The implementation of different rules, such as speed limits, the usage of seat belts, the use of motorcycle safety helmets, and so on, has resulted in a reduction in connected deaths and injuries in many nations.Effective traffic regulation enforcement necessitates traffic police training in a variety of areas, including incident investigation, highway patrols, motorcycle riding, vehicle driving, and managerial abilities.

Now a days, Bangladesh Police is working with other organizations to promote the importance of road safety among the population. The government has also imposed strict laws for them who breaks the rules on roads. The amount of fine has been increased too.

A Dhaka police officer speaks with a motorcyclist about Bangladesh's new traffic law, Nov. 1, 2019.

Figure 7.4 Traffic Law Enforcement

Source: Dhaka tribune (archive.dhakatribune.com/bangladesh/dhaka/2018/11/24/traffic-rule-violation-dmp-collects-tk29-31-lakh-in-fine)

C) Driver TrainingandTesting

Driver conduct, particularly that of commercial cars, is widely regarded as chaotic and devoid of regard for others. The majority of occurrences involve commercial vehicles. Effective driver training and testing are critical for long-term reductions in statistics. Toensurethatroaduserbehaviorbecomessafer,improvementsinthe training and testing of all drivers is required.A "motivational" training program for all drivers,organized with the involvement and support of the vehicle owners and professional associationsisoneexampleofthetypeoftrainingthatwouldbebeneficial. Many drivers hold fraudulent licenses, while others have gained regular licenses by unethical means. Because of a poor education level, most of the professional driverscannotqualifyforawrittentest,therebyfosteringamarketforfakedrivinglicenses.Theintroductionofnewlaminatedphotolicensesin1999,withnewhighersecurityfeaturessuchasa hologram, is efforts to try and improve the situation. Improved detection of false drivinglicensesisrequired to discourage forgeryattempts.

In recent times, the government of Bangladesh has imposed a law that all the drivers should be minimum class 10 passed to get a license and the bus helpers should be minimum class 8 passed. This rule is imposed so that the drivers and the helpers have the minimum education to understand all the traffic rules on roads.

Figure 7.5 Drivers Training and Testing

Source: Driving Training for Bangladesh (https://www.linkedin.com/pulse/defensive-driving-training-bangladesh-navy-arif-uddin)

Figure 7.6 Driver Training and Testing

Source: **Driving Training for Bangladesh (**https://www.linkedin.com/pulse/defensive-driving-training-bangladesh-navy-arif-uddin**)**

D) EducationandPublicity

To develop safe road user behavior, children need to be taught skills (i.e. how to cross a streetsafely, how to use traffic signals properly, how to watch for and anticipate driver behavior, etc.)rather than focusing simply on rules, regulations and knowledge of traffic signs. Road safety education requires a defined framework within a recognized curriculum, as well as a planned, sustained, and cohesive program of learning based on strong educational principles, in order to be effective. This is stillnot the case in Bangladesh.Children learn a lot from observation of others.The impact onchildren, of poor driving habits — those they observe as well as those they experience directly asthey are transported about — is a serious systemic problem which will contribute significantly tofuture generations ofpoordrivers.

Public awareness of road safety is equally vital. Road safety education is a long-term strategy that aims to instill good attitudes in youngsters so that they will be safer road users in the future. Publicity is an essential component of every nation's road safety plan.

Figure 7.7 Traffic signs

Source: Brta web site (https://bsp.brta.gov.bd/trafficDrivingTestGiudeline;lan=en?lan=en)

Figure 7.8 Posters on road safety for public awareness
Source: Brta web site (https://bsp.brta.gov.bd/trafficDrivingTestGiudeline;lan=en?lan=en)

E) VehicleSafety

Substandard, often overloaded, vehicles using roads that facilitate increasingly higher speeds,invariablywillleadtoincreasedincidents.PoorvehicleconditioniswidelyacceptedinBangladeshtocontributeto the numberand severity ofroad collisions. One study shows that, unfit vehicles are responsible for 15% of air pollution in Dhaka city.

Figure 7.9 UNFIT VEHICLES.

Source: The Financial Express (https://www.thefinancialexpress.com.bd/national/more-than-300000-unfit-vehicles-in-bd-1528288249)

Despite the fact that inspection forms and instructions were created as part of a recent aid effort, they have received little attention. While inspection monitoring methods are robust, no data is used, and no concern is expressed about the excessively high pass rate. Vehicle inspection is viewed as a formality, and the basic inspection processes reflect this. This sector has made little meaningful development and is unlikely to make further improvement without significant help. Motivational training for the authorities involved is required, as is rigorous adherence to inspection standards. Five computerized vehicle inspection stations have been built and equipped with theassistanceofloanfrom theADBandtheseareawaitingcommissioning.

F) MedicalServices

Lack of first aid and prompt transportation to adequate medical support facilities contribute towhat medical professionals call the "second accident", where injury severity is worsened for lackof proper care and quick transport services.Payment in advance is often required before adriverwilltransportaninjuredperson.Whilemajorhospitalshaveambulances,theyare primarily used for non-emergency situations and rarely if ever respond to a road incident scene.In addition, hospital facilities and rehabilitation services are inadequately equipped to provideneeded medical attention.As a consequence of such factors, the death rate is higher and theseverity ofinjuriesofthosewhosurviveishigherthanitwouldotherwisebe.

Figure 7.10Woman’s leg crushed in Dhaka bus accident; no first aid is being provided.

Source: Daily Bangladesh (https://www.daily-bangladesh.com/english/national/4579)

Initial,onthespotfirstaidcarecancontributegreatlytoreducingmorbidityandinjuryseveritybyensuringthevictimiskeptbreathing,bleedingreducedandshockcontrolled.

Figure 7.11 Accident victims are being provided with first aid.

CHAPTER 8

NOISE IMPACTS

8.1 Introduction

A pressure wave produced by a vibrating item is referred to as sound. However, when it becomes excessive or unneeded, we refer to it as noise. Noise pollution is a significant environmental issue. Outside noise is mostly created by industrial, transportation, and propagation systems all around the world. Today, traffic noise is a big source of irritation for those who travel on our country's highways. The perception of sound by the human ear, whether it be a basic musical instrument or a complicated spectrum like road noise, is dependent on four fundamental criteria: loudness, frequency, duration, and subjectivity.

Excessive noise can reduce the value of real estate and, more crucially, cause general discomfort and health issues. The noise emitted at a particular moment is not impacted by prior actions and will not affect future activities; unlike other pollutants, noise does not leave a residual effect to demonstrate its annoyance. As a result, there may be a propensity to overlook or undervalue the problem of noise pollution.

8.2 Study area

The Regional Highway R111 (Sing board-Chashara) Vehicular streams are sensibly talland large rates of buses (distinctive sorts), stacked trucks, passenger-car, micro-bus, pick-up van, CNG, auto-rickshaw, etc. Critical numbers of people on foot are utilizing thefootpath/shoulder.

8.3 Objective

Themain purposeofthestudy:

Identifying the sources and factors affecting transportation noise

Calculating the highway's noise impact

Comparingfiledobservedvaluewithstandard.

Noise level measurement

8.4 Analysis of the effect of noise barriers

8.4.1 SourcesofTransportationNoise

The most common transportation noise is from highway operations (autos, trucks, buses). Sourcesoftransportationnoiseareasfollows:

Vehicle–airinteraction

Tire–pavementinteraction

Vehicleengines

Vehicleexhaustsystems

Vehiclehornsandbrakes

Thelevelofhighwaytrafficnoisedepends on:

(1) Speed of the traffic

(2) Traffic volume

8.4.2 Factors Affecting Transportation Noise Propagation

There are many factors which is affecting the transportation noise propagation (temperature,natureofsource, distance, ground surface, noisebarrier).

8.4.3 NatureofSource,Distance,andGroundEffects

Important noise propagation factors are the nature of the source (linear source and point source)and the distance between the noise receiver (affected person) and the source. Geometric dispersion is an essential geometric property that defines the noise reduction effect as one moves away from the noise source. The effect of excessive attenuation is dependent on the kind of soil, the nature of the ground cover, and the surface topography. The impacts of soil are sometimes difficult to predict.

Thereare2 typesofsources.

Point source: A single truck cruising on a highway, a locomotive with an idling engine etc.

Linesource:Auniformtraffic flow.

8.4.4 Effect of Noise Barriers

Obstacles in the path of a sound, such as commotion, induce diffraction or reflection, resulting in a reduction in sound levels. The shadow zone is an area with decreased sound. As the sound wave shifts, sound weakening is highest immediately behind the question and reduces with the separation behind the protest. Sound may also be reflected by impediments in its path because such impediments create a deflection of the sound vitality.8.5 EstimatingNoiseImpactsforHighway

8.5.1 CollectedData

Road-way configuration: (collected from Google map)

Length of road-way segment- 7.9 km/ 4.9 mile/ 25918.6 ft

Pavementwidth- 76 ft

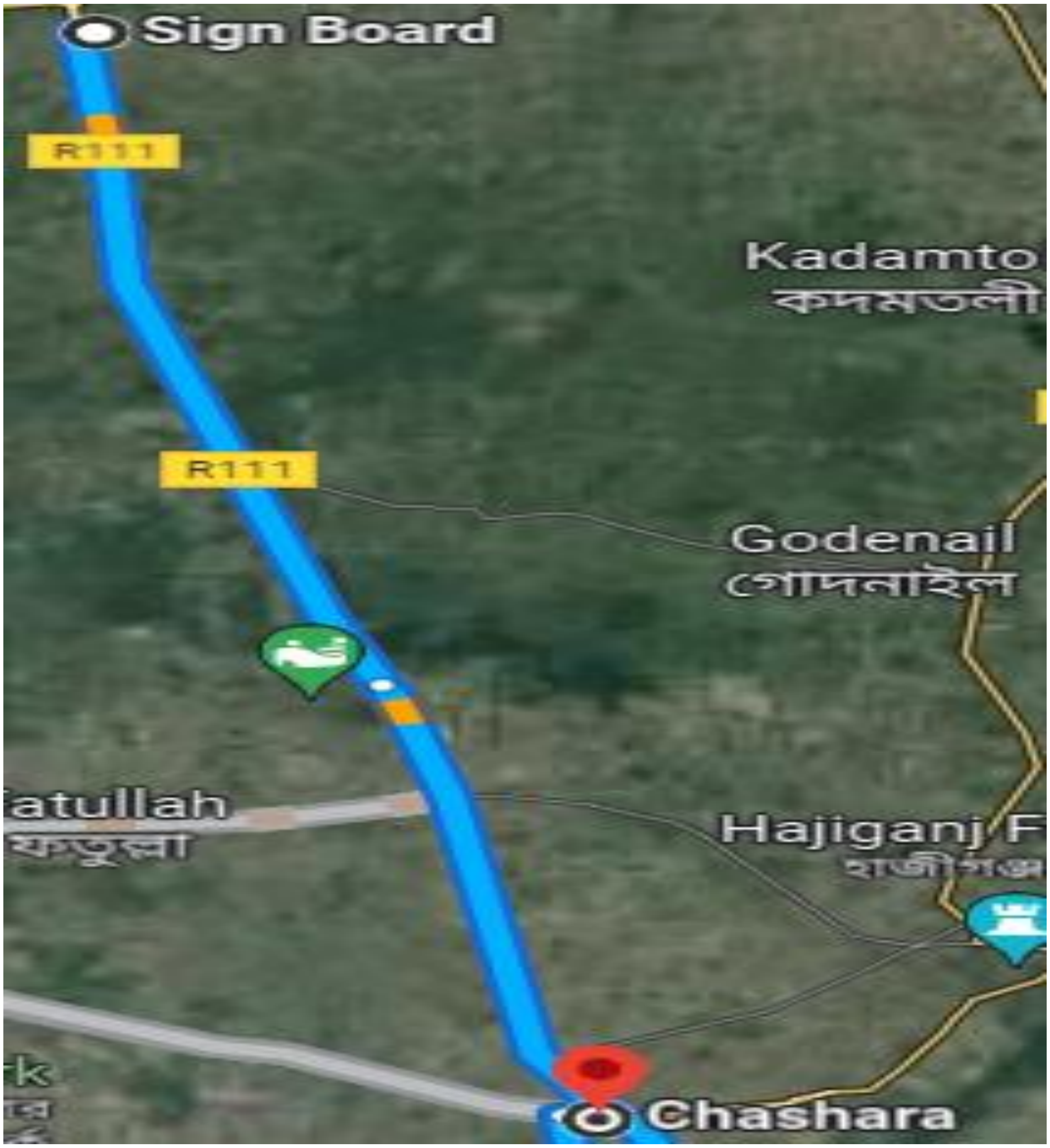


Figure 8.1: (Source: Google map)

8.5.2 Calculation and Result

$$L_{eq}(h)_i = \underbrace{(L_0)_{E,i}}_{\substack{\text{reference energy}\\ \text{mean emission level}}} + \underbrace{10\log_{10}\frac{N_i \pi D_0}{S_i T}}_{\substack{\text{traffic-flow}\\ \text{adjustment}}} + \underbrace{10\log_{10}\left(\frac{D_0}{D}\right)^{1+\alpha}}_{\substack{\text{distance}\\ \text{adjustment}}}$$

$$+ \underbrace{10\log\left(\frac{\psi\alpha(\phi_1, \phi_2)}{\pi}\right)}_{\substack{\text{finite roadway}\\ \text{adjustment}}} + \underbrace{\Delta_s}_{\substack{\text{shielding}\\ \text{adjustment}}} \qquad (11.3)$$

where $L_{eq}(h)_i$ = hourly equivalent sound level for the ith vehicle class

$(L_0)_{E,i}$ = reference energy mean emission level for vehicle class i [see Eqs. (11.4)]

N_i = number of class i vehicles passing a specified point during time T (1h)

S_i = average speed for the ith vehicle class (km/h)

T = time period over which L_{eq} is sought, in hours (typically, 1 h)

D = perpendicular distance traffic lane centerline to receptor

D_0 = reference distance at which the emission levels are measured; in the FHWA model, D_0 is 15 m

α = site-condition parameter, that indicates the hardness or softness of terrain surface

Ψ = adjustment for finite-length roadways

Δ_s = shielding attenuation parameter due to noise barriers, rows of houses, densely wooded area, etc. (dBA)

ReferenceEnergyMeanEmissionLevel

$$\textit{Automobiles (A):}$$

$$(L_0)_E = 38.1 \log_{10}(S) - 2.4$$

$$\textit{Medium-duty trucks (MT):}$$

$$(L_0)_E = 33.9 \log_{10}(S) + 16.4$$

$$\textit{Heavy-duty trucks (HT):}$$

$$(L_0)_E = 24.6 \log_{10}(S) + 38.5$$

Hereweassume,Automobiles=CNG,Car,Microbus,Motorcycle,Jeep.

Medium-dutytruck=Bus,Cover-van.Heavy-dutytruck = Truck.

Where,Sistheaveragevehiclespeedinkilometersperhourofeachvehicletype.

8.5.3 TrafficFlowAdjustment

$$10 \log_{10} \frac{N_i D_0}{S_i} - 25$$

8.5.4 DistanceAdjustment

$$10\log_{10}(D_0/D)^{1+\alpha}$$

8.5.5 Combining Noises from Various Vehicle Classes

$$L_{eq}(h) = 10\log\left(10^{L_{eq}(h)_A/10} + 10^{L_{eq}(h)_{MT}/10} + 10^{L_{eq}(h)_{HT}/10}\right) \quad ($$

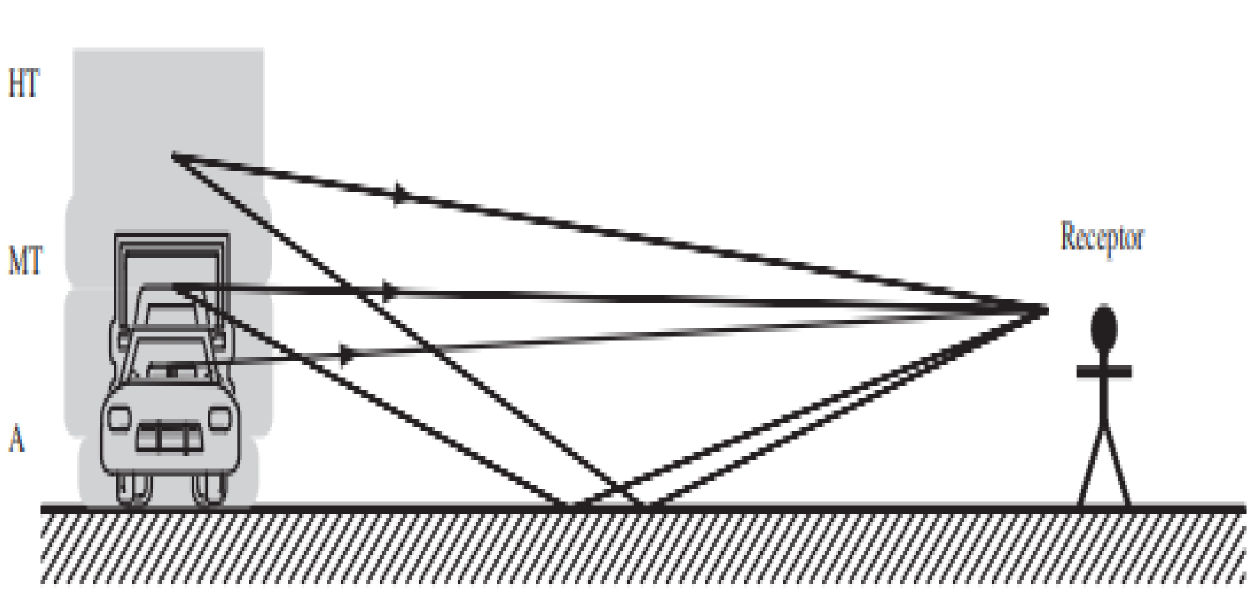


Figure 8.2Noise paths without barrier

Source: Sutori (https://www.sutori.com/es/historical16ERXrUE8gkQSGFxrj4UPz8)

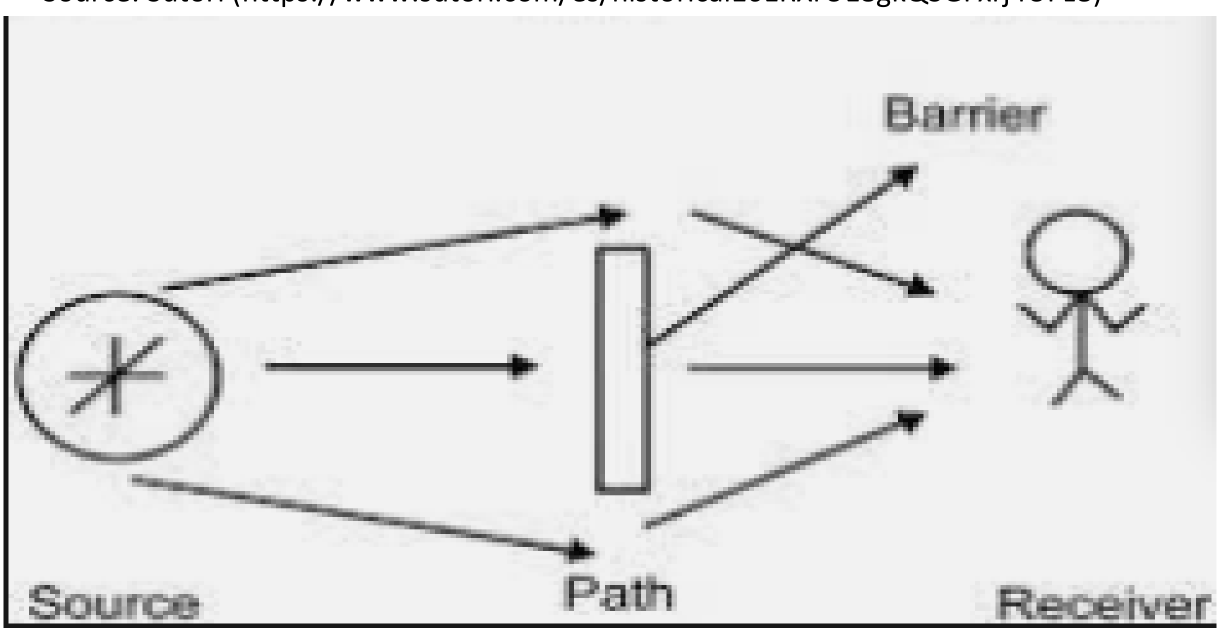


Figure 8.3 Noise paths with barrier

8.6 Noise paths with barrier.

Human ear can take sound of maximum 130 dB but for a very short time. Normally human ear can withstand 85 dB of sound for a couple of hours. High dB sound is very unpleasant and it creates disturbance. Levels of highway traffic noise typically range from 80 to 90 dB at a distance of 15 meters (50 feet) from the highway. These levels affect a majority of people, interrupting concentration, increasing heart rates, or limiting the ability to carry on a conversation.

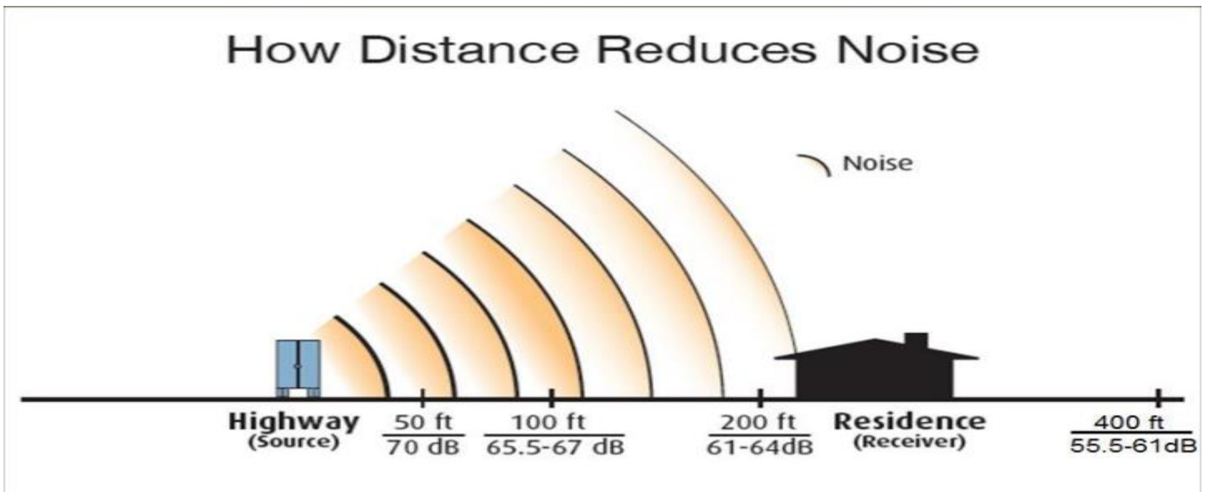


Figure 8.4 How distance reduces noise.
Source: Environmental Protection Department
(https://www.epd.gov.hk/epd/noise_education/web/ENG_EPD_HTML/m4/mitigation_1.html)

So, for protecting the residences from noise pollution generated from highway, a type of barrier should be provided.

The barrier will absorb most of the sound generated from the highway. Many countries had used sound barrier in their highways. Highway noise barriers are designed to mitigate the effects of traffic noise along the highway. Noise barriers primarily block the direct path of the sound between the source on the highway and the receiver exposed to the sound.

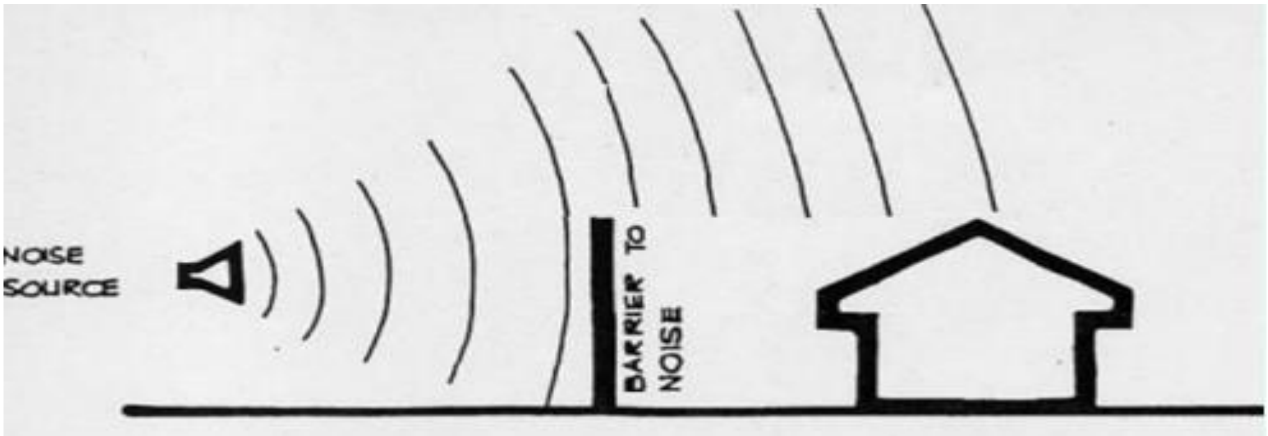


Figure 8.5 Barrier protecting residence from sound pollution

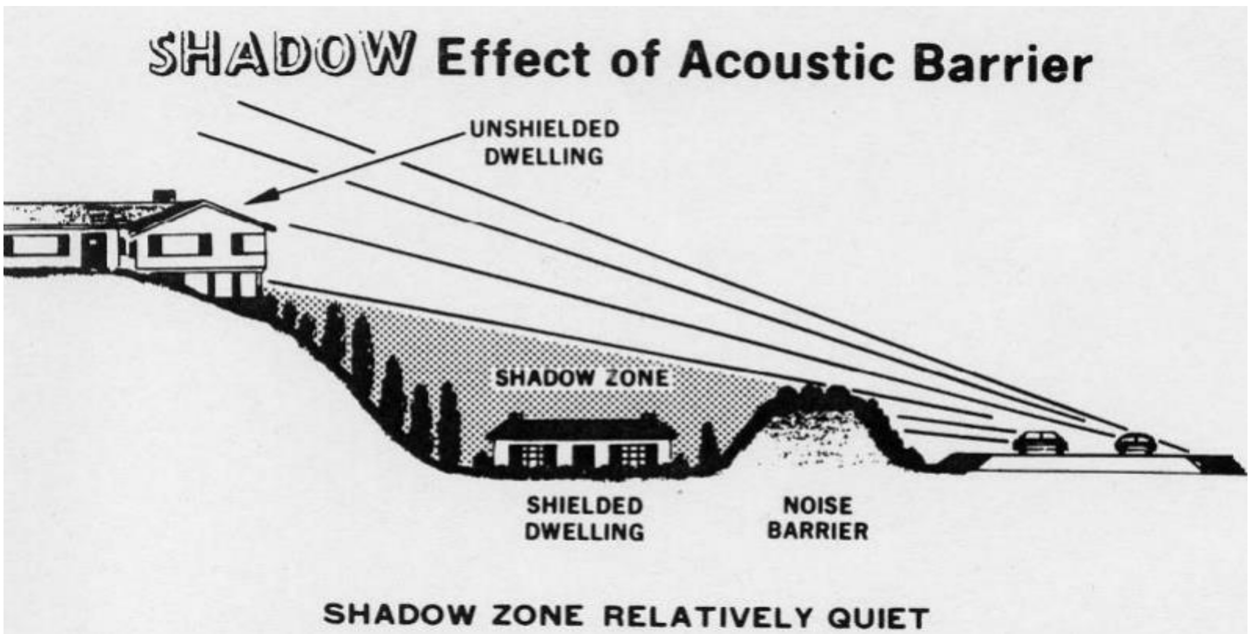


Figure 8.6 Noise barrier in highway

8.7 Results:

8.7.1 Energy mean emission level for different type of vehicle

Type of Vehicle (both way)	Average speed (km/h)	Energy mean emission level (dBA)
Automobiles (CNG, Car, Microbus, Motorcycle, Jeep)	75	69.039
Medium-duty trucks (Bus, Cover-Van)	75	79.964
Heavy-duty trucks (Truck)	75	84.626

Table 8.1 Energy mean emission level (dBA)

Table 8.1 Energy mean emission level for different types of vehicle

Weusereferencemeanemissionlevelequation.

8.7.2 Hourly equivalent sound level for different type of vehicle

Type of vehicle		Traffic Volume (vehicle/hr)			Hourly equivalent sound level(dBA)		
		Morning	Noon	Evening	Morning	Noon	Evening
Automobile	CNG	392	215	360	50.693	50.112	48.324
	Car	172	98	189	53.541	51.67	53.561
	Microbus	64	84	59	49.604	49.261	49.808
	Motorcycle	212	180	198	50.311	49.325	49.693
	Pick up	96	87	135	50.312	49.152	49.451
Medium-duty trucks	Bus	96	91	98	61.881	60.607	62.57
	Cover-Van	88	74	90	64.305	63.082	63.26
Heavy-duty trucks	Truck	84	70	123	65.23	64.607	64.926

Table 8.2 Hourly equivalent sound level

Table 8.2 Combined noises from variousvehicle

Source: Transportation noise source Transportation Decision Making: Principles of Project Evaluation and Programming. Kumares C. Sinha and Samuel Labi Copyright 2007 John Wiley & Sons, Inc

Classesare 62.73dBA

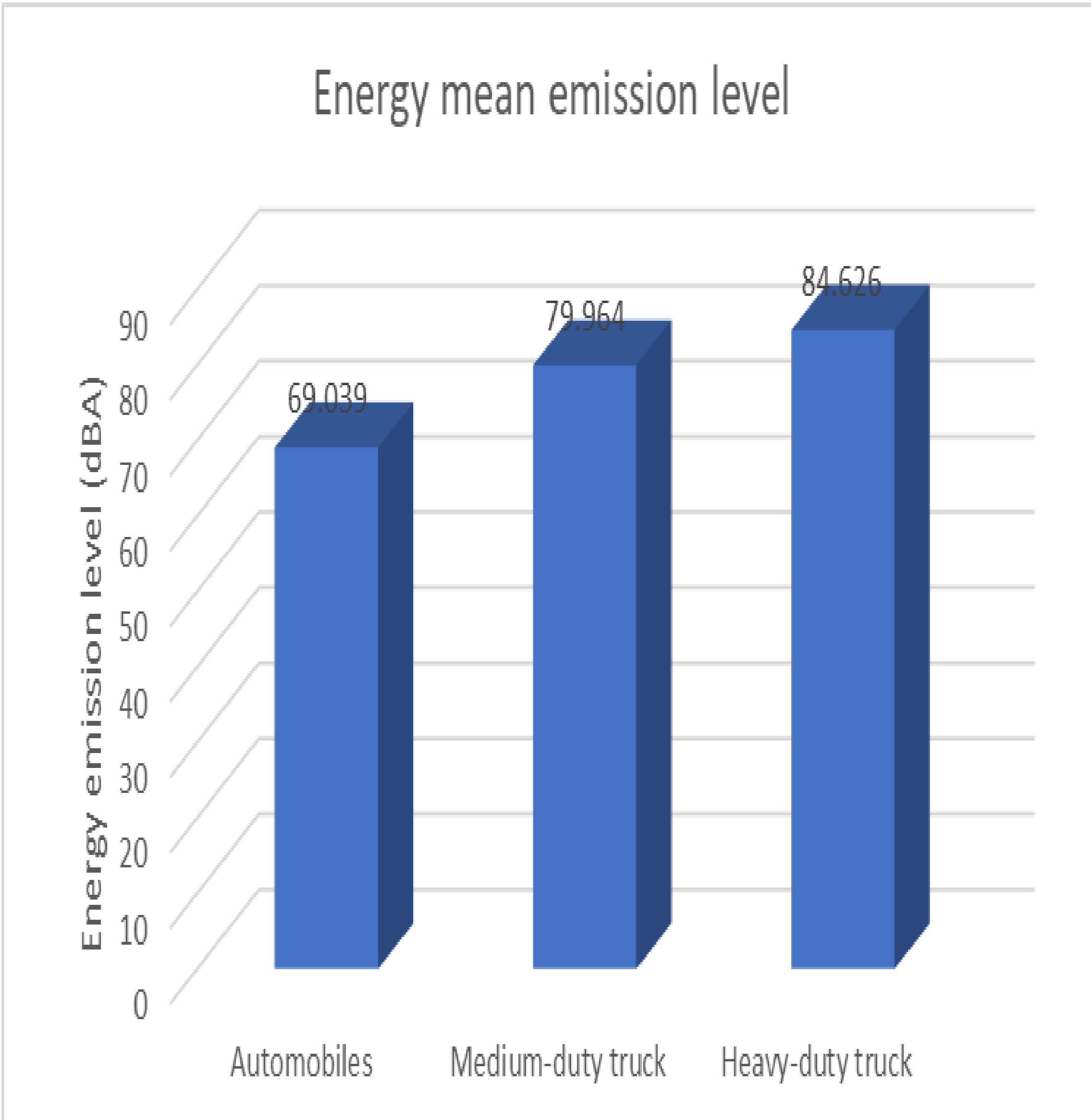


Figure 8.7 Energy emission level for different type of vehicle

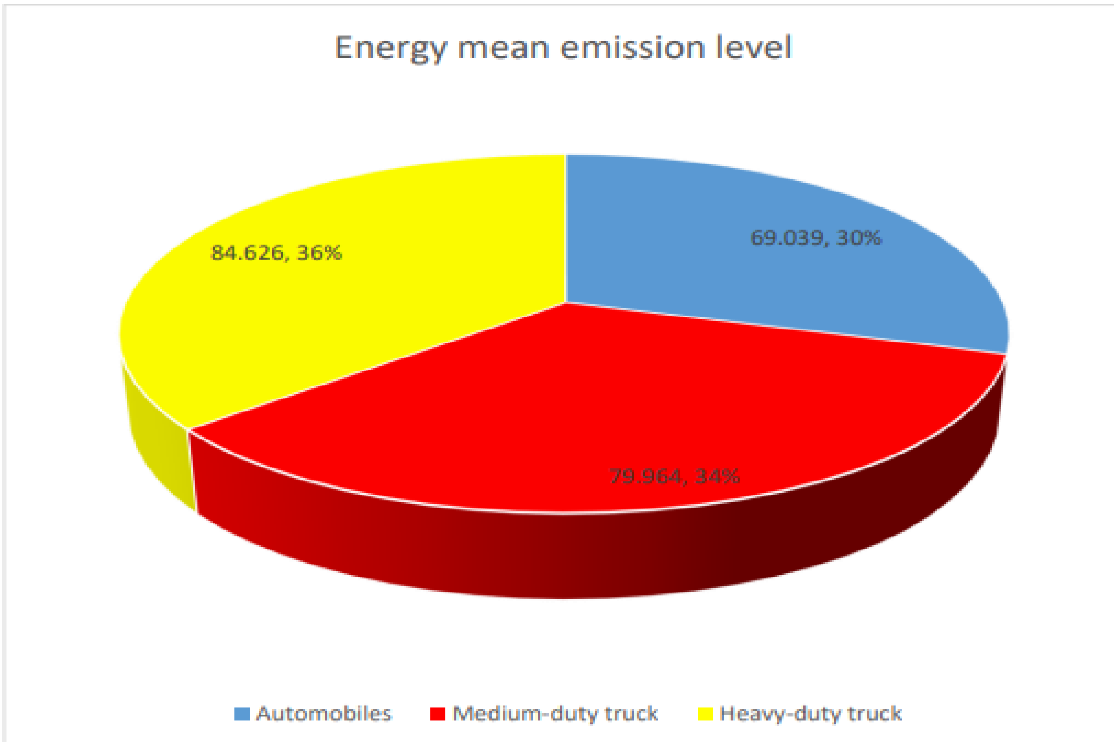


Figure 8.8 %ofEnergyemissionlevelfordifferenttypeofvehicle

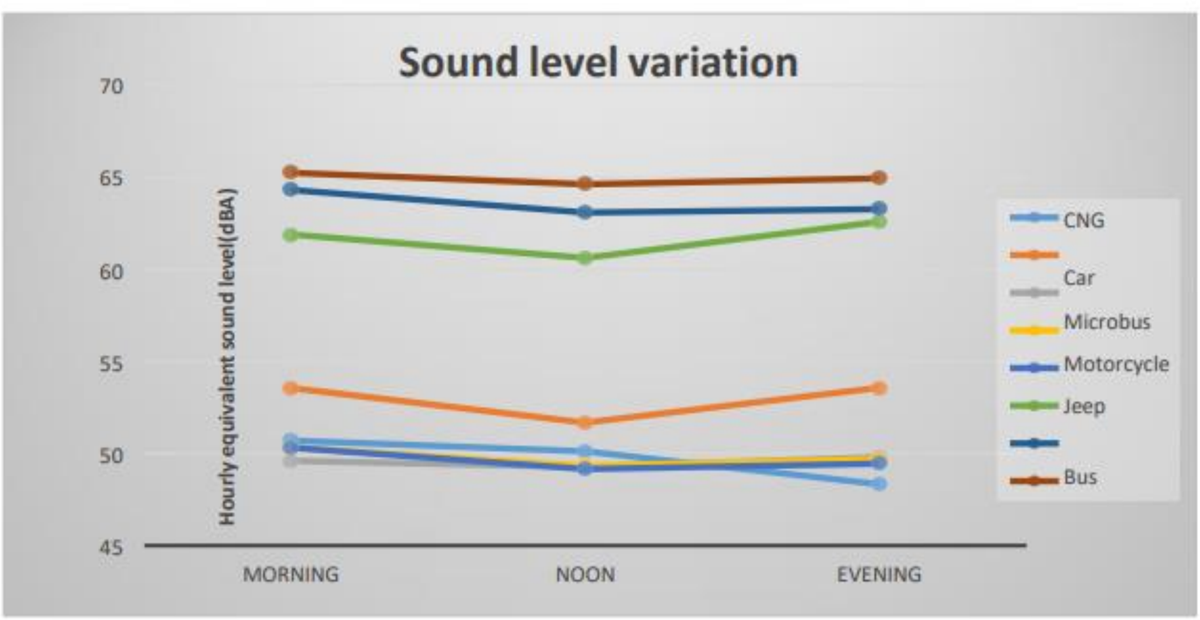


Figure 8.9 Sound level variation for different type of vehicle

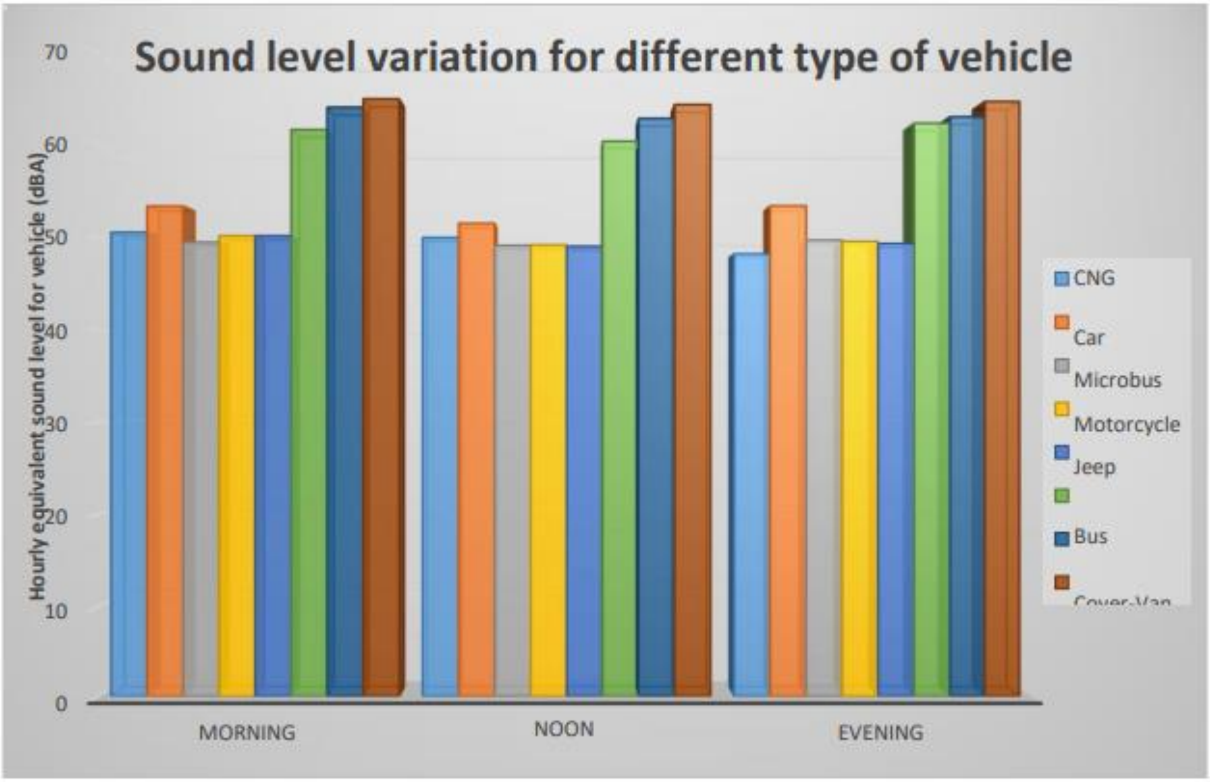


Figure8.10 level variations for different types of vehicles

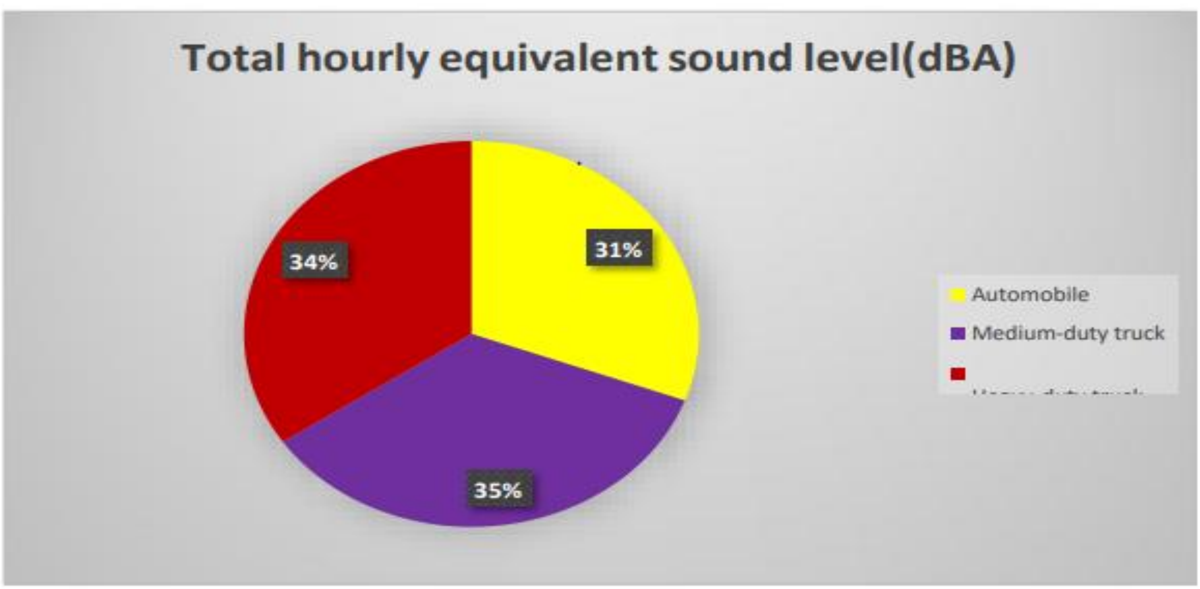


Figure8.11% of Total sound level variation for different type of vehicle

8.7.4 ComparisonwithStandardNoiseValue

The traffic noise standard for Highway ranges from 70 to 80 dBA. We chose 57.60 dBA, 65.78 dBA, 64.81 dBA highways, and the combined noise of cars, medium duty trucks, heavy trucks, and various vehicle categories is 62.73 dBA, which is within the standard range.

8.8 Noise Barrier Cost Estimation

Thecostandeffectivenessofthenoisebarrierdependonitsshape,height,material,directionand mainlyonitsmaterial.Amongthedifferenttypesofbarriers,themosteffectivebarrierisarobustnoiseb arrier,whichcanreducenoiseby15to20dBA.Thenoisebarriershouldbe200to300feetfor most effective results, and the distance between the receiver and the noise source should be300 feet. From historical data (USDOT, 1995), it can be seen that the costs of the barriers rangebetween US $ 0.55 and US $ 5.44 million per mile. The most recent cost data is in 2005 dollars,whichis approximately $25 to $ 30 per square foot.

Noisebarrierscostmodel(in2002dollars)developedfromthedataisshownbelow:Cost($M)/mi = −0.7269ln(length ofbarrier,inmi) + 4.5117

=-0.7269ln(4.9 mile)+4.5117

=5.67

Averageunitcostbyheightforselectedhighwaynoisebarrier(6’heightassume):

8.8.1 Averageunitcostbyheight

Material	Cost ($)
Concrete	21.49
Block	20.29
Wood	21.49
Metal	21.49
Berm	7.16
Brick	32.23
Combination	22.68
Clear absorption barrier	27.46

Table 8.3 Average unit cost by height

Source: Transportation noise source Transportation Decision Making: Principles of Project Evaluation and Programming. Kumares C. Sinha and Samuel Labi Copyright 2007 John Wiley & Sons, Inc

The chart shows that, Berm barrier is the lowest of cost (7.16$); Clear absorption barrier is in the middle (27.46$) & Brick barrier requires the highest cost (32.23$).

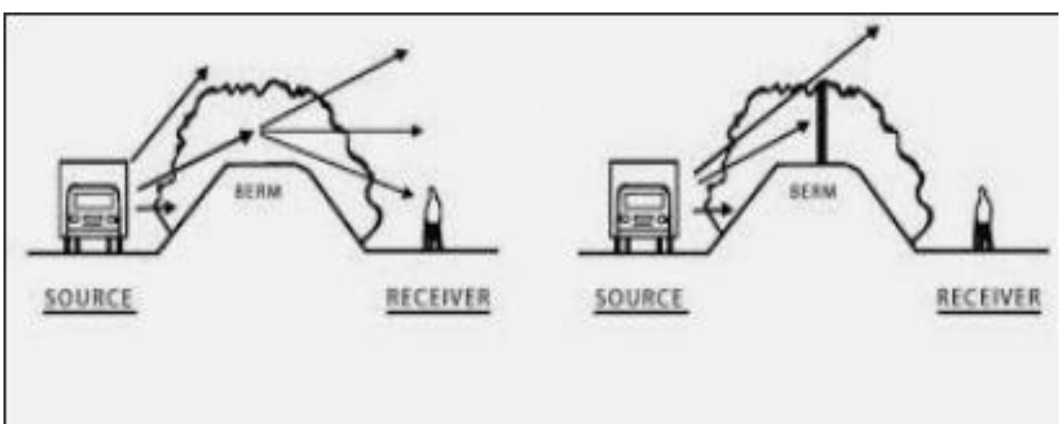


Figure 8.12 Barrier

The earth berm barrier requires a huge space to set up. There is no extra space in R111 road. So, setting earth berm barrier is not possible.

Figure 8.13 Brick wall barrier

Brick wall barrier needs a lot of earth work and labor. It also comes with a lot of cost. The brick wall barrier will protect the residence from sound but it will also reduce the aesthetics and block the side views.

Figure 8.14 Clear absorption barrier

Clear absorption barrier is a high-tech sound absorbing material that is used along the boundary line of the carriage way of the road. It increases the aesthetics of the road and for being clear, it does not block any kind of views. Light is also not blocked for the clear absorption barrier. It requires minimum work to set up and is also cheaper than brick barrier wall. The clear absorption barrier is capable of absorbing more sound than all the other sound barrier walls mentioned in the table. So, using the “Clear absorption barrier” is the right choice.

8.9 Conclusion

OurselectedroadRegionalroadR111whichisabranchofN1connectedwithSignboard to Chasara is very important road and its traffic volume is too muchhigh. Its noise level is varying for different time in a day. Morning and evening time noise level ishigherfromnoonthisisbecauseforhigher volumebut noiselevelis inthe standardrange.

Noisedecreasemethodsatthesource(vehicles)areinapersistentstageofimprovement.Illustrations incorporate the coordinate control of motor and other vehicle noise, open–graded orelasticbasedblack-topasphaltfortirenoisecontrol.Excessivenoisemaybereducingbycontrolthetrafficmanagement systemproperly.

By establish a greenbelt buffer zone beside residential area noise pollution will be reduced but itis more expensive. Another cost effective way for reduce noise level is establish a noise barrier.Butit is most popular inmuch country.

Since the sound level is in permitted level so there is no need to construct a noise barrier. But ifthere will be consider the safety issues for surrounding the residential area there can be construct anoise barrier. For construct noise barrier concrete should be choose because its price range is lessfrom other materials. From medium size vehicle noise level is high from another type of vehicle.Day by day traffic demand will be increase and also noise pressure with that. So it’s an importantthingthatauthorityshould takemoreeffectivestep forkeepingupits noiselevelinfuture.

CHAPTER-9

Air Impact

A gas, liquid droplet, or solid particle that, when present in sufficient concentrations in the air, poses a threat to flora and wildlife, as well as property and the climate Millionsofurbanpeopleareconcernedaboutairpollution,avisibleenvironmentalside-effectofmobility.

Air is an essential component of the physical universe since it supports life in both the plant and animal worlds, including humans. It is no longer news that anthropogenic air pollution is a major issue all over the world. Air pollution caused by the rise of megacities has been a serious environmental problem in Asia-Pacific. Building and construction damage, agricultural crops and plants, and forest destruction are only a few of the environmental repercussions of air pollution. As a growing fraction of the world's population moves to cities, urban air quality is becoming increasingly essential.Growing urbanization has increased air pollution as a result of increased transportation activity, higher energy consumption in enterprises, and a lack of air pollution management mechanisms in developing countries. Air pollution is an issue caused by the use of fossil fuels, and industrial operations have a negative impact on the environment and human health.

Primary air pollutants that are immediately emitted into the environment include particulate matter and carbon monoxide. Secondary air contaminants include ozone and acidic depositions. Natural sources of air pollution include forest fires and volcanoes, but man-made sources include power generation, fuel consumption, slash and burn farming, and transportation. Automobiles, inparticular,areamajorsourceoflocalcarbonmonoxideissuesandarebelievedtobetheprincipalcaus e of excess regional photochemical oxidant concentrations (PCOC). CO, NOx and otherhazardous chemicals are often released by transportation vehicles and may cause health issueswhen breathed. It is becoming more apparent that transportation vehicle usage contributes toglobalwarming.SOx,NOx,andCOxarereleasedintotheairasaresultoftrafficcongestion. (SOx andNOx),whicharelighterthanairbutextremelyhazardousto humanhealthandmayevencausedeath,areemittedbycarsthatarestoppedforextendedperiodsoftimewiththeirenginesrunning.

9.1Methodology

9.1.1 Introduction

Our chosen road's vehicle emissions were measured in this chapter using a methodology that wasdeveloped specifically for this investigation. You'll also get a description of the methods andrationale we're utilizing to arrive at these conclusions. You may find out more about the studyregionandits contaminants by reading this.

9.1.2 PollutantSelection

It was decided to construct an emission inventory based on four criterion pollutants. CarbonMonoxide (CO), Nitrogen Oxides, Sulfur Oxides, and Particulate Matter are among them (SOx).In terms of criterion pollutants, lead (Pb) was excluded due to a lack of data, and secondarypollutantOzone (O3) was notconsidered. [Arjumand,S. (2010)]

9.1.3 OnlineSource

The transport industry is the fastest increasing contributor to air pollution and one of the primaryperpetrators in metropolitan centers of industrialized and developing countries (SIM-air, 2009).Dhaka,Bangladesh'scapital,ischokedwithmotorvehicles,bothpublicandprivate.Accordingto experts,carsareamajorsourceofairpollution(Begumet.al.,2004).Inordertoassessthesourcecontribution for coarse and fine particulate matter, a study has been conducted. Automobiles areestimated to be responsible for approximately 40% of coarse particles and 55% of fine particles(Begumet.al.,2007)

.

9.2 EstimationSample

From following equation, we can calculate emission factor and pollution quantity from particularsource

Aor VKT=Lx AADT

Where,

A = Activity level for each pollutant source for each grid (km/day)

VKT=Vehicle Kilometers Traveled(km/day).

L =Roadlength(km)

AADT=AnnualAverageDailyTraffic(trafficvolume/day)

AftercalculatingthevehicleKilometertraveled,wewilluseitontotalemissioncalculation

Totalemissionhasbeencalculatedasfollowed

$\sum Emission = \sum_j \sum_k EF_{ij} \times A_{jk}$

Where,

i= Typeofapollutant

j = Emission sector like traffic, brick kilnsk

Emissioni=Emissionsofpollutanti

EF = Emission Factor for each pollutant sector

A= Activitylevelfor eachpollutant sector

The calculation of emission amounts is dependent on numerous factors and secondary data, thusit is easy to encounter uncertainties. As a result, we assumed a wide range of values in ourcomputation.

9.3 Vehicle Emission Inventory

9.3.1 Introduction

Aninventoryofpollutantsgeneratedbyon-andoff-roadmobilesourcesiscalledthemotorvehicleemission inventory. A road emissions inventory includes two components: emissions data andactivity data, both of which may be accessed through the same website. Among the emission-relateddataaretheresultsofvehicletestingandthemostrecentvehicleregistrationsinformation.There are also estimates of daily vehicle miles traveled, speed distributions, and the number ofstarts per vehicle per day by year in the activity data. In the off-road emissions inventory, apopulation,activity,andemissionsestimateforoff-roadequipmentarecalculated.Astherearenostatisticstoestimateoff-roademissionsinventories,thisstudyfocusessolelyonon-roademissions.

9.3.2 EmissionFactorandVehicleActivity

We are just considering road traffic since we lack statistics on air and rail transportation. We had to go through various studies that were developed following study to quantify these emissions. We utilized various emission coefficients for different contaminants in our overall emission computation.

Vehicle Type	AADT (veh/day)	Road Length (km)	VKT (Km/day)
Covervan	1308.15	7.9	10334.39
Car/MB	1662.9	7.9	13136.91
Bus	1352.87	7.9	10687.67
Auto rickshaw	5524.23	7.9	43641.42
Motorcycle	2987.59	7.9	23601.96
Truck	1183.76	7.9	9351.704
Total			**110754.1**

Table 9.1 TransportationModewithTotalVKT

Source: Nature of transportation source Transportation Decision Making: Principles of Project Evaluation and Programming. Kumares C. Sinha and Samuel Labi Copyright 2007 John Wiley & Sons, Inc

We have calculated the VKT. VKT for a particular vehicle type iscounted here. As we have shown the traffic demand for our roads before, that's why we are notshowingit here.

Vehicle Type	PM_{10}	NOx	SOx	CO	$PM_{2.5}$
LDV	0.8	8.5	0.4	8.7	0.8
Car/Jeep/MB	0.84	2.77	0.4	7.3	0.84
Bus	3	10	0.8	5.5	3
Auto rickshaw /3W	0.35	1. 5	0.03	7.3	1.5
Motorcycle	0.23	0. 31	0.02	6.5	0.23
HDT	1.50	10	0.8	3.5	1.5

Table 9.2 Emission factors from Appendix

Source: Nature of transportation sourceTransportation Decision Making: Principles of Project Evaluation and Programming. Kumares C. Sinha and Samuel Labi Copyright 2007 John Wiley & Sons, Inc

9.4 RESULTS:

Vehicle Type	Emission (gm/day)				
	PM_{10}	NOx	SOx	CO	$PM_{2.5}$
Covered van	8267.512	87842.32	4133.756	89909.19	8267.512
Car/MB	11035	36389.24	5254.764	95899.44	11035
Bus	32063.01	106876.7	8550.136	58782.185	32063.01
Auto rickshaw	15274.5	65462.13	1309.243	318582.4	65462.13
Motorcycle	5428.451	7316.608	472.0392	153412.7	5428.451
Truck	14027.56	93517.04	7481.363	32730.96	14027.56
Total	86096.03	397404	27201.3	749316.9	136283.7

Table 9.3 Vehicularemissioninventoryforthestudyarea

Source: Nature of transportation source Transportation Decision Making: Principles of Project Evaluation and Programming. Kumares C. Sinha and Samuel Labi Copyright 2007 John Wiley & Sons, Inc

We have calculated the emission rate for different vehicles and different pollutants.Wehave also calculatedthetotal emissions for aparticular vehicle.

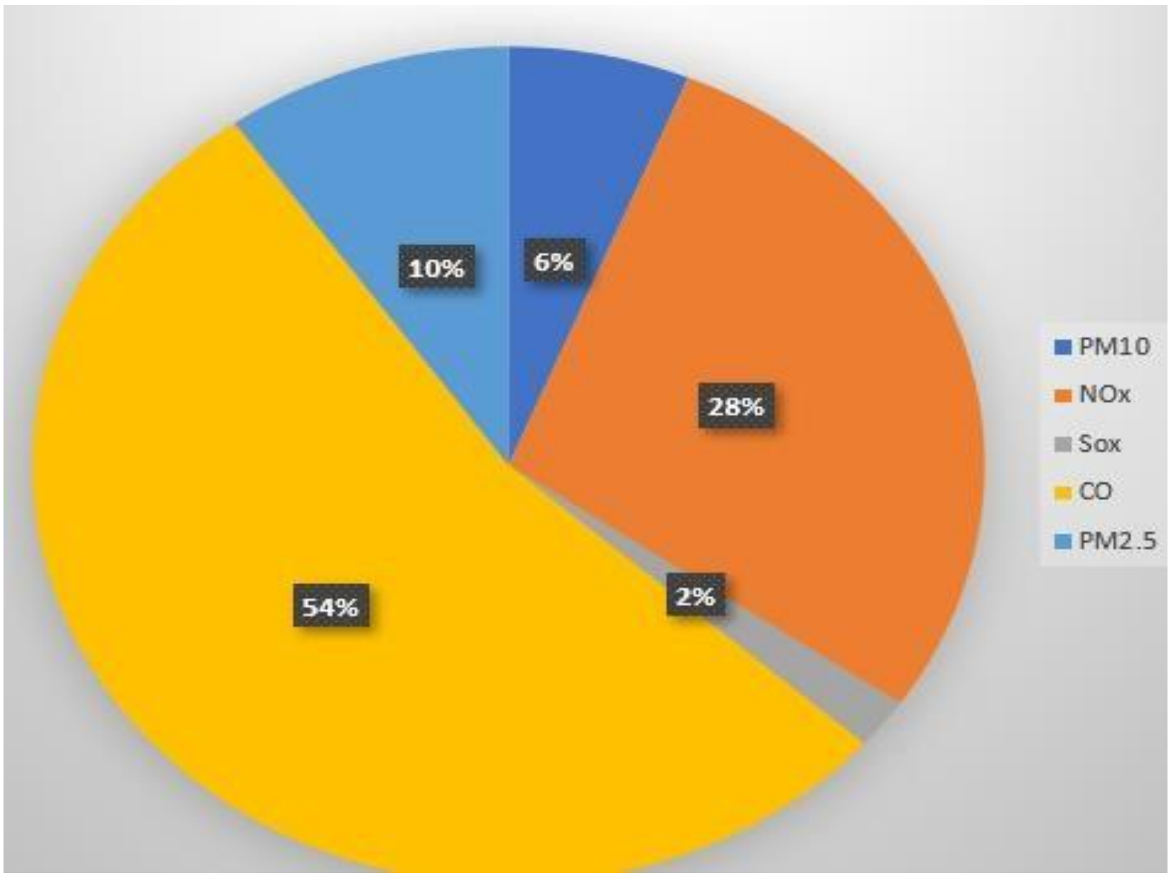


Figure 9.1 TotalConcentrationofvariouspollutants.

Here in this figure, we can see that for our selected road, this much concentration is emitted everyday. CO has the highest percentage of all the pollutants we have considered, and SOx has thelowest of all the pollutants. So, in this area, CO hampers the environment more than any otherpollutant.

In figure shows below, we can see that car/jeep/Microbus has the highest emission rate ratherthananyother vehicletypes here.

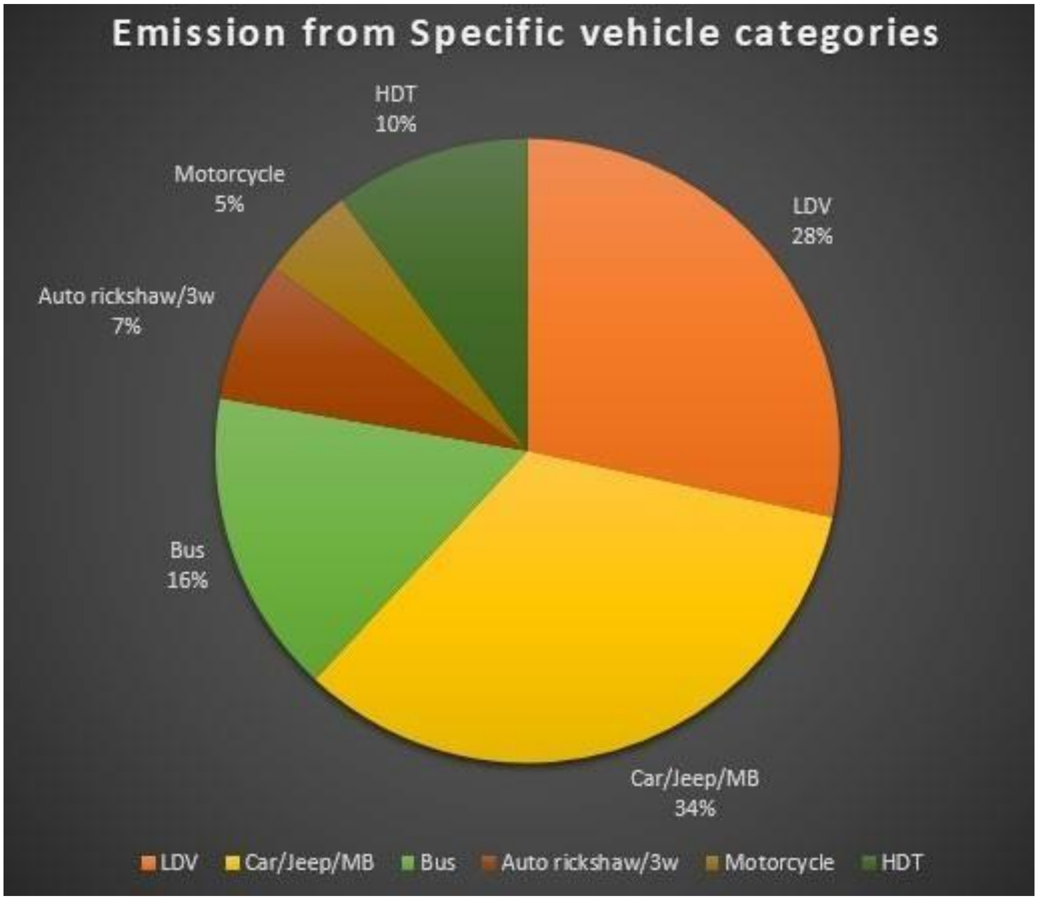


Figure 9.2 Emissioncontributionsofvariousvehicles.

9.5 EffectofPollutantonHumanHealth

9.5.1 Carbon Di-Oxide (CO2):

It is a significant absorber of infrared radiation produced by theearth's surface into space. As a result, it plays an important role in the planetary temperaturestructure.

9.5.2 CarbonMonoxide(CO):

Whenbreathed,itisabsorbed300timesquickerthanoxygenbythe lung alveoli. The presence of a high quantity of CO in the blood makes it harder for the hearttopump blood through the arteries.

9.5.3 Hydrocarbons(HC):

Unburnedhydrocarbonsmayproduceozone,acentralnervoussystemdepressant,whencombinedw ithnitrogenoxides.OtherhydrocarbonsinduceCNSconvulsions.

9.5.4 OxidesofNitrogen(NOx):

This causes dilation of the air passages in the lungs.Bronchiolesandalveolar ducts are harmed by NO2. NO2 is also suspected of impairing the respiratory system'sdefensivemechanism. Infants andchildren are especially vulnerable.

9.5.6 Particulate Matter:

Diesel produces suspended particulate matter (SPM) containing shot.Shoots are important for reducing air visibility as well as absorbing and transporting organiccompounds to thelungs.

9.6 Conclusion

The Dhaka metropolitan area's vehicle fleet is mostly made up of diesel-powered cars. Motorvehicles,particularlythosewithtwo-strokeengines,areagrowingsourceofairpollutionemissions in Dhaka. To develop a cost-effective action plan, a better knowledge of the sources ofair pollution, the role of cars to air pollution emissions, and the features of vehicular emissioncontrolsystemsisrequired.Legislationandenforcement,vehicleenginespecifications,pro motionof less polluting forms of transportation, better fuel quality, alternative fuels, transportationplanningandtrafficmanagement,andeconomicinstrumentsmayallhelptoreduceaut omobileairpollution.Allkindsoffuelmustbeofhighquality.Trafficcongestionshouldbereduced to reduce ambient air pollution through better traffic management, the imposition ofparking and pollution charges, fiscal measures to discourage private vehicles, and measures toimprovemassandrapidtransportationwhileensuringaneconomicalandsafeworkplacejourney.Ai rpollutionmustbeminimizedtoguaranteeahealthygeneration.Therearemanyanswerstotheissueof trafficcongestionmanagement.Someareonashort-termbasis,whileothersareonalong-term basis. We must concentrate on a long-term strategy while also addressing short-term issuesto alleviate present discomforts or difficulties. It requires a balance so that too many short-termsolutionsdonot jeopardize thelong-termstrategy

CHAPTER 10

Land-Use Impacts

10.1 Introduction

Transportation foundation can have a direct or indirect impact on the concentration and diffusion of arrival use designs in a region. These effects might be either beneficial or bad. For example, if an interstate is built in a range, the transportation framework will be easier and more convenient for the local people. As a result, the nearby territory will be more in demand.However, in ecologically sensitive areas, such progress can be hazardous to agricultural arrival jobs. Transportation pharmaceuticals, budgetary changes, current approach execution, and management, as well as the type and extent of the transportation extension, may all influence modifications in arrival utilization. There are a few laws in place to build a transportation system that has no negative consequences.

10.2 TheTransportation-LandUseRelationship

The advancement of transportation framework can change the design of arrive advancement by increasing arrive availability, improving arrive customer flexibility, decreasing transportation expenses, and enabling arrive advancement. Changes in arrive use, in turn, cause workouts that generate a need for travel, resulting in the need for contemporary transportation offices. And thus increases the availability and demand for encouraging progress.

10.3 LandUseImpactsonTransportation

Changesinarriveutilizedesignscanbeevaluatedbypopulacedensitiesinsidetherange,measuresofavailabilityandportabilityofapopulaceandotherquantitativeandsubjective.Travelcharacteristicscanincorporateadduptoafamilyvehiculartravel(VMTorVHT),tripfrequencies,andtrip lengths and showthe choice.

10.4 TransportationImpactsonLandUse

Different sorts of land use, depending on their demands and capacity to pay for accessibility The land-use versatility measures the extent to which land-use impacts are expected to occur. An activity with "high" land-use versatility has broad implications, not just in absolute terms, but in relation to other activities.

10.5 Land-UseImpactsintermsofMonetaryCosts

Land-use impacts can be difficult to monetize, in a portion since it is troublesome to anticipatechangesinland-usedesignscomingaboutfromaspecifictransportationapproachorarrangingthechoice, conjointly since the different related impacts (financial, social, and natural) is generallytroublesometomonetize.Assuch,therearefewexistingfinancialgaugesofthecostsrelated withchangesinland-use designs.

10.6 Observation and Result

Land-UseImpactsofHighwayInvestmentandPolicies

Action	Land-Use Elasticity	Land-UseImpact	MitigatingFactors
Safetyimproveme nts	Low	Nonelikely	The extent to which theimprovement changes capacity oraccessibility.
New facilities(highway corridors,interch anges)	High	Redistribution ofmetropolitan growth tohighwaycorridors. Decentralization ofpopulationandemploy ment. Increased landvalues and concentration ofdevelopment aroundinterchanges.	Local and regional economicconditions. Degree of impact onregional accessibility. Congestionlevels.Locallan d usepolicies.

Table 10.1 Land-UseImpactsofHighwayInvestmentandPolicies

Land-UseImpactCostEstimates(DollarsperVehicle-Mile)

CostCategory	Estimate(cents/VMT)
Transportation(bothuserandexternalcosts)	6.2
Environmentalcostsofpavinglandforroadways	2.5

Table 10.2 Land-UseImpactCostEstimates

LandConversionCostsperHectareperYear

From farmland to pavement cost is 22,000 dollars which will affect in environment negatively.

10.7 Conclusion

For develop a transportation project there is a very close relationship with land use impact. Landcan affect by various during the project established time and after. But if we analysis the land useimpactforsafetyissueandtrafficmanagementforourprojectwecanseethatthereisnoimpact.And cost is 6.5 and 2.5 cents/VMT for transportation and environmental cost of paving land forroadwaysland use impactwhich will affectin environment negatively.

CHAPTER 11

Cost Benefit Ratio

The benefit-cost ratio (BCR) is an indicator showing the relationship between the relative costs and benefits of a proposed project, expressed in monetary or qualitative terms. If a project has a BCR greater than 1.0, the project is expected to deliver a positive net present value to a firm and its investors.

Project Cost Benefits	Flexible Pavement	Rigid Pavement
Initial Constriction Cost	5489400	12439562
Routine Maintenance Cost	4751072.46	262688.40
Periodic Maintenance Cost	2095019.25	56849.86
Salvage Value	- 433688.51	-20337.31
Fuel Cost	9384726.90	8721417.57
Time Saving Benefit	-276903.81	-886941.34

Present Value of Benefit	320592.32	907278.65
Present Value Cost	21720219	21480517.03
Cost And Benefit Ratio	0.015	0.04

Table 11.1 Cost and Benefit Ratio

According to Bangladesh there are some issues that we have to consider so we decided that based on their importance we give them some numerical value. According to the importance numerical values the cases are given below.

Initial Cost = 3

Environmental Impact = 2

Health Impact = 2

Construction Rapidly = 1

Frame work Easier = 1

Sub grade (No Impact) = 1

Name	Flexible	Rigid
Initial Cost	3	0
Environment Impact	0	2
Health impact	0	2
Construction Rapidly	1	0
Framework Easier	1	0
Sub Grade(No Impact)	1	0
Total	6	4

Table 11.2 Cost and Benefit Ratio

For the road construction we chose to use RHD Flexible pavement design. Though RHD Rigid pavement design is far better than the flexible pavement, we are not using it. The main reason is the initial construction cost (country like can't afford this type of initial cost). It needs a lot of money initially to start a rigid pavement construction. Another reason is that rigid pavement takes a lot of time to gain strength. For this reason, we would have to keep the road out of service; which is not possible because of heavy demand on that road. That's why we are using Flexible pavement.

CHAPTER-12

Project Management

12.1 Work distribution

The project of upgrading the Signboard to Chashara road (R111) from 2 lanes to 6 lanes is started in 2022. This project will be carried up to 2026. It is a 5-year project. The feasibility study is started in 2022. Procurement of funding will start in the middle of 2022 and it will end in the middle of 2023. From the beginning of 2023 the tender will start; ending in the last of 2023. Detailed designing will start in the middle of 2023 and it will go on till the last of 2024. Land acquisition will start in 2024. It will take the whole 2024 to collect land for the project. The main construction will start in the middle of 2024 and it will last till the middle of 2026. After the construction it will take about 3 months to clean up the area. And after that the road will be opened for the public to use. The project ends in 2026 and road opens in the beginning of 2027.

Activity time	2022	2023	2024	2025	2026
Feasibility study					
Procurement of funding					
Tender					
Detailed design					
Land acquisition					
Construction					
Construction cleans up					
Project opening					

Table 12.1 Project Management

Procurement Procedure

Procurement encompasses all activities involved in getting the products and services required to support a company's everyday operations, including sourcing, negotiating terms, purchasing things, receiving and inspecting goods as needed, and keeping records of all phases in the process.

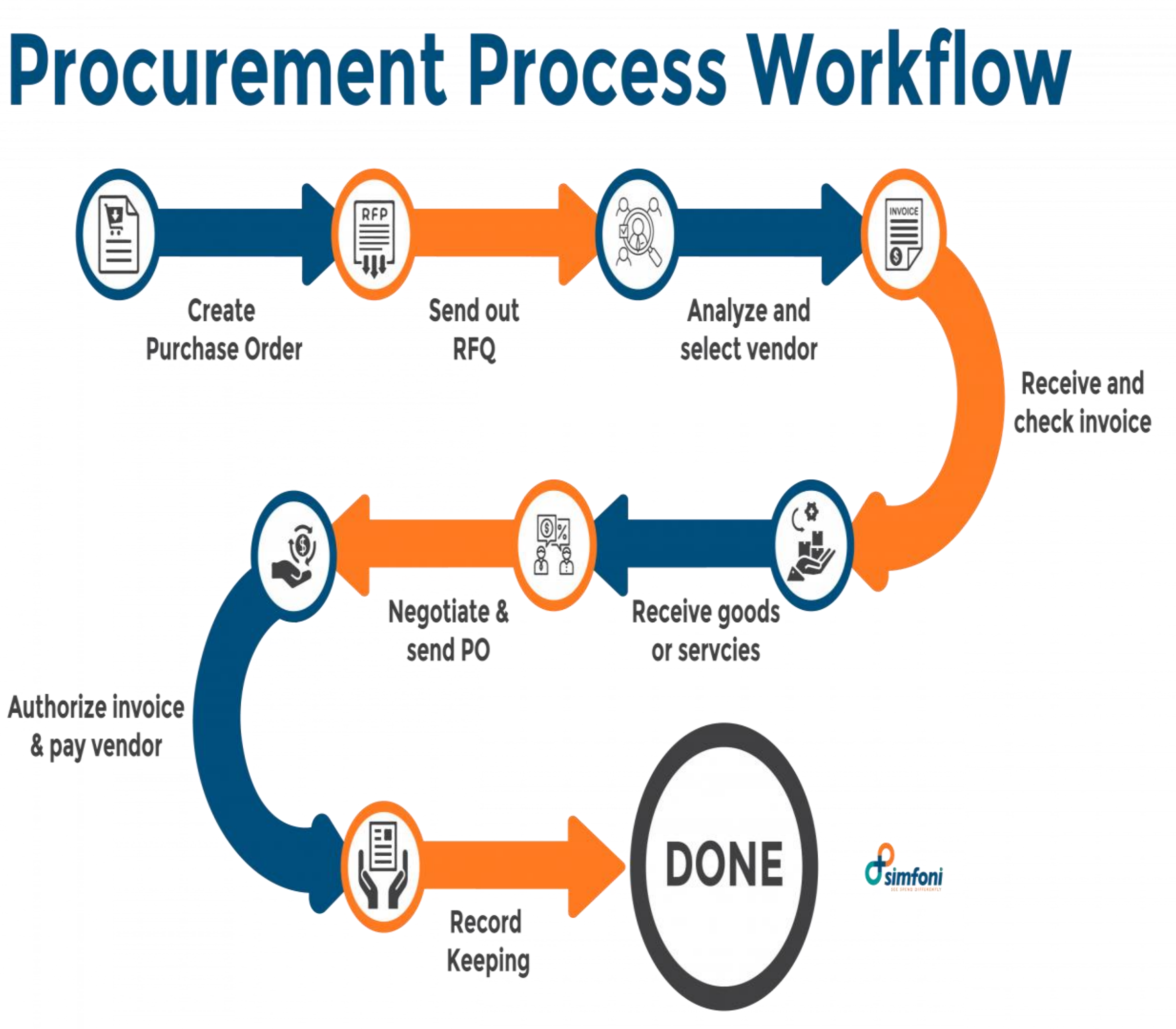


Figure 12.1 Procurement Process.
Source Simfoni [https://simfoni.com/procurement/]

CHAPTER-12

Conclusion

For feasibility study we selected the road R111, which is a regional highway. The study was to check if the up gradation from 4-lane to 6-lane was feasible or not. For both way traffic movements our AADT was 59000 veh/day. The vehicle counting method was “Manual Counting Method.” Counting period for each direction was 15 minutes. The road was 7.9 km long.

There are two curves present in the roadway. The curve radius is 500m. Our design speed is 80km/hr. We have designed the pavement in five methods. As the road is in Bangladesh, RHD is the only manual providing authority. So, RHD Flexible pavement design and RHD Rigid pavement design is the most accurate ones.

For the road construction we chose to use RHD Flexible pavement design. Though RHD Rigid pavement design is far better than the flexible pavement, we are not using it. The main reason is the construction cost. It needs a lot of money initially to start a rigid pavement construction. Another reason is that rigid pavement takes some time to gain strength. For this reason, we would have to keep the road out of service; which is not possible because of heavy demand on that road. That’s why we are using Flexible pavement.

After studying all the available aspects of the projects, we can come to a conclusion that, the up gradation of the road R111 from 4-lane to 6-lane is feasible.

Ethics

Any philosophical theory of what is morally right or wrong or morally good or bad, as well as any system or code of moral rules, principles, or values, can all be referred to as systems or codes of ethics. The term ethics can also refer to the philosophical study of the concepts of right and wrong moral behavior. The final one may be connected to specific religions, cultures, occupations, or practically any other group that is at least in part distinguished by its moral attitude.

In our project there are so many ethical issues. From construction till the road user everyone break their ethics. Some of the major ethical issues are given below:

1) Project Delay for miscalculation or careless work.

2) Use of bad materials in construction.

3) Unconsciousness of pedestrians

4) Bribing traffic police and other government officials

5) Illegal interference of the leaders in the tender.

As Engineers we have to solve above mention problems. It is not easy or on day work it takes lot of time and efforts. Some of the solution is given below:

1) If someone wants to extend the project time, he/she must show a solid response and rationalization. An audit to see if the excuse is correct or not

2) The quality of the material should be checked every time before starting the work. There will be separate people directly assigned by the government to check the materials. And if negligence is found at the end of the work, then the people appointed by the government will lose their jobs.

3) Fines should also be imposed for pedestrians if they don't follow traffic rules.

4) If the primary evidence of bribery of the government official is found, he will be suspended and if found guilty at the end of the trial, he will be sent to jail.

5) E-tendering should be done so that no one can take the work by using threats or force.

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Nuammer Ahmed (2018-2-22-030)	Acknowledgement, Abstract, Ethics, Introduction, Literature and Review, Concept of Economical Analysis
Zubaer Al Hasan (2018-2-22-013)	Method of counting, Geometric Design, Pavement Design, Level of service, Project Management.
Md Shamiul Haque (2018-2-22-011)	Safety, Noise Impact, Air Impact, Land use Impact, Cost Benefit Ratio, Conclusion