FEASIBILITY STUDY OF THE N808 FARIDPUR TOWN BY-PASS (GOALCHAMOT TO MUNSHIBAZAR) ROAD WIDENING PROJECT

CAPSTONE DESIGN PROJECT

Submitted to the Faculty of East West University

SUPERVITION UNDER

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

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Acknowledgement:

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Abstract:

The movement and use of the transportation infrastructure will expand due to the enormous growth in the number of cars. One of the solutions is to widen the roads. To determine whether or not a road widening is necessary, this study's goal is to answer that question. Then, in the context of Bangladesh, we must examine the pavement type that would be more economical and provide acceptable serviceability over time. To have a comprehensive understanding of the current pavement state and the necessary measures to be put into place, a study was conducted on the Faridpur town bypass road. In this project, two-lane roadways are expanded to four lanes. The road is 5.3 kilometers long in total.

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Chapter- 01

Introduction

1.1 Background

A country's economic structure determines how much it will develop; the transportation system is essential for national growth. The nation's economy, security, and mobility are all dependent on the National Highway System. National highways link the national capital to other divisional and former district headquarters port cities, as well as to international routes. Given their importance to the nation and their geographic locations, these routes have been designated as National Roads. To manage increased traffic development and to increase road safety, it is necessary to upgrade national highways to two or four lanes. National highways improve life in several ways by shortening your next trip.

Faridpur is one of the major districts of Bangladesh and Faridpur town bypass road is under the national highway, and for many reasons, a large amount of population and traffic flow into the city every day from different parts of the country.

1.2 Objectives of the Study

- Measuring traffic volume for our selected location
- Determine Geometric design
- For design its pavement and cost analysis
- Determine economic impact
- Determine safety of the road
- Determine noise pollution
- Determine air pollution
- To determine its land use impact

1.3 Problem Statement

The current service level of the road and the expected future road after widening will tell you if the road needs to be widened. There are several ways to design street sidewalks. In this project, the divides pavement design into two categories: rigid pavement and flexible pavement. For hard pavement, two types of pavement construction are considered. There are three possible pavement designs for flexible pavement. The best flooring design is selected based on the cost-effectiveness of each flooring. Expenses mainly consist of construction costs, repair/rehabilitation costs, and renovation costs. This advantage arises from several criteria. These come from two different types of costs. One of these is road user costs, travel time costs and vehicle operating costs. Another type is environmental pollution costs, which include noise pollution costs, vehicle emissions costs, and safety costs. Comparing all these costs in terms of the current state and expected growth state allows us to measure the benefits. Use these costs and benefits to calculate ratios and determine the best pavement design for that road.

Chapter - 02

Literature and Review

2.1 General

We have done a feasibility study on a national highway in Faridpur. We have also done the extra widening of this road. This whole project, we discuss about the overall features, design methodology, traffic volume, economic impact, safety of the road, noise pollution, air pollution etc. Some important observations have been made related to the data collection, life cycle cost of the flexible and rigid pavement, quality control system during construction of flexible pavement etc. For the data analysis, we collect some data from the RHD and AASHTO. While doing the project, we faced some problems as well.

About 2.2 million people live in Faridpur town. Their number is increasing every day. Poor traffic signals, understaffing, lack of space on the roads, and the tendency of cars to overtake each other mean a lot of time is spent on the roads, which is hurting the economy. Our goal is to analyze the pavement design of this road as well as many other things that are described below. Bypass road. Faridpur town is the fastest growing city in Bangladesh and this road will make it easier to pass through.

Design Life:

We have designed the road for 20 years. For doing this road we need to find the demand flow rate of this road. So, collect the AADT value from the Roads and Highway Department (RHD). After collecting the value, we found that our road is not in good condition now. So, we analysis this data. After analysis this data we saw that in 2019 the level of service of this road is C but in 3 years it becomes D and in 7 years it become E. That’s why we need to widen this road from two lanes to four lane. If we extend the lane of this road the road will be good for 20 years. After 20 years the road level of service is become E.

Pavement Design:

We use two type of pavement. For design this road we use flexible pavement and rigid pavement.

Flexible pavement: In this chapter, we have done our structural design by 5 methods. In flexible pavement design, we used AASHITO and RHD manual. We did not all values properly.so, some values we assumed. Most of highways in our country are flexible. Our first task for a flexible pavement is to measure the thickness of the layer, we used only 3 layers due to the good quality of our road soil. We used granular base, at the end of the process the three layers respectively D1=6", D2=8"and D3=15.5". Here we have used some Nomo graph and hand sketches. The two methods after yielded close values. So, we consider the RHD method to be more accurate.

Rigid pavement: Rigid pavement is constructed of PCC slabs resting on a prepared subbase of granular material. The load is transferred into the slabs to the underlying subgrade. The design of this pavement is a very important part of a project. Here, we have designed the rigid pavement. We have designed the pavement and found out the layers' thickness. For this design, we use two methods. One is the PCA design method, the other one is AASHTO design method. For the PCA method, we must choose a trial slab thickness. So, we chose a slab thickness of 11 inch. The design traffic volume is 73045308 trucks. Then, we take subgrade K that is 130 psi. Then, in some of the charts, we calculate the single axle and tandem axle. From the axle load, we calculate the fatigue and erosion analysis. From the total fatigue and damage, it is 80%. From that, we get the design thickness 11 inch, but this design thickness is actual or not, to find out we have designed another method, which is AASHTO method. From the charts and graphs, we get that the design thickness is 10.5 inch. So, from the two designs thickness, we take the design thickness of 10.5 inch. In Bangladesh the binder material of this pavement construction is produced. We have found that the first layer of rigid pavement is 10.5 inch, the second layer is 4 inches. This pavement provides visibility, skid resistance, a better road environment etc. It also provides safety.

Road safety:

All roads need to be safe. So, we work for the safety of this road. For safety we have to improve shoulder, remove visual obstruction, Improve Street light, Improve Horizontal Curve Friction and Delineator, and Increase the quality of the road surface. For road safety we worked for traffic signs. So, we worked for traffic rules.

Noise impact:

For the road to be constructed from 2 to 4 lanes the volume of noise will definitely increase. But if the traffic is moving according to our design speed then the noise level will be normal level. Moreover, we can create various types of barriers to prevent traffic noise pollution. If we think from the economic point of view, we have seen that if glass barriers can be made on both sides of the road, noise pollution control can be done at low cost. On the other hand the beauty of the road will increase and pedestrians will move freely.

Air Pollution:

Air pollution is a threat to the environment and affects everything like humans, animals, crops, cities, forests etc. This pollution is measured by chemical, biological, physical pollutants in the air. The reduction of the ozone layer and global warming caused by the release of greenhouse gases or. In this topic, we discuss the air pollution that is caused by transportation. We have discussed the pollutant type and sources, and the criteria of air pollutant. We estimate the pollutant emission. We also estimate the emission factor, the transportation mode with VKT etc. From the calculations, we have seen that the chemicals in the air have a great impact on the environment that comes from the vehicles. In Bangladesh, the Dhaka city has more vehicles than other part of the country and it creates the worse air pollution.

CHAPTER - 03

Level of Service

For highway portions with a minimum length of two miles, this method of determining Level of Service (LOS) is appropriate (3.22 km). Our section of the route is at mile 3.29327(5.3 km). This LOS determination method therefore works for our road segment.

Figure: Real picture of N808

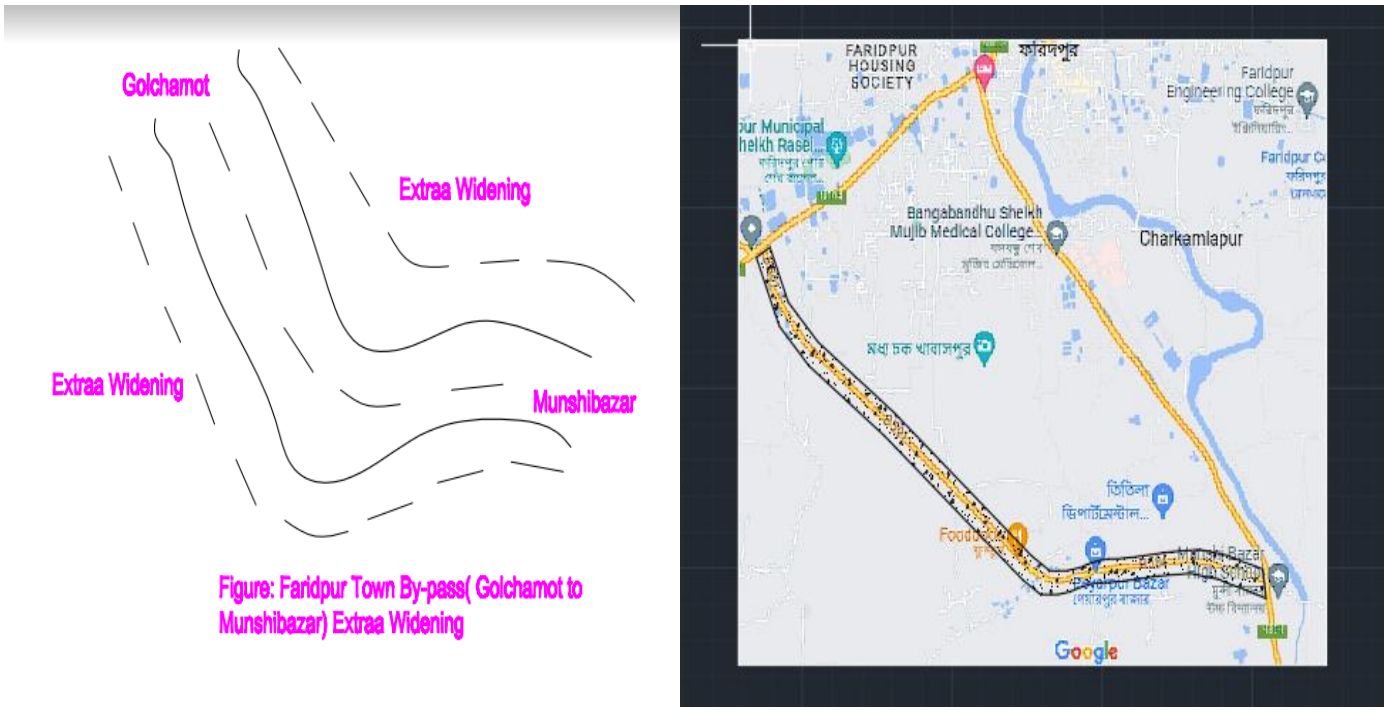


Figure: Faridpur Town By-pass(Golchamot to Munshibazar) Extraa Widening

Figure: AutoCAD Design of N808 Road

Demand Flow Rate:

Vehicle Type	Value	PCU	PCU Total
Truck	2330	3	6990
Bus	568	3	1704
Mini Bus	267	3	801
Utility	36	1	36
Car	291	1	291
Auto Rickshaw	1114	0.75	835.5
Motor Cycle	1241	0.75	930.75
Bicycle	355	0.5	177.5
Rickshaw	67	2	134
Cart	3	4	12
			12000

Table 2.4
Passenger Car Unit (PCU) Value

Vehicle Type	PCU Value
Truck	3.0
Bus	3.0
Minibus	3.0
Utility	1.0
Car	1.0
Baby taxi	0.75
Motorcycle	0.75
Bicycle	0.5
Cycle Rickshaw	2.0
Bullock Cart	4.0

So,

Demand volume for the full peak hour, V= $\frac{12000}{24} = 500$ veh/h (which is between 0-600)

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 20-9. 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

Grade adjustment factor, $f_G = 0.71$

Assuming, Peak hour factor, PHF = 0.95

Heavy vehicle adjustment factor, $f_{HV} = \frac{1}{1+P_T(E_T-1)+P_R(E_R-1)}$ Eq 1

Where.

PT = proportion of trucks in the traffic stream, expressed as a decimal;

PR = proportion of RVs in the traffic stream, expressed as a decimal;

ET = passenger-car equivalent for trucks, obtained from Exhibit 20-9 or Exhibit 20-10; and

ER = passenger-car equivalent for RVs, obtained from Exhibit 20-9 or Exhibit 20-10.

For Trucks (including buses),

To determine speed, $E_T = 1.5$

Here, proportion of trucks in the traffic stream, $P_T = \frac{8694}{12000} = 0.72$

For RVs,

To determine speed, $E_R = 1.1$

Proportion of RVs in the traffic stream, $P_R = \frac{213.5}{12000} = 0.018$

Using Eq 1, for determining speed, $f_{HV} = \frac{1}{1+0.72(1.5-1)+0.018(1.1-1)} = 0.73$

Demand flow rate, $v_p = \frac{V}{PHF*fG*fHV}$ Eq 2

Where,

V_p= passenger-car equivalent flow rate for peak 15-min period (pc/h),

V = demand volume for the full peak hour (veh/h),

PHF = peak-hour factor,

fG = grade adjustment factor, and

fHV = heavy-vehicle adjustment factor.

Demand flow rate, $v_p = \frac{V}{PHF*fG*fHV} = \frac{500}{0.95*0.71*0.73} = 1015.47$ veh/hr.

Two way flow rate = 0.5 v_P = 0.5 x 1015.47 = 507.74 pc/h

Estimating FFS:

FFS = BFFS – fLS – fA Eq 3

Where,

FFS = estimated FFS (mi/h);

BFFS = base FFS (mi/h);

fLS = adjustment for lane width and shoulder width,

fA = adjustment for access points

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

One lane = 3.65 m (13 ft.) ≥ 12 ft.

Shoulder width = 2ft ≥2 < 4 ft.

From Exhibit 20-5, Adjustment for lane width and shoulder width, fLS = 2.6

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

Total access points = 20

Total road length = 3.29327 mile

Access point per mile = $\frac{20}{3.29327}$ = 6.073 < 10

From Exhibit 20-6, Adjustment fA for access point density = 5 mi/h

Base FFS, BFFS = 28 mi/h (45 km/h)

Now From Eq 3 we get,

FFS = BFFS – fLS – fA

= 28 – 2.6 -5

= 20.4 mi/h

Average travel speed, ATS = FFS – 0.00776 v_P - f_{np}

Adjustment for percentage of no-passing zones, f_{np} = 0

Using Equation, average travel speed, ATS = 20.4 – (0.00776 x 1015.47) – 0 = 12.52 mi/h

Again,

$f_{HV} = \frac{1}{1+PT(ET-1)+PR(ER-1)} = \frac{1}{1+0.72(1.1-1)+0.018(1-1)} = 0.93$

$v_p = \frac{V}{PHF*fG*fHV} = \frac{500}{0.95*\ 0.71*0.93} = 798$ veh/hr.

So,

0.5 v_P = 0.5 x 798 = 399 pc/h

Percent time spent following, PTSF = BPTSF + $f_{d/np}$

BPTSF = 100 (1 – $e^{-0.000879xvp}$) = 100 (1 – $e^{-0.000879x798}$) =51

No passing zone 0%

EXHIBIT 20-12. ADJUSTMENT ($f_{d/np}$) FOR COMBINED EFFECT OF DIRECTIONAL DISTRIBUTION OF TRAFFIC AND PERCENTAGE OF NO-PASSING ZONES ON PERCENT TIME-SPENT-FOLLOWING ON TWO-WAY SEGMENTS

Two-Way Flow Rate, v_p (pc/h)	Increase in Percent Time-Spent-Following (%)					
	No-Passing Zones (%)					
	0	20	40	60	80	100
Directional Split = 50/50						
≤ 200	0.0	10.1	17.2	20.2	21.0	21.8
400	0.0	12.4	19.0	22.7	23.8	24.8
600	0.0	11.2	16.0	18.7	19.7	20.5
800	0.0	9.0	12.3	14.1	14.5	15.4
1400	0.0	3.6	5.5	6.7	7.3	7.9
2000	0.0	1.8	2.9	3.7	4.1	4.4
2600	0.0	1.1	1.6	2.0	2.3	2.4
3200	0.0	0.7	0.9	1.1	1.2	1.4

Directional Split = 50/50

No passing zone 0%

$f_{d/np} = 0$

No passing zone 0%

Percent time-spent-following, PTSF = 51+0 = 51%

Determining LOS:

LOS	Percent Time-Spent-Following
A	≤ 35
B	> 35–50
C	> 50–65
D	> 65–80
E	> 80

Percent tie spent following is almost 51%

So, according to table LOS is C.

Pavement Design life and traffic Growth rate

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

The future level of service was determined using the same process. According to the RHD pavement guide, a 10% traffic increase rate was taken into account for the forecast.

YEAR	LOS
1	C
3	D
7	E

The level service of in the following years is shown in the table. The figure presented a list of significant years to note. It demonstrated that, in the near future, the level of service (LOS) would deteriorate. LOS is C right now. In 3 years and 7 years, respectively, the LOS will be D and E.

Multilane Highway:

ESTIMATING FFS:

FFS = BFFS $-f_{LW}- f_{LC} - f_M - f_A$

Where,

BFFS = base FFS (mi/h);

FFS = estimated FFS (mi/h);

f_{LW} = adjustment for lane width, from Exhibit 21-4 (mi/h);

f_{LC} = adjustment for lateral clearance, from Exhibit 21-5 (mi/h);

f_M = adjustment for median type, from Exhibit 21-6 (mi/h); and

f_A = adjustment for access points, from Exhibit 21-7 (mi/h).

EXHIBIT 21-4. ADJUSTMENT FOR LANE WIDTH

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

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

EXHIBIT 21-6. ADJUSTMENT FOR MEDIAN TYPE

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

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

So,

Base FFS (mi/h), BFFS = 28 mi/h (45 km/h)

From Exhibit 21-4, adjustment for lane width, f_{LW} = 0 mi/h

From Exhibit 21-5, adjustment for lateral clearance, f_{LC} = 0 mi/h (for Four-Lane highways)

From Exhibit 21-6, adjustment for median type, f_M = 1.6 mi/h (for Undivided highways)

From Exhibit 21-7, adjustment for access points, f_A = 5 mi/h (for 20 access points)

So,

Estimated FFS = (28 – 0 – 0 – 1.6 – 5) = 21.4 mi/h

Determining flow rate for multi-lane:

We know,

$$V_P = \frac{V}{PHF*N*f_{HV}*f_P}$$

Where,

V_P = 15-min passenger-car equivalent flow rate (pc/h/ln),

V = hourly volume (veh/h),

PHF = peak-hour factor,

N = number of lanes,

f_{HV} = heavy-vehicle adjustment factor, and

f_P = driver population factor.

Here,

Hourly volume, V = 500 veh/h

Peak-hour factor, PHF = 0.95

Number of lanes, N = 4

Heavy vehicle adjustment factor, $f_{HV} = \frac{1}{1+P_T(E_T-1)+P_R(E_R-1)} = \frac{1}{1+0.72(1.5-1)+0.018(1.1-1)} = 0.73$

Driver population factor, $f_P = 1$

So,

$V_P = \frac{V}{PHF*N*f_{HV}*f_P} = \frac{500}{0.95*4*0.73*1} = 180.3$

DETERMINING LOS:

Determine the density of flow, D = $\frac{V_P}{S}$

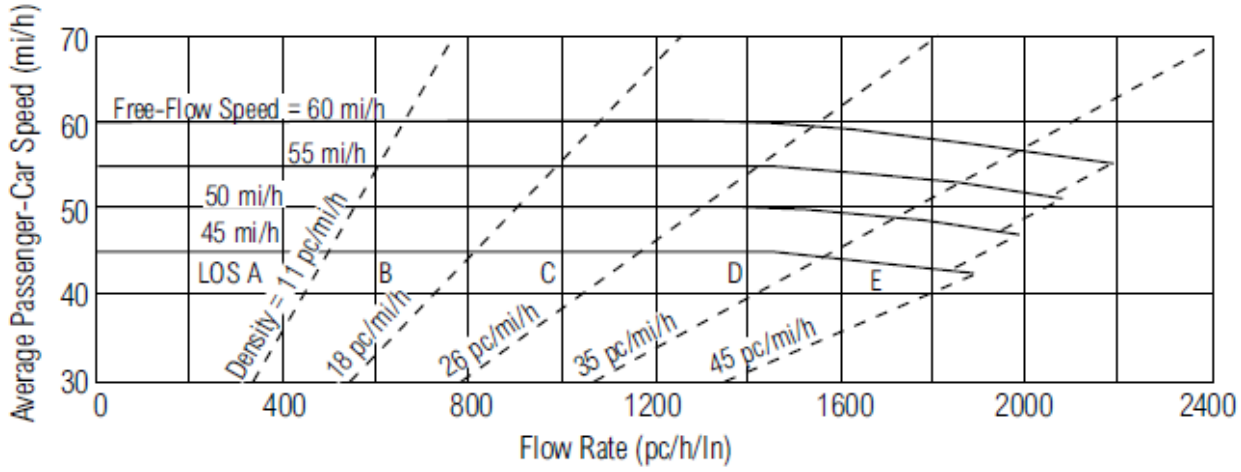
Where,

D = density (pc/mi/ln),

V_P = flow rate (pc/h/ln), and

S = average passenger-car travel speed (mi/h).

So, density of flow, D = $\frac{V_P}{S} = \frac{180.3}{28} = 6.43$



By using the graph LOS is A (Upgrade) and using the same process we found that,

Year	LOS
1	A
7	B
12	C
16	D
21	E

The key years are displayed in this table. The level of service will change to A, as indicated in the table, if the road is enlarged. Any route would benefit from having a LOS A.

In 7 years, the service level will change to B. In 12 years, LOS will become C, and in 16 years, D. RHD pavement design life is anticipated to be 20 years, as seen in figure.

After 20 years, the LOS will change to E. Hence, adding two additional lanes will be a wise choice given the LOS.

Source: HCM2000. Transportation Research Board, National Research Council Washington, D.C.2000

CHAPTER - 04

Geometric Design

According to Geometric Design Standard Manual (Revised) 2005. RHD, Type 4 is the minimal economic cost choice for a very wide range of traffic volumes. It allows most vehicles to pass with adequate clearance to avoid the need to slow down or move sideways. That's why we choose this type of road for feasibility study.

Type-1: 11m wide dual – This is a three-lane carriageway as one half of a dual 3 lane road.

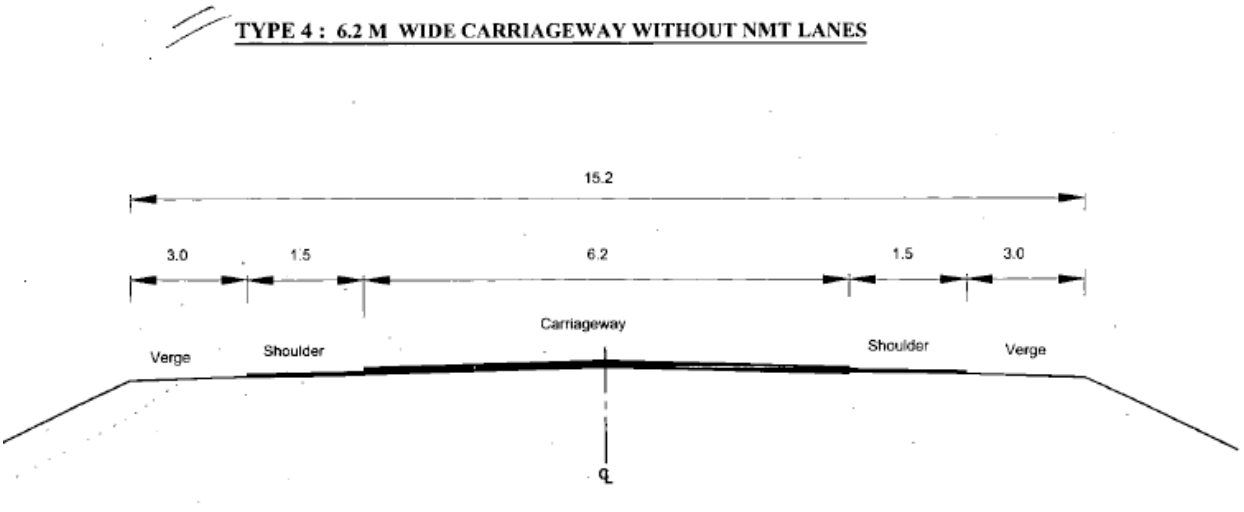
Type-2: 7.3m wide dual- This is a high standard carriageway as one half of a dual 2 lane road.

Type-3: 7.3m wide single- This is a high standard two lane single carriageway.

Type-4: 6.2m wide- This is the lowest economic cost option for a very wide range of traffic volumes. It allows most vehicles to pass with sufficient clearance to avoid the need to slow down or move aside.

Type-5: 5.5m wide- This is a minimum width two lane carriageway. Large vehicles can pass each other at slow speed. Appropriate only in constrained circumstances.

Type-6: 3.7m wide- This is the standard single lane carriageway width and is suitable for the more lightly traffic zilla roads. Vehicles travelling in opposite directions can pass each other by putting their outer wheels on the paved shoulder on either side of the pavement within optimum safe width.



Source-Geometric Design Standard Manual (Revised) 2005. RHD

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

Maximum capacity: 1900PCU/hr

Assumed NMT/MV ratio = 0.005

Assuming PCE values for,

Bicycle = 0.5

Rickshaw = 2

Car = 4

NMT = (355 ×0.5) + (67× 2) + (3×4)

= 323.5 PCU/hr

Here,

NMT 323.5 PCU/hr < 400 PCU/hr

So separate NMT lane is not required

Horizontal Curves:

Table 5.1 Minimum Curve Radii (meters)

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

Assumed,

Design Speed=80km/hr

For two lane single Carriageway Road (6.2m Carriage)

SSD= 500

ISD = 2000

OSD = 8000

Curves were selected according to SSD as such curves are clearly non-overtaken. So, curve radii is 500 m.

Table 5.2 Minimum Super-elevation Requirements (%)

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

According to table 5.2,

For sight distance 120 m and

Curve radii 500 m

Design speed is 80 km/hr

Minimum Super elevation requirement = 5%

Table 5.3 Minimum Design Transition Length (m)

Design Speed (km/h)	Super-elevation e			Straight Transition Length (m) Lc
	7%	5%	3%	
	Plan Transition Length (m) Lp			
30	25	15	10	10
40	35	20	13	13
50	45 [55]	25 [35]	15 [20]	15 [20]
65	55 [65]	35 [45]	20 [25]	20 [25]
80	65 [75]	45 [55]	25 [35]	25 [35]
100	75 [95]	55 [65]	35 [45]	35 [45]

Notes:
1. Values in brackets refer to dual carriageway roads.
2. Figure 5.1 illustrates the two types of transition Lp and Lc
3. To allow scope for future road upgrades and higher design speeds it is desirable to select Lp values for one design speed and one 'e' value larger than the values given by input.

Source : adapted from Table 7.58 and 7.59, RMSS, Vol. V11a

From table 5.3,

Lp =45m,

Lc = 25m

For curves with a 500 m radius and a 6.2 m wide two-lane road, the additional carriageway width is Nil.

So, no extra carriageway width on curve is required.

Vertical curves:

Parabolic vertical curve, K= L/A

Here,

K= length required for a 1% change of grade

L= length of vertical curve

A = change of grade in %

Table 6.1 Minimum Vertical Curve "K" Values

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	4	2	4	18	-
40	9	4	9	35	-
50	18	9	18	70	18
65	35	18	35	140	35
80	-	35	70	270	70
100	-	70	140	540	140

From table 6.1,

For Design Speed =80km/hr

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

Let,

L1 % = 5% & L2 % = -5%

A=5%-(-5%) = 10%

L = 35x 10 = 350m

Table 6.2 Vertical Curve Appearance Criteria

Design Speed (km/h)	Maximum Change of Grade Permitted Without Use of a Vertical Curve	Minimum Length of Vertical Curve for Good Appearance (m)
30	1.5	15
40	1.2	20
50	1.0	30
65	0.8	40
80	0.6	50
100	0.5	60

L = 350m > 50.

From table 6.2, L is acceptable

So, a curve length of 350m is selected.

Stopping sight distance**:**

tr = 2.5s

V= 80

Reaction distance, dr = 0.278×80×2.5 = 55.6 m

A= 3.4 m/s^2

V=80km/h

Braking distance, B_D= 0.039 × (80^2/3.4) = 73.4 m

∴ Stopping slight distance = (55.6 +73.4) = 129 m

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

= 0.04

Determination of Curve radius:

The radius of curvature, R, is the reciprocal of the curvature.

Curve radius = $\frac{a^2 + h^2}{2h}$

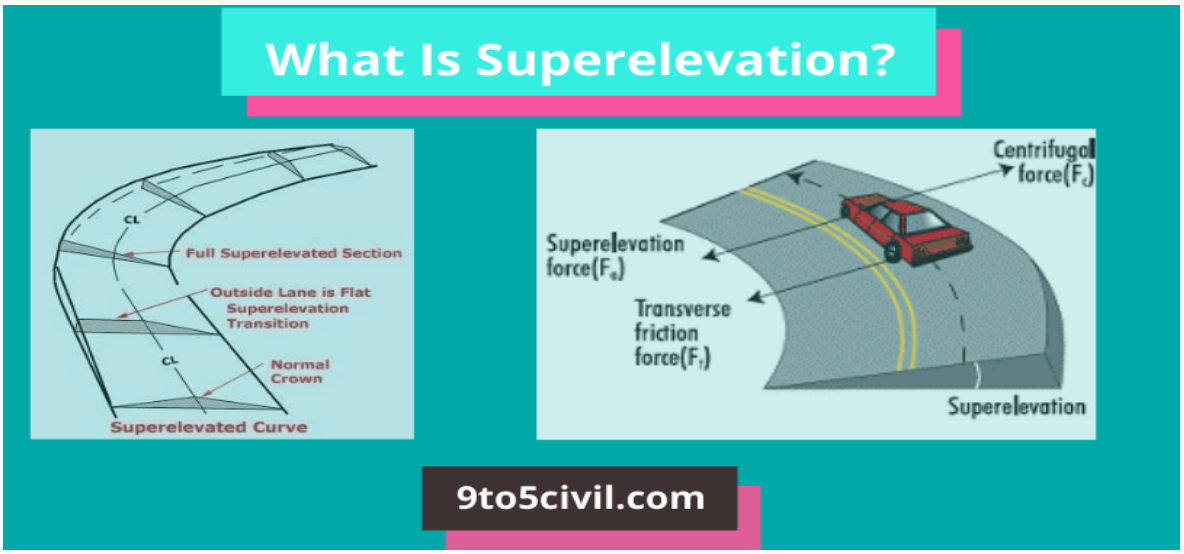
Now for radius of curvature, R = $\frac{170^2 + 49^2}{2*49}$ = 319.39 m

Where, L = 340

h = 49

a = L/2

Super-elevation:



Super elevation is tilting the roadway to help offset centripetal forces developed as the vehicle goes around a curve. Along with friction they are what keep a vehicle from going off the road.

Calculation:

$$H = \frac{Bv^2}{gR}$$

Where,

V = speed of vehicle = 80km/hr = 22.22 m/s

R = Radius of curvature

g = Acceleration = 9.8 m/s^2

B = Breath of the road

So, H = $\frac{6.2*22.22^2}{9.8*319.39}$ = 0.98 m

Chapter - 05

Structural Design

Design Analysis for flexible pavement

A flexible pavement is a structure that relies on particle friction, cohesion, and aggregate interlock for stability while maintaining close contact with and distributing load to the subgrade. Every layer takes the loads from the layer above, distributes them, and then transfers these loads to the layer below it. Therefore, a layer's load (measured in terms of force per unit area) must be carried by the pavement structure at a lower layer's depth. A flexible pavement is essentially a multilayered system.

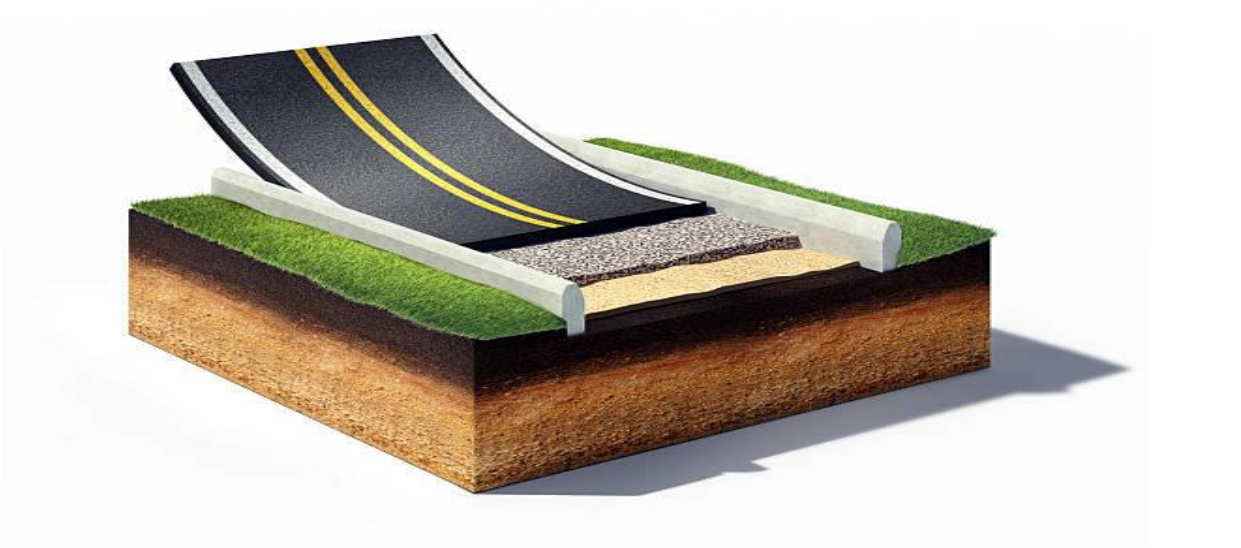


Fig: layers of flexible pavement (Google)

Sub-grade: Subgrade in transportation engineering refers to the natural material underlying a built-up road, paved surface, or railroad track.

Sub-base: subbase consist of granular materials like sand, crushed or uncrushed gravel and crushed or uncrushed slag.

Granular base: Crushed stone makes up more than 50% of the coarse aggregate particles in most granular base materials. There should be few fault 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.

Surface course: This part is the most upper part of a flexible pavement. This consist of asphalt.

(Collected from google)

Design of flexible payment based on RHD manual:

California Bearing Ratio (CBR):

It's measured as the strength of the subgrade of the road. The strength of every layer is expresses as CBR for that proper material should be used and also compaction is needed to get the expected CBR value for every layer.

Table: 5.1: Pavement Design life and traffic Growth rate

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

Table from RHD Manual.

Determining Cumulative ESAs over the Pavement Design Life:

A standard shaft is taken to be 8,160kg. Supported by shaft load studies antecedently undertaken in Bangladesh.

Table 5.2: Vehicle Equivalence Factors

Vehicle	**Equivalence Factor**
Large truck (Dual axle)	4.8
Medium truck (single axle)	4.62
Small truck	1.0
Large Bus	1.00
Mini Bus	0.5

Table from RHD Manual.

(rhd manual, 2005)

To get 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 5.3: Cumulative Growth Factors

Road Type	**Factor**
National Road	57.3
Regional Road	41.0

Cumulative ESA $=\frac{(1+r)^{2-1}}{r}$

Where r = annual traffic growth rate

N = design life in years

Note: for national roads r =10 % and foe regional roads r = 7%

Design of Flexible pavement based on RHD manual

Determining cumulative ESA_s Over the pavement Design life:

A standard shaft is taken to be 8,160 kg

Cumulative ESA = $\frac{(1+r)^n-1}{r}$

Where,

Annual traffic growth rate, r =10%

Design life in years, n = 20 years

Highway type = 4 lanes

Table:5.4 Calculating total ESA

Vehicle type	Existing flour day	ESA factors	Existing ESAS/ Day	Annual ESAs
Heavy truck	476	4.8	2284.8	83395.2
Medium Truck	1410	4.62	6514.2	2377683
Small Truck	444	1.0	444	162060
Large Bus	546	1.0	546	199290
Medium Bus	22	0.5	11	4015
Micro	267	0.5	133.5	48727.5
Car	291	0.5	145.5	53107.5
Motorcycle	1241	0.5	620.5	226482.5
Auto Rickshaw	1114	0.5	557	203305
				3358066

For National Road = 57.3

Cumulative ESA = 3358066 ×57.3

= 192,417,182

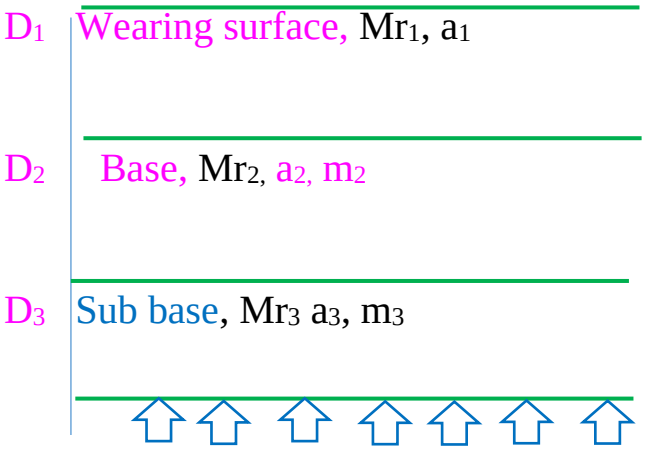
=192.42 million ESAs

mm	Surfacing (mm)		Roadbases (mm)* (Select one type)			Sub-bases (mm)** Subgrade CBR %		
Traffic ESA (mill)	Asphalt Wearing Course	Asphalt Base-Course	Cement-bound Granular	Granular Base Type I	Granular Base Type II	5	8 - 25	> 25
60 - 80	40	155	Refer to BRRL for design advice	N/A	N/A	300	150	0
40 - 60		140		250	300	250		
30 - 40		125				200		
25 - 30		110		200	250			
17 - 25		105						
15 - 17		95		175	200	175		
11 - 15		90						
9 - 11		80		150	175	150		
7 - 9		70						
6 - 7		65						
5 - 6		60						
4 - 5		55						
3 - 4		45						
< 3		35						

(rhd manual, 2005)

From thickness design table we can see that the highest value of ESA is 60-80 million ESAs but we got the higher than this for that. We cannot use this method for higher traffic volume because this method is applicable for low volume.

AASHTHO method for flexible pavement



Growth factor = (1+g) ^n/g

= (1+0.1)^20/0.1

= 67.27

Table: 5.5(ESAL Calculation)

Vehicle type	Current AADT(A)	Growth Factor	Forecasted Traffic(C)	ESAL Factor	Forecasted ESAL
Truck	1886	67.27	15580.889	0.8646	9062100822
Bus	568	67.27	3821.21	0.0021	539.810
Car	291	67.27	1957.70	0.008	1053.5582
Pickup	444	67.27	298700	0.0122	2451.4129
Covert van	267	67.27	1796.242	0.6560	79266.578
					9062184193.36

Directional Distribution = 0.5

Lane Distribution = 0.9

Therefore, design ESAL = 9062184193*0.5*0.9

=16.32*10^6 kip

*a_1, a_2, a_3 – larger co – efficient – depends on – material poverty

*m_2, m_3 – drainage co - efficient

Base → Treated

Base → Granular

For bituminous treated base, $a_2 \rightarrow$

If, ESAL = 16.32×10^6

R= 95% (assume)

S=0.35 (assume)

ΔPSI = 2.1

Now, D_1, D_2, D_3 =?

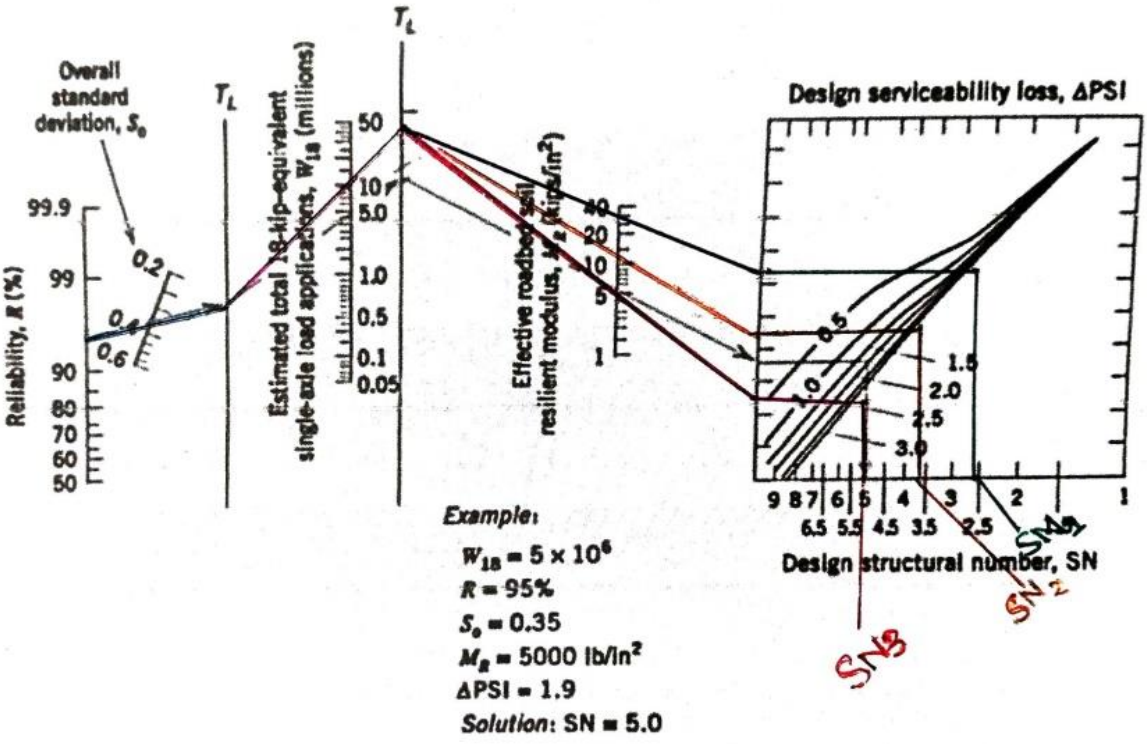


Figure 4.5 Design chart for flexible pavements based on the use of mean values for each input.

Redrawn from *AASHTO Guide for Design of Pavement Structures*, Washington, DC, The American Association of State Highway and Transportation Officials, 1993. Used by permission.

Calculation D1 (EM1 = 4000,000 Psi, So, a, = 0.42 from (Fig: 2.5)

Here, Mr = 250000 Psi

$\Longrightarrow SN_1 = 2.5$ (From fig -4.5)

$\therefore D_1 = \frac{SN_1}{a_1} = \frac{2.5}{0.42} = 5.95$ inches = 6″

Calculating D_2

Here, M_R = 100000 Psi, So, a_2= 0.13

$SN_1 = D_1 \times a_1 = 6 \times 0.42 = 2.52$

$$D_2 = \frac{SN_2 - SN_1}{a_2 m_2} = \frac{3.6 - 2.52}{0.13 \times 0.95} = 7.89\ inches\ \cong 8''$$

[∴ Granular base – CBR- 70%

Drainage quality –fair, Moisture content 10 % (assume)

Then use table: 2.4 and by interpolating we get, m_2 = 0.95

Now, SN_2 = 3.6 (From fig-4.5)

$SN_2 = D_2 * m_2 * a_2 + SN_1$

$$D_3 = \frac{SN_3 - SN_2 - SN_2}{a_{3m_3}} = \frac{6.5 - 2.52 - 3.5}{0.03 \times 1.05} = 15.24^{"} \cong 15.5^{"}$$

MR = 45000Psi; Form figure, 4.5 ⟹

SN_3=65

a_3 = 0.03 (Fromfig-27) MR = 10,000 Psi, CBR = 5% (assume)

m3 = 1.05 from fig – (2.4)

- Drainage – Fair;
- Moisture content = 5% of time saturation level

Check:

Given, ESAL → 16.32×10^6. From table for greater

Minimum thickness 4.0″. And Base 8″. We get, D_1 = 6″ and D2 =8″. So, our Design is ok.

Slope: 2.5%

= (14630.4/2+1900)*0.025

= 230.38mm

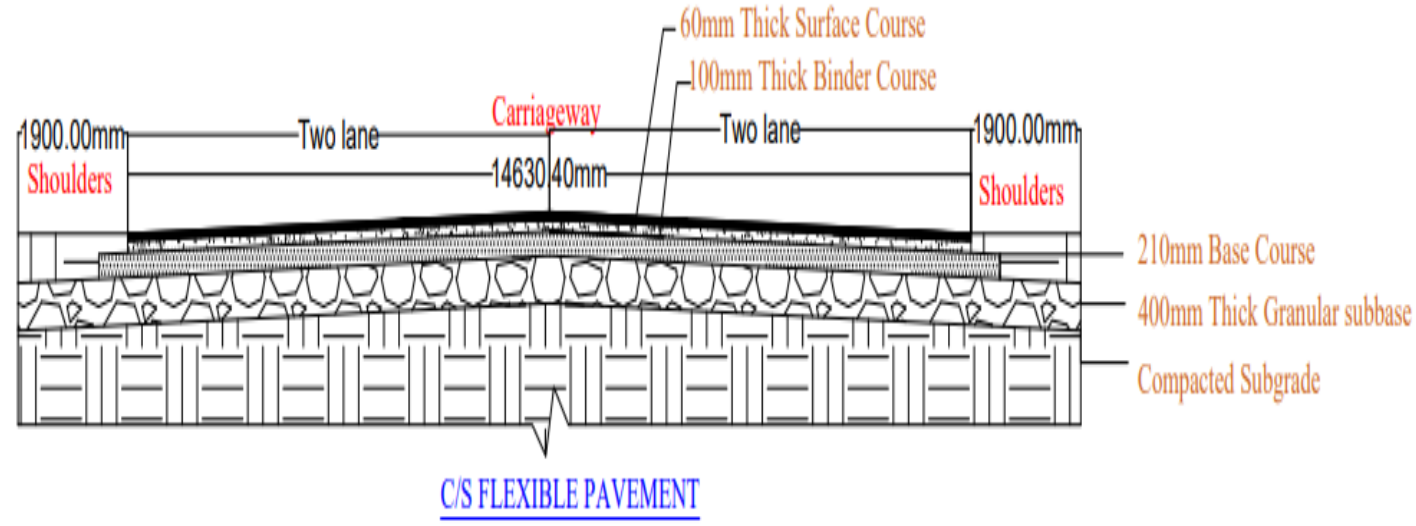


Fig: Cross Section of Flexible Pavement

Flexible Pavement design (Catalogue of pavement structures method)

Design flexible pavement for and undivided rural highway by using catalogue of pavement structures.

Method for the following data:-

Vehicle Type	AADT
Large Truck	476
Small Truck	444
Large Bus	546
Small Bus	267
Car	291
Auto Rickshaw	1114
Motor cycle	1241
Bicycle	355
Cart	3
Rickshaw	67

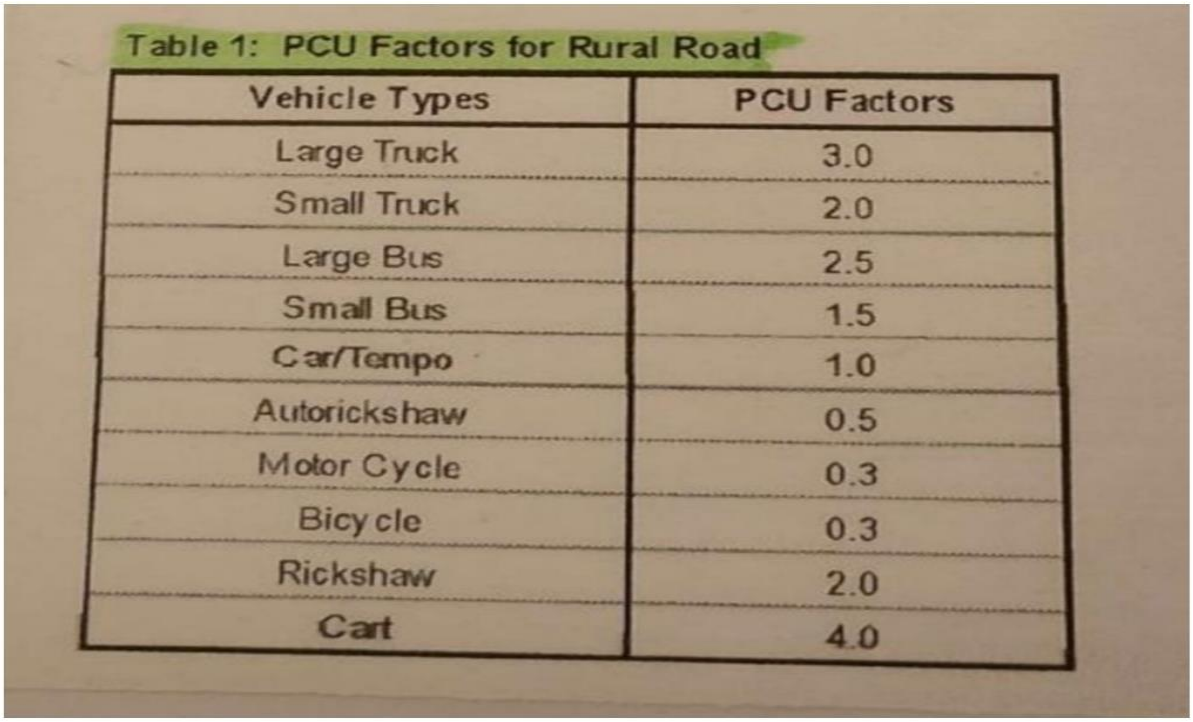


Table 1: PCU Factors for Rural Road

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

Solution:

Vehicle Type	AADT	PCU Factor	Traffic Volume X Pcu factor
Large Truck	476	3.0	1428
Small Truck	444	2.0	888
Large Bus	546	2.5	1365
Small Bus	267	1.5	400.5
Car	291	1	291
Auto Rickshaw	1114	0.5	557
Motor cycle	1241	0.3	372.3
Bicycle	355	0.3	106.5
Cart	3	4	12
Rickshaw	67	2.0	134
			Total = 5554.3

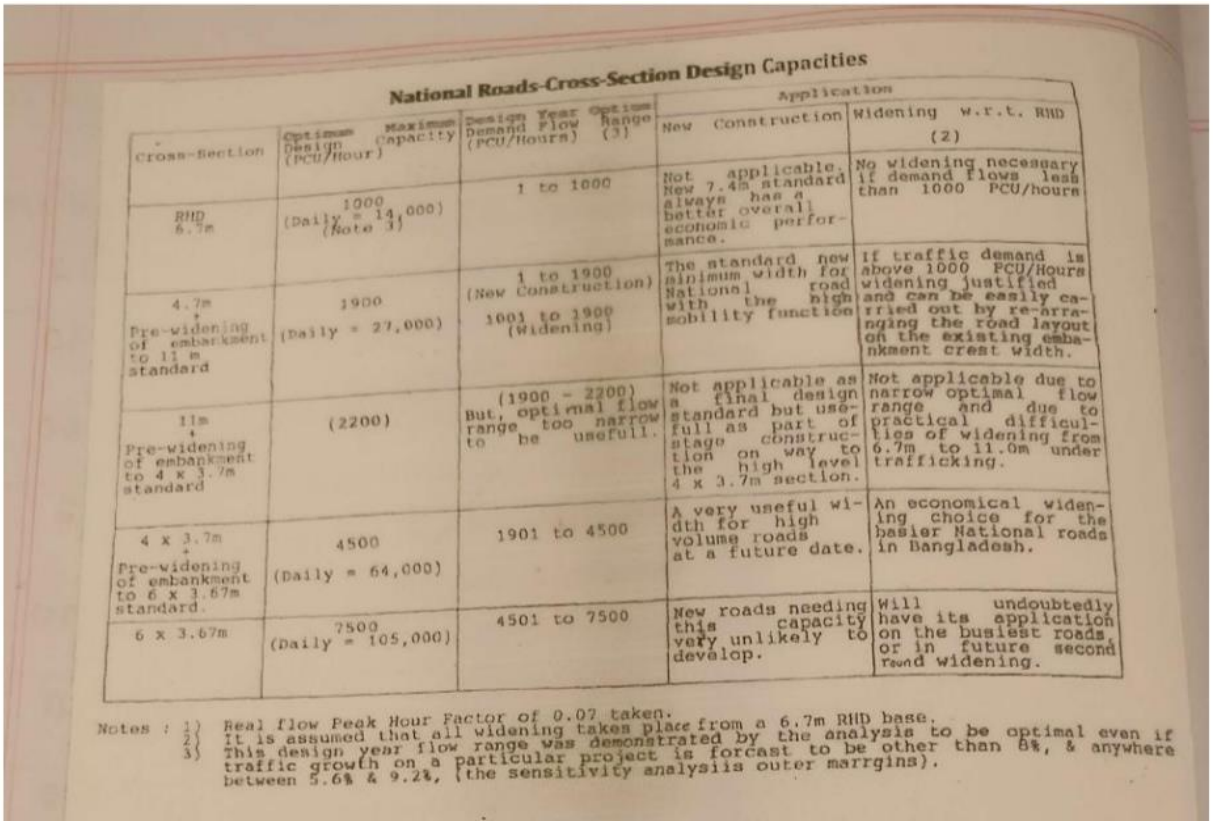
Forecasted design flow in (2039) (after 20 years) = 5554.3× (1+r) ^n

= 5554.3× $(1+0.1)^{20}$

= 37366.55297 Pcu/day

= 38,000 Pcu/day

From National Road – Cross Section Design capacities



National Roads-Cross-Section Design Capacities

Cross-Section	Optimum Design Capacity (PCU/Hour) Maximum	Design Year Optimum Demand Flow Range (PCU/Hours) (3)	Application: New Construction	Application: Widening w.r.t. RHD (2)
RHD 6.7m	1000 (Daily = 14,000) (Note 3)	1 to 1000	Not applicable. New 7.4m standard always has a better overall economic performance.	No widening necessary if demand flows less than 1000 PCU/hours
4.7m + Pre-widening of embankment to 11 m standard	1900 (Daily = 27,000)	1 to 1900 (New Construction) 1001 to 1900 (Widening)	The standard new minimum width for National road with the high mobility function	If traffic demand is above 1000 PCU/Hours widening justified and can be easily carried out by re-arranging the road layout on the existing embankment crest width.
11m + Pre-widening of embankment to 4 x 3.7m standard	(2200)	(1900 - 2200) But, optimal flow range too narrow to be usefull.	Not applicable as a final design standard but useful as part of stage construction on way to the high level 4 x 3.7m section.	Not applicable due to narrow optimal flow range and due to practical difficulties of widening from 6.7m to 11.0m under trafficking.
4 x 3.7m + Pre-widening of embankment to 6 x 3.67m standard.	4500 (Daily = 64,000)	1901 to 4500	A very useful width for high volume roads at a future date.	An economical widening choice for the basier National roads in Bangladesh.
6 x 3.67m	7500 (Daily = 105,000)	4501 to 7500	New roads needing this capacity very unlikely to develop.	Will undoubtedly have its application on the busiest roads, or in future second round widening.

Notes : 1) Real flow Peak Hour Factor of 0.07 taken.
2) It is assumed that all widening takes place from a 6.7m RHD base.
3) This design year flow range was demonstrated by the analysis to be optimal even if traffic growth on a particular project is forcast to be other than 8%, & anywhere between 5.6% & 9.2%, (the sensitivity analysiis outer marrgins).

(A)From the manual of geometric Design standards: -

Road class = National category

Road width = 4×3.7 m = 14.8 m

Shoulder width = 14.8-11 = 3.8 m (total)

(B) Determination of cumulative ESAL for pavement Design: -

ESAL per Vehicle

Vehicle type	**ESAL Per veh**
Large Truck (10 – wheeler)	4.80
Medium truck (6-wheeler)	4.62
Small truck (4- wheeler)	1.00
Large Bus	1.00
Small Bus	0.50

Considering damaging effect, only heavy vehicles are take into account

Table: 5.6

Heavy Vehicle Types	**Two-way AADT**	**EASL per Vehicle**	**Cumulative ESAL**
	VPD	**Table 2**	**$365\times AADT\times EASL\times\frac{(1+r)^n-1}{r}$**
Large Truck	476	4.80	47764600.38
Small Truck	444	1.00	9281986.418
Large Bus	546	1.0	11415331.2
Small Bus	267	0.5	2791111.2
			Total = 71,253,029.2

Total cumulative ESAL in both direction = 71253029.2

Total cumulative ESAL in one direction

= Directional distribution ×71253029.2

= 0.5×71253029.2

= 35626514.6

Determination of the channelization factor

The proportion of non-motorized traffic to heavy vehicle

$$P = \frac{1114 + 1241 + 355 + 3 + 67}{476 + 444 + 546 + 267 + 291}$$

= 1.37

= 1.4

From table – 3

Channelization factor = 1.6

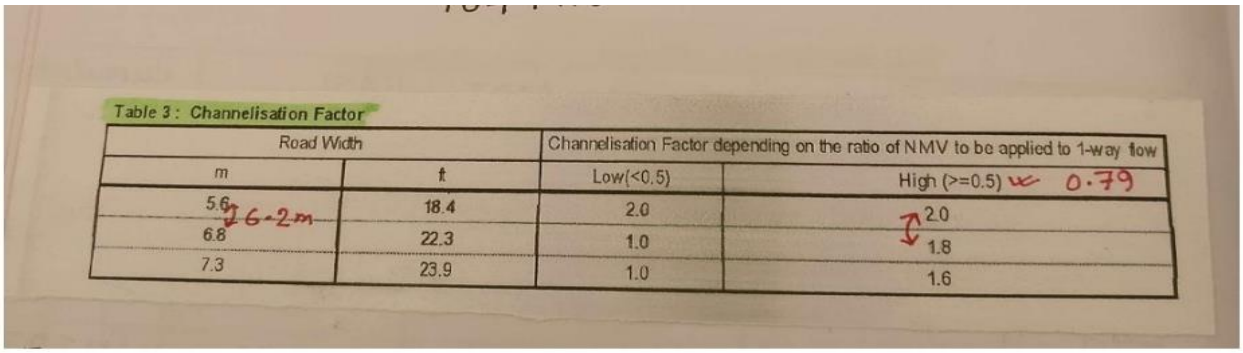


Table 3 : Channelisation Factor

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) ≈ 0.79
5.6	18.4	2.0	2.0
6.8	22.3	1.0	1.8
7.3	23.9	1.0	1.6

Design cumulative traffic = Total cumulative traffic in one direction × channelization faction

= 35626514.6×1.6

= 57002423.36 ESA

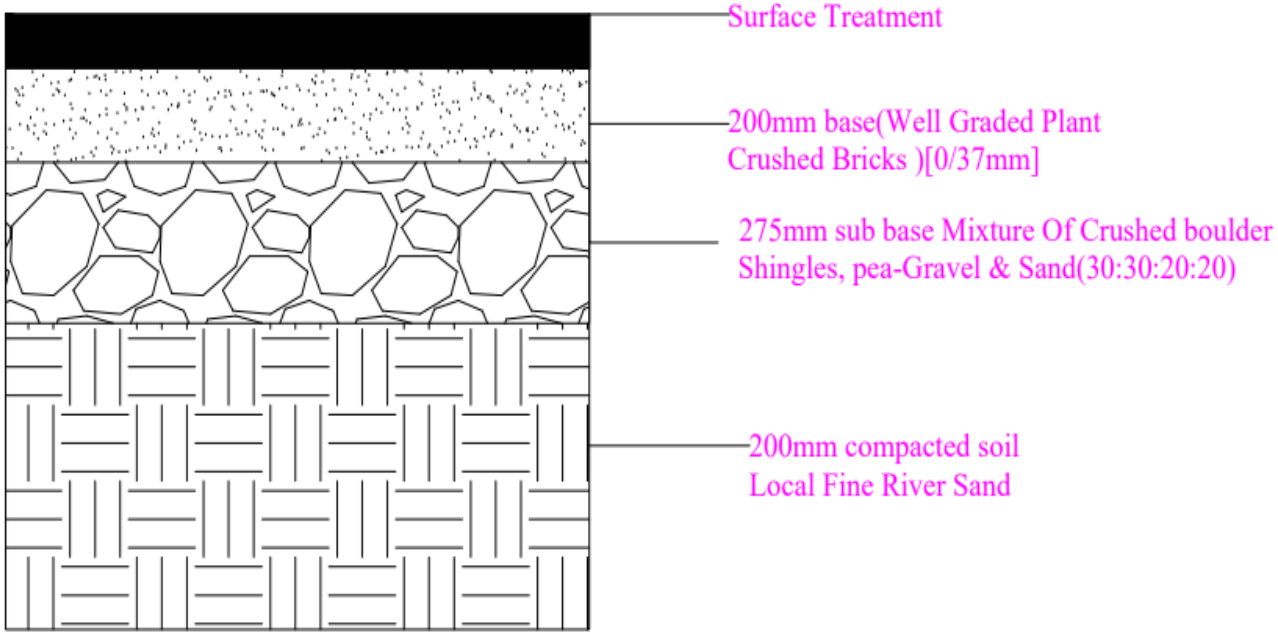
= 5.7 MSA

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

32

From Table:
Catalogue for pavement type - 3
Subgrade definition, S2 = (CBR 5%)



We have use Granular base and surface base is bituminous.

Advantage of Flexible pavement:

Flexible pavements, also known as asphalt pavements, respond flexibly to traffic loads, minimizing their vulnerability to damage and requiring infrequent maintenance. The pavement's multi-layered structure, composed of several materials, enables the road to withstand this flexing. So, major roadway engineer chose this pavement system. Flexible pavement requires regular maintenance, but it is fairly easy to do. Some important points are given below:

1. This pavement is essentially a system with multiple layers.
2. It has low flexural strength.
3. Though this pavement itself is very strong, it was constructed on loose and poor subgrade and it can fail.

Disadvantage of Flexible pavement:

As flexible pavement has some good advantages besides it has some bad disadvantage. Here is given below:

- In the summer, the bitumen gets soft when the temperatures are high. This causes the sidewalk to lead, rut, and separate before it breaks.
- The bitumen becomes brittle in the winter because of the cold, resulting in cracking, raveling, and uneven pavement.
- Water seeps through the pavement during the rainy season, occasionally leading to the complete loss of the bituminous layer and creating pothole.

1. Joint Reflection cracking.
2. Cold joints in flexible pavements.
3. Bumps and sags
4. Block cracking in flexible pavement. This is also called as thermal cracking.

Figure: Real picture of N808 (this is an actual flexible pavement)

Pavement Design for Rigid Pavement:

Rigid pavements are structured of Portland Cement Concrete (PCA) slabs laying on a prepared subbase of granular material. By flexure of the slabs, the load is transmitted through the slabs. The layers of this pavement are.

Subgrade: subgrade can be earth or soil. It is the base layer of the pavement.

Subbase: it can be hard earth or stone. This part is just over part of subbase layer. This part is not mandatory to give.

Base course: this part consists of granular crushed stone or chip stone.

Concrete slab: this part is RCC structure. This is the top of all the layers.

PCA Design Method:

Two types of failure:

1. Fatigue failure
2. Erosion failure

Design Parameters:

1. Axle Load Spectrum
2. Modulus of subgrade reaction (k)
3. Design traffic volume
4. Concrete modulus of rupture (MR

Design Procedure:

- Choose a trial slab thickness.
- Calculate the fatigue and erosion failure.
- Sum of fatigue and erosion failure of the axle load classes.

We have AADT value our AADT is 6272 we assume the data was collected at the month of august for that we can now calculate ADT which is AADT/MEF = 6272/0.521 = 12038.38772

Percentage of Truck Determination:

Vehicle Type	AADT	Percentage
Large Bus	546	11
Minibus	22	0.18
Private Car	291	2.4
Motorcycle	1241	10.3
CNG	276	2.3
Micro	267	2.2
Truck	2330	19
Total	4973	

Growth Rate: 10%

Design Year: 20 years

Direction Distribution factor: 0.5

Clay sub-grade, k = 100 psi/in (assume)

Concrete MR = 650 psi (assume)

Use subbase = 4" untreated (assume)

Use Doweled JPCP and Asphalt shoulders.

Traffic Growth Multiplier:

G = $(1+r)^{y}/_{2}$ = 2.64

Lane Distribution Factor: (ADT)*(D)*(G) = 8816.420*0.5*2.64 = 11637.6744 (two way)

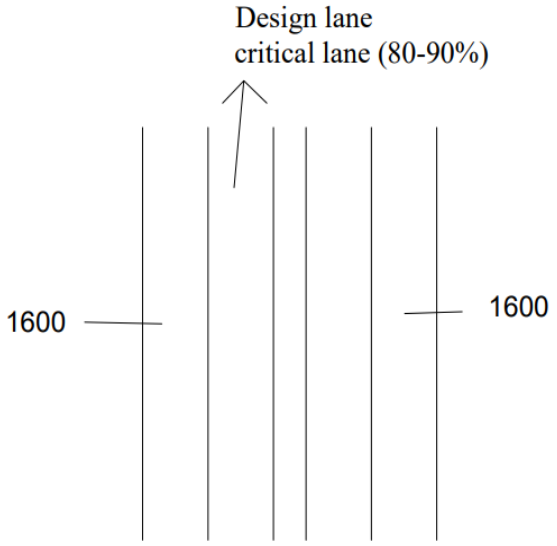
The design ADT= 12,038*1.5= 18,057.57 Vehicles per day

The AADT = 6272*0.51 = 3198.72

Truck Traffic Each way, direction distribution = 3198.72/2= 1599

For design lane and a design period of 20years = 1600*0.85*365*20= 9928000=9.9x10^6

We assume design thickness= 9.5 in



Design Traffic Volume:

V = 365* (ADT)*(T)*(L)*(G)*(Y)*(D)

= 365*11637.6744*11*8816.420*2.64*20*0.5

= 10875467 Truck

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

Table: Design K value for untreated subbase

When

Subgrade K = 100 psi

Untreated subbase: 4 in

So, the subgrade k value from table is: 130 psi

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

Table : Load safety Factor

For high volume (interstates, multilane highways), The load safety factor LSF = 1.2. As our road is national highway, so we can get the LSF 1.2. For both axles, Subbase subgrade k = 130 psi. We can assume, slab thickness = 9.5 inch

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

Slab thickness, in.	*k* of subgrade-subbase, pci k = 130 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

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

Single Axle:

- Equivalent Stress: 206 (Using Interpolation)
- Stress Ration Factor: 0.32
- Erosion factor: 2.59

Tandem Axle:

- Equivalent Stress: 192
- Stress Ration Factor: 0.295
- Erosion factor: 2.79

From the traffic data calculation, we can estimate the total 20 years expected repetitions of various axle loads. The calculate data from the traffic volume are**,**

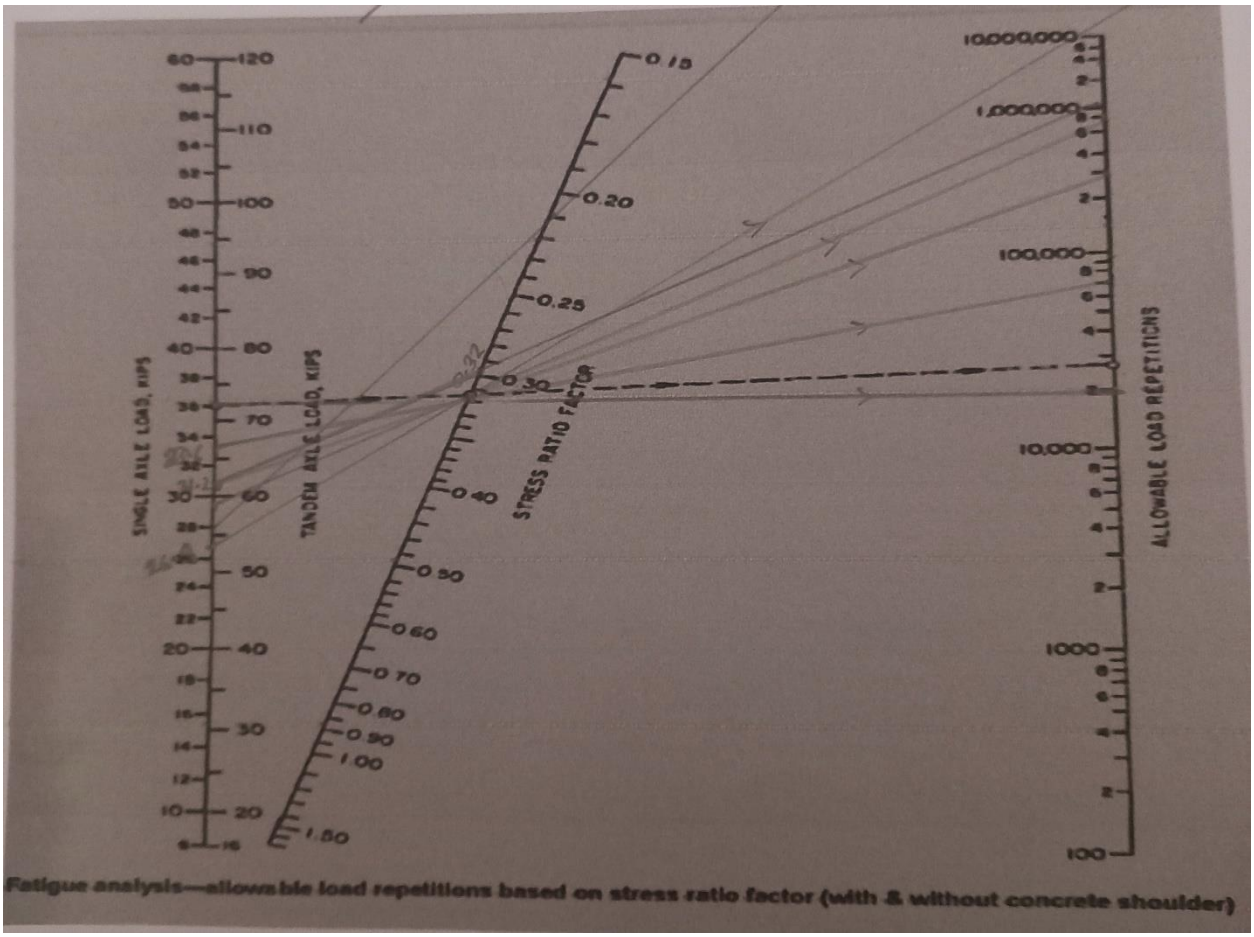


Fig: Fatigue Analysis

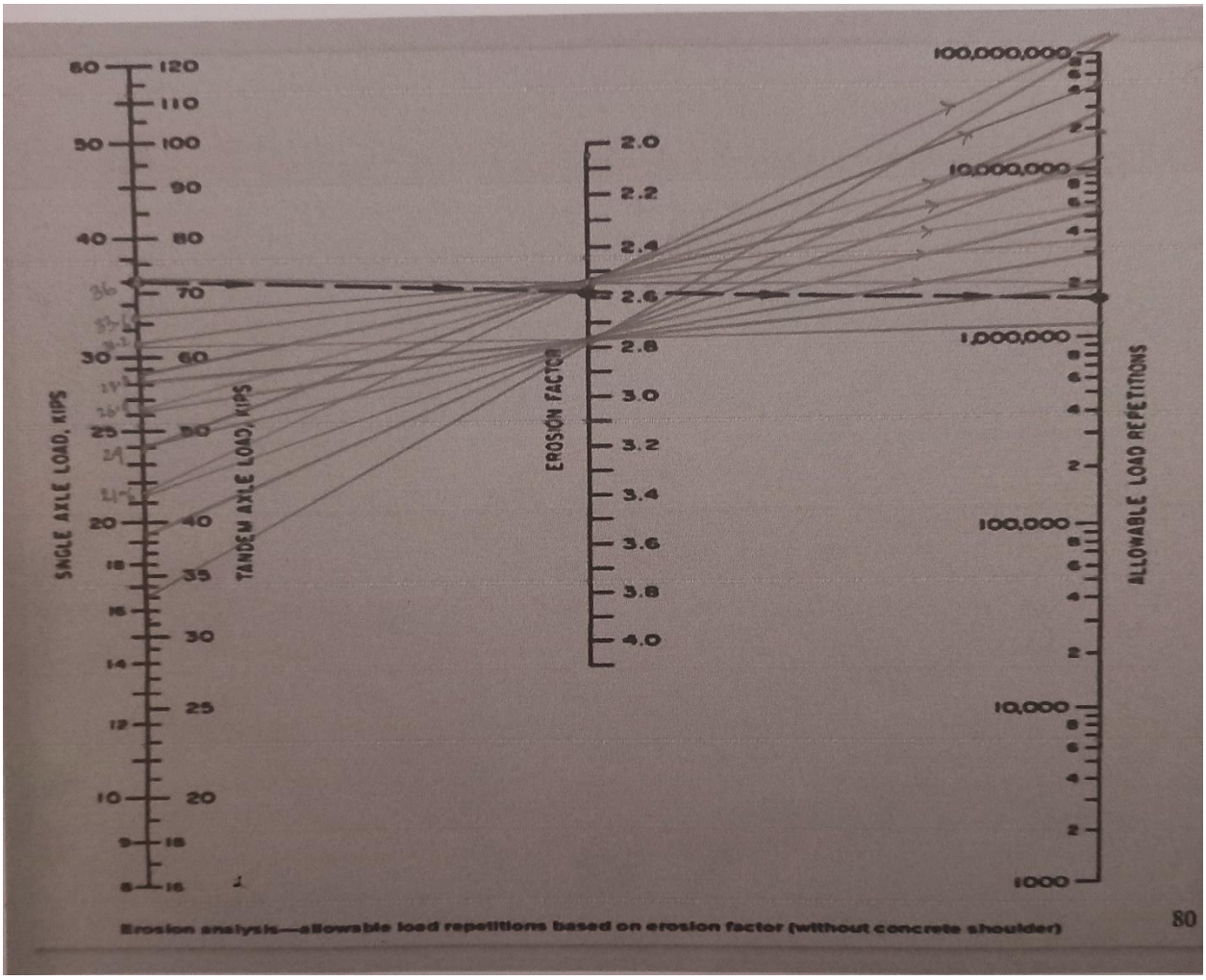


Fig: Erosion Analysis

Table: Single Axle Load

Axle load kips	LSF	Multiplied by LSF	Expected repetition	Fatigue Analysis		Erosion Analysis	
				Allowable repetitions	Fatigue Percent	Allowable repetitions	Fatigue percent
30	1.2	36	9563.4	20000	47.8	2000000	0.4
28	1.2	33.6	10519.74	380999	1.2	3800000	0.2
26	1.2	31.2	11571.714	8000000	3.03	6000000	0.1
24	1.2	28.8	12728.88	unlimited	0.2	10000000	0.2
22	1.2	26.4	14001.77	unlimited	0	10900000	0.1
20	1.2	24	15401.95	unlimited	0	50000000	1.1
18	1.2	21.6	16942.14	unlimited	0	unlimited	0
				Total	52.23		2.1

Table: Tandem Axle Load

Axle load kips	LSF	Multiplied by LSF	Expected repetitions	Fatigue Analysis		Erosion Analysis	
				Allowable repetitions	Fatigue percent	Allowable repetitions	Damage percent
52	1.2	62.4	24804.99	1000000	2.4	1110000	2.3
48	1.2	57.2	27295.49	Unlimited	0	2000000	2.6
44	1.2	52.8	30014.04	Unlimited	0	3000000	1.0
40	1.2	48	33015.45	Unlimited	0	5100000	6.4
36	1.2	43.2	3631699	Unlimited	0	10100000	3.6
32	1.2	38.4	4394356	Unlimited	0	29000000	15.1
28	1.2	30.6	4833792	Unlimited	0	Unlimited	0
				Total	54.63%		33.1%

Comments:

Total Fatigue and Damage = Fatigue % + Damage %

= 54.63% + 33.1%

= 87.73%

Which is acceptable, therefore design thickness = 9.5 inch

Which is acceptable, therefore design thickness = 9.5 inch

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.

- If total fatigue and damage was >>100%;

  thickness was under-estimated. As such, 2nd

  trial would have been needed with increased thickness.

AASHTO Rigid Pavement Design:

$$\log_{10} W_{18} = Z_R S_o + 7.35\left[\log_{10}(D+1)\right] - 0.06 + \frac{\log_{10}\left[\Delta PSI / 3.0\right]}{1+\left[1.624\times10^7 / (D+1)^{8.46}\right]} + (4.22 - 0.32TSI)\log_{10}\left(\frac{S_c' C_d\left[D^{0.75} - 1.132\right]}{215.63J\left\{D^{0.75} - \left[18.42/(E_c/k)^{0.25}\right]\right\}}\right) \quad (4.4)$$

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 subgrade reaction K is = 200 lb/ 〖in〗^3

Here,

Z_R= - 1.645

S_0= 0.29

ΔPSI = 2.1

〖S'〗_c= 650 lb/〖in〗^2

C_d=1

J=3.2

E_c = 3.6 million

R = 95%

K= 200

From this information, we can calculate w_18=9.9 X 10^6. From our given traffic data, we estimate the W_18=9.9 x10^6.

$$\log_{10} W_{18} = Z_R S_o + 7.35\left[\log_{10}(D+1)\right] - 0.06 + \frac{\log_{10}\left[\Delta PSI / 3.0\right]}{1+\left[1.624\times10^7/(D+1)^{8.46}\right]} + (4.22-0.32TSI)\log_{10}\left(\frac{S_c' C_d\left[D^{0.75}-1.132\right]}{215.63J\left\{D^{0.75}-\left[18.42/(E_c/k)^{0.25}\right]\right\}}\right)$$

W_18 = 9.9X 10^6

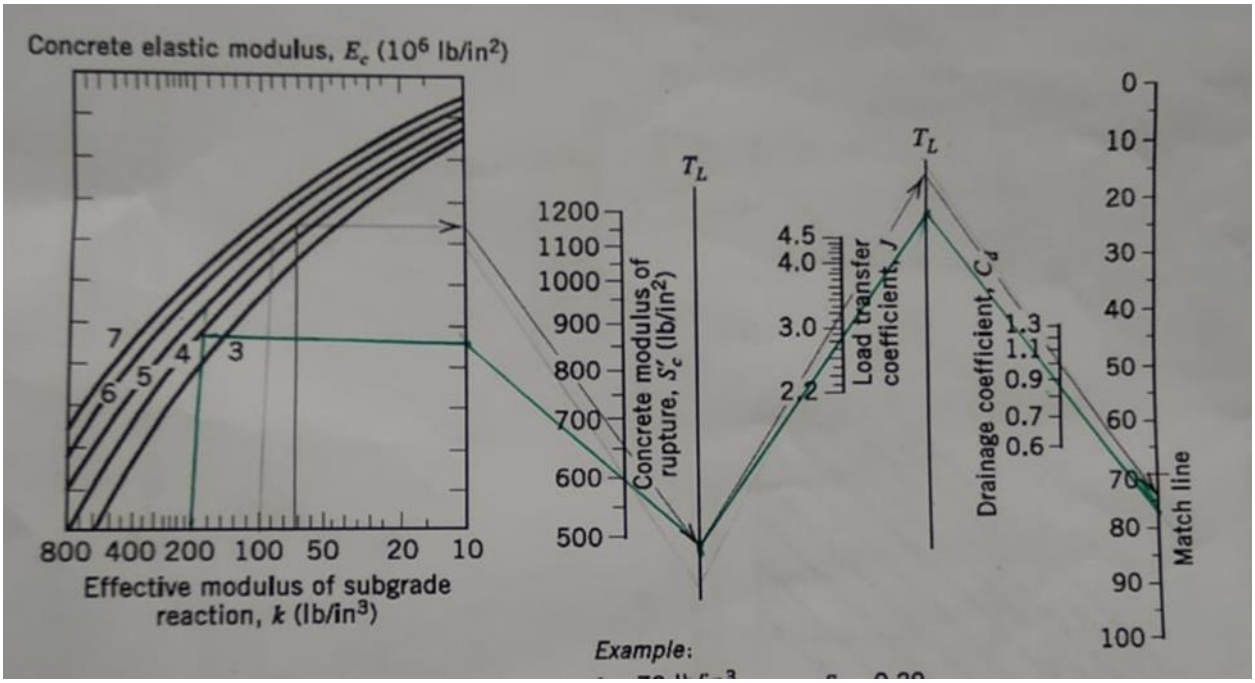


Figure: Design chart for rigid pavement

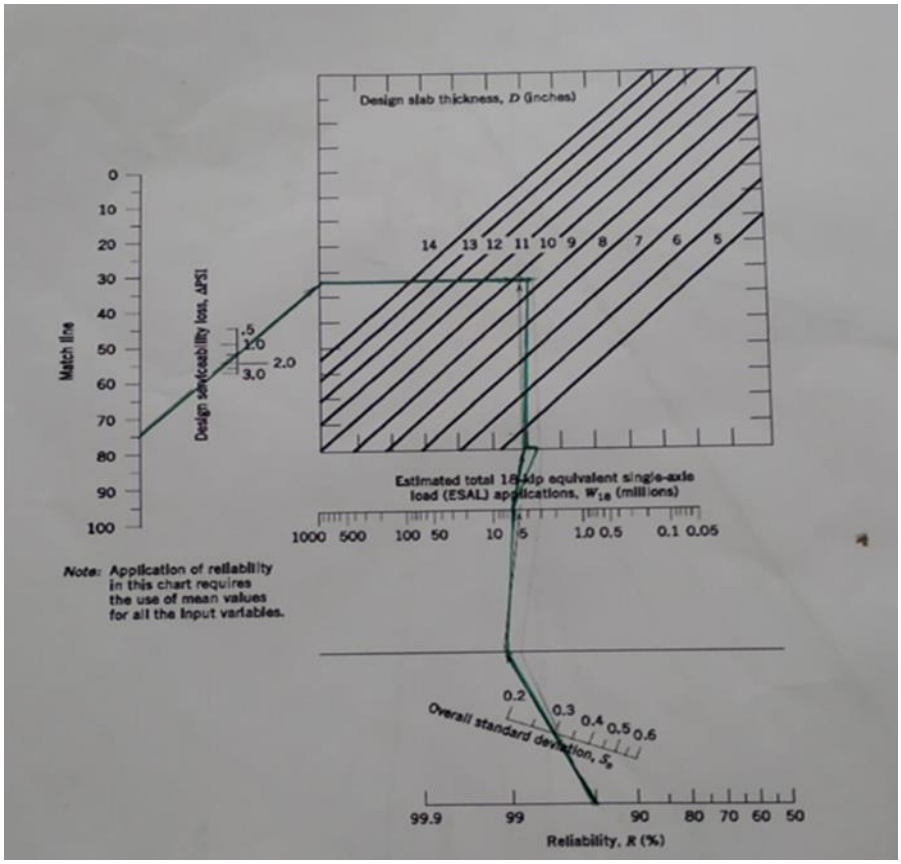


Figure: Design chart for rigid pavement

So, from the nomograph we can get D = 10.5 inch

So, we get the rigid pavement layer thickness from these designs;

Table: Relative Thickness of Rigid Pavement

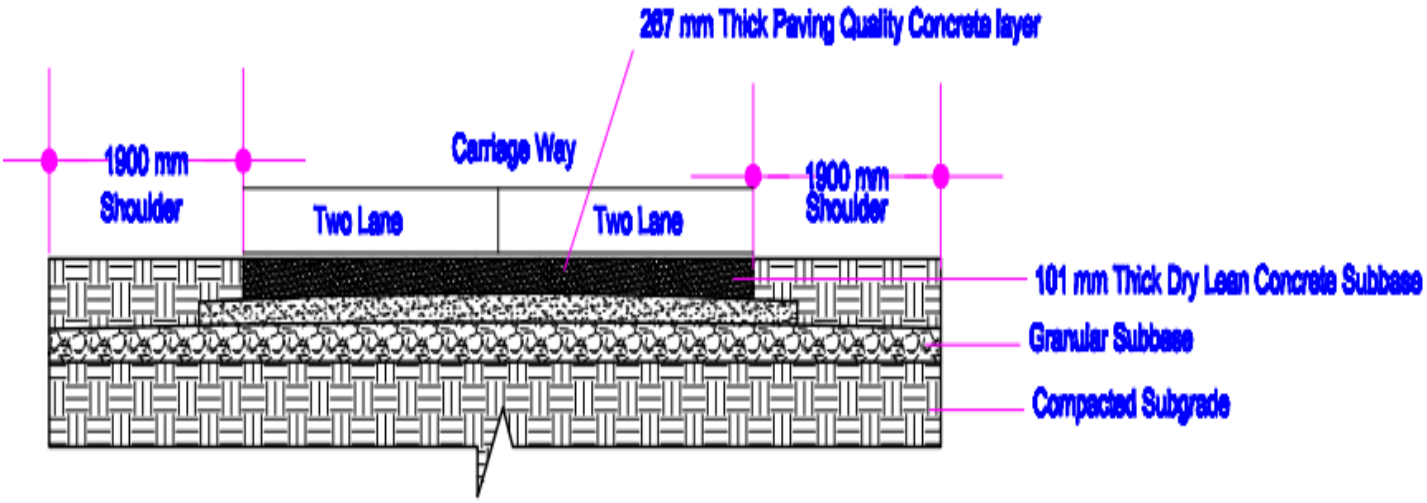
Cement Concrete Pavement (20 years)	
Cement Concrete Slab	267mm (10.5 inch)
Base Course	101mm (4 inch)

Usefulness of Rigid Pavement:

Since rigid pavement consists of RCC work, it remains more durable over the time. It does not bend for heavy load and regular maintenance is not necessary and it is less expensive.

Disadvantages of Rigid Pavement:

Since it is RCC work, curing time is 28 days so that road remains off for a long time.



Cross Section of Rigid Pavement

Chapter - 06

Road Safety

Introduction:

Road safety refers to the steps taken to lower the risk of traffic-related fatalities and injuries. There are an estimated 1.3 million fatalities and 50 million injuries annually due to car accidents around the world. In low- and middle-income nations, more than 85% of these fatalities and 96% of all child fatalities take place. Road user error is the major cause of road accidents. Road safety is an important agenda for every country.

Road Accident has different classification like fatality and injury. Fatalities can be defined as deaths that occur within 30 days of RTA. Injuries are not any major issues but require some medical treatment but not hospitalization. Here is the data of recent years of Faridpur Sadar Thana.

Year	No. of Accidents	Fatalities	Injuries
2018	4	5	56
2019	17	34	63
2020	13	21	4
2021	5	5	10
2022	14	16	37

Source: National Road Traffic Accidents Report

The average age of RTA fatality is 32 years.

Average lost working years is 27 years.

If we took the year 2022,

Considering 10 working people from 16 fatalities,

Income from 10 people can be = (10*312000*27) taka

= 84 million

Considering 30 working people from 37 injuries,

Taking two days recovery time for injury,

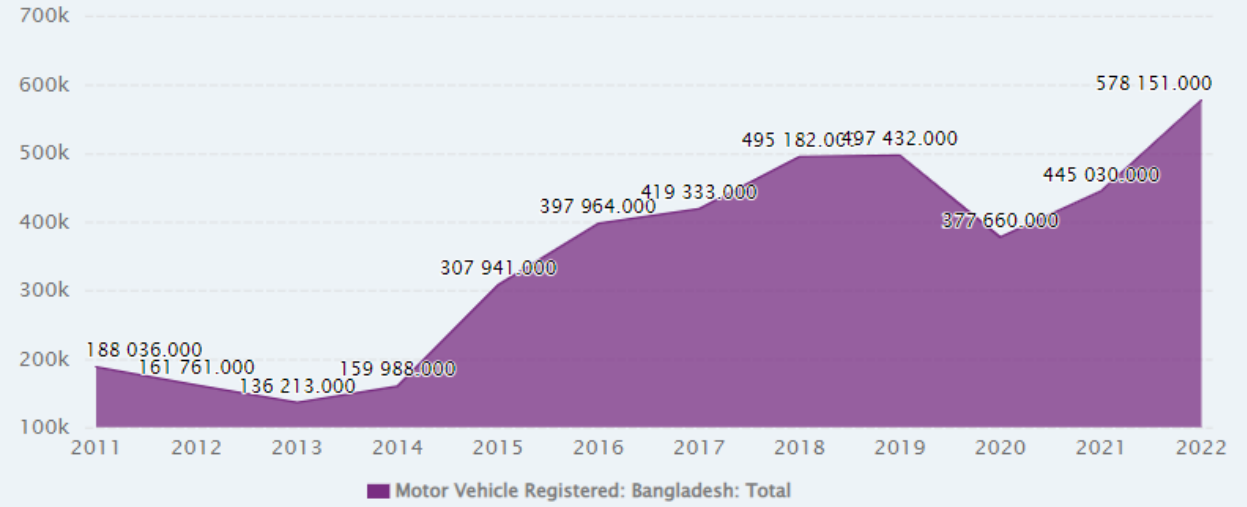
Lost money will be = (30*855*2) taka

= 51300 takas

So, if we can reduce the number of accidents by safety improvement, a good percentage of that lost money can be added to our national economy.

Importance of road safety:

In Bangladesh, road accidents are one of the major social issue, and it's increasing day by day. In Bangladesh nowadays, the number of vehicles is rising quickly. Bangladesh: Registration of motor vehicles in 2022, 578,151.000 Units of data were reported overall. The prior figure for 2021 was 445,030.000 Units, so this represents an increase.



On the national and regional highways, there are now four times as many registered motor vehicles—especially motorcycles and unregistered simple bikes as well as small and unauthorized vehicles like motorcycles and three-wheelers. As a result, 2022 will experience the highest number of traffic fatalities and accidents in the previous eight years. The majority of incidents (28.59%) were motorcycles, followed by accidents involving trucks, pickups, covered vans, and Lorries (24.50%), buses (13.95%), battery-powered rickshaws and simple bikes (11.42%), and nasimon, Mahindra-tractors, and Lagunas (8.32%). CNG-powered auto rickshaws were to blame for 6.95 percent of vehicles, jeeps, and microbuses and 6.22 percent of accidents.

We must take proper steps to reduce road accidents. By establishing a road safety we have to improve some extents like,

- multimodal transport and land-use planning
- safe road structure
- vehicle safety
- post-crash response

It can reduce accidents by 50 percent.

Road improvements and the environment:

By establishing a successful and coordinated safety policy and taking steps that call for major improvements in the relevant industries, it is feasible to considerably decrease the number of traffic accidents and fatalities.

Shoulder improvement: To increase usable width and driver safety, pave over unstable or narrow shoulders. Surface color variations also have a positive safety impact. The Texas DOT views this treatment as beneficial due to the visual, aural, and tactile indications that notify a vehicle who has strayed onto the shoulder.

They believe that it can reduce the number of single-vehicle ROR crashes.

Remove visual obstruction: Any fence, hedge, tree, shrub, device, wall, or structure between three and a half feet (forty-two (42) inches) and eight feet above the adjacent curb height are considered as obstruction. We need to clear this obstruction. Clearing obstruction on roadway can decrease road accidents.

Improve street lighting: At midblock and intersection locations, street lighting can boost public safety. It can also increase pedestrian safety, particularly at crossing points. A Street light is an

elevated source of light that is frequently suspended on a wire above the road or put on a lamp column or pole either on the side of the road or within the median to give lighting. Pedestrian facility lighting is essential for developing the overall safety act of the road network for all users.

Improve Horizontal Curve Friction and Delineator: On every roadway, driving at night or in bad weather can result in accidents. According to the safety of the curve and the local speed limit, traffic safety engineers have observed safety gains when adding delineation and increasing pavement friction at specific locations. It alerts drivers about upcoming dangers.

Increasing the quality of the road surface: Increasing the quality of the road surface is necessary to offer a safer, non-skid road surface, to seal and waterproof the road, and to lengthen the life of the road surface.

Methods to improve vehicle and traffic operations: The GOB places a high priority on road safety. In with the 2018 Road Transport Act, more severe penalties are now available for a variety of traffic infractions, such as operating a vehicle without a valid license, driving an unfit vehicle, overloading, and parking infractions. The 2018 Road Transport Act also emphasizes the need for increased operator and designer liability for safety performance as well as stronger administration of unsafe user actions using mobile courts. To address growing public concerns about road safety, GOB has also requested assistance from its National Road Safety Council (NRSC).

Conclusion: As we can see, by accidents people face a huge loss that can affect our national economy. So, if we can reduce the accident rates by following safety rules, that can improve our national economy. There are many safety rules we should strictly follow such as wearing a helmet and seatbelt, following speed limit, maintaining traffic signals properly, setting penalty for breaking any rules etc.

Chapter 07
Air Quality Impact

Nowadays, air pollution is a significant problem that has a global impact on public health and is believed to cause 7 million preventable fatalities annually. As the climate and greenhouse gases are all primary pollutants, air pollution and climate change are closely related. Improving air quality is beneficial for the environment, economy, and health. Air pollution can affect human health. Air pollutants can infiltrate the bloodstream and make breathing disorders worse when inhaled. It can cause or exacerbate itchy eyes and wheezing. Poor air quality is a global concern because it can affect human health and the environment. This pollution inhibits photosynthesis, which has significant consequences. This pollution contributes significantly to climate change and global warming. The elevated carbon dioxide concentrations in the atmosphere contribute to the greenhouse effect. Since greenhouse gases absorb the infrared radiation that the planet's surface emits, they should be environmentally friendly.

Maintaining clean air benefits everyone, and it may prevent air pollution. The solutions to this pressing issue are crucial for stopping the climate crisis, fostering inclusive communities, and improving child development. Working together, we can alter how we approach one of the great hidden killers.

Pollutant Types and Sources:

Natural events like volcanic eruptions, dust storms, and wildfires, which lower the air quality, air pollution is caused by the presence in the atmosphere of toxic substances, primarily produced by human activities.

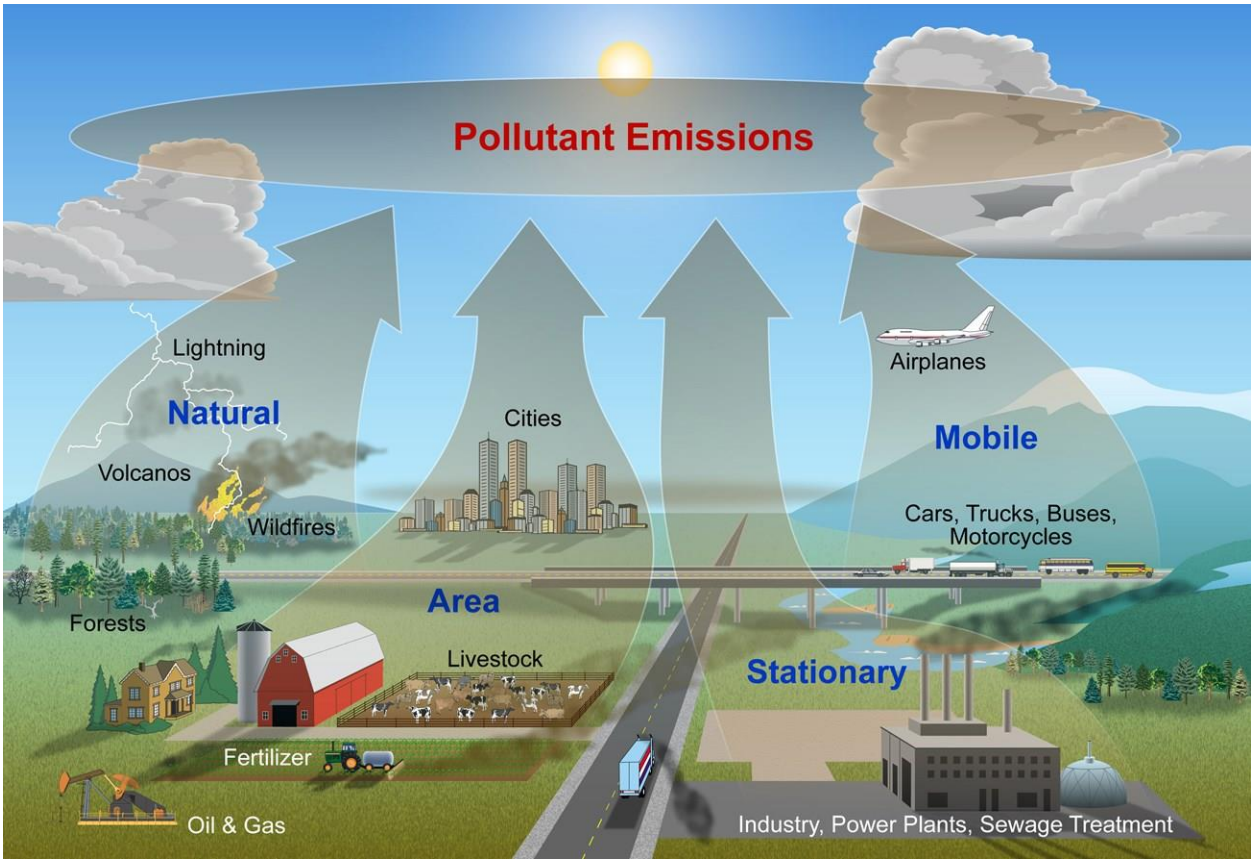
There are four main sources of air pollution:

Mobile sources – cars, buses, planes, trucks, and trains

Stationary sources – power plants, industrial facilities, and factories

Area sources – agricultural areas, cities

Natural sources – wind-blown dust, wildfires and volcanoes



Estimating Pollutant Emissions:

• Emission: Pollutants are being released into the atmosphere in this manner. For instance, at higher elevations, more pollutants are released by moving automobiles because of inefficient combustion brought on by thin air.

• Emissions factors: A representative number called an emissions factor tries to tie the amount of a pollutant emitted into the atmosphere to a particular activity that was responsible for the release of that pollutant.

Method of Estimating:

From the following equation, we can calculate emission factor and pollution quantity from particular.

• A or VKT = (L x AADT) (research gate, n.d.)

• Where,

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

• VKT = Vehicle Kilometers Traveled (km/day).

• L = Road length (km)

• AADT =Annual Average Daily Traffic (traffic volume/day)

• After calculating the vehicle Kilometer Travel, we will use it on total emission

calculation.

• Total emission has been calculated as follows:

• £ Emission = (Zi Ek EFij× Aik) (research gate, n.d.)

• Where,

• ¡= Type of a pollutant

• j= Emission sector like traffic, brick kilns

• k =Grid cell

• Emission i = Emissions of pollutant i

• EF = Emission Factor for each pollutant sector

• A =Activity level for each pollutant sector

The calculation of emission amounts is dependent on numerous factors and secondary data. It is easy to encounter uncertainties. That's why we assumed a wide range of values to calculate .as much as possible to be done accurately.

By using this formula, we get VKT, (research gate, n.d.)

Vehicle Type	ADT (veh/Day)	Road length (Km)	VKT (Km/day)
Truck	2330	5.3	12349
Bus	568	5.3	3010.4
Micro	267	5.3	1415.1
Motorcycle	1241	5.3	6577.3
Car	291	5.3	1542.3
Auto Rickshaw	1114	5.3	5904.2
		Total	30,798.3

Table : 7.1 Transportation mode with VKT

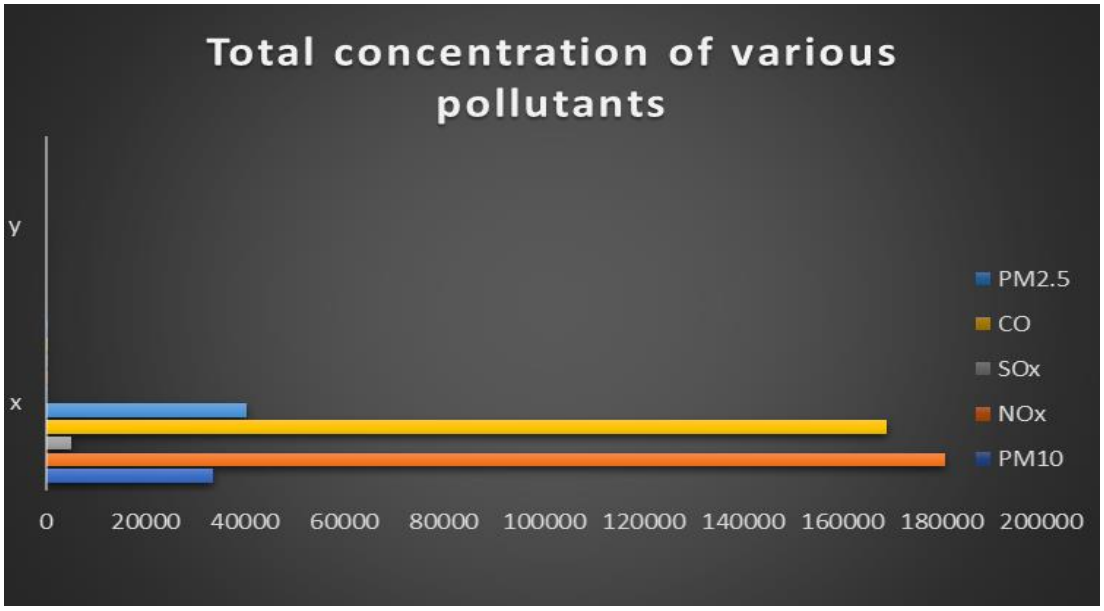
Table 7.2: Emission factor

Vehicle Type	PM_{10}	NOx	SOx	CO	$PM_{2.5}$
LDV	0.8	8.5	0.4	8.7	0.84
Car/jeep/MD	0.84	2.77	0.4	7.3	0.84
Bus	3	10	0.8	5.5	3
Auto Rickshaw	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	0.08	3.5	1.5

Now we can calculate our required emission inventory. Our getting VKT of multiplying with emission factor and get study areas vehicle emission inventory.

Vehicle Type	**Emission(gm/day)**				
	PM_{10}	**NOx**	**SOx**	**CO**	**$PM_{2.5}$**
Truck	18523.5 (research gate, n.d.)	123490	987.92	43,221.5	18523.5
Bus	9031.2	30,104	2408.32	16557.2	9031.2
Micro bus	1132.08	12028.35	566.04	12,311.37	1132.08
Motorcycle	1512.894	2039.118	131.556	42,755.7	1512.894
Car	1295.532	4272.171	616.92	11258.79	1295.532
Auto rickshaw	2066.47	8856.3	177.126	43100.66	8856.3
Total	33,561.676	180,789.939	4887.882	169,205.22	40,351.506

After calculation, we get the highest value of NOx. We can see that the different vehicles have different pollutants. Now, we find a chart and the percentage of total pollutant.



As our highest pollutant is NOx so, we can find out the way of how to reduce nitrogen dioxide. Some ways are given below:

- If we can reduce nitrogen dioxide, then we can use some air pollutant control equipment.
- The current technology used for this SCR process is a copper-zeolite catalyst that operates efficiently at temperatures around 200* and above. (physoorg, n.d.)
- Utilizing specifically created low-NOx burners, reburning, combustion staging, gas recirculation, reducing air preheat and firing rates, injecting water or steam, and low excess air (LEA) firing are a few examples of process improvements. The amount of NOx emissions can be cut by 50 to 80% thanks to these adjustments. (google, n.d.)

Conclusion:

Air pollution is still mostly caused by transportation. It contributes to global warming, which has negative repercussions. The dangers of air pollution to human health are well known. It is widely acknowledged that vehicle emissions are the primary factor in both air pollution and health issues. This pollution is measured by chemical, biological, physical pollutants in the air. The reduction of the ozone layer and global warming caused by the release of greenhouse gases or 〖CO〗_2. In this topic, we discuss the air pollution that is caused by transportation. We have discussed the pollutant type and sources, and the criteria of air pollutant. We estimate the pollutant emission. We also estimate the emission factor, the transportation mode with VKT etc. From the calculations, we have seen that the chemicals in the air have a great impact on the environment that comes from the vehicles. In Bangladesh, the Dhaka city has more vehicles than other part of the country and it creates the worse air pollution.

Chapter - 08

Noise Impact

Introduction

Unwanted or excessive sound that's called Noise. Noise is one of the most significant issues with road vehicles. When a transport moves on a road, it creates sound mainly by the engine and the friction of the tire. Basically, this noise impacts on people living close to the road. Sometimes, it will be incredibly dangerous for human life. As a result, people are affected by many health diseases. Long-term exposure to consistent noise pollution has been linked to various health issues, including hypertension, cardiovascular disease, depression, anxiety, and stress. People who are involved with loud noises at home and in the working sector are among those who are more susceptible to hearing loss.

Table-1 Valuation of AMI impacts of noise.

Volume LAeq, 18 hr. dB(A)	Additional risk of AMI
55-60 dB	0.00010%
60-65 dB	0.00168%
65-70 dB	0.00336%
70-75 dB	0.00504%
75-80 dB	0.00720%
80-85 dB	0.039%

(researchgate, n.d.)According to this table 1, the health value is set in a monetary unit. From this table, the highest volume level considered is 80-85 dbA. As our road is a national highway so, their junctions usually create more noise.

Study area

The National Highway N808 (Faridpur Town By-Pass) Vehicle streams consist of logically tall and substantial volumes of buses (of various types), stacked trucks, passenger cars, microbuses, pick-up vans, CNG, autorickshaws, etc. Significant numbers of pedestrians are using the sidewalk and shoulders.

Objectives

To determine the main objects are given below:

calculating the highway's noise impact

#Identifying the source and factors affecting transportation noise

#comparing filed observation value with standard.

Analysis of the effect of noise barriers

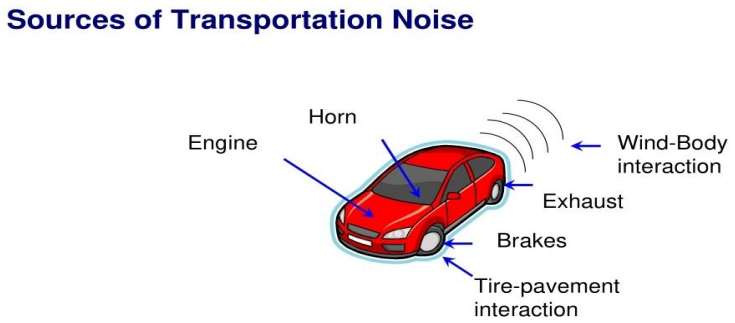
Fundamental Concepts of sound

- Loudness
- Frequency
- Duration
- Subjectivity

Source of transportation noise

The maximum noise come from autos, trucks, buses.

Sources of transportation noise are as follows:



*Vehicle–wind interaction

*Tire–pavement interaction

*Aerodynamic noise

*Vehicle engines

*Transmission gear noise

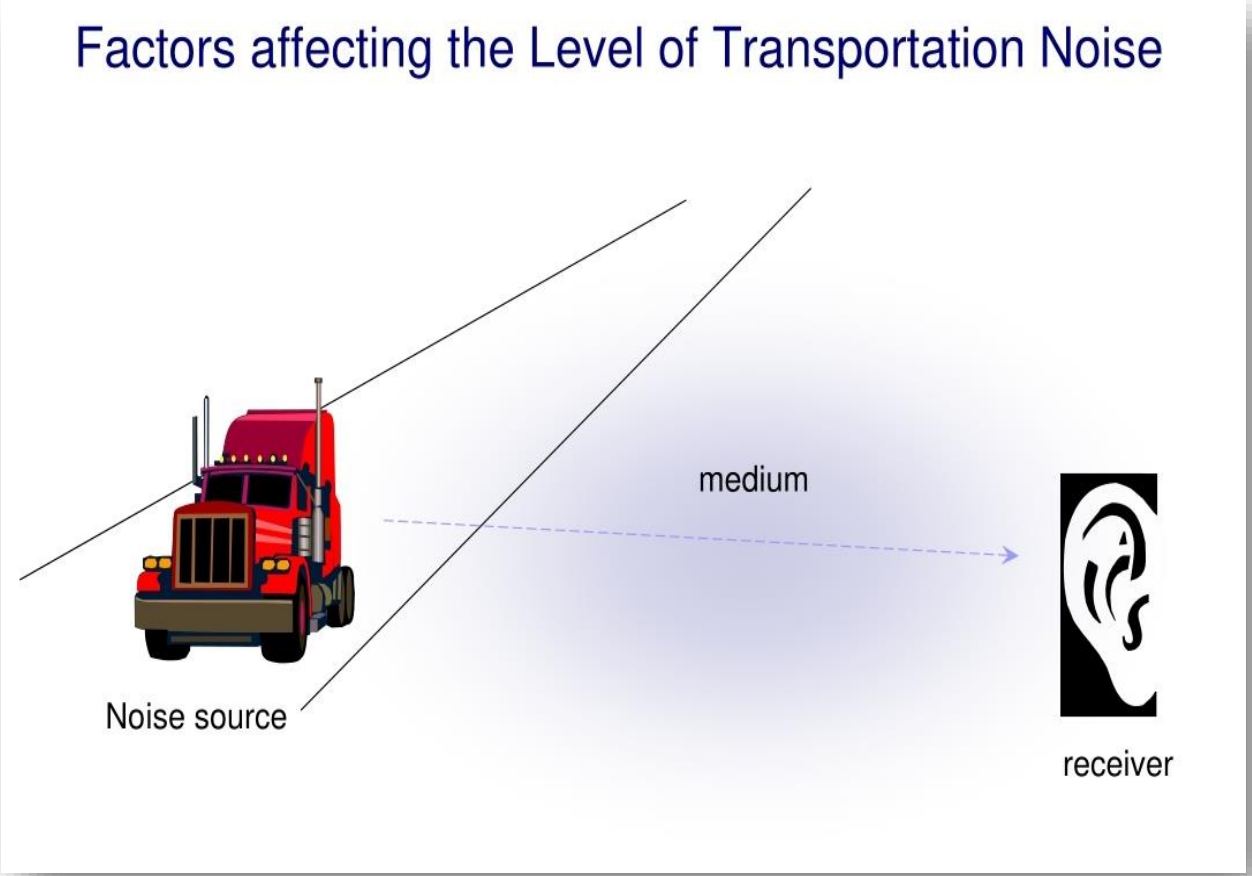
*Vehicle horn sand brakes

The level of highway traffic noise depends on:

(1) Speed of the traffic

(2) Traffic volume

Factors Affecting Transportation Noise Propagation



((source : principles of project Evaluation and programming/chapter-11)

(Reference energy mean emission level) Vehicle type and size. guideway length that is visible to the receiver. nature of the traffic flow (volume, speed, etc.). between the source and receiver of

b/n noise. Source and receiver of the media are noise-prone by nature. Any shielding between the noise source and the receiver, including its nature.

Nature of Source, Distance, and Ground Effects (noise pollution , n.d.)

There are two types of sources.

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

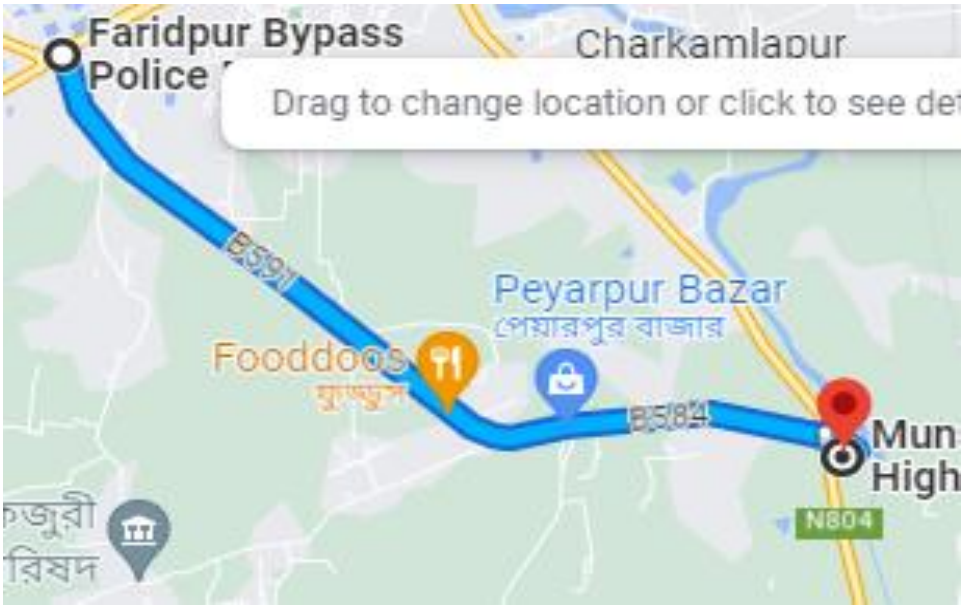
2. Line source: A uniform traffic flow.

Collected Data

Road-way configuration :(collected form Google map)

Length of roadway segment-5.3km/3.3mile/17388.5ft

Pavementwidth-48 ft



Reference Energy Emission Level

Automobiles (A): $(L_0)\ E = 38.1 \log_{10}(S) - 2.4$

Medium Truck (MT): $(L_0)\ E=33.9\log_{10}(S)+16.4$

Heavy-duty truck (HT): $(L_{10})\ E = 24.6\log_{10}(S)+38.5$ (source : principles of project Evaluation and programming/chapter-11, Kumares Sinha and Samuel Labi))

By using reference energy emission level,

We got our equivalent sound level for different types of vehicles.

Energy mean emission level for different type of vehicle

We have AADT, from AADT we got average daily traffic then we calculate emission level with respect 24 hourly equivalent sound level and its given below,

Types of vehicles	Traffic volume	Equivalent sound level
Truck	65	49.58
Bus	54	48.14
Car	20	45.16
Pickup	5	24.23
Motorcycle	82	70.52
Auto rickshaw	74	68.81

Table: Hourly Equivalent sound level

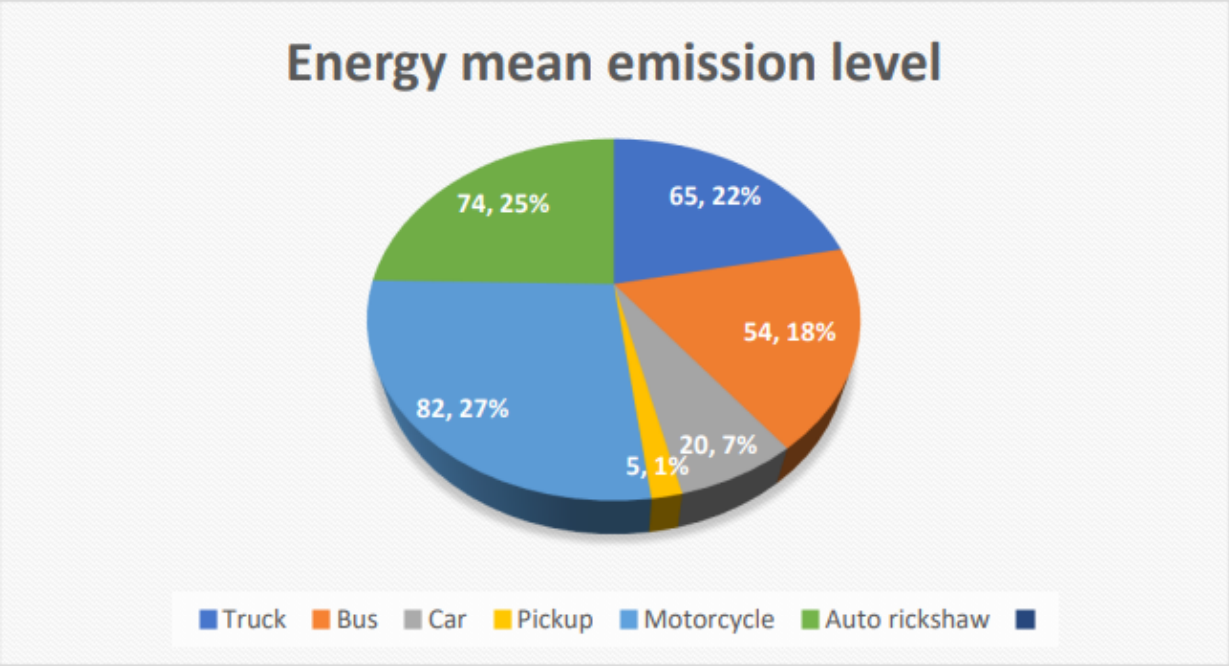


Fig: percentage of emission level for different types of vehicle

We use reference to mean mission level equation.

Our combined dBA is,

Leq = log 10 (10^ 81.626/10 +10^ 62.039/10+10^73.964/10)

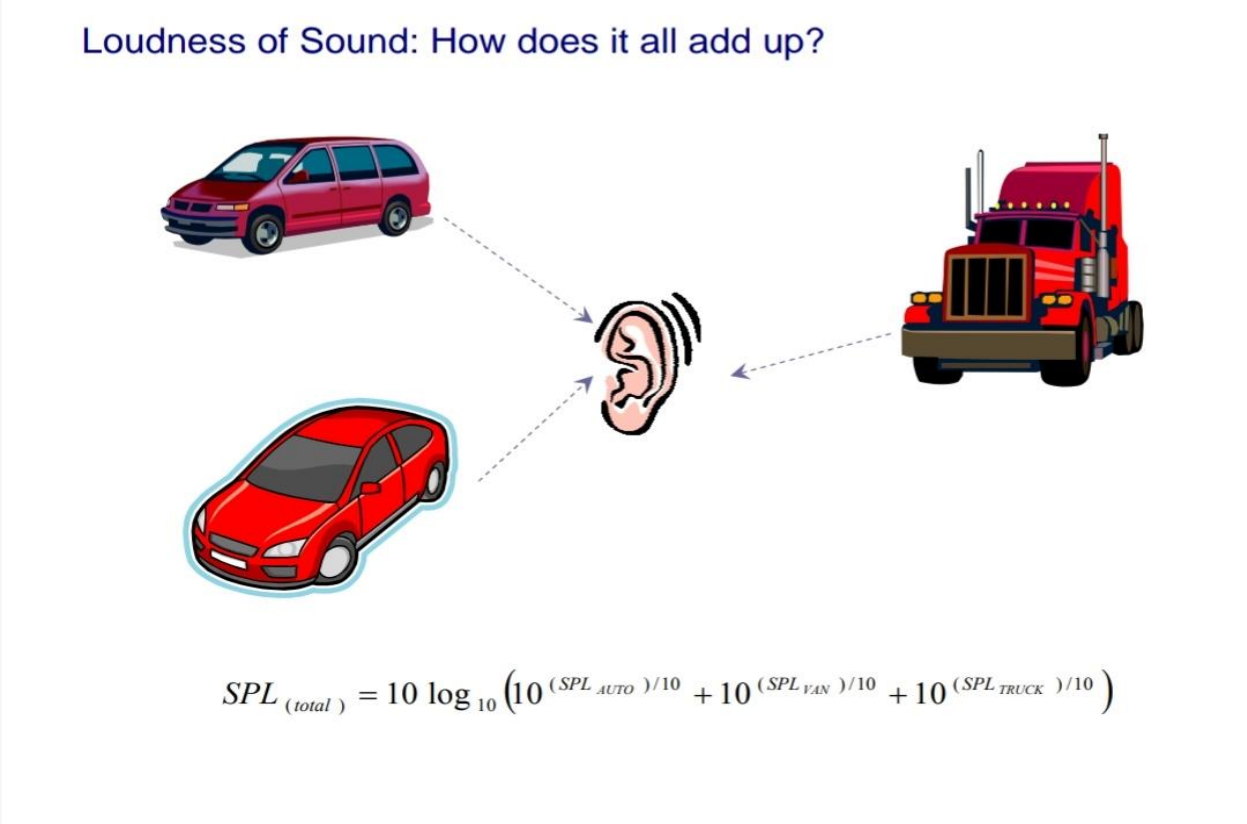
Type of vehicle (Both way)	Average Speed (Km/h)	Energy mean Emission level (dBA)
Car, motorcycle, jeep, CNG (automobiles)	75	62.039
Medium truck, medium bus, cover van	75	73.964
Heavy truck, large bus	75	81.626

= 72.54 dBA (which is combined dBA)

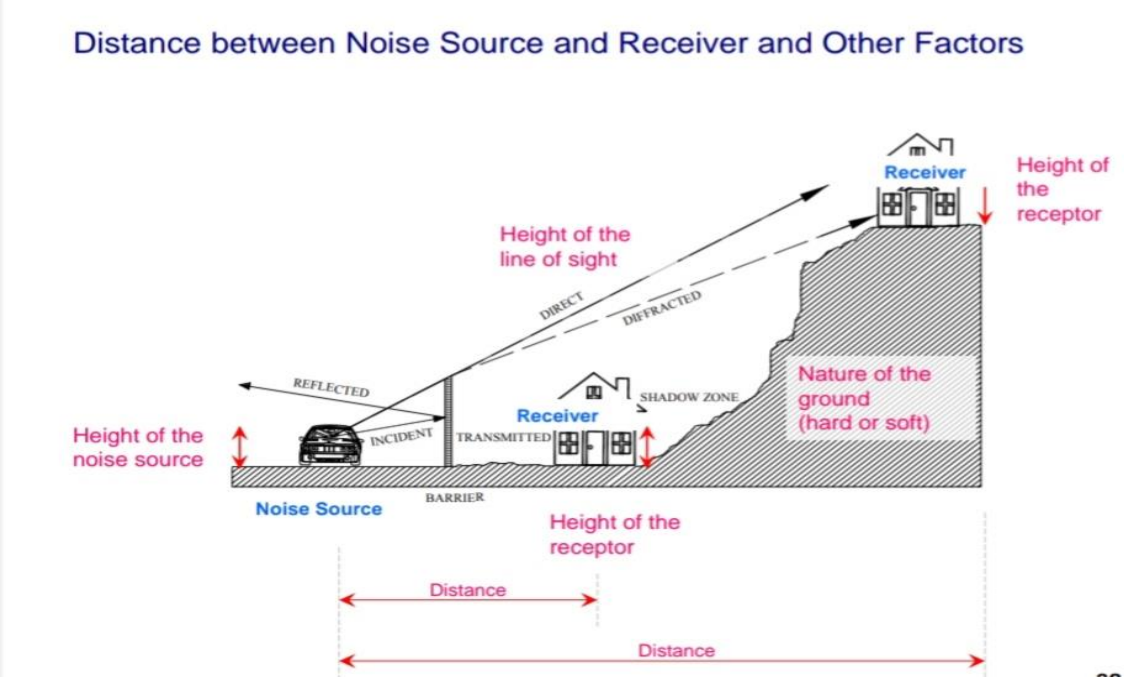
Table: Energy mean emission level (dBA)

Comparison with standard noise value

We know the traffic noise standard for Highway ranges from 70 to 80 dBA. We chose 24.23 dBA, 49.58dBA, 70.52 dBA and the combined noise of cars, medium trucks, heavy trucks, and various categories is 72.54 dBA, which is within the standard range.



(Formula collect from principles of project Evaluation and programming/chapter-11, Kumares Sinha, and Samuel Labi)



(source : principles of project Evaluation and programming/chapter-11, Kumares Sinha and Samuel Labi))

Noise paths with Barrier

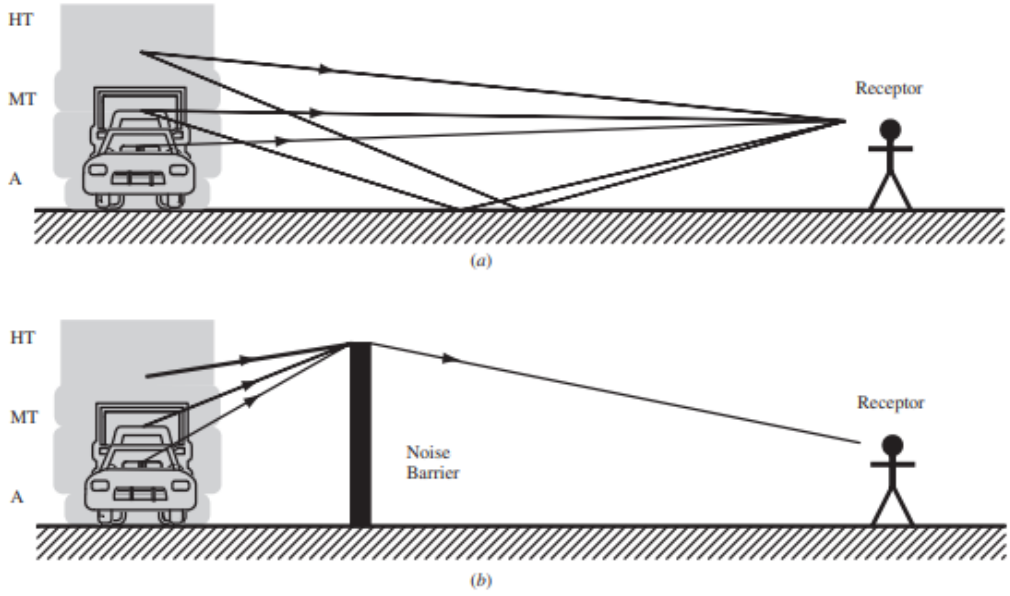


Figure 11.13 Noise paths (*a*) without and (*b*) with barrier.

Generally, noise barriers are not used on highway roads in our country. But, in many districts including Dhaka noise pollution is increasing day by day. Now, I think the government should use noise barriers on every road to reduce noise pollution. Most of the people of our country are now going out on the streets with health risks. A normal person takes a maximum of 130 dB but for a short time. It is possible for a normal person to listen to 85 dB sound for several hours. Around 11.7% of the population in Bangladesh has lost their hearing due to noise pollution, says the department of environment. (Source: google)

Area	**Maximum noise level (dB)**
Sensitive areas (Education, hospital)	40-50
Residential zones	45-55
Mixed areas	60-70
Commercial areas	65-70
Industrial areas	70-75

So, we can see that this is a high-risk situation. In our country, noise is one of the major problems and it's increasing day by day. Now, we can see how to distance reduce noise.

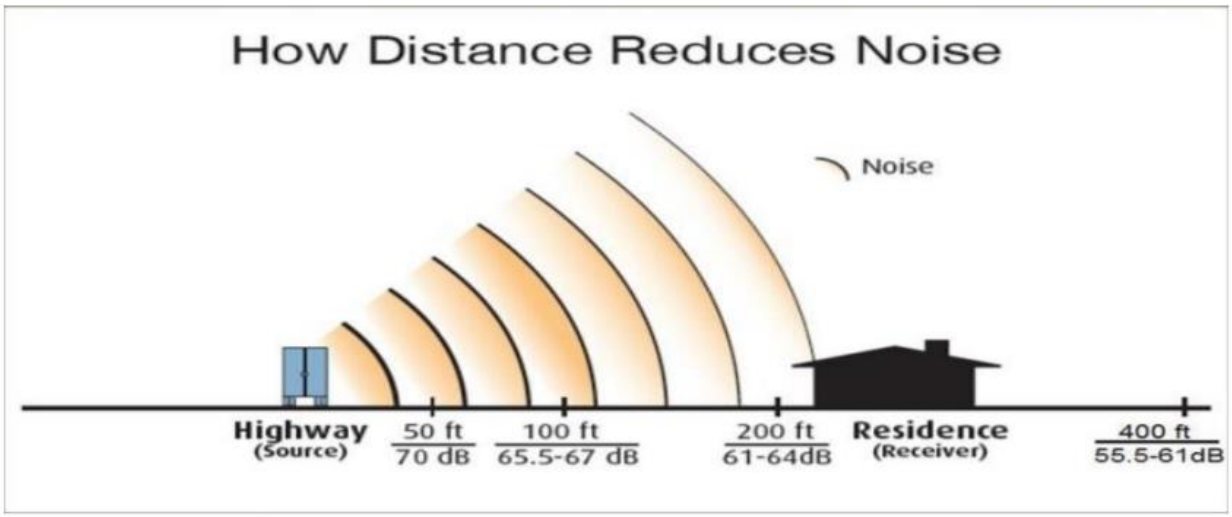


Figure 8.4 How distance reduces noise.
Source: Environmental Protection Department
(https://www.epd.gov.hk/epd/noise_education/web/ENG_EPD_HTML/m4/mitigation_1.html)

so, protecting the residence from noise a noise barrier must be provided to highway.

Fig: noise impact from traffic in Bangladesh (noise pollution , n.d.)

The traffic noise standard for highway ranges from 70 to 80 dBA. I think our energy means emission level and combined dBA which is within the standard range.

Conclusion:

Our selected road N808 (Faridpur Town By-Pass) which is connect from Munsibazar to goalchamot is very important road and its traffic volume is too high. Its noise level varies depending on the time of day. The noise level is higher in the morning and evening than it is at noon due to higher volume, but it is still within the normal range.

Noise barriers stop unwanted noise from contaminating the surroundings. Noise is contained at the source and does not permeate the surrounding area. Rubber-made noise barriers can be recycled. Long-lasting and inexpensive**.**

There is no need to build a noise barrier because the sound level is within the permissible range. However, if the adjacent residential area's safety concerns are considered, a barrier can be built. Concrete should be used to build noise barriers since it is.

Prices are lower than for other materials. When compared to other types of vehicles, the noise level from medium-sized vehicles is considerable. Demand for transportation will rise day by day, and noise pressure will follow. Therefore, it is crucial that authorities take stronger action to maintain its noise level in the future.

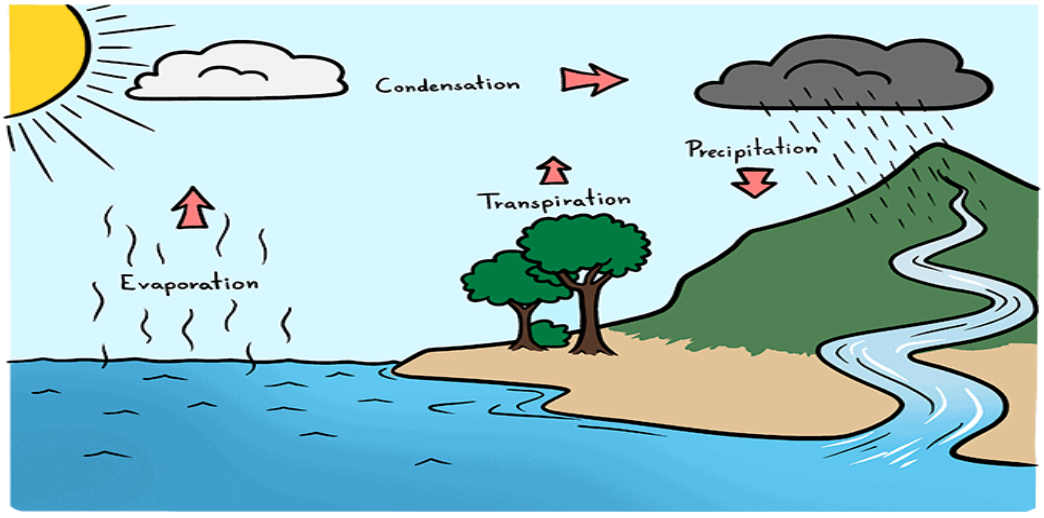
Chapter-09

Impacts on Water Resources

Introduction: In addition to being required for maintaining life, water is also important for various human activities, including residential and industrial use, agriculture, and leisure. In this chapter, we can see the impact on water resources by this transport construction. We already know about air quality impact and noise impact. Now, we will know the source of water is impacted by this project.

What is hydrology?

Hydrology is the study of water. The hydrological cycle comes from hydrology. Hydrology has different branches. It's important for our environmental ecosystem. Not only ecosystem but also our daily life.



(easy drawing guides, n.d.)

CATEGORIES OF HYDROLOGICAL IMPACTS

The transportation facility or the vehicles that use it may impact the water resources. Physical transportation structures are one example. The impact of waterborne transport is more significant. Each automobile, for example, requires an average of 300,000 liters of water to produce. (Rothengatter, 2003)

Impact Types on Water Resources:

(a) Water Quality (Polluting or Degrading Effects)
(b) Water Course (Flow Pattern Effects)
(c) Water Quantity (Deprivation Effects)

Water sources affected: there are two types of water system. **(1)** surface water system **(2)** groundwater system. First, rivers, creeks, streams, lakes, lagoons, sea etc. including surface water. Among them river and sea are too much affected by transportation, Generally, water quality or quantity is vulnerable to transport effects due to erosion by rivers or natural flows. Surface water have a natural power that is liquid, sedimentation, flocculation, biodegradation, aeration to recover relatively quickly. Secondly, groundwater system is less vulnerable from surface water system because, it's quite difficult to find and mitigate. The main function of ground water is to purify polluted water. On top of this, ground water has lower flow than surface water.

Every transportation has mode and activity such as, highways, rail, air and marine transportation. These are affecting water resources adversely. These activities include construction, maintenance, infrastructure facilities, manufacture, and other parts. Many facilities development phases in various pattern flow and quantity, quality, water affected by transportation vehicles and facilities.

Hydrological impacts by transportation mode

As, our project is all about the highway road widening. So, we will go into detail about only highway impact in this chapter.

Highway Impact

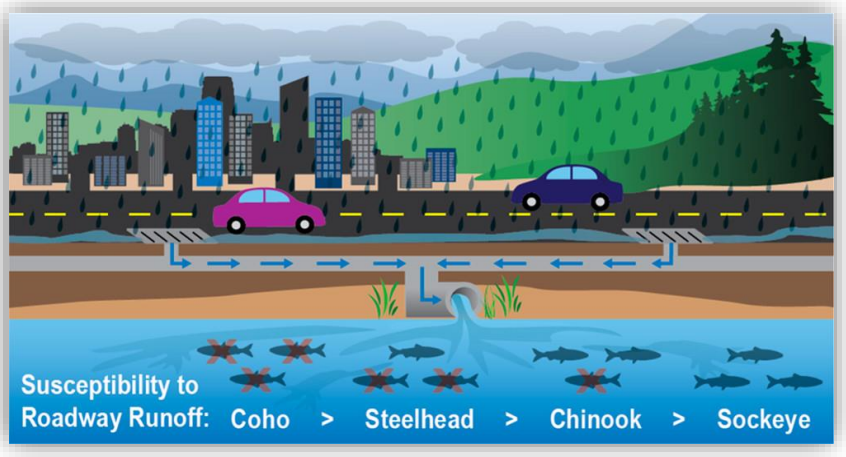
Highway impacts can occur in three ways. These are highway construction, maintenance, and operations.

For construction: permanent land is required for construction or expansion of highways, for which permanent allocations have a greater impact on water. Also, for various construction activities, such as excavation operations production disposal, the right-of-way of hazardous materials can have a significant impact. In the case of rigid pavement construction water infiltration into the soil surface is almost negligible. Typically, less than 10% of stormwater runoff goes into receiving waters for a completely natural ground cover. For example: about 20% of stormwater runoff can be expected when 10 to 30% of the site is paved (US EPA, 1982; 1996). During excavation soil accumulation water turbidity. Moreover, slit from roads reduces the depletion of natural or man-made canal water bodies. Highway construction has a long-term hydrological impact. Emission from transportation can be directly reduced by spillage. Road construction can sometimes lead to the release of radioactive material underground by humans, which can contaminate ground or surface water.

For maintenance: changes in volume and flow patterns during highway maintenance have the greatest impact on water. Rock salt is the most versatile agent. Rock salt contains primarily sodium chloride, but 10% is a concentration of trace metals including insoluble iron, nickel, lead, zinc, chromium, and cyanide. (DEFRA,2005). Another pollutant source associated with maintenance is bridge paint. Limited paint chips can be released into the dance water during bridge cleaning.

For operations: highway operation pollutants are heavy metals suspended solids and particles, liquids, oxygen scavenging compounds, nutrients, and microorganisms. In many cases the pollutants are deposited onto the road directly from vehicles. Oil, grease, antifreeze, hydraulic fluid are water contaminants. Released by tires, other

debris, brake lining, tires are solid pollutants. Studies have shown that more than 95% of solids are deposited by vehicle tires. Collect them from construction sites, parking lots, farms and dirt roads. Moreover, pollution is also caused by road users. Mixing with rainwater pollutes river water including reservoirs.



source: Google

Now, we can see how many percentages reduction in groundwater flow due to the construction and impacts on water quality:

Our estimation suggests that the highway layers occupy approximately 7% of the cross-sectional area of the aquifer. Let us assume that the value of k is 1000 meters per day. The hydraulic gradient is noted to be 0.05. It carries a reduction of 10% in the medium's permeability following its construction.

We have, Q=KA*(aH/aL) source:(Lohani et al,1997).

Solution: flow before the project, 1000a (0.05) = 50 m_3 /day

Flow after the project, 0.90*1000*0.90A*0.05 = 41.85 m_3/day

Percentage reduction in groundwater flow

=50A- 41085A/50A = 16.3%

Using equation 13.5(Gupta et al.) the load of surface pollutant after a storm due to construction of the bypass is: P= (0.007) *(12000) ^0.89*(3.3)*(6)

= 1.16lbs

Our pollutant loas of 1016lbs to the water bodies in the vicinity of the proposed bypass.

Conclusion: In this chapter we identify and describe the various categories of hydrological impacts, such as the polluting source (facility or vehicle), the water source affected (surface water, ground water). We also find out water quality and reduced percentage of ground water flow.

source: Google

chapter-10
Economic Analysis

It is very important to calculate the economical fact of a project. The feasibility of the project is very much relatable to economic analysis. We will do the cost analysis for flexible pavement and rigid pavement. We must calculate construction cost and maintenance cost for both pavements. Initial cost and life cycle cost must be calculated for both pavements. We must find the monetary value of benefit that we are going to gain from this project. Benefit-cost ratio is one of the key factors to know the feasibility of a project. After doing economical calculation and considering the situation of our country, we will take decision that which pavement will be more feasible for our project.

Flexible Pavement

Item	Thickness (m)	Length (m)	Width (m)	Quantity (m^3)	Rate	Amount (lacs)
Sub-base	0.4	1000	7.93	3172	5496	174.33
Base Course	0.21	1000	7.93	1665.3	10457	174.14
Asphalt Concrete	0.16	1000	7.93	1268.8	14000	177.63
Total						526.1

[value of rates is taken from 'RHD SCHEDULE of RATES 2022']

For Dhaka division the cost of Dense bituminous surfacing-wearing course (Plant Method-Bitumen Grade 60/70) is 26511 per cubic meter.

Considering 60 mm overlay in the 11^{th} year,

Cost per km for 20 years = 526.1+ (0.06*1000*7.93*26511)/100000 lac

=652.24 lacs

Considering the routine maintenance cost 50000tk per year,

For 20 years, Cost of routine maintenance = 1 lac

As our designed road is length of 5.3 km, cost of 5.3 km is = (652.24+1) *5.3 lacs

=3462.172 lacs

=346.22 million

Rigid Pavement

Item	Thickness (m)	Length (m)	Width (m)	Quantity (m^3)	Rate	Amount (lacs)
Cement Concrete slab	0.267	1000	7.93	2117.31	21415	453.42
Base Course	0.101	1000	7.93	800.93	10457	83.75
Total						537.17

[value of rates is taken from 'RHD SCHEDULE of RATES 2022']

The weight of reinforcement for concrete slab is having to be 5.5kg/m^2.[O.F. Hamim, Sep,2017, BUET]. According to survey, unit cost of rebar is 72tk,

The cost of reinforcement = 1000*7.93*5.5*72 lacs

=31.4 lacs

Considering the routine maintenance cost 50000tk per year,

For 20 years, Cost of routine maintenance = 1 lac

There is no periodic maintenance cost (overlay cost) for rigid pavement.

As or designed road is length of 5.3 km,

The cost for 5.3km is= (537.17+31.4+1) *5.3 lac

=3018.721 lac

=301.9 million

For the 20 years design period, we can see that the cost of flexible pavement is 346.22 million which is higher than the cost of rigid pavement which requires cost of 301.9 million.

Vehicle Operating Cost

We consider the road roughness is 5 which is in fair grade according to RHD.

Here is a table of VOC of different vehicles for before and after road widening:

Vehicle Type	Number of Vehicles	VOC (Before) (Tk/km)	Total Amount (Before) (Tk)	VOC (After) (Tk/km)	Total Amount (After) (Tk)
Truck	34	89.7	3049.8	85.62	2912
Bus	9	42.2	380	32.51	293
Minibus	4	24.41	98	18.97	76
Utility	2	15.7	31.4	16.02	32.04
Car	5	26.12	131	19.03	95.15
Auto-Rickshaw	17	9.23	157	5.28	89.76
Motorcycle	19	7.45	141.6	3.14	60
Total			3988.8		3557.95

Travel Time Cost

Vehicle Type	Occupancy Number	TTC per passenger (Before) (Tk/hour)	TTC per vehicle (Before) (Tk/hour)	TTC per passenger (After) (Tk/hour)	TTC per vehicle (After) (Tk/hour
Truck	3	95	285	97	291
Bus	47	45	2115	39	1833
Minibus	35	44	1540	41	1435
Car	4	107	428	104	416
Auto-rickshaw	5	51	255	52	260
Motorcycle	2	72	144	69	138
Total	96	414	4767	402	4373

Saved hours per passenger = 3 hours

Total saved hours for 96 passengers = 288 hours

As per survey we get that the average income of people of Bangladesh is 150 takas.

For 20 years if we covert the saved hours in monetary value, it stands 315.36 million.

Fuel Cost

According to the RUC report the cost of petrol is 72.91 TK/liter and the cost of diesel is 59.48 Tk/liter. For our road except cars and motorcycles, other vehicles fuel is diesel. And petrol is used for cars and motorcycles.

Vehicle Type	Number of Vehicles	Before	After
Truck	34	945.5	882.45
Bus	9	117.74	92.67
Minibus	4	19.47	22.99
Car	4	52.24	48.92
Auto Rickshaw	5	48.64	41.45
Motorcycle	17	56.62	45.42
Total	96	1240.15	1133.9

Fuel saved per day = 2 liter

If we consider 20 years, the monetary value of saved fuel is 1.5 million.

Benefit Cost Ratio

The total cost of Flexible pavement for 20 years = 346.22 million

The total cost of Rigid pavement for 20 years = 301.9 million

Total benefit from saving travel time and fuel is =347.22 million

Benefit cost ratio for flexible pavement is = 1.003

Benefit cost ratio for rigid pavement is = 1.15

Conclusion

As we can see that our designed project is feasible for both flexible and rigid pavement, as benefit cost ratio is higher than 1 in case of both pavements. But Rigid pavement cost is higher than flexible pavement which is tough to manage for developing country like Bangladesh. Flexible pavement requires maintenance cost but as it will be needed after a certain period, it won't affect you that much. After considering all the matters including benefit cost ratio, we will go for flexible pavement for our road widening project.

Ethics

Ethics means any system or code of moral laws and values. The greatest standards of ethics and honesty must govern engineers in all their interactions. If Engineers see that project won't be successful by calculations, they must inform their clients. In our project there are so many ethical issues. Some important ethical issues are given below: -

1. Project delay may be due to mismanagement of works.
2. Bad row materials may be used though unscrupulous contactors.
3. Money may be stolen by the politician or there may be miscalculations.
4. Pedestrians may disrupt work during road works.
5. To pass the bill of the project the government official may take bribe unethically.

There may be errors in the work of the workers.

From the above problems we understand that there are many things to successfully complete a project, but we engineers can solve these problems with a little care. Everyone should follow ethics. The first job of an engineer is maintaining ethics. It can be any job. We must have an honest field engineer to check whether we are working by maintaining ethics in this project.

Project Management

Work distribution:

The project of upgrading the Goalchamot to Munsibazar road (N808) from 2 lanes to 4 lanes is started in 2023. This project will be carried out up to 2027. It is a 5-year project. The feasibility study is started in 2023. Procurement of funding will start at the end of 2023, and it will end in the middle of 2024. From the beginning of 2024 the tender will start, ending in the last of 2024. Detailed designing will start in the middle of 2024, and it will go on till the end of 2025. Land acquisition will start in 2025. It will take the whole of 2025 to collect land for the project. The main construction will start in the middle of 2025, and it will last till the middle of 2027. 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 2027 and the road opens in the beginning of 2028.

Procurement Procedure:

Activity time	2023	2024	2025	2026	2027
Feasibility study					
Procurement Of funding					
Tender					
Detailed design					
Land acquisition					
Construction					
Construction Cleans up					
Project Opening					

Table: Project Management

Procurement is the process of discovering or obtaining something. Governments may employ contractors or service providers, while companies purchase raw materials. Steps are shown by diagram given below.

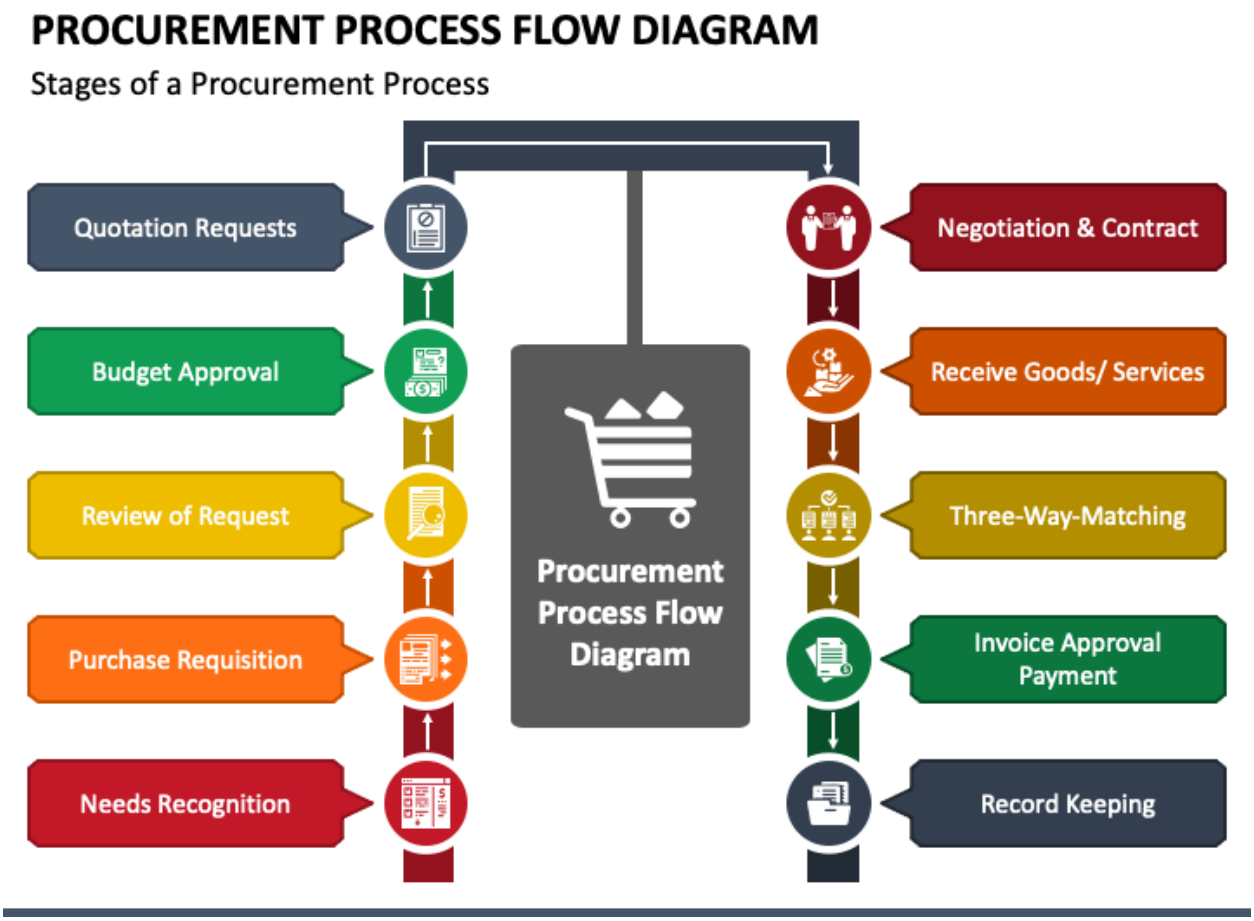


Figure: Procurement process

Conclusion

For feasibility study we selected the road N808 Faridpur Town By-Pass (Goalchamot to Munshibazar). The road is a National Highway. The main goal of our feasibility study was to convert the road from 2 lanes to 4 lanes. For both way traffic movement our AADT was 12000 Veh/day. We got this value from an RHD officer, his name is Sheikh Shoel Ahmed (Executive Engineer). After getting the AADT value we get the level of service of the road as type C and after 7 years the level of service is type E. So, we have decided to make the road from 2 to 4 lanes. Our design speed was 80 Km/hr. The road was 5.3 Km. We have one curve present in the roadway. The radius of curvature is 319.39m. We have designed the pavement in five methods. We have done flexible design in 3 methods and rigid design in 2 methods.

According to the road of Bangladesh following the RHD manual road is constructed. So, RHD flexible pavement design and RHD rigid pavement design are most accurate for road construction. We designed flexible pavement design and rigid pavement design using RHD manual. However, rigid pavement design is better than flexible pavement design, but we will choose flexible pavement design. The main reason for not choosing rigid pavement design is that a lot of money is needed initially before the construction work starts. Moreover, it takes a lot of time to make rigid pavement design because it takes a lot of time to gain strength. Which is almost impossible to do on the busiest highways. So, we think flexible design to be more suitable here. On the other hand, the cost of flexible design is relatively less than rigid design. Moreover, there is no need to close the entire road for this design. Another important factor is that the maintenance cost of flexible pavement is less than of rigid pavement.

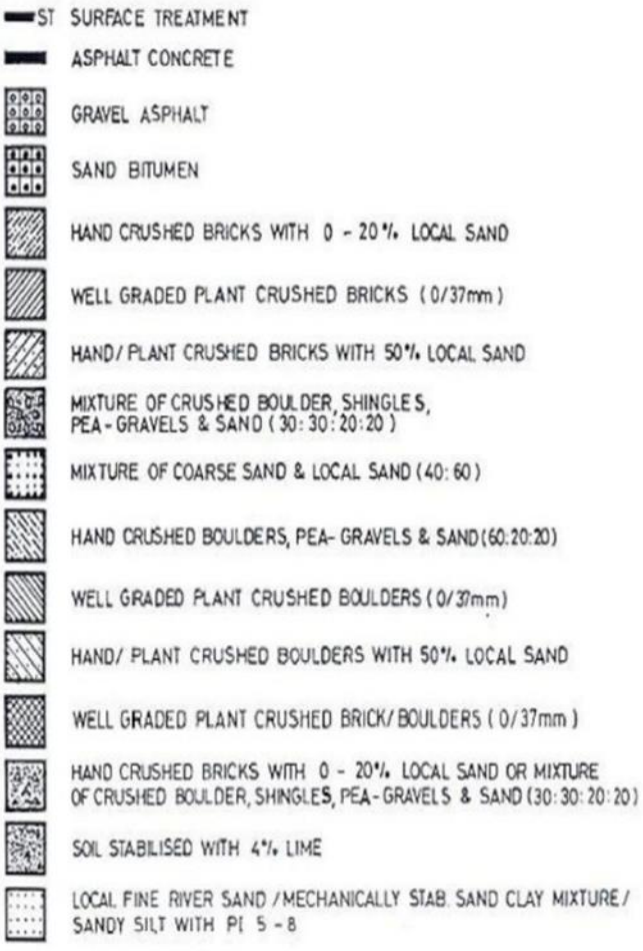
It we think from the economic aspect of Bangladesh, we think that flexible pavement design will be better. After studying all the available aspects of the projects, we can come to a conclusion that the upgradation N808 from 2 lane to 4 lane is feasible.

APPENDIX

Chapter-3(Flexible Pavement Design)

PAVEMENT CATALOGUE

MATERIAL DEFINITION



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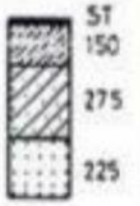
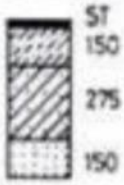
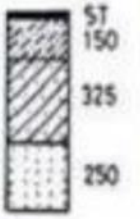
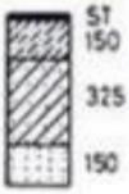
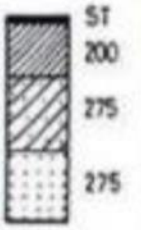
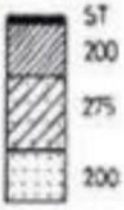
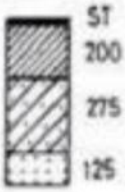
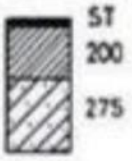
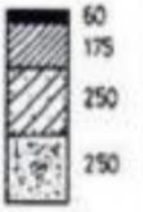
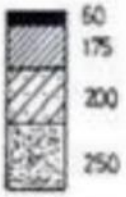
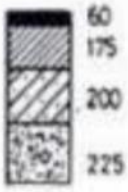
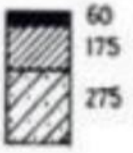
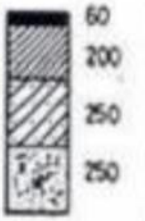
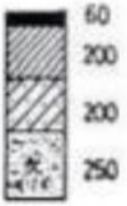
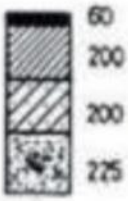
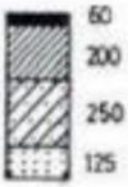
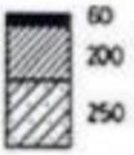
CATALOGUE FOR PAVEMENT TYPE - 1

(BRICKS)

	S1	S2	S3	S4	S5
T1					
T2					
T3					
T4					
T5					

CATALOGUE FOR PAVEMENT TYPE - 2

(GRAVELS & STONE)

	S1	S2	S3	S4	S5
T1					
T2					
T3					
T4					
T5					

CATALOGUE FOR PAVEMENT TYPE - 3

(GRAVEL ASPHALT BASE)

	S1	S2	S3	S4	S5
T1					
T2					
T3					
T4					
T5					

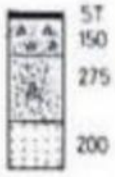
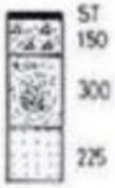
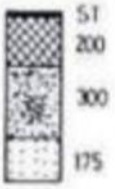
CATALOGUE FOR PAVEMENT TYPE - 4

(SAND BITUMEN BASE)

	S1	S2	S3	S4	S5
T1					
T2					
T3					
T4					
T5					

CATALOGUE FOR PAVEMENT TYPE - 5

(LIME STABILISED SUB - BASE)

	S1	S2	S3	S4	S5
T1					
T2					
T3					
T4					
T5					

CATALOGUE FOR PAVEMENT TYPE-6

(TO: ESA ≤ 0.5 MILLIONS)

	S1	S2	S3	S4	S5
ALT-1					
ALT-2					

MATERIAL DEFINITION

ST — SURFACE TREATMENT

HAND CRUSHED BRICKS WITH 0 – 20% LOCAL SAND OR MIXTURE OF CRUSHED BOULDER, SHINGLES, PEA-GRAVELS & SAND (30:30:20:2

SOIL STABILISED WITH 4% LIME

HAND CRUSHED BRICKS WITH 50% LOCAL SAND OR MIXTURE OF SYLHET SAND + LOCAL SAND (40 : 60)

LOCAL FINE RIVER SAND / MECHANICALLY STAB. SAND CLAY MIXTURE / SANDY SILT WITH PI 5 - 8

Work Contribution (Group-06)

FEASIBILITY STUDY OF THE N808 FARIDPUR TOWN BY-PASS (GOALCHAMOT TO MUNSHIBAZAR) ROAD WIDENING PROJECT

Serial	Topic	Lead Contributor in Analysis	Lead Contributor in Writing	Supporting Contributor in Analysis	Supporting Contributor in Writing	Comment
1	Acknowledgement	Md. Mehedi Hasan Prince	Md. Mehedi Hasan Prince	Mohammad Sayed Anwar	Mohammad Sayed Anwar	
	Abstract	Mohammad Sayed Anwar	Mohammad Sayed Anwar	Md. Mehedi Hasan Prince	Md. Mehedi Hasan Prince	
2	Introduction	Md. Mehedi Hasan Prince	Md. Mehedi Hasan Prince	Mohammad Sayed Anwar	Mohammad Sayed Anwar	
3	Literature Review	Mohammad Sayed Anwar	Mohammad Sayed Anwar	1) Tamanna Binta Asad 2)Md. Mehedi Hasan Prince 3) Umma Samia	1) Tamanna Binta Asad 2)Md. Mehedi Hasan Prince 3) Umma Samia	
4	Level of Service	Md. Mehedi Hasan Prince	Md. Mehedi Hasan Prince	Mohammad Sayed Anwar	Mohammad Sayed Anwar	
5	Geometric Design	Md. Mehedi Hasan Prince	Md. Mehedi Hasan Prince	Mohammad Sayed Anwar	Mohammad Sayed Anwar	
6	Structural Analysis (Flexible)	Tamanna Binta Asad	Tamanna Binta Asad	Umma Samia	Umma Samia	
7	Structural Analysis (Rigid)	Umma Samia	Umma Samia	Tamanna Binta Asad	Tamanna Binta Asad	

8	Road Safety	Mohammad Sayed Anwar	Md. Mehedi Hasan Prince	Mohammad Sayed Anwar	Md. Mehedi Hasan Prince	
9	Air Impact	Umma Samia	Umma Samia	Tamanna Binta Asad	Tamanna Binta Asad	
10	Noise Impact	Tamanna Binta Asad	Tamanna Binta Asad	Umma Samia	Umma Samia	
11	Impact on Water Resources	Tamanna Binta Asad	Tamanna Binta Asad	Tamanna Binta Asad	Tamanna Binta Asad	
12	Concept of Economic Analysis	Mohammad Sayed Anwar	Mohammad Sayed Anwar	Md. Mehedi Hasan Prince	Md. Mehedi Hasan Prince	
13	Cost-Benefit Ratio	Mohammad Sayed Anwar	Mohammad Sayed Anwar	Md. Mehedi Hasan Prince	Md. Mehedi Hasan Prince	
14	Project Management	Tamanna Binta Asad	Tamanna Binta Asad	Tamanna Binta Asad	Tamanna Binta Asad	
15	Ethics	Tamanna Binta Asad	Tamanna Binta Asad	Tamanna Binta Asad	Tamanna Binta Asad	
16	Conclusion	Tamanna Binta Asad	Tamanna Binta Asad	Tamanna Binta Asad	Tamanna Binta Asad	

Signature

1. Tamanna Binta Asad …….
2. Md. Mehedi Hasan Prince …….
3. Umma Samia …….
4. Mohammad Sayed Anwar ……..