FEASIBILITY STUDY of the R112 (Demra Staff Quarter to Rampra) ROAD WIDENING PROJECT

Submitted to the Faculty of East West University

by

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Dr. Md. Naimul Haque, Chairperson Dr. Md. Tawfiq Sarwar, Advisor

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Executive Summary

The goal of this report is to find out if a road widening is needed or not. To find that out, level of service (LOS) is calculated in the very beginning. The LOS provides evidence as how long the current pavement can sustain and the expected lifetime of the planned widened road. As the level of service is found to be quite good for the future planned road, so the next task is to choose the type of pavement. Cost benefit analysis helps to choose the best possible pavement.

Introduction

Dhaka is known for having the highest population density, according to a report from Statista Research Department, 2022. Traffic congestion is a common scenario in Dhaka city. To reduce the day-to-day traffic congestion, road widening and construction of new roads are inevitable. However, the budget for this sector is limited. The road construction authorities like RHD, LGED, or city corporations cannot start widening any road due to the strict budget. That is why a feasibility study is required. A feasibility study compares multiple options based on service and budget, and forecasts these for a future time period, and provides the best possible solution.

The R112 is an important highway in Dhaka city. Each lane should be at least 12 ft wide to call it a lane. Following this definition, the R112 highway is a two-lane highway. This highway connects North Dhaka to two major highways in Bangladesh. One is N1, which connects Dhaka to Chattogram. Another one is N2 which connects Dhaka to Sylhet. The R112 is the only road that connects North Dhaka to these two major national highways. Due to it, the demand for this road is increasing exponentially.

The road was able to provide free flow speed even three to four years ago. Nowadays, traffic congestion can often be seen on this road. That is why this road was chosen for this feasibility study. The feasibility study will provide evidence as to if the road width is sufficient for upcoming days and if a road widening is implemented, whether it will be beneficial.

1.2 Problem Statement:

The level of service of the current road and the future anticipated road after widening will provide us with evidence of whether to widen the road. There are several ways to design pavement for a road. In this project, the pavement design is broadly classified into two categories, one is rigid pavement, another one is flexible pavement. Among rigid pavement, two types of pavement design are considered. Among flexible pavement, three types of pavement design are considered. The best possible pavement design will be chosen from the cost-benefit ratio of each pavement. The cost mainly comes from the construction cost, repair and rehabilitation cost, and reconstruction cost. The benefit comes from multiple criteria. Those come from two different types of cost. One is road user cost which includes travel time cost, and vehicle operating cost. The other type is environmental impact cost which includes noise pollution cost, vehicle emission cost, and safety cost. Comparing all these costs in terms of current condition and anticipated widening condition, the benefit can be measured. Using these costs and benefits, a ratio will be calculated to find out the best possible pavement design for this road.

1.3 Objectives of the Study:

- Find out the level of service for current and future anticipated road
- Geometric design to find out the visible portion of the road
- Structural design to find out the thickness of each layer of the pavement
- Cost Analaysis for each type of pavement
- Benefit Analaysis for each type of pavement
- Choosing the best possible pavement based on the cost benefit analysis

Chapter 1

Level of Service

This method of finding Level of Service (LOS) is applicable for highway sections of at least 2 miles (3.22 km). Our road segment is 5.28 mile (8.508 km). So, this method to find LOS is applicable to our road segment.

Estimating FFS:

FFS = BFFS – f_{LS} - f_A Eq 1

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

Lane Width (ft)	Reduction in FFS (mi/h) Shoulder 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 (12 ft) ≥ 12 ft

Shoulder width = 2ft ≥2 < 4 ft

From Exhibit 20-5, Adjustment for lane width and shoulder width, f_{LS} = 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 = 5.28 mile

Access point per mile = $\frac{20}{5.28}$ = 3.79 < 10

From Exhibit 20-6, Adjustment f_A for access point density = 2.5 mi/h

Base FFS, BFFS = 49.71 mi/h (80 km/h)

From Eq 1,

FFS = BFFS – f_{LS} - f_A = 49.71 – 2.6 -2.5 = 44.61 mi/h

Demand Flow Rate:

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

Assuming, Peak hour factor, PHF = 0.95

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

Passenger car per hour = $\frac{2916}{24}$ = 121.5 which is between 0-600

Range of directional flow = 60.75 which is between 0-300

Terrain level = Level

From Exhibit 20-7, f_G to determine speeds = 1

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

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

From Exhibit 20-8, f_G to determine percent-time-spent-following = 1

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

For Trucks (including buses),

Range of two way flow rates = $\frac{10116}{24}$ = 421.5 pc/h within 0-600

Range of directional flow rate = 210.75 pc/h within 0-300

Type of terrain = Level

From Exhibit 20-9, E_T to determine speeds = 1.7

For RVs (including utility),

Range of two way flow rates = $\frac{276}{24}$ = 11.5 pc/h within 0-600

Range of directional flow rates = 5.75 within 0-300

Type of terrain = Level

From Exhibit 20-9, E_R to determine speeds = 1.0

From Exhibit 20-10, Trucks, E_T to determine percent-time-spent-following = 1.1

From Exhibit 20-10, RVs, E_R to determine percent-time-spent-following = 1.0

Heavy vehicle adjustment factor, $f_{HV} = \frac{1}{1+PT(ET-1)+PR(ER-1)}$ Eq 3

Here, proportion of trucks in the traffic stream, $P_T = \frac{10116}{17074} = 0.59$

proportion of RVs in the traffic stream, $P_R = \frac{276}{17074} = 0.016$

Using Eq 3,

For determining speed, $f_{HV} = \frac{1}{1+0.59(1.7-1)+0.016(1-1)} = 0.71$

For determining percent-time-spent-following, $f_{HV} = \frac{1}{1+0.59(1.1-1)+0.016(1-1)} = 0.94$

Flow rate, $v = \frac{17074}{24} = 711.42$ v/hr

Demand flow rate, $v_p = \frac{V}{PHF*fG*fHV} = \frac{711.42}{0.95\ x1x\ 0.71} = 1054.74$ veh/hr

As the value of v_p (1682.83) is within than the flow rate range (600-1200), so the v_P should be used.

Two way flow rate = 0.5 v_P = 0.5 x 1054.74 = 527.37 pc/h

Average travel speed, ATS = FFS – 0.00776 v_P - f_{np} Eq 4

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

Using Eq 4, average travel speed, ATS = 44.61 – (0.00776 x 1054.74) – 0 = 36.43 mi/h

Percent time spent following, PTSF = BPTSF + $f_{d/np}$ Eq 5

BPTSF = 100 $(1 – e^{-0.000879xvp})$ = 100 $(1 – e^{-0.000879x1054.74})$ =60.43

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

	Increase in Percent Time-Spent-Following (%)					
	No-Passing Zones (%)					
Two-Way Flow Rate, v_p (pc/h)	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%

$v_P \geq 800$, $f_{d/np} = 0$

No passing zone 0%

Percent time-spent-following, PTSF = 60.43+0 = 60.43%

Determining LOS:

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

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

Percent tie spent following is almost 60.43%

So, according to Exhibit 20-4, LOS is C.

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

Table 2: Pavement Design Life and Traffic Growth Rates

Following the same procedure, future level of service was determined. In the A-Table 1, the AADT forecast is shown. For the forecast, 7% traffic growth rate was considered as mentioned in the RHD pavement guide.

Table 1.1: LOS on current two lane condition

Year	LOS
1	C
8	D
14	E
20	F

A-Table 5 shows the level of service in the upcoming years. Some important years to note was provided in the figure. It showed, the level of service(LOS) will be worsen in near future. The current LOS is C. The LOS will be D in 10 years, and E in 14 years. Within 20 years, the LOS will be F.

As the LOS will get lower soon, a new road construction can be considered. For trial purpose, widening of two lane roadway was considered. Under that consideration, multilane highway procedure was followed to find out the LOS for the proposed road.

Table 1.2: LOS on expected four lane condition

Year	LOS
1	A
12	B
19	C

25	D
29	E
33	F

This table is a summery of A-Table 8. This table shows the important years to look at. As shown in the table, the level of service will become A if the road is widened. Having a LOS A is desirable in any road.

The level of service will become B in 12 years. LOS will become C in 19 years. As the figure 1 shows, RHD pavement design life is considered to be 20 years. After the expected design life, LOS C is excellent.

The LOS will turn to F after 33 years. The road will be able to accommodate the growing demand till 33 years. So, widening two more lane will be a good decision based on the LOS.

A-Table 1: AADT Forecast

Year	AADT Forecast	Year	AADT Forecast
1	18269.18	26	99154.74
2	19548.02	27	106095.6
3	20916.38	28	113522.3
4	22380.53	29	121468.8
5	23947.17	30	129971.6
6	25623.47	31	139069.7
7	27417.11	32	148804.5
8	29336.31	33	159220.9
9	31389.85	34	170366.3
10	33587.14	35	182292

11	35938.24	36	195052.4
12	38453.92	37	208706.1
13	41145.69	38	223315.5
14	44025.89	39	238947.6
15	47107.7	40	255673.9
16	50405.24	41	273571.1
17	53933.61	42	292721
18	57708.96	43	313211.5
19	61748.59	44	335136.3
20	66070.99	45	358595.9
21	70695.96	46	383697.6
22	75644.68	47	410556.4
23	80939.81	48	439295.3
24	86605.59	49	470046
25	92667.98	50	502949.2

A-Table 2: Truck Forecast

Year	Truck Forecast	Year	Truck Forecast
1	10824.12	26	58747.18
2	11581.81	27	62859.48
3	12392.53	28	67259.65
4	13260.01	29	71967.82
5	14188.21	30	77005.57
6	15181.39	31	82395.96
7	16244.09	32	88163.68
8	17381.17	33	94335.14
9	18597.85	34	100938.6
10	19899.7	35	108004.3
11	21292.68	36	115564.6
12	22783.17	37	123654.1
13	24377.99	38	132309.9

14	26084.45	39	141571.6
15	27910.36	40	151481.6
16	29864.09	41	162085.3
17	31954.57	42	173431.3
18	34191.39	43	185571.5
19	36584.79	44	198561.5
20	39145.73	45	212460.8
21	41885.93	46	227333.1
22	44817.94	47	243246.4
23	47955.2	48	260273.6
24	51312.06	49	278492.8

A-Table 3: RV Forecast

Year	RV Forecast	Year	RV Forecast
1	295.32	26	1602.829
2	315.9924	27	1715.027
3	338.1119	28	1835.079
4	361.7797	29	1963.535
5	387.1043	30	2100.982
6	414.2016	31	2248.051
7	443.1957	32	2405.415
8	474.2194	33	2573.794
9	507.4147	34	2753.959
10	542.9338	35	2946.736
11	580.9391	36	3153.008
12	621.6049	37	3373.719
13	665.1172	38	3609.879
14	711.6754	39	3862.57
15	761.4927	40	4132.95
16	814.7972	41	4422.257
17	871.833	42	4731.815

18	932.8613	43	5063.042
19	998.1616	44	5417.455
20	1068.033	45	5796.677
21	1142.795	46	6202.444
22	1222.791	47	6636.615
23	1308.386	48	7101.178
24	1399.973	49	7598.261
25	1497.971	50	8130.139

A-Table 4: Estimating FFS for current condition

Year	BFFS	fLS	fA	FFS
1	49.71	2.6	2.5	44.61
2	49.71	2.6	2.5	44.61
3	49.71	2.6	2.5	44.61
4	49.71	2.6	2.5	44.61
5	49.71	2.6	2.5	44.61
6	49.71	2.6	2.5	44.61
7	49.71	2.6	2.5	44.61
8	49.71	2.6	2.5	44.61
9	49.71	2.6	2.5	44.61
10	49.71	2.6	2.5	44.61
11	49.71	2.6	2.5	44.61
12	49.71	2.6	2.5	44.61
13	49.71	2.6	2.5	44.61
14	49.71	2.6	2.5	44.61
15	49.71	2.6	2.5	44.61
16	49.71	2.6	2.5	44.61
17	49.71	2.6	2.5	44.61
18	49.71	2.6	2.5	44.61
19	49.71	2.6	2.5	44.61
20	49.71	2.6	2.5	44.61

21	49.71	2.6	2.5	44.61
22	49.71	2.6	2.5	44.61
23	49.71	2.6	2.5	44.61
24	49.71	2.6	2.5	44.61
25	49.71	2.6	2.5	44.61
26	49.71	2.6	2.5	44.61
27	49.71	2.6	2.5	44.61
28	49.71	2.6	2.5	44.61
29	49.71	2.6	2.5	44.61
30	49.71	2.6	2.5	44.61
31	49.71	2.6	2.5	44.61
32	49.71	2.6	2.5	44.61
33	49.71	2.6	2.5	44.61
34	49.71	2.6	2.5	44.61
35	49.71	2.6	2.5	44.61
36	49.71	2.6	2.5	44.61
37	49.71	2.6	2.5	44.61
38	49.71	2.6	2.5	44.61
39	49.71	2.6	2.5	44.61
40	49.71	2.6	2.5	44.61
41	49.71	2.6	2.5	44.61
42	49.71	2.6	2.5	44.61
43	49.71	2.6	2.5	44.61
44	49.71	2.6	2.5	44.61
45	49.71	2.6	2.5	44.61
46	49.71	2.6	2.5	44.61
47	49.71	2.6	2.5	44.61
48	49.71	2.6	2.5	44.61
49	49.71	2.6	2.5	44.61
50	49.71	2.6	2.5	44.61

A-Table 5: Finding fHV for current condition

PHF	Pass car/hr	fg	truck two way flow rate	RV two way flow rate	ET	ER	PT	PR	fHV
0.95	130.005	1	451.005	12.305	1.7	1	0.59248	0.016165	0.706846
0.95	139.1054	1	482.5754	13.16635	1.7	1	0.59248	0.016165	0.706846
0.95	148.8427	1	516.3556	14.08799	1.7	1	0.59248	0.016165	0.706846
0.95	159.2617	1	552.5005	15.07415	1.7	1	0.59248	0.016165	0.706846
0.95	170.41	1	591.1756	16.12934	1.7	1	0.59248	0.016165	0.706846
0.95	182.3387	1	632.5578	17.2584	1.2	1	0.59248	0.016165	0.894058
0.95	195.1024	1	676.8369	18.46649	1.2	1	0.59248	0.016165	0.894058
0.95	208.7596	1	724.2155	19.75914	1.2	1	0.59248	0.016165	0.894058
0.95	223.3728	1	774.9106	21.14228	1.2	1	0.59248	0.016165	0.894058
0.95	239.0089	1	829.1543	22.62224	1.2	1	0.59248	0.016165	0.894058
0.95	255.7395	1	887.1951	24.2058	1.2	1	0.59248	0.016165	0.894058
0.95	273.6413	1	949.2988	25.9002	1.2	1	0.59248	0.016165	0.894058
0.95	292.7962	1	1015.75	27.71322	1.2	1	0.59248	0.016165	0.894058
0.95	313.2919	1	1086.852	29.65314	1.2	1	0.59248	0.016165	0.894058
0.95	335.2223	1	1162.932	31.72886	1.2	1	0.59248	0.016165	0.894058
0.95	358.6879	1	1244.337	33.94988	1.1	1	0.59248	0.016165	0.944066
0.95	383.796	1	1331.441	36.32637	1.1	1	0.59248	0.016165	0.944066
0.95	410.6618	1	1424.641	38.86922	1.1	1	0.59248	0.016165	0.944066
0.95	439.4081	1	1524.366	41.59007	1.1	1	0.59248	0.016165	0.944066
0.95	470.1667	1	1631.072	44.50137	1.1	1	0.59248	0.016165	0.944066
0.95	503.0783	1	1745.247	47.61647	1.1	1	0.59248	0.016165	0.944066
0.95	538.2938	1	1867.414	50.94962	1.1	1	0.59248	0.016165	0.944066
0.95	575.9744	1	1998.133	54.51609	1.1	1	0.59248	0.016165	0.944066
0.95	616.2926	1	2138.003	58.33222	1.1	1	0.59248	0.016165	0.944066

0.95	659.4331	1	2287.663	62.41548	1.1	1	0.59248	0.016165	0.944066
0.95	705.5934	1	2447.799	66.78456	1.1	1	0.59248	0.016165	0.944066
0.95	754.9849	1	2619.145	71.45948	1.1	1	0.59248	0.016165	0.944066
0.95	807.8339	1	2802.485	76.46164	1.1	1	0.59248	0.016165	0.944066
0.95	864.3822	1	2998.659	81.81396	1.1	1	0.59248	0.016165	0.944066
0.95	924.889	1	3208.566	87.54093	1.1	1	0.59248	0.016165	0.944066
0.95	989.6312	1	3433.165	93.6688	1.1	1	0.59248	0.016165	0.944066
0.95	1058.905	1	3673.487	100.2256	1.1	1	0.59248	0.016165	0.944066
0.95	1133.029	1	3930.631	107.2414	1.1	1	0.59248	0.016165	0.944066
0.95	1212.341	1	4205.775	114.7483	1.1	1	0.59248	0.016165	0.944066
0.95	1297.205	1	4500.179	122.7807	1.1	1	0.59248	0.016165	0.944066
0.95	1388.009	1	4815.192	131.3753	1.1	1	0.59248	0.016165	0.944066
0.95	1485.17	1	5152.255	140.5716	1.1	1	0.59248	0.016165	0.944066
0.95	1589.131	1	5512.913	150.4116	1.1	1	0.59248	0.016165	0.944066
0.95	1700.371	1	5898.817	160.9404	1.1	1	0.59248	0.016165	0.944066
0.95	1819.397	1	6311.734	172.2063	1.1	1	0.59248	0.016165	0.944066
0.95	1946.754	1	6753.555	184.2607	1.1	1	0.59248	0.016165	0.944066
0.95	2083.027	1	7226.304	197.159	1.1	1	0.59248	0.016165	0.944066
0.95	2228.839	1	7732.146	210.9601	1.1	1	0.59248	0.016165	0.944066
0.95	2384.858	1	8273.396	225.7273	1.1	1	0.59248	0.016165	0.944066
0.95	2551.798	1	8852.533	241.5282	1.1	1	0.59248	0.016165	0.944066
0.95	2730.424	1	9472.211	258.4352	1.1	1	0.59248	0.016165	0.944066
0.95	2921.553	1	10135.27	276.5256	1.1	1	0.59248	0.016165	0.944066
0.95	3126.062	1	10844.73	295.8824	1.1	1	0.59248	0.016165	0.944066
0.95	3344.886	1	11603.87	316.5942	1.1	1	0.59248	0.016165	0.944066
0.95	3579.029	1	12416.14	338.7558	1.1	1	0.59248	0.016165	0.944066

A-Table 6: Finding Level of service (LOS) for current condition

Year	v	vp	ATS	PTSF	
1	761.2158	1133.599	35.81327	63.08063	C
2	814.5009	1212.951	35.1975	65.56801	C

3	871.516	1297.858	34.53862	68.04422	C
4	932.5221	1388.708	33.83363	70.49688	C
5	997.7987	1485.917	33.07928	72.91314	C
6	1067.645	1257.006	34.85563	66.87589	C
7	1142.38	1344.997	34.17282	69.34126	C
8	1222.346	1439.147	33.44222	71.77635	D
9	1307.911	1539.887	32.66048	74.16812	D
10	1399.464	1647.679	31.82401	76.50329	D
11	1497.427	1763.017	30.92899	78.76866	D
12	1602.247	1886.428	29.97132	80.95127	D
13	1714.404	2018.478	28.94661	83.0388	D
14	1834.412	2159.771	27.85018	85.01977	E
15	1962.821	2310.955	26.67699	86.8839	E
16	2100.218	2341.739	26.4381	87.23405	E
17	2247.234	2505.661	25.16607	88.94708	E
18	2404.54	2681.057	23.805	90.52629	E
19	2572.858	2868.731	22.34865	91.96702	E
20	2752.958	3069.542	20.79035	93.26685	F

A-Table 7: FFS for proposed multilane highway

Year	BFFS	fLW	fLC	fM	fA	FFS
1	49.71	0	1.8	0	0	47.91
2	49.71	0	1.8	0	0	47.91
3	49.71	0	1.8	0	0	47.91
4	49.71	0	1.8	0	0	47.91
5	49.71	0	1.8	0	0	47.91
6	49.71	0	1.8	0	0	47.91
7	49.71	0	1.8	0	0	47.91
8	49.71	0	1.8	0	0	47.91
9	49.71	0	1.8	0	0	47.91
10	49.71	0	1.8	0	0	47.91

11	49.71	0	1.8	0	0	47.91
12	49.71	0	1.8	0	0	47.91
13	49.71	0	1.8	0	0	47.91
14	49.71	0	1.8	0	0	47.91
15	49.71	0	1.8	0	0	47.91
16	49.71	0	1.8	0	0	47.91
17	49.71	0	1.8	0	0	47.91
18	49.71	0	1.8	0	0	47.91
19	49.71	0	1.8	0	0	47.91
20	49.71	0	1.8	0	0	47.91
21	49.71	0	1.8	0	0	47.91
22	49.71	0	1.8	0	0	47.91
23	49.71	0	1.8	0	0	47.91
24	49.71	0	1.8	0	0	47.91
25	49.71	0	1.8	0	0	47.91
26	49.71	0	1.8	0	0	47.91
27	49.71	0	1.8	0	0	47.91
28	49.71	0	1.8	0	0	47.91
29	49.71	0	1.8	0	0	47.91
30	49.71	0	1.8	0	0	47.91
31	49.71	0	1.8	0	0	47.91
32	49.71	0	1.8	0	0	47.91
33	49.71	0	1.8	0	0	47.91
34	49.71	0	1.8	0	0	47.91
35	49.71	0	1.8	0	0	47.91
36	49.71	0	1.8	0	0	47.91
37	49.71	0	1.8	0	0	47.91
38	49.71	0	1.8	0	0	47.91
39	49.71	0	1.8	0	0	47.91
40	49.71	0	1.8	0	0	47.91

41	49.71	0	1.8	0	0	47.91
42	49.71	0	1.8	0	0	47.91
43	49.71	0	1.8	0	0	47.91
44	49.71	0	1.8	0	0	47.91
45	49.71	0	1.8	0	0	47.91
46	49.71	0	1.8	0	0	47.91
47	49.71	0	1.8	0	0	47.91
48	49.71	0	1.8	0	0	47.91
49	49.71	0	1.8	0	0	47.91
50	49.71	0	1.8	0	0	47.91

A-Table 8: Estimating Vp for proposed multilane highway

TLC	V	PHF	N	fHV	fp	vp
1.8	761.2158	0.95	4	0.769543	1	260.3104
1.8	814.5009	0.95	4	0.769543	1	278.5321
1.8	871.516	0.95	4	0.769543	1	298.0293
1.8	932.5221	0.95	4	0.769543	1	318.8914
1.8	997.7987	0.95	4	0.769543	1	341.2138
1.8	1067.645	0.95	4	0.769543	1	365.0987
1.8	1142.38	0.95	4	0.769543	1	390.6556
1.8	1222.346	0.95	4	0.769543	1	418.0015
1.8	1307.911	0.95	4	0.769543	1	447.2616
1.8	1399.464	0.95	4	0.769543	1	478.57
1.8	1497.427	0.95	4	0.769543	1	512.0699
1.8	1602.247	0.95	4	0.769543	1	547.9148
1.8	1714.404	0.95	4	0.769543	1	586.2688
1.8	1834.412	0.95	4	0.769543	1	627.3076
1.8	1962.821	0.95	4	0.769543	1	671.2191
1.8	2100.218	0.95	4	0.769543	1	718.2045
1.8	2247.234	0.95	4	0.769543	1	768.4788
1.8	2404.54	0.95	4	0.769543	1	822.2723

1.8	2572.858	0.95	4	0.769543	1	879.8314
1.8	2752.958	0.95	4	0.769543	1	941.4196
1.8	2945.665	0.95	4	0.769543	1	1007.319
1.8	3151.862	0.95	4	0.769543	1	1077.831
1.8	3372.492	0.95	4	0.769543	1	1153.279
1.8	3608.566	0.95	4	0.769543	1	1234.009
1.8	3861.166	0.95	4	0.769543	1	1320.39
1.8	4131.448	0.95	4	0.769543	1	1412.817
1.8	4420.649	0.95	4	0.769543	1	1511.714
1.8	4730.094	0.95	4	0.769543	1	1617.534
1.8	5061.201	0.95	4	0.769543	1	1730.761
1.8	5415.485	0.95	4	0.769543	1	1851.915
1.8	5794.569	0.95	4	0.769543	1	1981.549
1.8	6200.189	0.95	4	0.769543	1	2120.257
1.8	6634.202	0.95	4	0.769543	1	2268.675
1.8	7098.596	0.95	4	0.769543	1	2427.482
1.8	7595.498	0.95	4	0.769543	1	2597.406
1.8	8127.183	0.95	4	0.769543	1	2779.225
1.8	8696.086	0.95	4	0.769543	1	2973.77
1.8	9304.812	0.95	4	0.769543	1	3181.934
1.8	9956.148	0.95	4	0.769543	1	3404.67
1.8	10653.08	0.95	4	0.769543	1	3642.997
1.8	11398.79	0.95	4	0.769543	1	3898.006
1.8	12196.71	0.95	4	0.769543	1	4170.867
1.8	13050.48	0.95	4	0.769543	1	4462.827
1.8	13964.01	0.95	4	0.769543	1	4775.225
1.8	14941.49	0.95	4	0.769543	1	5109.491
1.8	15987.4	0.95	4	0.769543	1	5467.156
1.8	17106.52	0.95	4	0.769543	1	5849.856
1.8	18303.97	0.95	4	0.769543	1	6259.346

1.8	19585.25	0.95	4	0.769543	1	6697.501
1.8	20956.22	0.95	4	0.769543	1	7166.326

A-Table 9: Estimating Level of Service for proposed multilane highway

Year	ET	ER	PT	PR	fHV	D	
1	1.5	1.2	0.59248	0.016165	0.769543	5.43332	A
2	1.5	1.2	0.59248	0.016165	0.769543	5.813652	A
3	1.5	1.2	0.59248	0.016165	0.769543	6.220608	A
4	1.5	1.2	0.59248	0.016165	0.769543	6.65605	A
5	1.5	1.2	0.59248	0.016165	0.769543	7.121974	A
6	1.5	1.2	0.59248	0.016165	0.769543	7.620512	A
7	1.5	1.2	0.59248	0.016165	0.769543	8.153948	A
8	1.5	1.2	0.59248	0.016165	0.769543	8.724724	A
9	1.5	1.2	0.59248	0.016165	0.769543	9.335455	A
10	1.5	1.2	0.59248	0.016165	0.769543	9.988937	A
11	1.5	1.2	0.59248	0.016165	0.769543	10.68816	A
12	1.5	1.2	0.59248	0.016165	0.769543	11.43633	B
13	1.5	1.2	0.59248	0.016165	0.769543	12.23688	B
14	1.5	1.2	0.59248	0.016165	0.769543	13.09346	B
15	1.5	1.2	0.59248	0.016165	0.769543	14.01	B
16	1.5	1.2	0.59248	0.016165	0.769543	14.9907	B
17	1.5	1.2	0.59248	0.016165	0.769543	16.04005	B
18	1.5	1.2	0.59248	0.016165	0.769543	17.16285	B
19	1.5	1.2	0.59248	0.016165	0.769543	18.36425	C
20	1.5	1.2	0.59248	0.016165	0.769543	19.64975	C
21	1.5	1.2	0.59248	0.016165	0.769543	21.02523	C
22	1.5	1.2	0.59248	0.016165	0.769543	22.497	C
23	1.5	1.2	0.59248	0.016165	0.769543	24.07179	C
24	1.5	1.2	0.59248	0.016165	0.769543	25.75681	C
25	1.5	1.2	0.59248	0.016165	0.769543	27.55979	D
26	1.5	1.2	0.59248	0.016165	0.769543	29.48898	D

27	1.5	1.2	0.59248	0.016165	0.769543	31.55321	D
28	1.5	1.2	0.59248	0.016165	0.769543	33.76193	D
29	1.5	1.2	0.59248	0.016165	0.769543	36.12527	E
30	1.5	1.2	0.59248	0.016165	0.769543	38.65403	E
31	1.5	1.2	0.59248	0.016165	0.769543	41.35982	E
32	1.5	1.2	0.59248	0.016165	0.769543	44.255	E
33	1.5	1.2	0.59248	0.016165	0.769543	47.35285	F

Chapter 2

Geometric Design

Type 1 : 11 m wide dual –	This is a three-lane carriageway as one half of a dual 3 – lane road.
Type 2 : 7.3 m wide dual –	This is a high standard carriageway as one half of a dual 2-lane road.
Type 3: 7.3 m wide single –	This is a high standard two-lane single carriageway.
Type 4 : 6.2 m 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 : 5.5 m 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 : 3.7 m wide –	This is the standard single lane carriageway width, and is suitable for the more lightly trafficked Zila Roads. Vehicles traveling in opposing directions can pass each other by putting their outer wheels on the *paved* shoulder on either side of the pavement within optimum safe width.

According to RHD Geometric design manual, type 3 is a high standard two-lane single carriageway option. As the space available to widen the lanes are limited. The environmental impact was aimed to keep at a minimum. So, this type of road was chosen for the feasibility study.

Design type 3-7.3 m wide carriageway width of sectional element

Table 2.2 Typical Design Speeds

Design Type	Design Speed (km/h)		
	Plain	Rolling	Hilly
1 – 2	80 - 100	80	-
3	80	65	50
4	65	50	40
5 – 6	50	40	30

According to table 2.2, design type level 3 and plain terrain should have 80 km/hr velocity. So, this speed limit was chosen for this study.

Trucks are usually 4m high. However, there can be transports of abnormal loads crossing this road. So, a vertical clearance of 5.7m headroom was chosen. This headroom was ensured throughout the length of the road.

Lateral clearance is suggested to be 1 meter in the RHD manual. As there are only waterbody on the side of the road, so lateral clearance is available. Tree plantation was chosen throughout the length of road. However, trees will not be provided in places where there are horizontal curves.

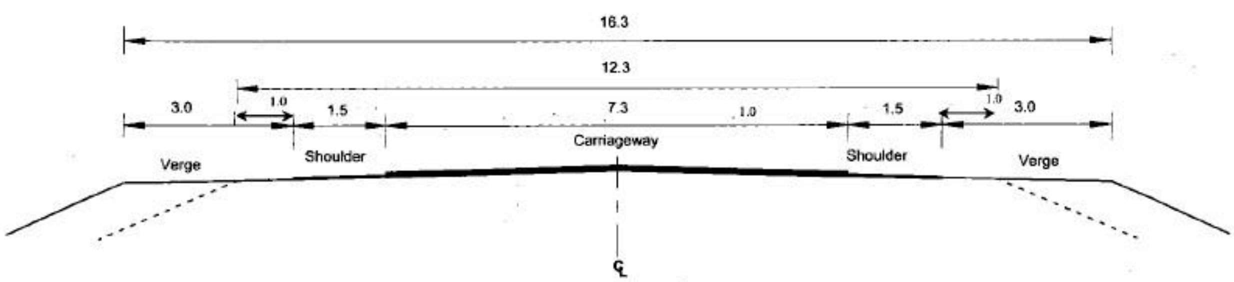
According to RHD manual, standard cross-fall of 3% was chosen for the curved carriageways.

The RHD manual suggests to place the road pavement 1m above the flood level. However, the goal of this extended lanes is to work adjacently to the existing two lanes. So, the flood level calculation is excluded for now. The existing road was built only 9 years ago. So, the same elevation of the extended lanes is considered to be adequate.

										NMT					
Heavy truck	Medium truck	Small truck	Large bus	Medium bus	Micro bus	Utility	Car	Auto rickshaw	Motor cycle	Bi cycle	Cycle	Cart	Total	Total NMT	Percentage of NMT
606	4258	2204	89	1199	1764	276	2916	1767	1912	17	70	0	17078	87	0.509427

According to the AADT data, only 0.5% of the vehicles are non-motorized. So, additional non-motorized lane (NMT) was not provided.

Design Type 3 – 7.3 M Wide Carriageway without NMT Lane



Crest= 16.3 m

Carriageway = 7.3m

Shoulder paved = 1.5m

Verge = 3.0m

Design capacity

Maximum capacity: 2100PCU/hr

Assumed NMT/MV ratio = 0.005

Assuming PCE values for,

bicycle = 0.5

Rickshaw = 2

Car = 4

NMT = (17 ×0.5)+ (70× 2)+(4×0)

= 148.5 PCU/hr

As NMT 148.5 PCU/hr < 400 PCU/hr

So separate NMT 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

According to table 5.1

Assume design speed = 80 km/h

For two lane – single carriageway roads 6.2 an

SSD= 500

ISD = 2000

OSD = 8000

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

Design speed = 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,

For Design speed 80 km/hr and super elevation 5%,

Plan transition length, Lp = 45m

Straight transition length, Lc = 55m

Table 5.4 Extra Carriageway Widths on Curves (m)

Radius (m)	Single Lane Roads	Two Lane Roads	
	3.7m wide	6.2m wide	7.3m wide
15	1.8	2.4	2.1
16 to 20	1.5	2.1	1.8
21 to 35	1.2	1.8	1.5
36 to 65	0.9	1.5	1.2
66 to 120	0.6	1.2	0.9
121 to 200	Nil	0.9	0.6
201 to 350	Nil	0.6	Nil
351 to 600	Nil	0.6	Nil
601 to 1000	Nil	Nil	Nil

Notes:

1 For transitioned curves half the widening is applied on each side of the centerline, and it is developed uniformly over the length of the transitions curve.

2 For curves without transitions the widening is applied on the inside of the curve, and it is developed uniformly over a 20m length leading up to the start of the circular curve. Values in brackets refer to dual carriageway roads.

Source : adapted from Table 7.56, Vol. V11a, RMSS

Table 5.4

Extra carriageway width on curves for 500 m radius and 7.3 m wide two lane road 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 80 km/h

K= 35 for SSD

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

From table 6.2 Vertical Curve Appearance Criteria

Let, A1 = 5%

A2 = - 5%

∴ A = 5% - (-5%) = 10%

L = 35 x 10 = 350 m > 50 m

From table 6.2, L is acceptable

A curve length of 350m is selected

Table 6.3 Maximum Gradients

Design Type	Design Speed	Maximum Gradient %		
		Plain	Rolling	Hilly
All Design Type	All Design Speeds	0 - 3	1 - 5	1 – 7

From table 6.3, gradients plain for all design type and speed, maximum gradient in plain terrain should be = 0- 3%

Stopping sight distance

tr = 2.5s

V= 80

Reaction distance, dr = 0.278×80 = 22.24m

a= 3.4m/s2

V=80km/h

Braking distance, dv= 0.039 × (30^2/3.4) = 10.32m

.'. Stopping slight distance = (20.85 +10.32) = 31.17m

Stopping distance on grades,

d=0.278.t.v + {v^2/254(a/9.81+- h)}

=(0.278×2.5×30) +{(30)^2/254(3.4/9.81+-3/10)}

=30.26 (for downgrade) And , 32.04. (for upgrade)

≈ 31m (for downgrade)

≈33m (for upgrade)

Horizontal Alignment:

Max side friction, f = (v^2/127R)- e/100

= (30^2/127×35)-6/100

=0.14

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 R1 = $\frac{1077.78^2 + 213.24^2}{2*213.24}$ = 2830.34m

Where, L1 = 2155.56

H1 = 213.24

A1 = L1/2

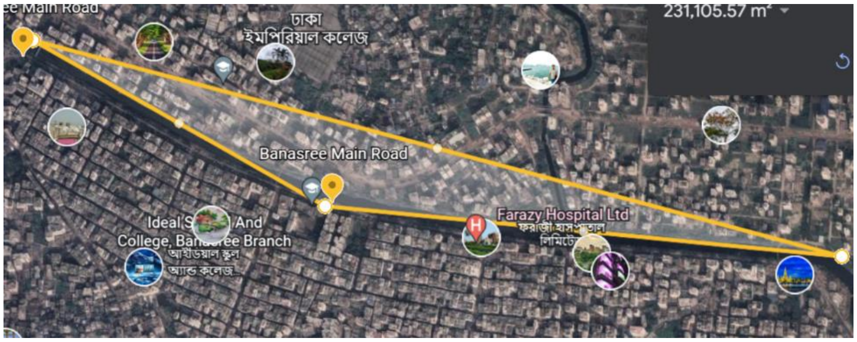


Fig 2.1 : Location of curvature 1

For radius of curvature R2 = $\frac{1591^2 + 556^2}{2*556}$ = 2554.33m

Where, L2 = 3182

H2 = 556

A2 = L2/2

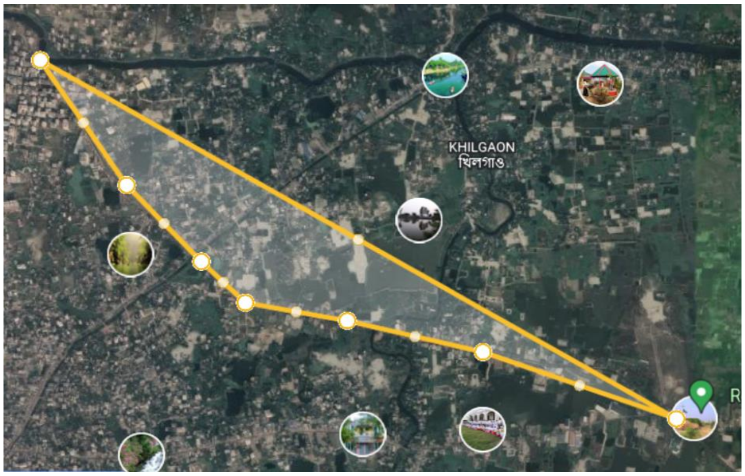


Fig 2.2 : Location of curvature 2

For radius of curvature 3 = $\frac{1636^2 + 346^2}{2*346}$ =4041m

Where, L3 = 3272

H3 = 346

A3 = L2/2

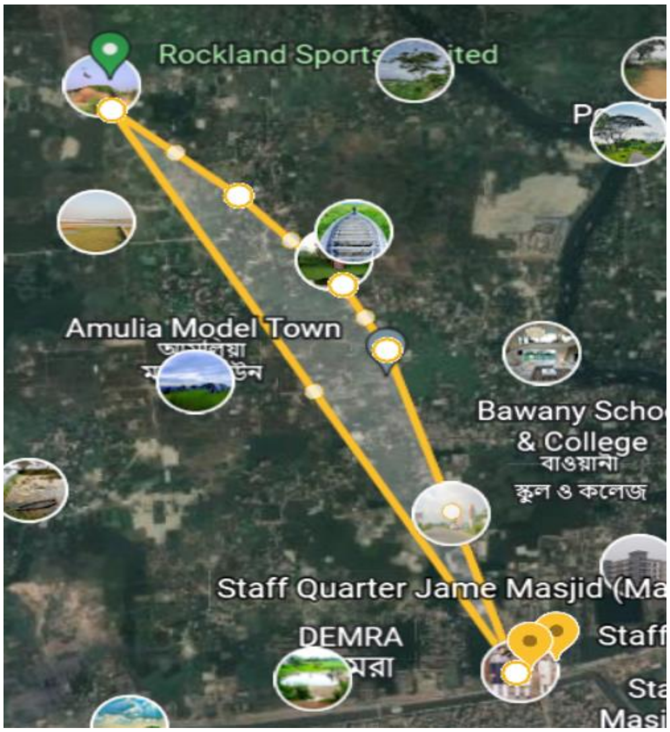


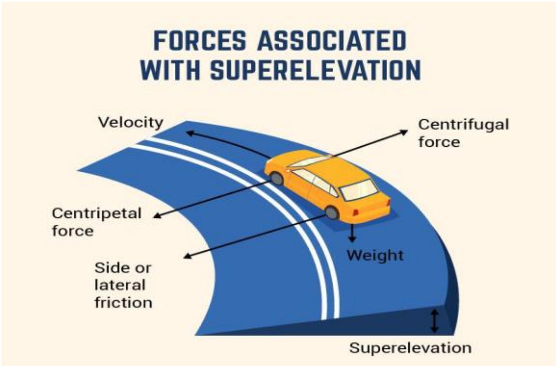
Fig 2.3: radius of curvature 3

Fig 2.4 : total radius of curvature taken

Super-elevation : The rise given to the outer edge of a road on curves is known as super elevation. When a vehicle passes over a curved path centrifugal force acts on the vehicle. The centrifugal force tends to push the vehicle off the road. It is resisted by the friction between the tires and the road. If the frictional force is not sufficient the vehicle skids sideways. To avoid this outer edge of the road at the horizontal curve rose above the inner edge.

Why Super-elevation is needed?

- Super elevation on curves helps keep vehicles on the road.
- Super elevation increases the stability of the fast moving vehicles on horizontal curves.
- Super elevation reduces the accidents in curves (skidding, toppling).
- On super elevated curves the vehicles need not necessarily to slow down.



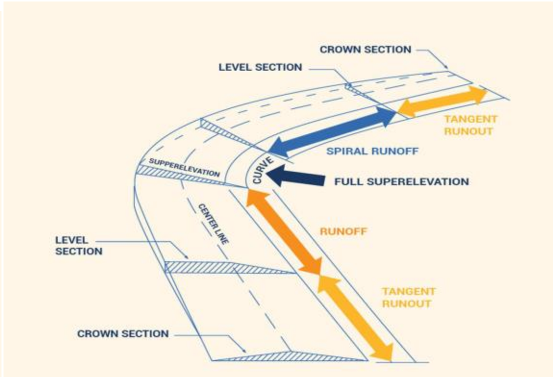
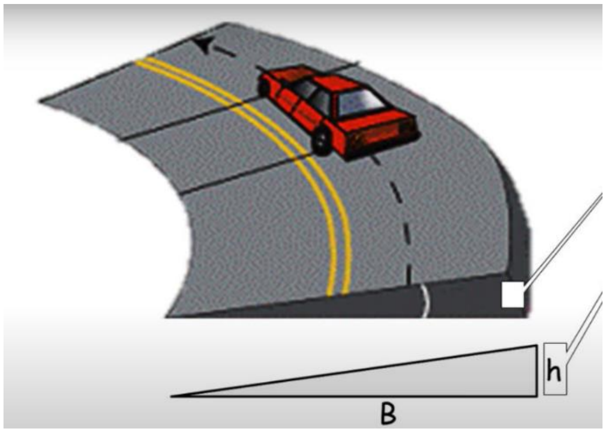


Fig 2.5 : Super-elevation

Super-elevation Calculation :

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



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

For R1,

$$H1 = \frac{7.3*22.22^2}{9.8*2830.34} = 0.13 \text{ m}$$

For R2,

$$H2 = \frac{7.3*22.22^2}{9.8*2554.33} = 0.14 \text{ m}$$

For R3,

$$H3 = \frac{7.3*22.22^2}{9.8*4041} = 0.1 \text{ m}$$

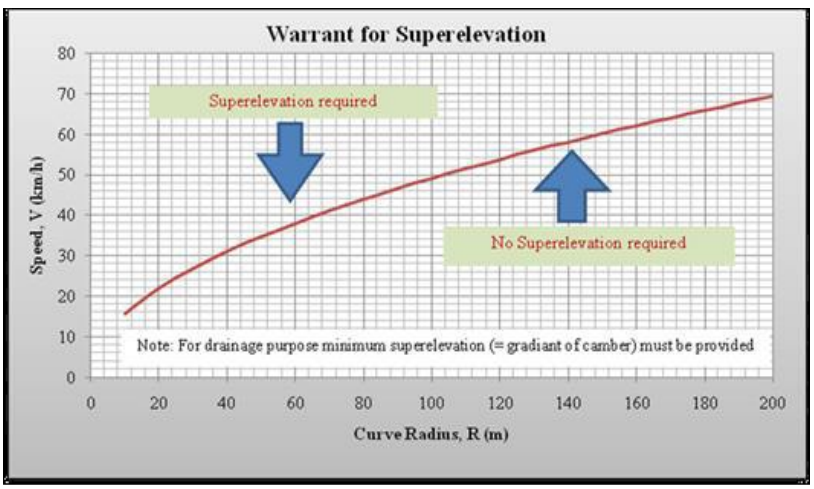


Fig 2.6: Warrant for Super-elevation

From the above calculation of curve we can say that we need to provide super-elevation in our road construction.

Extra widening : Extra widening refers to the additional width of carriageway that is required on a curved section of a road over and above that required on a straight alignment.

When necessary?

In general extra width is provided on the horizontal curves when the radius is less than 300 m.

From calculation we can say that our radius of curvature value is greater than 300 m for that we don’t need to provide extra width

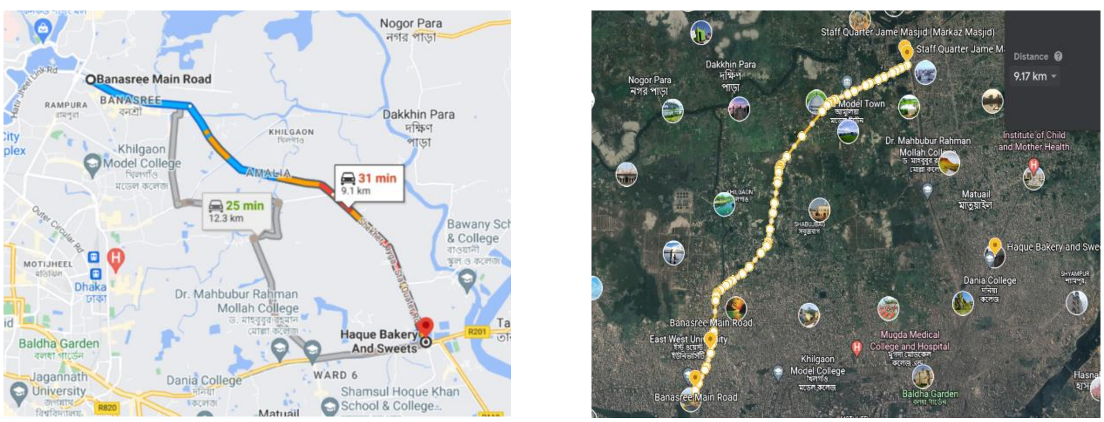


Fig 2.7: Study Area

Traffic Sign: Technical guidance on the design, application, location and production of traffic signs in Bangladesh is offered in the Traffic Signs Manual. Any object, gadget, line, or mark on the road that serves to convey limitations, warnings, or other information to road users or a certain class of road users is referred to as a "traffic sign." any kind of restrictions, alerts, or information. Consequently, the phrase "traffic sign" covers not only signs on posts, but also traffic lights, road studs, delineators, road markings, and other traffic management tools.

General Principles of Traffic Signs:

Each traffic sign must fulfill the following criteria in order to be effective:

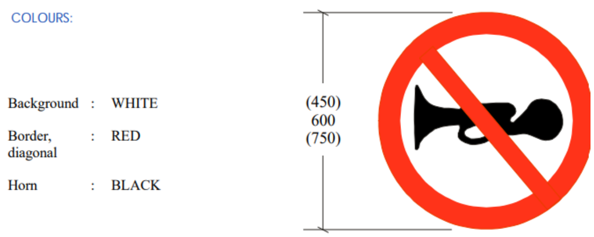
- Satisfy a demand;
- Command attention;
- Be legible;
- Express a simple, clear meaning at a glance;

  Be positioned to allow for adequate response time from drivers;
- Command respect.

Signs must only be utilized when absolutely necessary. Drivers get annoyed when signs are used incorrectly or unnecessarily, and when this happens repeatedly, drivers lose respect for the sign and it loses its effectiveness when it is actually needed.

Use of traffic sign in our study area :

From the map we can see there is a hospital where we can use the sign “**NO USE OF HORN**”

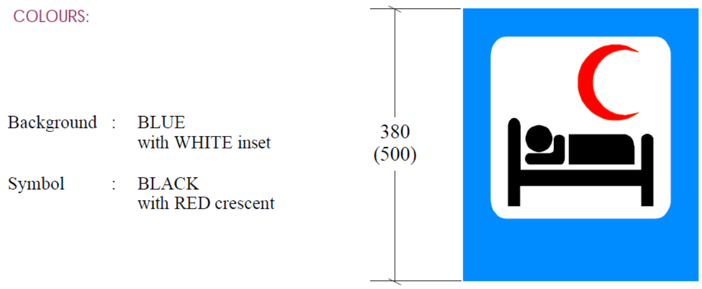


Description: The use of vehicle horns is forbidden, as shown by this circular sign with a red diagonal running from top left to bottom right over a representation of a horn.

Application: This sign is placed outside hospitals and other places where cars are forbidden to honk their horns.

Location: The sign should be posted on the left side of the road at the start of the restriction and again after each significant intersection.

We can also use the sign of “Hospital” which is information sign C9.



Description:

Square sign with a bed symbol, a red crescent above, and an optional panel The distance to the hospital is indicated below with an arrow or text, respectively.

Application: This sign directs drivers to a hospital's location.

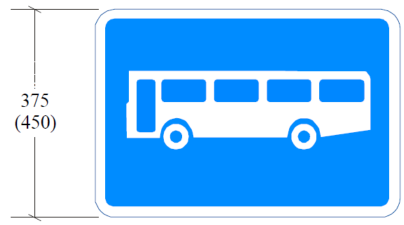
Location: The sign should be placed next to the hospital and on the same side of the street. Another sign we can provide on this road is "BUS STOP" which is information sign C21.

COLOURS:

Background : BLUE

Border : WHITE

Symbol : WHITE



DESCRIPTION:

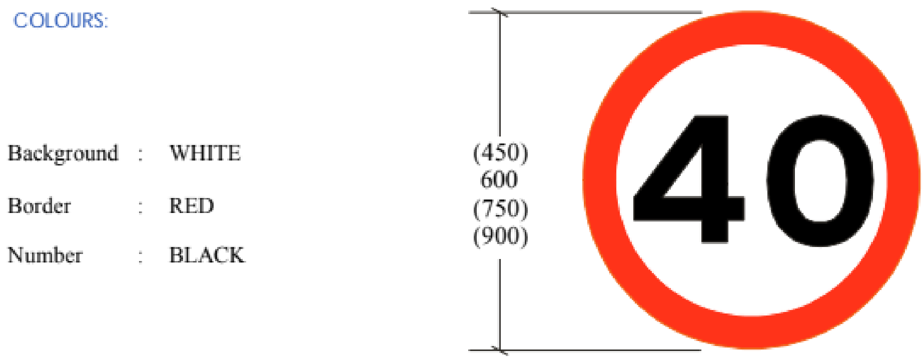
A rectangular sign with a bus icon heading left.

Application: This sign is placed to show where a bus stop is located. The sign is especially helpful at bus bays because it deters other drivers from parking there in addition to showing passengers where the bus stop is.

Location: Normally, the sign should be put up near where the buses stop.

Where a bus bay exists, though, it may be situated at the beginning of the bay.

As there is a Bazar in that road for that there should be a speed limit in that particular place which can be defined as "Special Speed Limit" which is in Regulatory Sign No A26



Description:

Circular sign with numbers indicating the speed limit.

APPLICATION:

The maximum speed that is permitted on this road is given by this traffic sign.

LOCATION:

The sign should be positioned on both sides of the road, for maximum impact. The sign should be repeated after every major junction and about every 400 meters between junctions.

These are the traffic signs we can use in our study area.

Chapter 3

Structural Design

3.1 Design analysis for flexible pavement

Flexible pavements are ashphalt making roads where asphalt make roads less susceptible to damage to bends or deflects of roads due to traffic load and it require fewer repairs over time. A flexible pavement structure is composed of several layers of different materials which together enable the road to accommodate this flexing.

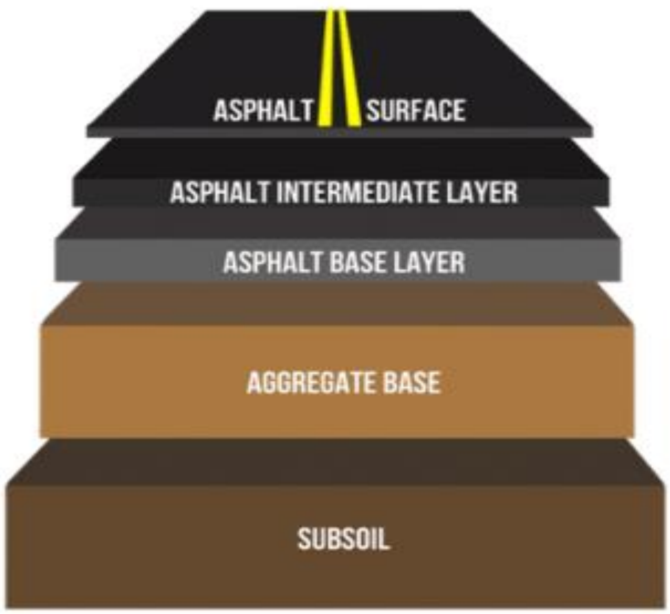


Figure: layers of flexible pavement

Sub soil: sub soil or sub grade mainly consist of natural elements like sand. This part needs proper treatment so that road gets proper strength.

Aggregate base: aggregate base or subgrade base consist of stone. It is upper part of sub soil part.

Asphalt base layer: this part consist of granular materials like sand, crushed or uncrushed gravel and crushed or uncrushed slag.

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

3.1.1 Design of flexible pavement 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 expressed as CBR for that proper material should be used and also compaction is needed to get the expected CBR value for every layer.

Table 3.1: Pavement Design life and traffic Growth rate

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

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 3.2: Vehicle Equivalence Factors

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

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 3.3: Cumulative Growth Factors

Road Type	Factor
National Road	57.3
Regional Road	41.0

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

Where r = annual traffic growth rate

n = design life in years

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

Table 3.4: Calculating Total ESA

Vehicle Tpye	Existing Flow/day	ESA Factors	ESA/day	Annual ESAs
Large truck	606	4.8	2909	1061785
Medium truck	4258	4.62	19672	7180280
Small truck	2204	1.0	2204	804460
Large bus	85	1.0	85	31025
Mini bus	1199	0.5	600	219000
Car	2916	0.5	1458	532170
Motor cycle	1912	0.5	956	348940

CNG	276	0.5	138	50370
Micro	1764	0.5	882	321930
			Total	10549960

Cumulative ESAs = 10549960 * 41

= 432548360

=432.54 million ESAs

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

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						
30 - 40		125						
25 - 30		110		250	300	250		
17 - 25		105						
15 - 17		95				200		
11 - 15		90						
9 - 11		80		200	250			
7 - 9		70						
6 - 7		65						
5 - 6		60						
4 - 5		55						
3 - 4		45		175	200	175		
< 3		35		150	175	150		

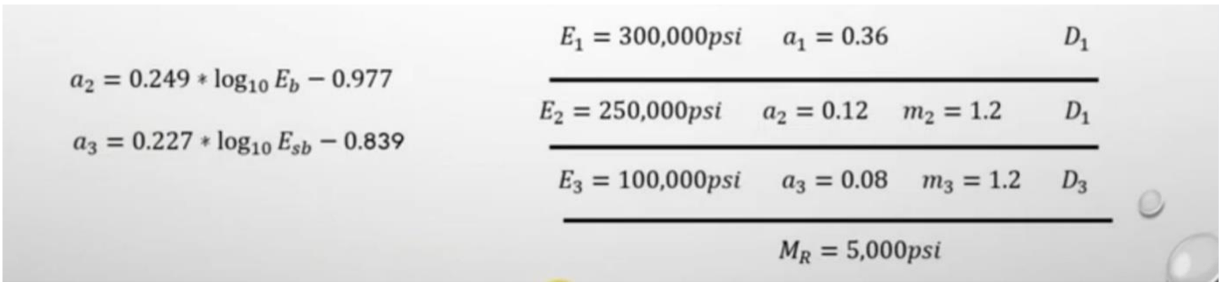
* CBR of granular base type I is min. 80%   N/A. = not applicable
* CBR of granular base type II is min. 50%
** CBR of sub-base material is 25%

Table 3.1: Thickness Design Table for Flexible Pavements

From the above 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 high traffic volume because this method is applicable for low traffic volume.

3.1.2 AASHTHO method for flexible pavement

Figure below is a pavement system with the resilient module, layer co efficient and drainage coefficient as shown. If predicted ESAL =18.6 $x|\dot{0}^6$, R=95%, s.= 0.35 and Δ PSI= 2.1, select thickness D1, D2, D3



Sol: calculation of D1, here Mr= 250000psi

We have equation: log(W18)= Zr* S.+ 9.36 log (SN +1) -0.20 + $\frac{\log\left(\frac{\Delta PSI}{4.2-1\cdot5}\right)}{0.40+\frac{1094}{(SN+1)^{5.19}}}$ +2.32 log((M_R) - 8.07

here, w_{18}=18.6 $^{x}10^6$and for R= 95 %, ZR = -1.645, So = 0.35 and APSI=2.1 then putting these values,

we get,

log(18.6 $^{x}10^6$)

= -1.645 x 0.35 + 9.36 log(SN₁ + 1) - 0.20 + + $\frac{\log\left(\frac{2.1}{4.2-1\cdot5}\right)}{0.40+\frac{1094}{(SN+1)^{5.19}}}$ + 2.32 log((250000) - 8.07

So, SN1= 1.420

D1=$\frac{SN_1}{a_1}$ =$\frac{1.420^-}{0.36}$ =3.944 inches

calculating D2: here $M_R = 100000$ psi

We have equation: log(W18)= Zr* S.+ 9.36 log (SN +1) -0.20 + $\frac{\log\left(\frac{\Delta PSI}{4.2-1.5}\right)}{0.40+\frac{1094}{(SN+1)^{5.19}}}$ +2.32 log((M_R) - 8.07

here, w_{18}=18.6 $^{x}10^{6}$and for R= 95 %, ZR = -1.645, So = 0.35 and APSI=2.1 then putting these values,

we get,

log(18.6 $^{x}10^{6}$)

= -1.645 x 0.35 + 9.36 log(SN_1 + 1) - 0.20 + + $\frac{\log\left(\frac{2.1}{4.2-1.5}\right)}{0.40+\frac{1094}{(SN+1)^{5.19}}}$ + 2.32 log((100000) - 8.07

So, SN2= 2.0359

D2=$\frac{SN_2-a1*D1}{a2*m2}$ =$\frac{2.0359-0.36*3.944}{0.12*0.12}$ =4.27 inches

calculating D3: here $M_R = 5000$ psi

We have equation: log(W18)= Zr* S.+ 9.36 log (SN +1) -0.20 + $\frac{\log\left(\frac{\Delta PSI}{4.2-1.5}\right)}{0.40+\frac{1094}{(SN+1)^{5.19}}}$ +2.32 log((M_R) - 8.07

here, w_{18}=18.6 $^{x}10^{6}$and for R= 95 %, ZR = -1.645, So = 0.35 and APSI=2.1 then putting these values,

we get,

log(18.6 $^{x}10^{6}$)

= -1.645 x 0.35 + 9.36 log(SN_1 + 1) - 0.20 + + $\frac{\log\left(\frac{2.1}{4.2-1.5}\right)}{0.40+\frac{1094}{(SN+1)^{5.19}}}$ + 2.32 log((5000) - 8.07

So, SN3= 5.377

D3=$\frac{SN3-a1*D1-a2*D2*M2}{a3*m3}$ =$\frac{5.377-0.36*3.944-0.12*4.278*1.2}{0.08*1.2}$ = 34.80 inches

3.1.3 Flexible pavement design:

Design flexible pavement for an undivided rural highway by using Catalogue of Pavement Structures

Method for the following data.

Table 3.2:

VEHICLE type	AADT
Large truck	606
Small truck	2204
Large bus	85
Small bus	1764
car	2916
Auto rickshaw	1767
Motor cycle	1912
Bi cycle	17

Solution:

Table 1: PCU Factors for Rural Road

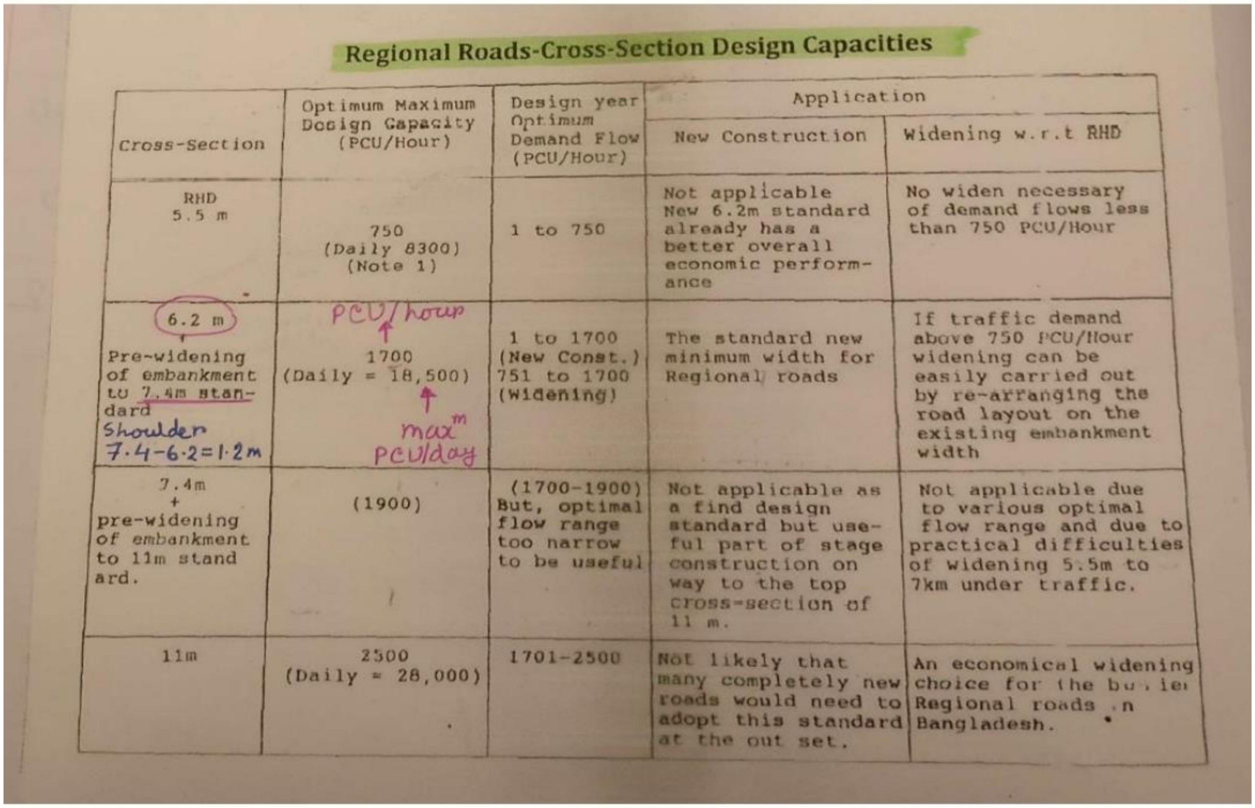
Vehicle Types	PCU Factors
Large Truck	3.0
Small Truck	2.0
Large Bus	2.5
Small Bus	1.5
Car/Tempo	1.0
Autorickshaw	0.5
Motor Cycle	0.3
Bicycle	0.3
Rickshaw	2.0
Cart	4.0

Table 3.3:

Vehicle type	AADT	PCU factors	Traffic volume * PCU factors
Large truck	606	3.0	1818
Small truck	2204	2.0	4408
Large bus	85	2.5	212.5
Small bus	1764	1.5	2650.5
car	2916	1.0	2916
Auto rickshaw	1767	0.5	883.5
Motor cycle	1912	0.3	573.6
Bi cycle	12	0.3	5.1
			Total= 13467.2

Forecasted design flow= 13467.2* $\left(1 + r\right)^{n}$

13467.2* $\left(1 + 0.08\right)^{20}$ = 62770.04 pcu / day



Regional Roads-Cross-Section Design Capacities

Cross-Section	Optimum Maximum Design Capacity (PCU/Hour)	Design year Optimum Demand Flow (PCU/Hour)	Application	
			New Construction	Widening w.r.t RHD
RHD 5.5 m	750 (Daily 8300) (Note 1)	1 to 750	Not applicable New 6.2m standard already has a better overall economic perform-ance	No widen necessary of demand flows less than 750 PCU/Hour
6.2 m Pre-widening of embankment to 7.4m stan-dard Shoulder 7.4-6.2=1.2m	PCU/hour 1700 (Daily = 18,500) max^m PCU/day	1 to 1700 (New Const.) 751 to 1700 (Widening)	The standard new minimum width for Regional roads	If traffic demand above 750 PCU/Hour widening can be easily carried out by re-arranging the road layout on the existing embankment width
7.4m + pre-widening of embankment to 11m stand ard.	(1900)	(1700-1900) But, optimal flow range too narrow to be useful	Not applicable as a find design standard but use-ful part of stage construction on way to the top cross-section of 11 m.	Not applicable due to various optimal flow range and due to practical difficulties of widening 5.5m to 7km under traffic.
11m	2500 (Daily = 28,000)	1701-2500	Not likely that many completely new roads would need to adopt this standard at the out set.	An economical widening choice for the bu[illegible] Regional roads in Bangladesh.

So we can see our design forecast flow is not matching with any optimum design capacity so that it is impossible to choose a cross section.

So this method is impossible.

Usefulness of flexible pavement:

Flexible usually applied in thick layer which gives it the ability to withstand heavy load and more traffic flows. So for major roadway engineer chose this pavement system. Flexible pavement requires regular maintainance but it is fairly easy to do.

Problems of flexible pavement:

As we have mentioned flexible pvament needs regular maintainance. If not than there are few problems can be seen. Like-

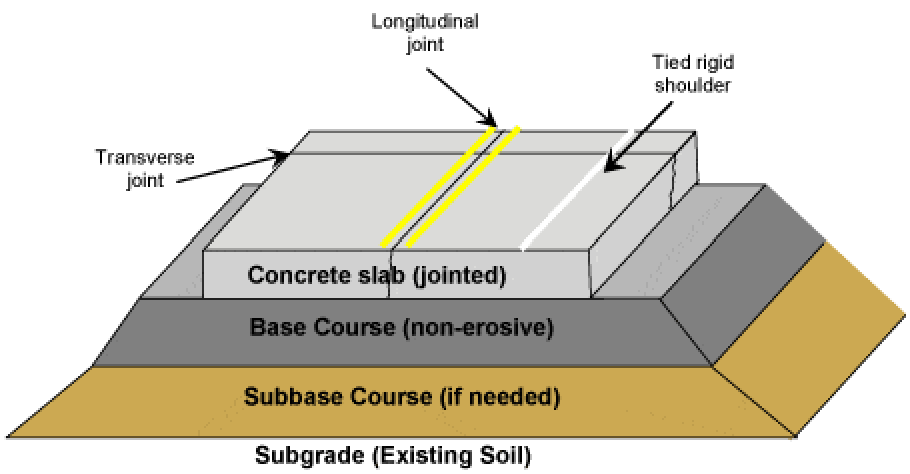
- Bleeding in Flexible Pavements.
- Block Cracking in Flexible Pavements. This is also called as thermal cracking.
- Bumps and Sags.
- Edge Cracking in Flexible Pavements.
- Joint Reflection Cracking.
- Raveling.
- Cold Joints in Flexible Pavements.

  (source : google)

3.1.4 Pavement design for rigid pavement:

Rigid pavements are constructed of portland cement concrete(PCA) slabs resting on a prepared subbase of granular material or directly on a granular subgrade. Load is transmitted through the slabs to the underlying subgrade by flexure of the slabs.

(source: google)



Subgrade: subgrade can be earth or soil. It is the base layer 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 consist 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 mode considered

1.Fatigue failure

2. Erosion failure

Design parameters:

1. Concrete modulus of rupture (MR)

2. Modulus of subgrade reaction (k)

3. Design traffic volume

4. Axle load spectrum

Design procedure:

- **C**hoose a trial slab thickness
- Calculate the fatigue and erosion failure
- Sum of fatigue and erosion failure of the axle load classes

Data Analysis:

Annual Average Daily Traffic :17074 from which we can assume the data was collected at the month of August for that we can now calculate ADT which is

$\frac{AADT}{MEF} = \frac{17074}{0.521}$ =32772

Percentage of truck determination:

Vehicle type	**Number ofvehicle**	**Percentage**
Large bus	85	0.55
Mini bus	1199	7..87
Private car	2919	19.17
Motor cycle	1912	12.56
CNG	276	1.81
Micro	1764	11.58
Truck	7068	46
Total	15223	

Growth Rate : 7%

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 $=(1+r)^{Y}/_{2}$ = 1.97

Lane Distribution Factor: (ADT)*(D)*(G) = 32772*0.5*1.97 = 32280

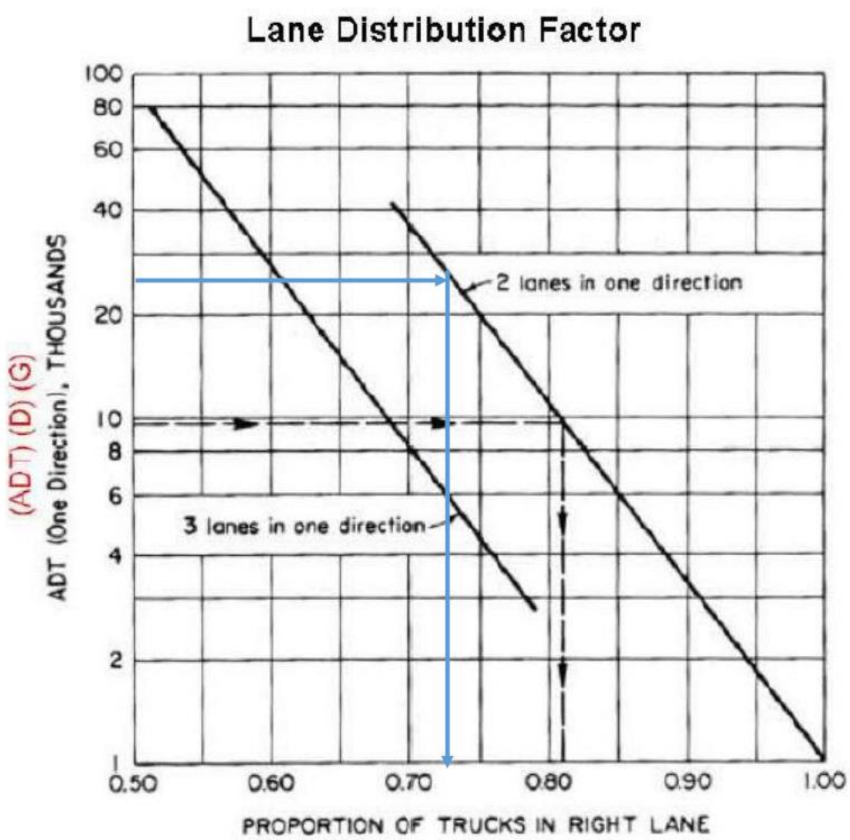


Figure: Lane Distribution Factor

From the above figure we can say the of L = 0.73

Design traffic Volume:

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

=78046308 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

Untreatedsubbase : 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 Both Axle :

Subbase subgrade k = 130 psi

Slab thickness = 9.5 in

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

Slab thickness, in.	k of subgrade-subbase, pci						
	50	100	150	200	300	500	700
4	825/679	726/585	671/542	634/516	584/486	523/457	484/443
4.5	699/586	616/500	571/460	540/435	498/406	448/378	417/363
5	602/516	531/436	493/399	467/376	432/349	390/321	363/307
5.5	526/461	464/387	431/353	409/331	379/305	343/276	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	285/261	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	$\boxed{215/205}$	$\boxed{200/183}$	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	167/183	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	158/183	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)

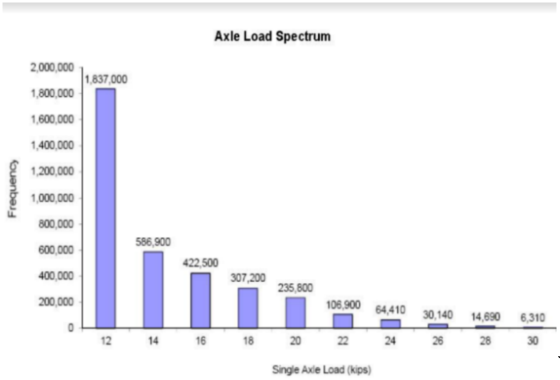
Slab thickness, in.	k of subgrade-subbase, pci					
	50	100	200	300	500	700
4	3.74/3.83	3.73/3.79	3.72/3.75	3.71/3.73	3.70/3.70	3.68/3.67
4.5	3.59/3.70	3.57/3.65	3.56/3.61	3.55/3.58	3.54/3.55	3.52/3.53
5	3.45/3.58	3.43/3.52	3.42/3.48	3.41/3.45	3.40/3.42	3.38/3.40
5.5	3.33/3.47	3.31/3.41	3.29/3.36	3.28/3.33	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	2.95/3.05	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	2.25/2.49	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

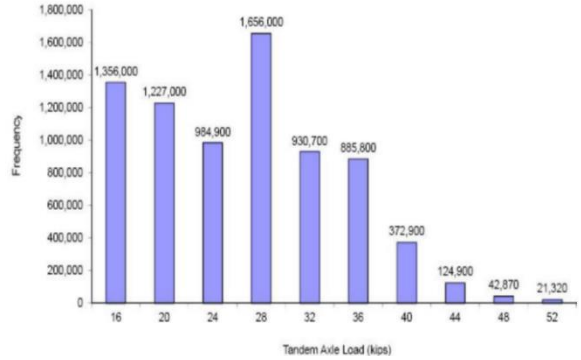
Single Axle :

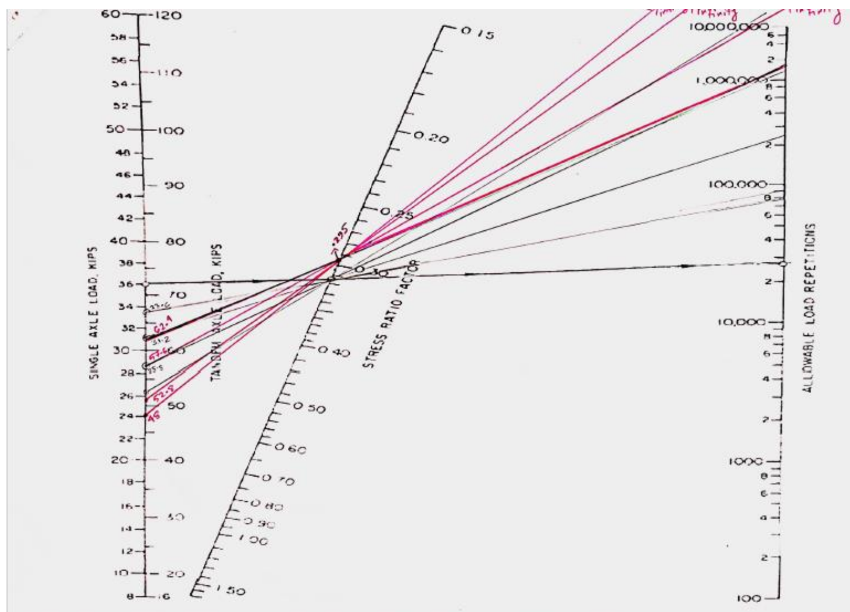
- **Equivalent Stress** : 206 (using interpolation)
- **Stress Ration factor** : $\frac{206}{Mr} = \frac{206}{650} = 0.317$

Tandem Axle :

- **Equivalent Stress** : 192 (using interpolation)
- **Stress Ration factor** :$\frac{190}{Mr} = \frac{190}{650} = 0.295$







Fatigue analysis—allowable load repetitions based on stress ratio factor (with & without concrete shoulder)

Figure : Fatigue Analysis Based on Stress ratio factor

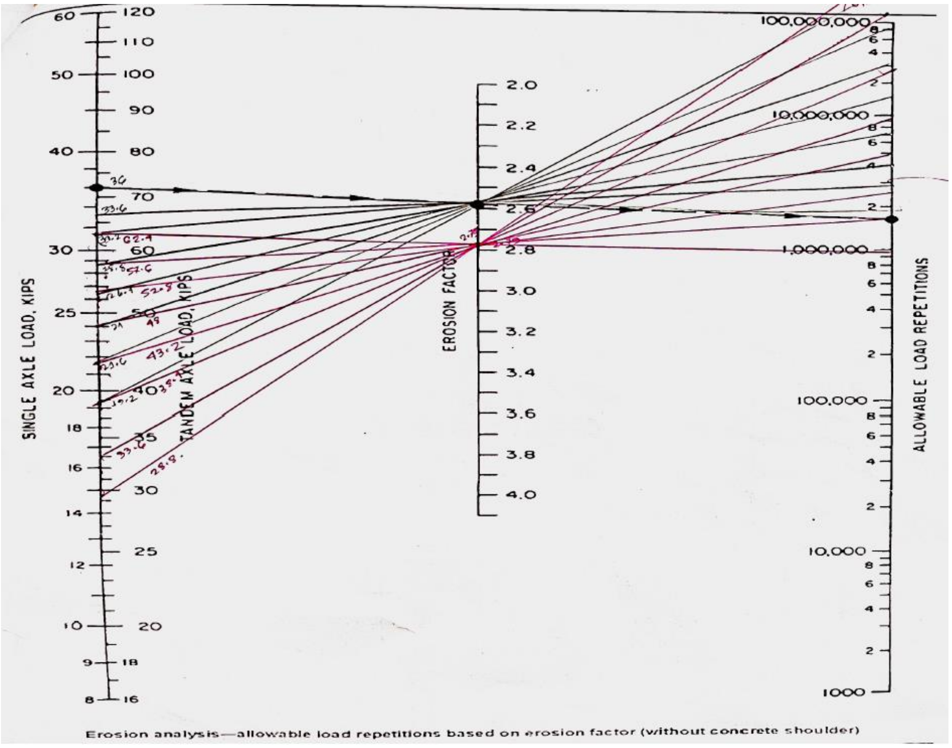


Table :Damage analysis Based on Erosion Factor

Table : Single Axle load

Axle load kips	LSF	Multiplied By LSF	Expected repetition	Fatigue Analysis		Erosion Analysis	
				Allowable repetition	Fatigue percent	Allowable repetitions	Demage percent
30	1.2	36	6310	27000	23.34	1900000	0.33
28	1.2	33.6	14690	79000	18.60	2500000	0.59
26	1.2	31.2	30140	220000	13.7	7000000	0.75
24	1.2	28.8	64410	1800000	3.58	15000000	0.92
22	1.2	26.4	106900	unlimited	0.00	25000000	0.71
				total	59.28	80000000	0.94
						Unlimited	
						total	4.62

Table : Tandem Axle load

Axle load kips	LSF	Multiplied By LSF	Expected repetition	Fatigue Analysis		Erosion Analysis	
				Allowable repetition	Fatigue percent	970000	2.19
52	1.2	62.4	21320	1100000	1.9	1900000	2.25
				unlimited		2500000	5
				total	61.18	4600000	8.1
						9500000	9.3
						24000000	3.9
						92000000	1.8
						Unlimited	0.0
						total	32.57
				Total 61.18		Total 37.19	

Comments :

Total Fatigue and Damage = Fatigue % + Damage %

=61.18 + 37.19

= 98.37 %

Which is acceptable

Therefore Design thickness, t = 9.5 in

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%; which would have implied that the assumed thickness was under-estimated. As such, 2nd trial would have been needed with increased thickness.

3.1.5 AASHTO Rigid Pavement Design

Analysis: A rigid pavement is to be designed to provide a service life of 20 years and has an initial

PSI of 4.4 and a TSI of 2.5. The modulus of subgrade reaction is determined to be 300 lb/in³. For design, the daily car, pickup truck, and light van traffic is 5120; and the daily truck traffic consists of 4864 passes of single-unit trucks with single and tandem axles, and

. The axle

weights are

cars, pickups, light vans = two 2000-lb single axles

single-unit trucks =10,000-lb steering, single axle

22,000-lb drive, tandem axle

Reliability is 95%, the overall standard deviation is 0.45, the concrete's modulus of elasticity is 4.5 million lb/in², the concrete's modulus of rupture is 900 lb/in², the load transfer coefficient is 3.2, and the drainage coefficient is 1.0. Determine the required slab thickness.

Solution:

Because the axle-load equivalency factors presented in Tables are
function of the slab thickness (D), we have to assume a D value to start the problem (later we will arrive at a slab thickness and check to make sure that it is consistent with our assumed value). A typical assumption is to let D = 10 inches. Given this, the 18-kip-equivalent single-axle load (18-kip ESAL) for cars, pickups, and light vans is

2-kip single-axle equivalent = 0.0002 (from the table)

Table 4.6 Axle-Load Equivalency Factors for Rigid Pavements, Single Axles, and TSI = 2.5

Axle load (kips)	Slab thickness, *D* (inches)								
	6	7	8	9	10	11	12	13	14
2	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
4	0.003	0.002	0.002	0.002	[illegible]	0.002	0.002	0.002	0.002
6	0.012	0.011	0.010	0.010	0.010	0.010	0.010	0.010	0.010
[illegible]	0.039	0.035	0.033	0.032	[illegible]	0.032	0.032	0.032	0.032
10	0.097	0.089	0.084	0.082	0.081	0.080	0.080	0.080	0.080
[illegible]	0.203	0.189	0.181	0.176	[illegible]	0.174	0.174	0.174	0.173
14	0.376	0.360	0.347	0.341	0.338	0.337	0.336	0.336	0.336
16	0.634	0.623	0.610	0.604	0.601	0.599	0.599	0.599	0.598
18	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
20	1.51	1.52	1.55	1.57	1.58	1.58	1.59	1.59	1.59
22	2.21	2.20	2.28	2.34	2.38	2.40	2.41	2.41	2.41
24	3.16	3.10	3.22	3.36	3.45	3.50	3.53	3.54	3.55
26	4.41	4.26	4.42	4.67	4.85	4.95	5.01	5.04	5.05
28	6.05	5.76	5.92	6.29	6.61	6.81	6.92	6.98	7.01
30	8.16	7.67	7.79	8.28	8.79	9.14	9.35	9.46	9.52
32	10.8	10.1	10.1	10.7	11.4	12.0	12.3	12.6	12.7
34	14.1	13.0	12.9	13.6	14.6	15.4	16.0	16.4	16.5
36	18.2	16.7	16.4	17.1	18.3	19.5	20.4	21.0	21.3
38	23.1	21.1	20.6	21.3	22.7	24.3	25.6	26.4	27.0
40	29.1	26.5	25.7	26.3	27.9	29.9	31.6	32.9	33.7
42	36.2	32.9	31.7	32.2	34.0	36.3	38.7	40.4	41.6
44	44.6	40.4	38.8	39.2	41.0	43.8	46.7	49.1	50.8
46	54.5	49.3	47.1	47.3	49.2	52.3	55.9	59.0	61.4
48	66.1	59.7	56.9	56.8	58.7	62.1	66.3	70.3	73.4
50	79.4	71.7	68.2	67.8	69.6	73.3	78.1	83.0	87.1

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

Table 4.7 Axle-Load Equivalency Factors for Rigid Pavements, Tandem Axles, and TSI = 2.5

Axle load (kips)	Slab thickness, D (inches)								
	6	7	8	9	10	11	12	13	14
2	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
4	0.0006	0.0006	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
6	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
8	0.007	0.006	0.006	0.005	0.005	0.005	0.005	0.005	0.005
10	0.015	0.014	0.013	0.013	0.012	0.012	0.012	0.012	0.012
12	0.031	0.028	0.026	0.026	0.025	0.025	0.025	0.025	0.025
14	0.057	0.052	0.049	0.048	0.047	0.047	0.047	0.047	0.047
16	0.097	0.089	0.084	0.082	0.081	0.081	0.080	0.080	0.080
18	0.155	0.143	0.136	0.133	0.132	0.131	0.131	0.131	0.131
[illegible]	0.234	0.220	0.211	0.206	[illegible]	0.203	0.203	0.203	0.203
22	0.340	0.325	0.313	0.308	0.305	0.304	0.303	0.303	0.303
[illegible]	0.475	0.462	0.450	0.444	[illegible]	0.440	0.439	0.439	0.439
26	0.644	0.637	0.627	0.622	0.620	0.619	0.618	0.618	0.618
28	0.855	0.854	0.852	0.850	0.850	0.850	0.849	0.849	0.849
30	1.11	1.12	1.13	1.14	1.14	1.14	1.14	1.14	1.14
32	1.43	1.44	1.47	1.49	1.50	1.51	1.51	1.51	1.51
34	1.82	1.82	1.87	1.92	1.95	1.96	1.97	1.97	1.97
36	2.29	2.27	2.35	2.43	2.48	2.51	2.52	2.52	2.53
38	2.85	2.80	2.91	3.03	3.12	3.16	3.18	3.20	3.20
40	3.52	3.42	3.55	3.74	3.87	3.94	3.98	4.00	4.01
42	4.32	4.16	4.30	4.55	4.74	4.86	4.91	4.95	4.96
44	5.26	5.01	5.16	5.48	5.75	5.92	6.01	6.06	6.09
46	6.36	6.01	6.14	6.53	6.90	7.14	7.28	7.36	7.40
48	7.64	7.16	7.27	7.73	8.21	8.55	8.75	8.86	8.92
50	9.11	8.50	8.55	9.07	9.68	10.14	10.42	10.58	10.66
52	10.8	10.0	10.0	10.6	11.3	11.9	12.3	12.5	12.7
54	12.8	11.8	11.7	12.3	13.2	13.9	14.5	14.8	14.9
56	15.0	13.8	13.6	14.2	15.2	16.2	16.8	17.3	17.5
58	17.5	16.0	15.7	16.3	17.5	18.6	19.5	20.1	20.4
60	20.3	18.5	18.1	18.7	20.0	21.4	22.5	23.2	23.6
63	23.5	21.4	20.8	21.4	22.8	24.4	25.7	26.7	27.3
64	27.0	24.6	23.8	24.4	25.8	27.7	29.3	30.5	31.3
66	31.0	28.1	27.1	27.6	29.2	31.3	33.2	34.7	35.7
68	35.4	32.1	30.9	31.3	32.9	35.2	37.5	39.3	40.5
70	40.3	36.5	35.0	35.3	37.0	39.5	42.1	44.3	45.9
72	45.7	41.4	39.6	39.8	41.5	44.2	47.2	49.8	51.7
74	51.7	46.7	44.6	44.7	46.4	49.3	52.7	55.7	58.0
76	58.3	52.6	50.2	50.1	51.8	54.9	58.6	62.1	64.8
78	65.5	59.1	56.3	56.1	57.7	60.9	65.0	69.0	72.3
80	73.4	66.2	62.9	62.5	64.2	67.5	71.9	76.4	80.2
82	82.0	73.9	70.2	69.6	71.2	74.7	79.4	84.4	88.8
84	91.4	82.4	78.1	77.3	78.9	82.4	87.4	93.0	98.1
86	102.0	92.0	87.0	86.0	87.0	91.0	96.0	102.0	108.0
88	113.0	102.0	96.0	95.0	96.0	100.0	105.0	112.0	119.0
90	125.0	112.0	106.0	105.0	106.0	110.0	115.0	123.0	130.0

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

This gives an 18-kip ESAL total of 0.0004 for each vehicle. For single-unit trucks,
10-kip single-axle equivalent = 0.081 (from the table)
22-kip tandem-axle equivalent=0.305 (from the table)

This gives an 18-kip ESAL total of 0.386 for single-unit trucks.

.

Given the computed 18-kip ESAL, the daily traffic on this highway produces an 18-kip ESAL total of 1879.552 (0.0004 x 5120+ 0.386 x 4864). Traffic (total axl accumulations) over the 20-year design period will be

1879.552 × 365 × 20 = 13720729.6 18-kip ESAL

Here w_{18}= 13720729.6

Z= 0.95

s_0=0.45

TSI=2.5

$\Delta\text{PSI} = 1.9$

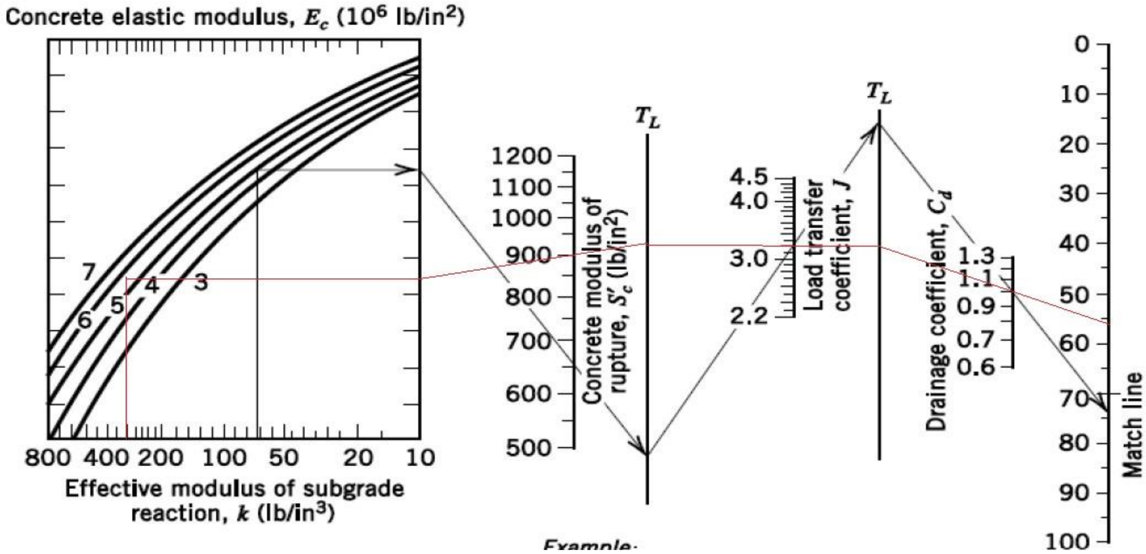
s_c'= 900

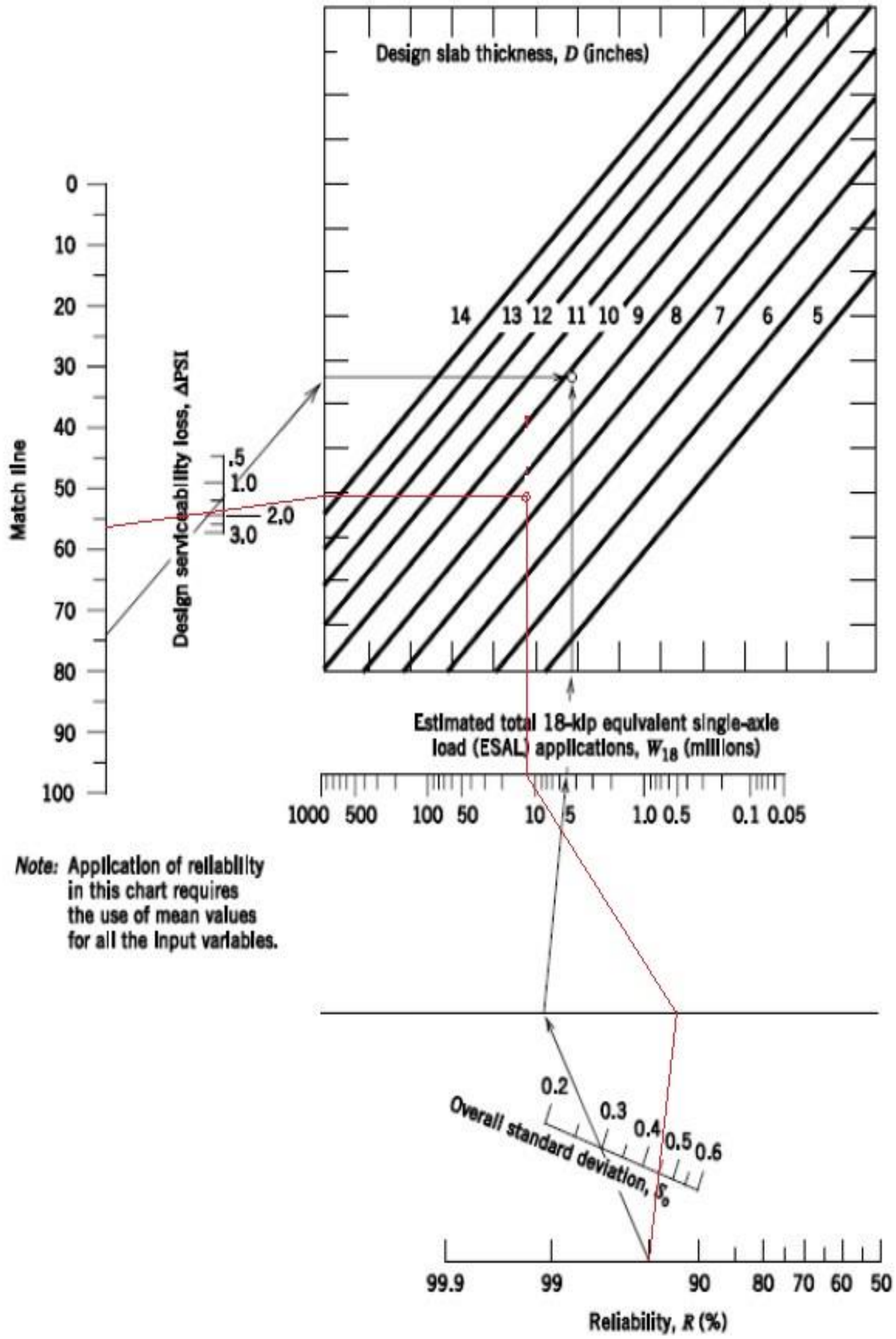
C_d=1

J=3.2

$E_{C\_}$=4.5 million

K= 300


Concrete elastic modulus, E_c (10^6 lb/in^2)
7
6
5
4
3
800 400 200 100 50 20 10
Effective modulus of subgrade reaction, k (lb/in^3)
1200
1100
1000
900
800
700
600
500
Concrete modulus of rupture, S'_c (lb/in^2)
T_L
4.5
4.0
3.0
2.2
Load transfer coefficient, J
T_L
1.3
1.1
0.9
0.7
0.6
Drainage coefficient, C_d
0
10
20
30
40
50
60
70
80
90
100
Match line



Note: Application of reliability in this chart requires the use of mean values for all the input variables.

So from the nomograph we can get D= 8.5 inches

Usefulness of rigid pavement:

Since rigid pavement consist 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.

Chapter 4

Transportation Road Safety

Introduction

For predominantly humanitarian, health, and financial reasons, nations place a high focus on the case of road safety. As stated by the ‘World Health Organization(WHO)’,Around 1.3 million individuals per year perish due to road accidents., just around 3400 deadly accidents everyday , and, in addition, around 30 and 50 million people face non destructive injuries annually . It is possible to pinpoint,and survey the damaging points of accidents ,utilizing resources like the Institution of Highways Transportation's Highway safety protocols: Accident prevention and elimination.This is one of the most effective approaches to the prevention of traffic accidents.

Why is road safety important

Road safety is using all available road safety measures to avoid and protect against traffic accidents. Road safety is ensured when someone is driving on a roadway. All users of the road, including pedestrians and users of two-, four-, multi-, and other transport vehicles, must be protected.It is beneficial and safe for everyone to practice road safety precautions throughout their lives. While driving or walking on the road, everyone should show consideration for others and guarantee their safety. One of the most critical factors in stemming roadside accidents, harm, and fatalities is ensuring that people are safe while driving. Based on national statistical data regarding the total number of reported casualties and fatalities, we may assess the significance of road safety. Road accidents can be significantly reduced by following all traffic safety precautions. Basic vehicle knowledge, defensive driving by weather and roadway conditions, the usage of automotive body lights and horns, using a seat-belt, making good usage of automotive looking glasses , avoiding excessive acceleration , comprehension of road lights, maintaining a safe following distance, knowing how to handle emergencies, broadcasting awareness tv programs on Broadcast, and so on. seem to be some effective methods of road safety. Road Safety regulations are designed to reduce the likelihood of accidents. Every day, millions of automobiles travel the world's roads. Because of this, there ought to rule that must be adhered to when using the roadways.

Humans and automobiles can both benefit from these guidelines. Following all road safety measures will go a long way in preventing all road problems. Some effective road safety measures are basic vehicle recognition, protection, etc. Driving in climatic and street condition, using car light and horns, using Proper seat belts, and vehicle mirrors, avoiding excessive speed, understanding street lights, maintaining vehicle distance on the road, and correct understanding of how to deal with crises, television broadcastingAwareness-raising documentaries on TV, etc. Traffic safety rules are in place to contain opportunities for the traffic accident. Millions of vehicles regularly move on our roads. that's why they're a set of rules that must be observed when using the road. These rules not only applies not only to cars but also to people walking or biking on the street results. Road safety rules are important for many reasons. There are various traffic safety rules for motorcycles, passenger cars, trucks, tractors, etc. Driver's license and car license plate is valid evidence. Properly identified vehicles serve as protection for road transport. Most accidents are caused by the high speed of the vehicle. to reduce irresponsible behavior of driving where traffic safety rules are in place. implemented by the government Various strict rules for vehicles. Drivers must obey traffic lights and signs near schools. hospitals and other public places.

Road safety rules

Vehicle traffic safety regulations state:

• Always stop your vehicle at red lights.

• Avoid using your mobile phone while driving.

• Do not cross before the light turns green.

• Always leave space for unauthorized persons.

• Do not ride on footbridges or sidewalks.

• Wear a helmet when riding a motorcycle.

• Wear seat belts when riding in a four-wheeled vehicle.

• Always carry your driver's license and important vehicle documents with you while driving.

• Do not drive under the influence of alcohol or drugs.• Slow down when crossing pedestrian crossings.

• Obey signs and instructions near hospitals and schools.

• Do not attempt to pass ambulances or other emergency vehicles.

Awareness and traffic safety rules are linked. When people realize the importance of life, The probability of traffic accidents is automatically reduced. Observance of traffic safety rules being a citizen of a particular country also helps reduce the chances of road traffic accidents. Traffic safety rules are also one of the manners that can be incorporated into daily life. when we are time management helps when you run out of time. Need traffic safety rules for all of us. In short, traffic safety rules are life-saving disciplines that must be strictly adhered to Note.

ROAD INFRASTRUCTURE AND STREET PROTOCOLS

Road geometry plays an important role in the frequency and rate of traffic accidents. car accident severity. Various fundamentals of street design are important. However, some boundaries are regarded to be more pronounced and are talked about below.

Road way crosssection

Lane width not only affects driving and maneuvering comfort It is a characteristic of the road surface, but it is also an important parameter that influences the frequency of traffic accidents, and crash seriousness . For each useful classification of road, it may be a trunk road, For each road environment, rural roads, and whether urban or country roads, Lane width narrows, greatly increasing the probability of an accident. for example, A study of safety issues on an undivided two-lane highway found the lanes to be wider and decrease the likelihood of head-on or other related collisions from 2.

75 meters to 3. 65 meters50% (50%). 5 Increased traffic and narrower lane widths reduce the probability of accidents. In particular, accidents such as head-on collisions and road deviations are increasing.

The significance of wide hard shoulder is even more precise on two lane roads.A paved shoulder is the best shoulder from a traffic welfare wise and is better than gravel. Gravel shoulders are better than composite shoulders (a combination of different types). However, grass shoulders are considered the worst from a traffic safety viewpoint and can result in a 10. Percentage (10%) more crashes.

According to the literature, skidding accidents are a major concern for road safety

Roadside Conditions

The term "free zone" means the unobstructed passable area that extends beyond the edge of a road. moving vehicle. in some places available right-of-way or width to provide clear space is insufficient or impractical, As expected, we can generally recognize the concept of free zones. Lateral offset is allowed for safety consideration of vertical obstacles (signs, poles, etc.) are required to keep away from collisions. The existence of medians is one of serious factor in accidents, mainly frontal crashes . However, for safety and security reasons, medians are highly desirable on multi-lane highways. operational efficiency.

Road Curvature

Curve lanes are served with angular features on the curves section of the road known as "Superelevation". i. e. outside the lane Since the curve is higher than the inside, the component of its weight The vehicle prevents the vehicle from moving to the outside.

However, vehicle speed is also an important factor. at a driving speed When the cars crosses the preferred or designated limit of the curve, the car loses control and Serious "runaway" accidents can occur.On the off chance that the progress bend isn't as expected gave, Then a diffusive power is out of nowhere applied to the vehicle, and contingent upon the speed and speedThe weight of your vehicle can make you fail to keep a grip on your vehicle. He could have 15D44 more car crashes on his two-path parkway on steep landscape than on comparable streets on level territory.therefore, Climbing lanes for heavy vehicles (additional lanes) can reduce the chance of an accident on a two-lane section by 25%.

Sight Distance

Sufficient visibility is required for the driver to control the operation Protect your vehicle from hitting unexpected objects on the road. Passing Visibility should be enabled on two-lane roads Drivers use oncoming traffic to overtake (overtake) other vehicles without hindrance coming cars. The concepts of SSD and PSD are most important from a traffic safety point of view, Decision Sight Distance (DSD) is one more significant issue that should be tended to for individuals' wellbeing. street clients.

Be that as it may, under typical conditions, drivers need longer distances to go with complex choices. DSD is the distance it takes a driver to recognize a startling or difficult to-identify occasion. See sources or conditions in the street climate.

Road Construction safety Tips

As transportation is very important without them the finencial condition will collapse in a country roads are the main means of transportation. This are the reason why the structure should be taken very seriously. Still every year road workers risk their life in building them. And if not serious and careful we can suffer a serious loss.

some roadworks safety tips for workers:

A plan

All street development projects require a transportation the executives plan. The arrangement ought to comprise of a brief traffic signal intend to safeguard laborers by securely coordinating traffic around or through the workspace. You likewise need a traffic signal arrangement inside the work zone that controls the progression of weighty gear, development vehicles, and laborers.

Traffic Control

work area ought to comprise a progressed caution region with caution signs cautioning drivers of up-and-coming changes in driving conditions, a move range utilizing activity control gadgets for path closures and activity design shifts, a buffer region, the working range, and an end region to permit activity to continue to ordinary and a signs showing that the construction area has finished.

A separate work space

Street development construction areas are active zones as a rule with a few work exercises taking put at the same time. To maintain a strategic distance from mishaps, utilize cones, barrels, and obstructions to depict particular regions of the work area such as fabric capacity, regions where overwhelming hardware is utilized, car stops, and secure ranges for foot specialists to move approximately in.

Site Safety Program

Every road improvement adventure is different and each work zone has its case of fascinating dangers and difficulties so making a security program prepared especially for the area can go quite far in keeping away from mishaps. The site-explicit security program should consolidate recognizing all dangers and plans to control and direct them, plans to regularly survey all equipment and texture, orchestrate in the first place help and emergency supportive consideration inside the event of a mishap, and security planning plans for all specialists.

Start workers with safety instructions

As well as guaranteeing that all staff at the Place of work have the legitimate preparation required it is likewise really smart to have a speedy security meeting before work starts. Since conditions can change significantly from one day to another in the work zone, laborers ought to be advised on the work movement booked every day and told of every possible risk. This is likewise a great opportunity to guarantee that all laborers have and are wearing the legitimate PPE expected for the work being done that day.

Avoid spots that are not visible

Vehicles and weighty gear, for example, dump trucks, compactors, graders, backhoes, pavers, and rollers are continually traveling through the workspace. The administrator should guarantee that all mirrors and visual guides are appropriately situated and working appropriately including reinforcement alerts and lights. Know that the driver's perceivability might be limited while strolling or working close to these machines when they are in activity. Continuously keep visual contact with the driver. As a guideline, on the off chance that you can't see them, they won't see you by the same token.

Saty Haydrated

Street laborers are inclined to exhaust and heatstroke. Black-top assimilates 95% of the sun's beams and the black-top temperature effectively increases 30°F or more over the encompassing temperature. Laborers ought to drink a lot of water or electrolyte-rich liquids, for example, sports beverages or coconut water. Likewise, avoid the intensity and sun however much as could reasonably be expected, particularly on exceptionally blistering days, to keep away from heat stroke, lack of hydration, and intensity stroke. What other wellbeing tips should street laborers remember? Share your considerations and experiences in the remarks underneath.

Calculation:

3 CASUALTY ACCIDENTS

Table 3-1 : Recorded Casualty Accidents by Division and City

Division or City	number of accidents [1]				population[2]	accident rates	
	severity			total	('000,000)	(no. per 10,000 pop'n)	
	fatal	grievous	simple injury			fatal accidents	fatal + injury accidents
Divisions, excluding Cities							
Barisal	95	14	2	111	8.603	0.110	0.129
Chittagong	426	85	42	553	22.055	0.193	0.251
Sylhet	214	60	16	290	8.378	0.255	0.346
Dhaka	680	168	37	885	35.315	0.193	0.251
Khulna	111	7	1	119	14.525	0.076	0.082
Rajshahi	521	118	23	662	31.401	0.166	0.211
Total	2047	452	121	2620	120.278	0.170	0.218
Cities							
Chittagong City	61	28	8	97	3.397	0.180	0.286
Dhaka City	265	140	9	414	5.704	0.465	0.726
Khulna City	12	2	4	18	0.820	0.146	0.220
Rajshahi City	39	9	0	48	0.407	0.959	1.180
Total	377	179	21	577	10.327	0.365	0.559
TOTAL	2424	631	142	3197	130.605	0.186	0.245

Notes: 1. This is the recorded number of accidents involving casualties (fatal and injury). Property damage only accidents are not included.
2. Year 2005 populations are extrapolated from statistics published in the 2000 Statistical Yearbook and the Population Census 2001 Preliminary Report.

Figure 4.1

Figure 4.1 was used to calculate the fatal accident per 10000 population. People per square kilometer in Dhaka city was noted from world bank data. Based on these two values people around R112 was calculated by taking the total length of the R112 road. The value was then converted in 10000's.

Table 4.1:

Year	fatal accidents per 10000 population	fatal + injury accidents	People Per km^2	People around R112	People in 10,000	Fatal

		per 10,000 population				
1	0.465	0.726	1278	10873.22	1.087322	5056.049
2				11634.35	1.163435	5409.973
3				12448.75	1.244875	5788.671
4				13320.17	1.332017	6193.878
5				14252.58	1.425258	6627.449
6				15250.26	1.525026	7091.37
7				16317.78	1.631778	7587.766
8				17460.02	1.746002	8118.91
9				18682.22	1.868222	8687.234
10				19989.98	1.998998	9295.34
11				21389.28	2.138928	9946.014
12				22886.53	2.288653	10642.23
13				24488.58	2.448858	11387.19
14				26202.78	2.620278	12184.29
15				28036.98	2.803698	13037.2
16				29999.57	2.999957	13949.8
17				32099.54	3.209954	14926.29
18				34346.51	3.434651	15971.12
19				36750.76	3.675076	17089.1
20				39323.31	3.932331	18285.34
21				42075.95	4.207595	19565.31
22				45021.26	4.502126	20934.89
23				48172.75	4.817275	22400.33
24				51544.84	5.154484	23968.35
25				55152.98	5.515298	25646.14
26				59013.69	5.901369	27441.37
27				63144.65	6.314465	29362.26
28				67564.77	6.756477	31417.62

29				72294.31	7.229431	33616.85
30				77354.91	7.735491	35970.03
31				82769.75	8.276975	38487.94
32				88563.64	8.856364	41182.09
33				94763.09	9.476309	44064.84
						Total Cost

The traffic accident data used in this study were collected by the Accident Research Institute (ARI), BUET. This study used the human capital method to estimate the cost of road accidents in Bangladesh. Estimating the cost of a road accident using the human capital approach includes the economic cost of all casualties, as well as the economic cost considering pain, grief and sufferings, resource of cost like damage of road, damage of vehicleas and medical expenditure.

Table : 4.2

Current Condition:

Table 14: Human Costs

	per casualty	Fatal RTA		Grievous RTA		Simple RTA	
	cost	no.	cost	no.	cost	no.	cost
Fatality	206451	1.7	350967	0	0	0	0
Grievous	2530	1.4	3542	1.7	4301	0	0
Simple	193	1.4	270	2.2	424	1.5	289
Total			354779		4726		289

Table 13: Medical Costs per RTA Casualty

	per casualty	Fatal RTA		Grievous RTA		Simple RTA	
	cost	no.	cost	no.	cost	no.	cost
Fatality	100	1.7	170	0	0	0	0
Grievous	4200	1.4	5880	1.7	7140	0	0
Simple	100	1.4	140	2.2	220	1.5	150
Total			6190		7360		150

Table 15: Vehicle related costs (Taka)

	Unit costs
fatal	70000
grievous	52500
simple	35000
pdo	1750

These data's were used to forecast the human cost, medical cost, and vehicle related cost for current and future.

Table 4.3:

Human Cost	Medical Cost	Vehicle related cost
1043826405	505604.9	353923441.2
1116894253	540997.3	378698082.1
1195076851	578867.1	405206947.8
1278732231	619387.8	433571434.2
1368243487	662744.9	463921434.6
1464020531	709137	496395935
1566501968	758776.6	531143650.4
1676157106	811891	568323706
1793488103	868723.4	608106365.4
1919032271	929534	650673811
2053364530	994601.4	696220977.7
2197100047	1064223	744956446.2
2350897050	1138719	797103397.4
2515459843	1218429	852900635.2
2691542033	1303720	912603679.7
2879949975	1394980	976485937.3
3081546473	1492629	1044839953
3297254726	1597112	1117978750

3528062557	1708910	1196237262
3775026936	1828534	1279973870
4039278821	1956531	1369572041
4322028339	2093489	1465442084
4624570323	2240033	1568023030
4948290245	2396835	1677784642
5294670562	2564614	1795229567
5665297502	2744137	1920895637
6061868327	2936226	2055358331
6486199110	3141762	2199233415
6940233048	3361685	2353179754
7426049361	3597003	2517902336
7945872816	3848794	2694155500
8502083913	4118209	2882746385
9097229787	4406484	3084538632

Table 2: We calculated 3 types of cost for the road Human Cost, Medical Cost and Vehicle related cost. The total cost for Human Cost, Medical Cost and Vehicle related cost was found to be 166299309926.20 in the current condition.

Table: 4.4

Four Lane Condition:

Human Cost	Medical Cost	Vehicle related cost
521913202.6	252802.5	176961720.6
558447126.7	270498.6	189349041
597538425.6	289433.5	202603473.9
639366115.4	309693.9	216785717.1
684121743.5	331372.5	231960717.3
732010265.5	354568.5	248197967.5
783250984.1	379388.3	265571825.2
838078553	405945.5	284161853
896744051.7	434361.7	304053182.7
959516135.3	464767	325336905.5
1026682265	497300.7	348110488.9
1098550023	532111.7	372478223.1
1175448525	569359.6	398551698.7
1257729922	609214.7	426450317.6
1345771016	651859.8	456301839.8
1439974987	697490	488242968.6
1540773237	746314.3	522419976.4
1648627363	798556.2	558989374.8
1764031278	854455.2	598118631
1887513468	914267.1	639986935.2
2019639411	978265.7	684786020.7
2161014169	1046744	732721042.1
2312285161	1120016	784011515.1
2474145123	1198418	838892321.1
2647335281	1282307	897614783.6
2832648751	1372068	960447818.4
3030934163	1468113	1027679166
3243099555	1570881	1099616707

3470116524	1680843	1176589877
3713024680	1798502	1258951168
3972936408	1924397	1347077750
4251041957	2059105	1441373192
4548614894	2203242	1542269316
83149654963		

Benefit: 83149654963.10

In this we calculated the cost for improvement of the road or for the 4 lane condition of the road, in that case we got the total cost as 83149654963 Which is lower than the current condition, calculating which stands that we will save. After improved the road we got Benifite cost 83149654963.10.

Chapter 5

Air Quality Impact

An air pollutant is a gas, liquid droplet, or solid particle that, when released into the atmosphere in high enough concentrations, endangers the health of people, animals, property, and the environment. For millions of urban dwellers throughout the world, air pollution—an obvious environmental side consequence of transportation—has become a health concern (TRB, 1997). Transportation is one of the main causes of air pollution, especially the usage of motor vehicles, which are also the main source of excess regional photochemical oxidant concentrations and a key contributor to local carbon monoxide issues. Typical emissions from transportation vehicles include poisonous gases including carbon monoxide, nitrogen oxides, tiny particulate matter, and others that can be harmful when inhaled. Additionally, rivers, lakes, and forests are negatively impacted by air pollution. As anthropogenic effects on the higher atmosphere grow more obvious, there is still much worry about the role that transportation vehicle use plays in contributing to global warming. For instance, airports are a significant local source of ambient CO breaches and a regional contributor to photochemical oxidant issues. Except in situations where the source of rail energy generation is connected with major pollution, such as coal-based electrical power generation, rail travel is normally not associated with significant air pollution in the modern period.

Pollutant Types and Sources:

Carbon monoxide, hydrocarbons, sulfur oxides, nitrogen oxides, and particulate matter are examples of primary air pollutants that are released directly into the atmosphere. Secondary air pollutants are those that are created in the atmosphere as a result of physical and chemical processes (such as hydrolysis, oxidation, and photochemistry) on primary pollutants. Examples of secondary air pollutants include ozone and acidic depositions. Carbon dioxide and other greenhouse gases are examples of direct emissions. Forest fires and volcanic eruptions are examples of natural sources of air pollution, while power plants, fuel use, slash-and-burn farming methods, and transportation are examples of artificial sources.Vehicles are the source of three main pollutants:

- One in particular is SOX, a combination of solid particles and liquid droplets that is found in the air and contributes to atmospheric haze that can harm our lungs.
- Carbon monoxide (CO) When fuel is consumed in cars, carbon monoxide is released; breathing air with a high CO_2 concentration can harm vital organs like the heart. According to a poll, cars account for 95% of all carbon monoxide.
- Nitrogen dioxide (NO_2) is produced when fuel burns because of a reaction between nitrogen and oxygen. Nitrogen dioxide is created as a result of vehicles and other

ESTIMATING POLLUTANT EMISSIONS:

• Emission: Pollutants are being released into the atmosphere in this manner. The quantity of emitting sources, the variety of source types, the kind and extent of activity at the polluting source, and the emission characteristics all affect the overall amount of emissions. For instance, at higher elevations, more pollutants are released by moving automobiles as a result of inefficient combustion brought on by thin air.

• Mobile emission: A motorized vehicle is an example of a movable source of air pollution because it has the ability to move from one location to another. Mobile emissions are those produced by moving sources. The ambient concentration of pollutants released by fixed and mobile sources is used to calculate the overall air quality in a given location.

• Emissions factors: In terms of activity levels like VMT (vehicle miles traveled) or VHT (vehicle hours traveled) for motor vehicles, an emission factor is an average estimate of the rate at which a pollutant is emitted into the atmosphere as a result of some activity (such as motor vehicle operating).

Method of Estimation :

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

- A or VKT = (L x AADT)
- 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 Traveled we will use it on total emission calculation.
- Total emission has been calculated as follows:
- £ Emission = (Zi Ek EFij× Aik)
- 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.

Emission Calculation :

Table 5.1 :Emission Factors

Vehicle type	SOx	NOx	CO	PM2.5	PM10
Car	0.40	2.77	7.30	0.84	0.84
CNG	0.20	2.77	5.00	1.50	0.75
Motor Cycle	0.02	0.31	6.5	0.23	0.23
Bus	1.75	19.0	5.5	3.0	3.0

Trucks	0.80	9.50	5.5	3.0	1.50

Table 5.2: Transportation mode with VKT

Vehicle type	**AADT**	**Road length (km)**	**VKT (km/day)**
Car	2919	8.508	35903
CNG	276		3395
Motor Cycle	1912		23517
Bus	85		1046
Trucks	7068		86936
		Total	**150797**

Table 5.3: Emission for this study area

Vehicle type	**Emission (gm/day)**				
	SOx	NOx	CO	PM2.5	PM10
Car	14361	99451	262092	30159	30159
CNG	679	9404	16975	5093	2546
Motor Cycle	470	7290	152860	5409	5409
Bus	1831	19874	5753	3138	3138
Trucks	69549	825892	478148	260808	130404
total	**86890**	**961911**	**915828**	**304607**	**171656**

Table 5.4: Total VKT for 20 years

Number of vehicles	Road length (km)	Total VKT (km in 20 year)
15223	8.508	2590346

Table 5.5 :Taken Maximum emission factor for 20 year

SOx	NOx	CO	PM2.5	PM10

1.75	19.0	7.30	3.0	3.0

Table 5.6 : Emission for this study Area for 20 years

Component	Emission factor	Total VKT (km in 20 year)	Emissions (ton in year)
SOx	1.75	2590346	4.533
NOx	19.0		49.21
CO	7.30		19.00
PM2.5	3.0		7.80
PM10	3.0		7.80

Table 5.7:

IRI	Fuel per km	Fuel unit rate (taka/litre)	Cost for 1 km	VKT (km in 20 years)	Total Fuel Cost
8	0.08	130	10.4	2590346	26939598.4
3	-0.27	130	8.02	2590346	18372056.2

As the emission occurs by burning the fuel, so total fuel cost for 20 years had been calculated. The total fuel cost found to be 26939598.4 BDT if the existing road is left unchanged.

In case of the widening, the IRI will become 3. Then cost for 1 km will become 22% less than the previous cost. As a result, the total fuel cost will become 18372056.2.

Total benefit = 26939598.4-18372056.2 = 8567542.15 BDT.

Conclusion:

Air pollution is still mostly caused by transportation, particularly the highway mode. It contributes to global warming, which has negative repercussions not only on a local and regional scale but also on a worldwide one. 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. Industrialized nations have been at the forefront of efforts to reduce automotive air pollution through a number of strategies, such as legislation and enforcement, vehicle engine standards, encouraging the use of less polluting modes of transportation, better fuel quality, the use of alternative fuels, and transportation planning and traffic management.

Figure : Air pollution created by vehicles

Appendix:

Table D.1: Emission Factor (gm/km) of SOx

	Fuel	The World Bank	VAPIS	SIM-air	AQMP	Cai-Asia	UNEP
LDV	Gasoline	0.08			0.05		
	CNG		0.00				
	Disel	0.40	0.30				
Taxis	CNG	0.00		0.10			
	Gasoline			0.12			0.13
	Disel			0.50			
Car/Jeep/Microbus/St.Wagon	CNG		0.00	0.08			
	Gasoline		0.07	0.08			0.13
	CNG						
	Disel		0.40	0.29		0.41	0.38
Autorickshaw/3W	CNG	0.00	0.00			0.20	
	Gasoline		0.02		0.03		
Tem poo	Gasoline						0.05
	Disel						0.39
Bus	CNG	0.80	0.00		0.40		
	Disel		1.00			3.14	1.75
Minibus	Disel					1.08	0.39
Trucks		0.80			1.13	4.27	1.75
HDT	Disel		1.00				
Motorcycle/2w	2-stroke	0.02			0.19		0.02
	4-stroke					0.22	

Table D.2: Emission Factor (gm/km) of NOx

Vehicle Type/	Fuel	The World Bank	VAPIS	SIM-air	Bangkok Case Study		AQMP	URBAIR	Cai-Asia	UNEP	Malé Declaration
					Engine Category						
LDV	Gasoline	1.50					1.57	2.70			
	Disel	8.50	2.00								3.15
	CNG		3.50								
Taxis	Gasoline			1.00	Fumi	0.50				2.70	
	CNG	1.50		0.80	Fumi	1.65					
	Disel			1.50		1.05				1.40	
Car/Jeep/Microbus/St.Wagon	Gasoline		0.20	0.98	Fumi	0.50				2.70	1.80
	CNG		0.20	0.79	Fumi	1.65					2.10
	Disel		1.25	1.47		0.50		1.48			2.77
Pick- Up	Gasoline					0.50					
	NGV_Gasoline				Fumi	0.50					
	NGV_Disel				DDF	0.61					
	Disel					0.50					
Van	Gasoline					0.50					
	NGV_Gasoline					.5,.3					
	NGV_Disel					0.91					
	Disel					1.05					
Autorickshaws /3W	Gasoline		0.10								0.05
	CNG	1.50	0.35								
	Disel						0.03	0.13			2.77
Tem poo	Gasoline									0.20	
	Disel									13.00	
Buses	CNG	17.00	2.50				2.50				5.70
	Disel		10.00					22.5		13.00	19
Minibus	Disel							7.55		13.00	
Trucks	Disel	17.00				8.83	6.48	22	22	13.00	9.50
HDT	Disel		10.00								
Motorcycle/2w	2-stroke	0.30	0.15				0.02	0.11		0.07	0.03
	4-stroke										0.31

Table D.3: Emission Factor (gm/km) of CO

Vehicle Type	Fue l	The WorldBank	VAPIS	SIM-air			AQMP	Cai-Asia	UNEP	MaléDeclarat ion
					Engine Category					
LDV	Gasoline	25.0					28.1			
	CNG		3.5							
	Disel	5.0	2.5				24.0			8.7
Taxis	Gasoline				Fumi	6.0				
	CNG	5.0			OEM	2.0				4.0
	Disel			sd		1.0				7.3
Car/Jeep/Microbus/St.Wagon	Gasoline		5.0		Fumi	6.0				9.8
	CNG		1.0		Fumi	1.3				4.0
	Disel		2.0			1.0				7.3
Pick- Up	Gasoline					2.8				
	NGV_Gasoline				Fumi	4.0				
	NGV_Disel				DDF	1.3				
	Disel					1.0				
Van	Gasoline					2.8				
	NGV_Gasoline				Fumi	4.0				
	NGV_Disel				DDF	4.9				
	Disel					1.0				
Autorickshaws /3W	CNG	5.0	3.5							
	Gasoline		8.0							14.0
	Disel									7.3
Buses	CNG		3.5							12.0
	Disel	10.0	3.5			9.0	1.3			5.5
Trucks	Disel	10.0				2.9	3.4			5.5
HDT	Disel		3.5							
Motorcycle/2w	2-stroke	5.0	2.5				26.0	2.2		6.5
	4-stroke									3.0

Table D.4: Emission Factor (gm/km) of PM2.5

	Fuel	VAPIS	Malé Declaration
LDV	CNG	0.01	
	Disel	0.50	0.80
Car	Gasoline	0.03	0.06
	CNG	0.20	0.01
	Disel	0.60	0.84
Three wheels	CNG	0.05	
	Disel		1.50
	Gasoline	0.08	0.35
Buses	CNG	0.01	0.01
	Disel	0.80	3.00
HDT	Disel	1.00	1.50
Two wheels	2-stroke	0.05	0.23
	4-stroke		0.07

Table D.5: Emission Factor (gm/km) of PM10

Vehicle Type	Fuel	The World Bank	VAPIS	SIM-air	Bangkok CaseStudy		AQMP	URBAIR	Cai-Asia	UNEP	Malé Declaration
					Engine Category						
LDV	Gasoline	0.10					-	0.06			0.04
	CNG		0.02								
	Disel	0.80	1.25								0.80
Taxis	CNG	0.03		0.10				0.01			0.01
	Gasoline			0.35						0.20	
	Disel			0.90		0.20		0.84			0.84
Car/Jeep/Microbus/St.Wagon	Gasoline	0.10	0.10	0.39						0.20	0.06
	CNG	0.03	0.05	0.20					0.18		0.01
	Disel	0.80	1.00	0.93		0.16				0.90	0.84
Pick- Up	Gasoline										
	NGV_Gasoline										
	NGV_Disel				DDF	0.08					
	Disel					0.16					
Van	Gasoline										
	NGV_Gasoline				MPI	0.00					
	NGV_Disel				DDF	0.20					
	Disel					0.20					
Autorickshaw/3W	CNG	0.03	0.10	0.10							
	Gasoline		0.20	0.20					0.75		0.35
	Disel						0.75	0.50			0.04
Tem poo	Gasoline									0.21	
	Disel									1.50	
Buses	CNG	1.60	0.02				0.10				0.01
	Disel		1.50					2.00		3.00	3.00
Minibus									0.10	1.50	
Trucks	Disel	1.60		2.50		0.66	0.45	2.00	0.45	3.00	1.50
HDT	Disel		2.00								
Motorcycle/2w	Gasoline	0.10	0.10	0.10			0.75		0.05	0.50	0.23 0.07

Chapter 6

Noise Impact

Noise has become one of the major defects of road vehicle. When a vehicle runs on a pavement, it creates sound mainly through the engine and the friction of the tire. These noise have health impacts on people living near the roads.

Table 1: Valuation of AMI impacts of noise

Volume LAeq, 18hr dB(A)	Additional risk of AMI	Cost per household per dB change		
		Health value	Current value (amenity/annoyance costs only[33])	% change in costs (from inclusion of health costs)
55 – 60 dB	0.00010%	£2.70	£40.00	+ 6.75%
60 – 65 dB	0.00168%	£10.47	£53.20	+ 19.68%
65 – 70 dB	0.00336%	£15.71	£66.40	+ 29.29%
70 – 75 dB	0.00504%	£29.62	£79.60	+ 37.21%
75 – 80 dB	0.00720%	£41.01	£92.80	+ 44.19%
80 – 85 dB	0.039%	£53.60	£98.00	+ 54.7%

Note: *Mid-point marginal values are used for each volume range.*

According to this figure, the health value is set in a monetary unit. In the picture, the highest volum level considered is 80-85 dB. Even though Dhaka city junctions usually create more noises.

Table 6. Traffic sound in the Main Road of Dhaka (peak & off peak hours)

S.L.	Location	No Of Observations	Sound Pressure Levels, dB			
			Peak Hours		Off Peak Hours	
			Min.	Max.	Min.	Max.
01	Jahangir Gate	15	78.0	120.2	54.2	90.5
02	Bangladesh Air Force Officers' Mess	10	75.5	117.2	53.1	88.5
03	Awlad Hossain Market	20	71.2	112.5	50.6	84.4
04	Farmgate Bus Stop	20	73.5	110.5	48.6	81.2
05	Bijoy Sarani	25	72.6	109.9	48.2	80.6

The picture shows, the busy roads of Dhaka city and their produced sound pressure level, dB. During peak hour, the sound pressure level is around 110 or more. However, Rampura Banasree road has fewer vehicle, congestion and noise than these major junctions. So, to work with the data collected through internet to set the noise impact into monetary unit, it is safe to consider 85 dB.

The monetary unit was converted to BDT with the rate of 2010 and then it was converted into present value. Later, the current density of Dhaka city was noted from the world health bank. The density multiplied by 8.508, the total population living close to the R112 road was estimated. It was assumed that each family has four members on average. So, the total population was divided by 4 to get the number of the households. Finally multiplying the household number by the health value, the total health value for current condition was calculated.

Founding on air impact and considering the fact that the congestion will be very less in multilane system as the LOS becomes A, the noise reduction is estimated to be 30% less than the current condition.

Thus the benefit was calculated.

Table 6.1:

Volume dB	Health value in 2010	Current Health value	people per km^2	people around R112	Total household	Total health value
85	3958.896	5025.027	1278	10873.22	2718.306	13659560.2
				11634.35	2908.587	14615729.4
				12448.75	3112.189	15638830.5
				13320.17	3330.042	16733548.6
				14252.58	3563.145	17904897
				15250.26	3812.565	19158239.8
				16317.78	4079.444	20499316.6
				17460.02	4365.005	21934268.8
				18682.22	4670.556	23469667.6
				19989.98	4997.495	25112544.3
				21389.28	5347.319	26870422.4
				22886.53	5721.632	28751352
				24488.58	6122.146	30763946.6
				26202.78	6550.696	32917422.9
				28036.98	7009.245	35221642.5
				29999.57	7499.892	37687157.4
				32099.54	8024.884	40325258.5
				34346.51	8586.626	43148026.6
				36750.76	9187.69	46168388.4
				39323.31	9830.828	49400175.6
				42075.95	10518.99	52858187.9
				45021.26	11255.32	56558261.1
				48172.75	12043.19	60517339.3
				51544.84	12886.21	64753553.1
				55152.98	13788.25	69286301.8
				59013.69	14753.42	74136342.9
				63144.65	15786.16	79325886.9

				67564.77	16891.19	84878699
				72294.31	18073.58	90820208
				77354.91	19338.73	97177622.5
				82769.75	20692.44	103980056
				88563.64	22140.91	111258660
				94763.09	23690.77	119046766
					Total Cost	1624578280
30% reduction in multilane system					Total Cost	1137204796
Benefit						487373484

Chapter 7

Travel time cost

Travel time cost is very important in road construction costing. It is also known as value of time. This time could be used in an alternative activity which has the potential to produce significant ‘utility’ known as ‘benefit’. If the alternative activity can have a monetary value assigned to it, this can be used as a part of Road construction in the economic appraisal of projects, particularly of the transport projects having relation with consumption of time in the use of their output.

Table 2. Level of services corresponding to delay at the intersection (Highway Capacity Manual, 2010)

Level of service	The average delay (seconds per vehicle)
A	Less than 10
B	10-20
C	20-35
D	35-55
E	55-85
F	More than 80

This table was used to calculate the delay time extension for each hour.

Total Intersection	LOS	Delay	Hour increase
20	A	10	3.333333333
	B	15	5
	C	25	8.333333333
	D	45	15
	E	70	23.33333333
	F	80	26.66666667

From the above chart we can see how time increases over the time

Now we will show travel time costs of vehicles.

Catergory	Occupancy	TTC Per Passenger (Tk/hr)	TTC per vehicle (Tk/Hr)
Ordinary L Bus	47	49	2280

Mini Bus	35	52	1803
Microbus	7	107	749
Car	3	130	390
Auto Rickshaw	5	66	328
Motorcycle	1	86	86

Category	Number of vehicle	TTC of total passenger	TTC of total vehicle
Ordinary L Bus	85	195755	193800
Mini Bus	1199	2182180	2161797
Microbus	1764	1321236	1321236
Car	2916	1137240	1137240
Auto Rickshaw	1767	583110	579576
Motorcycle	1912	164432	164432

category	`occupancy	TTC per passenger(tk/ hr)					
Ordinary L Bus	47	51.45	53.08333333	55.80555556	61.25	68.05555556	70.77777778
Mini Bus	35	54.6	56.33333333	59.22222222	65	72.22222222	75.11111111
Microbus	7	112.35	115.9166667	121.8611111	133.75	148.6111111	154.5555556
Car	3	136.5	140.8333333	148.0555556	162.5	180.5555556	187.7777778
Auto Rickshaw	5	69.3	71.5	75.16666667	82.5	91.66666667	95.33333333

Motorcycle	1	90.3	93.16666667	97.94444444	107.5	119.4444444	124.2222222

Now we will show travel time cost years by years for two lane:

TTC of Two Lane							
LOS	Year	Ordinary L Bus	Mini Bus	Micro Bus	Car	Autorickshaw	Motorcycle
C	1	222943.1944	4970521.111	3009482	6044220	1859473	2621776.889
C	2	238549.2181	5318457.589	3220145.74	6467315.4	1989636.11	2805301.271
C	3	255247.6633	5690749.62	3445555.942	6920027.478	2128910.638	3001672.36
C	4	273114.9998	6089102.094	3686744.858	7404429.401	2277934.382	3211789.425
C	5	292233.0497	6515339.24	3944816.998	7922739.46	2437389.789	3436614.685
C	6	312689.3632	6971412.987	4220954.188	8477331.222	2608007.074	3677177.713
C	7	334577.6186	7459411.896	4516420.981	9070744.407	2790567.57	3934580.153
D	8	785849.3823	3679309.433	2652020.369	2282698.658	1170434.046	330052.3247
D	9	840858.8391	3936861.094	2837661.794	2442487.564	1252364.429	353155.9874
D	10	899718.9578	4212441.37	3036298.12	2613461.693	1340029.939	377876.9065
D	11	962699.2849	4507312.266	3248838.988	2796404.012	1433832.035	404328.29

D	12	1030088.235	4822824.125	3476257.718	2992152.293	1534200.277	432631.2703
D	13	1102194.411	5160421.814	3719595.758	3201602.953	1641594.297	462915.4592
E	14	1310386.689	7303771.615	4422186.068	3806350.178	1951673.22	550355.0459
E	15	1402113.757	7815035.628	4731739.092	4072794.69	2088290.345	588879.8991
E	16	1500261.72	8362088.122	5062960.829	4357890.319	2234470.669	630101.4921
E	17	1605280.041	8947434.29	5417368.087	4662942.641	2390883.616	674208.5965
E	18	1717649.643	9573754.69	5796583.853	4989348.626	2558245.469	721403.1983
E	19	1837885.118	10243917.52	6202344.723	5338603.03	2737322.652	771901.4222
F	20	2045198.56	11399431.41	6901969.207	5940797.451	3046092.647	858971.9026
F	21	2188362.459	12197391.61	7385107.052	6356653.273	3259319.132	919099.9358
F	22	2341547.831	13051209.03	7902064.545	6801619.002	3487471.471	983436.9313
F	23	2505456.179	13964793.66	8455209.064	7277732.332	3731594.474	1052277.516
F	24	2680838.112	14942329.21	9047073.698	7787173.595	3992806.088	1125936.943
F	25	2868496.78	15988292.26	9680368.857	8332275.747	4272302.514	1204752.529
F	26	3069291.554	17107472.72	10357994.68	8915535.049	4571363.69	1289085.206

F	27	3284141.963	18304995.81	11083054.3	9539622.503	4891359.148	1379321.17
F	28	3514031.9	19586345.51	11858868.11	10207396.08	5233754.288	1475873.652
F	29	3760014.133	20957389.7	12688988.87	10921913.8	5600117.089	1579184.808
F	30	4023215.123	22424406.98	13577218.09	11686447.77	5992125.285	1689727.744
F	31	4304840.181	23994115.47	14527623.36	12504499.11	6411574.055	1808008.686
F	32	4606178.994	25673703.55	15544557	13379814.05	6860384.239	1934569.294
F	33	4928611.524	27470862.8	16632675.99	14316401.04	7340611.135	2069989.145
F	34	5273614.33	29393823.2	17796963.3	15318549.11	7854453.915	2214888.385
F	35	5642767.333	31451390.82	19042750.74	16390847.54	8404265.689	2369930.572
F	36	6037761.047	33652988.18	20375743.29	17538206.87	8992564.287	2535825.712
F	37	6460404.32	36008697.35	21802045.32	18765881.35	9622043.787	2713333.512
F	38	6912632.623	38529306.16	23328188.49	20079493.05	10295586.85	2903266.858
F	39	7396516.906	41226357.6	24961161.68	21485057.56	11016277.93	3106495.538
F	40	7914273.09	44112202.63	26708443	22989011.59	11787417.39	3323950.225
F	41	8468272.206	47200056.81	28578034.01	24598242.4	12612536.6	3556626.741

F	42	9061051.26	50504060.79	30578496.39	26320119.37	13495414.17	3805590.613
F	43	9695324.848	54039345.04	32718991.14	28162527.73	14440093.16	4071981.956
F	44	10373997.59	57822099.2	35009320.52	30133904.67	15450899.68	4357020.693
F	45	11100177.42	61869646.14	37459972.96	32243278	16532462.66	4662012.141
F	46	11877189.84	66200521.37	40082171.06	34500307.45	17689735.04	4988352.991
F	47	12708593.13	70834557.87	42887923.04	36915328.98	18928016.5	5337537.7
				Total TTC=	2814889910		

Now we will show travel time cost years by years for multi lane:

LOS	Year	Ordinary L Bus	Mini Bus	Micro Bus	Car	Autorickshaw	Motorcycle
A	1	205542.75	2291289	1387297.8	1194102	612265.5	172653.6
A	2	219930.7425	2451679.23	1484408.646	1277689.14	655124.085	184739.352
A	3	235325.8945	2623296.776	1588317.251	1367127.38	700982.771	197671.1066
A	4	251798.7071	2806927.55	1699499.459	1462826.296	750051.5649	211508.0841
A	5	269424.6166	3003412.479	1818464.421	1565224.137	802555.1745	226313.65

A	6	288284.3397	3213651.352	1945756.93	1674789.827	858734.0367	242155.6055
A	7	308464.2435	3438606.947	2081959.916	1792025.115	918845.4192	259106.4979
A	8	330056.7406	3679309.433	2227697.11	1917466.873	983164.5986	277243.9527
A	9	353160.7124	3936861.094	2383635.907	2051689.554	1051986.12	296651.0294
A	10	377881.9623	4212441.37	2550490.421	2195307.822	1125625.149	317416.6015
A	11	404333.6996	4507312.266	2729024.75	2348979.37	1204418.909	339635.7636
B	12	446371.5684	4975929.653	3012756.689	2593198.654	1329640.24	374947.1009
B	13	477617.5782	5324244.728	3223649.657	2774722.56	1422715.057	401193.398
B	14	511050.8087	5696941.859	3449305.133	2968953.139	1522305.111	429276.9358
B	15	546824.3653	6095727.79	3690756.492	3176779.858	1628866.469	459326.3213
B	16	585102.0709	6522428.735	3949109.446	3399154.448	1742887.122	491479.1638
B	17	626059.2158	6978998.746	4225547.108	3637095.26	1864889.22	525882.7053
B	18	669883.3609	7467528.658	4521335.405	3891691.928	1995431.466	562694.4947
C	19	753532.8986	8400012.365	5085922.673	4377654.484	2244604.574	632959.1662
C	20	806280.2015	8988013.231	5441937.26	4684090.298	2401726.895	677266.3078

C	21	862719.8156	9617174.157	5822872.868	5011976.619	2569847.777	724674.9494
C	22	923110.2026	10290376.35	6230473.969	5362814.982	2749737.122	775402.1958
C	23	987727.9168	11010702.69	6666607.146	5738212.031	2942218.72	829680.3495
C	24	1056868.871	11781451.88	7133269.647	6139886.873	3148174.031	887757.974
D	25	1241176.491	13836022.15	8377242.28	7210623.243	3697184.868	1042574.304
D	26	1328058.846	14804543.7	8963649.24	7715366.87	3955987.808	1115554.505
D	27	1421022.965	15840861.76	9591104.686	8255442.55	4232906.955	1193643.32
D	28	1520494.572	16949722.08	10262482.01	8833323.529	4529210.442	1277198.353
E	29	1807699.103	20151336.25	12200950.84	10501840.2	5384727.97	1518446.93
E	30	1934238.04	21561929.79	13055017.4	11236969.01	5761658.928	1624738.215
E	31	2069634.703	23071264.87	13968868.62	12023556.84	6164975.053	1738469.891
E	32	2214509.132	24686253.41	14946689.42	12865205.82	6596523.306	1860162.783
F	33	2464305.762	27470862.8	16632675.99	14316401.04	7340611.135	2069989.145
F	34	2636807.165	29393823.2	17796963.3	15318549.11	7854453.915	2214888.385
F	35	2821383.667	31451390.82	19042750.74	16390847.54	8404265.689	2369930.572

F	36	3018880.523	33652988.18	20375743.29	17538206.87	8992564.287	2535825.712
F	37	3230202.16	36008697.35	21802045.32	18765881.35	9622043.787	2713333.512
F	38	3456316.311	38529306.16	23328188.49	20079493.05	10295586.85	2903266.858
F	39	3698258.453	41226357.6	24961161.68	21485057.56	11016277.93	3106495.538
F	40	3957136.545	44112202.63	26708443	22989011.59	11787417.39	3323950.225
F	41	4234136.103	47200056.81	28578034.01	24598242.4	12612536.6	3556626.741
F	42	4530525.63	50504060.79	30578496.39	26320119.37	13495414.17	3805590.613
F	43	4847662.424	54039345.04	32718991.14	28162527.73	14440093.16	4071981.956
F	44	5186998.794	57822099.2	35009320.52	30133904.67	15450899.68	4357020.693
F	45	5550088.709	61869646.14	37459972.96	32243278	16532462.66	4662012.141
F	46	5938594.919	66200521.37	40082171.06	34500307.45	17689735.04	4988352.991
F	47	6354296.563	70834557.87	42887923.04	36915328.98	18928016.5	5337537.7
				Total TTC=	2509071453		

So total save= 305818457.4

So for TTC we can say multilane is more preferable where we can save 305818457.4 taka almost.

Chapter 8

Vehicle Operating Cost

Vehicle operating cost in Multilane

Heavy Truck	Medium Truck	Small Truck	Large Bus	Minibus	Microbus	Utility	Car	Auto-Rickshaw	Motorcycle
199686	847970.7	338466.9576	21514.61	183109.6	254537.6	34542.14	454754.982	76972.22	50916.64
213664	907328.7	362159.6446	23020.63	195927.3	272355.2	36960.09	486587.831	82360.27	54480.8
228620.5	970841.7	387510.8198	24632.07	209642.2	291420.1	39547.3	520648.979	88125.49	58294.46
244623.9	1038801	414636.5771	26356.32	224317.1	311819.5	42315.61	557094.408	94294.27	62375.07
261747.6	1111517	443661.1375	28201.26	240019.3	333646.8	45277.7	596091.016	100894.9	66741.32
280069.9	1189323	474717.4172	30175.35	256820.7	357002.1	48447.14	637817.387	107957.5	71413.22
299674.8	1272575	507947.6364	32287.62	274798.1	381992.3	51838.44	682464.605	115514.5	76412.14
320652.1	1361656	543503.9709	34547.75	294034	408731.7	55467.13	730237.127	123600.6	81760.99
343097.7	1456972	581549.2489	36966.1	314616.4	437343	59349.83	781353.726	132252.6	87484.26
367114.6	1558960	622257.6963	39553.72	336639.5	467957	63504.31	836048.486	141510.3	93608.16
392812.6	1668087	665815.735	42322.48	360204.3	500713.9	67949.62	894571.881	151416	100160.7
420309.5	1784853	712422.8365	45285.06	385418.6	535763.9	72706.09	957191.912	162015.1	107172
449731.1	1909793	762292.435	48455.01	412397.9	573267.4	77795.52	1024195.35	173356.2	114674
481212.3	2043478	815652.9055	51846.86	441265.8	613396.1	83241.2	1095889.02	185491.1	122701.2
514897.2	2186522	872748.6089	55476.14	472154.4	656333.8	89068.09	1172601.25	198475.5	131290.3
550940	2339578	933841.0115	59359.47	505205.2	702277.2	95302.85	1254683.34	212368.8	140480.6
589505.7	2503349	999209.8823	63514.64	540569.5	751436.6	101974.1	1342511.17	227234.6	150314.2
630771.2	2678583	1069154.574	67960.66	578409.4	804037.2	109112.2	1436486.96	243141	160836.2
674925.1	2866084	1143995.394	72717.91	618898.1	860319.8	116750.1	1537041.04	260160.9	172094.8
722169.9	3066710	1224075.072	77808.16	662220.9	920542.2	124922.6	1644633.91	278372.1	184141.4
772721.8	3281379	1309760.327	83254.73	708576.4	984980.1	133667.2	1759758.29	297858.2	197031.3
826812.3	3511076	1401443.55	89082.56	758176.7	1053929	143023.9	1882941.37	318708.3	210823.5
884689.2	3756851	1499544.598	95318.34	811249.1	1127704	153035.6	2014747.27	341017.8	225581.2

946617.4	4019831	1604512.72	101990.6	868036.5	1206643	163748	2155779.57	364889.1	241371.8
1012881	4301219	1716828.611	109130	928799.1	1291108	175210.4	2306684.14	390431.3	258267.9
1083782	4602304	1837006.613	116769.1	993815	1381486	187475.1	2468152.03	417761.5	276346.6
1159647	4924465	1965597.076	124942.9	1063382	1478190	200598.4	2640922.68	447004.8	295690.9
1240822	5269178	2103188.872	133688.9	1137819	1581663	214640.3	2825787.26	478295.2	316389.2
1327680	5638020	2250412.093	143047.1	1217466	1692379	229665.1	3023592.37	511775.8	338536.5
1420617	6032682	2407940.939	153060.4	1302689	1810846	245741.7	3235243.84	547600.1	362234
1520061	6454970	2576496.805	163774.7	1393877	1937605	262943.6	3461710.91	585932.1	387590.4
1626465	6906817	2756851.581	175238.9	1491448	2073237	281349.6	3704030.67	626947.4	414721.8
1740318	7390295	2949831.192	187505.6	1595850	2218364	301044.1	3963312.82	670833.7	443752.3
1862140	7907615	3156319.375	200631	1707559	2373649	322117.2	4240744.71	717792.1	474814.9
1992490	8461148	3377261.731	214675.2	1827088	2539805	344665.4	4537596.84	768037.5	508052
2131964	9053429	3613670.053	229702.4	1954985	2717591	368792	4855228.62	821800.1	543615.6
2281201	9687169	3866626.956	245781.6	2091834	2907823	394607.4	5195094.63	879326.1	581668.7
2440885	10365271	4137290.843	262986.3	2238262	3111370	422229.9	5558751.25	940879	622385.5
2611747	11090840	4426901.202	281395.4	2394940	3329166	451786	5947863.84	1006741	665952.5
2794570	11867198	4736784.286	301093	2562586	3562208	483411	6364214.31	1077212	712569.2
2990189	12697902	5068359.187	322169.5	2741967	3811562	517249.8	6809709.31	1152617	762449
3199503	13586755	5423144.33	344721.4	2933905	4078372	553457.3	7286388.96	1233300	815820.5
3423468	14537828	5802764.433	368851.9	3139278	4363858	592199.3	7796436.19	1319631	872927.9
3663111	15555476	6208957.943	394671.5	3359027	4669328	633653.3	8342186.72	1412006	934032.8
3919528	16644360	6643584.999	422298.6	3594159	4996181	678009	8926139.79	1510846	999415.1
4193895	17809465	7108635.949	451859.5	3845751	5345913	725469.6	9550969.58	1616605	1069374
4487468	19056127	7606240.465	483489.6	4114953	5720127	776252.5	10219537.4	1729768	1144230
	Total=	793942656.3							

VOC in two lane

Year	Heavy Truck	Medium Truck	Small Truck	Large Bus	Minibus	Microbus	Utility	Car	Auto-Rickshaw	Motorcycle
1	206491.7	882823.9	351968.1	22512.5934	188618.2	263992.7	36068.47	463934.4	78174.91	50916.64
2	220946.1	944621.6	376605.9	24088.47494	201821.5	282472.2	38593.27	496409.8	83647.15	54480.8
3	236412.4	1010745	402968.3	25774.66818	215949	302245.2	41294.8	531158.5	89502.45	58294.46
4	252961.2	1081497	431176.1	27578.89496	231065.4	323402.4	44185.43	568339.6	95767.62	62375.07
5	270668.5	1157202	461358.4	29509.4176	247240	346040.6	47278.41	608123.4	102471.4	66741.32
6	289615.3	1238206	493653.5	31575.07684	264546.8	370263.4	50587.9	650692	109644.4	71413.22
7	309888.4	1324881	528209.3	33785.33221	283065	396181.8	54129.05	696240.5	117319.5	76412.14
8	331580.6	1417622	565183.9	36150.30547	302879.6	423914.6	57918.09	744977.3	125531.8	81760.99
9	354791.2	1516856	604746.8	38680.82685	324081.2	453588.6	61972.36	797125.7	134319	87484.26
10	379626.6	1623036	647079.1	41388.48473	346766.9	485339.8	66310.42	852924.5	143721.4	93608.16
11	406200.5	1736648	692374.6	44285.67866	371040.5	519313.6	70952.15	912629.3	153781.9	100160.7
12	434634.5	1858214	740840.8	47385.67617	397013.4	555665.5	75918.8	976513.3	164546.6	107172

13	465058.9	1988289	792699.7	50702.6735	424804.3	594562.1	81233.12	1044869	176064.9	114674
14	497613	2127469	848188.6	54251.86065	454540.6	636181.5	86919.43	1118010	188389.4	122701.2
15	532445.9	2276392	907561.8	58049.49089	486358.4	680714.2	93003.79	1196271	201576.7	131290.3
16	569717.1	2435739	971091.2	62112.95525	520403.5	728364.2	99514.06	1280010	215687	140480.6
17	609597.3	2606241	1039068	66460.86212	556831.8	779349.6	106480	1369610	230785.1	150314.2
18	652269.2	2788678	1111802	71113.12247	595810	833904.1	113933.6	1465483	246940.1	160836.2
19	697928	2983885	1189628	76091.04104	637516.7	892277.4	121909	1568067	264225.9	172094.8
20	746783	3192757	1272902	81417.41392	682142.9	954736.8	130442.6	1677832	282721.7	184141.4
21	799057.8	3416250	1362006	87116.63289	729892.9	1021568	139573.6	1795280	302512.2	197031.3
22	854991.8	3655388	1457346	93214.79719	780985.4	1093078	149343.8	1920949	323688.1	210823.5
23	914841.2	3911265	1559360	99739.833	835654.4	1169594	159797.8	2055416	346346.2	225581.2
24	978880.1	4185053	1668515	106721.6213	894150.2	1251465	170983.7	2199295	370590.5	241371.8
25	1047402	4478007	1785312	114192.1348	956740.7	1339068	182952.5	2353246	396531.8	258267.9
26	1120720	4791467	1910283	122185.5842	1023713	1432803	195759.2	2517973	424289	276346.6
27	1199170	5126870	2044003	130738.5751	1095372	1533099	209462.4	2694231	453989.3	295690.9

28	1283112	5485751	2187083	139890.2754	1172048	1640416	224124.7	2882827	485768.5	316389.2
29	1372930	5869754	2340179	149682.5947	1254092	1755245	239813.5	3084625	519772.3	338536.5
30	1469035	6280636	2503992	160160.3763	1341878	1878112	256600.4	3300549	556156.4	362234
31	1571868	6720281	2679271	171371.6026	1435810	2009580	274562.4	3531587	595087.3	387590.4
32	1681898	7190701	2866820	183367.6148	1536316	2150250	293781.8	3778798	636743.4	414721.8
33	1799631	7694050	3067498	196203.3479	1643859	2300768	314346.5	4043314	681315.5	443752.3
34	1925605	8232633	3282222	209937.5822	1758929	2461822	336350.8	4326346	729007.6	474814.9
35	2060398	8808918	3511978	224633.213	1882054	2634149	359895.3	4629190	780038.1	508052
36	2204626	9425542	3757816	240357.5379	2013797	2818539	385088	4953234	834640.8	543615.6
37	2358949	10085330	4020864	257182.5655	2154763	3015837	412044.2	5299960	893065.6	581668.7
38	2524076	10791303	4302324	275185.3451	2305597	3226946	440887.3	5670957	955580.2	622385.5
39	2700761	11546694	4603487	294448.3193	2466989	3452832	471749.4	6067924	1022471	665952.5
40	2889814	12354963	4925731	315059.7016	2639678	3694530	504771.8	6492679	1094044	712569.2
41	3092101	13219810	5270532	337113.8807	2824455	3953147	540105.9	6947167	1170627	762449
42	3308549	14145197	5639469	360711.8524	3022167	4229868	577913.3	7433468	1252571	815820.5

43	3540147	15135360	6034232	385961.682	3233719	4525958	618367.2	7953811	1340251	872927.9
44	3787957	16194836	6456628	412978.9998	3460079	4842776	661652.9	8510578	1434068	934032.8
45	4053114	17328474	6908592	441887.5298	3702285	5181770	707968.6	9106318	1534453	999415.1
46	4336832	18541467	7392194	472819.6568	3961444	5544494	757526.4	9743761	1641865	1069374
47	4640410	19839370	7909647	505917.0328	4238746	5932608	810553.3	10425824	1756795	1144230
		Total=	838041238.7							

Vehicle Operating cost reduce: 44098582.3

Chapter 9

Benefit cost ratio

For flexible pavement:

Accident Benefit	1298207516.20
VOC	146909646.6
TTC	305818457.4
Fuel Benefit	8567542.15
Noise Benefit	487373484.1
Total Benefit	2246876646.46
Cost	131848319.6
Earth Fill	45203004
Maintenance	301770095.6
Total Cost	478821419.2
B/C ratio	4.692514905

In previos discussion we have calculated accident benefit, VOC, TOC, fuel benefit, noice benefit. So our total benefit was 2246876646.46. afterthan we calculated cost part. Cost was total 478821419.2. we got benefit cost ratio 4.692514905.

For rigid pavement:

Accident Benefit	1298207516.20
VOC	146909646.6
TTC	305818457.4
Fuel Benefit	8567542.15
Noise Benefit	487373484.1
Total Benefit	2246876646.46
Cost	322644265.9

Earth Fill	45203004
Total Cost	367847269.9
B/C ratio	6.108178122

Accident Benefit	1298207516.20
VOC	146909646.6
TTC	305818457.4
Fuel Benefit	8567542.15
Noise Benefit	487373484.1
Total Benefit	2246876646.46
Cost	288956949.2
Earth Fill	45203004
Total Cost	334159953.2
B/C ratio	6.723955475

For first method of rigid pavement we have got benefit cost ratio 6.108178122

And for second method we have got 6.723955475.

Since the second ratio is higher. So we will choose this one.

So our selected road thickness is 8.5 inches.

Chapter 10

Decision on the Pavement

There were three options to make the final decision. The first one was to do nothing, the second one was to choose rigid pavement, and the final option was to choose the flexible pavement.

First of all, doing nothing will not be feasible at all. The level of service will become F within 20 years. The user cost, safety cost, and environmental cost will keep rising up as the level of service got decrease. So, doing nothing was not a viable option.

So, the option remained to choose between rigid pavement and flexible pavement. To choose between these two, weightages were set. The weightages considered were:

Cost/Benefit	Weightage
Construction and Maintenance Cost	4
Environmental Benefit	3
User Benefit	2
Safety Benefit	3

The weightage of construction and maintenance were the highest. This was considered as saving money is extremely important in todays condition. The rate of dollar is high, the heavy constructions like Padma bridge had already reduced the fund available to the government. Apart from these, many other construction work was ongoing like Metro rail. So, having a lower construction cost was extremely important.

The second highest weightage was set to environmental benefit and safety benefit. These criteria cannot be overlooked. The safety is always the first priority. Accident cost falls under it. In terms of environmental benefit, it was high time environmental benefit of Dhaka city should be taken into consideration. So, these two got the weightage as 3.

User benefit is important in the long run. However, the other benefits were considered as more important than this one. So, the user benefit got a weightage of 2.

Table: Rigid Pavement D=8.5 in

Cost/Benefit Type	Cost/Benefit in BDT	Weightage Type	Weightage	Weighted Amount in BDT
Accident Benefit	1298207516.20	Safety	3	3894622549
VOC	146909646.6	User Cost/Benefit	2	293819293.2
TTC	305818457.4			611636914.7
Fuel Benefit	8567542.15	Environmental Cost/Benefit	3	25702626.45
Noise Benefit	487373484.1			1462120452
Total Benefit	2246876646.46			6287901835
Cost	288956949.2	Construction and Maintenance Cost	4	1155827797
Earth Fill	45203004			180812016
Total Cost	334159953.2			1336639813
B/C ratio				4.704260472

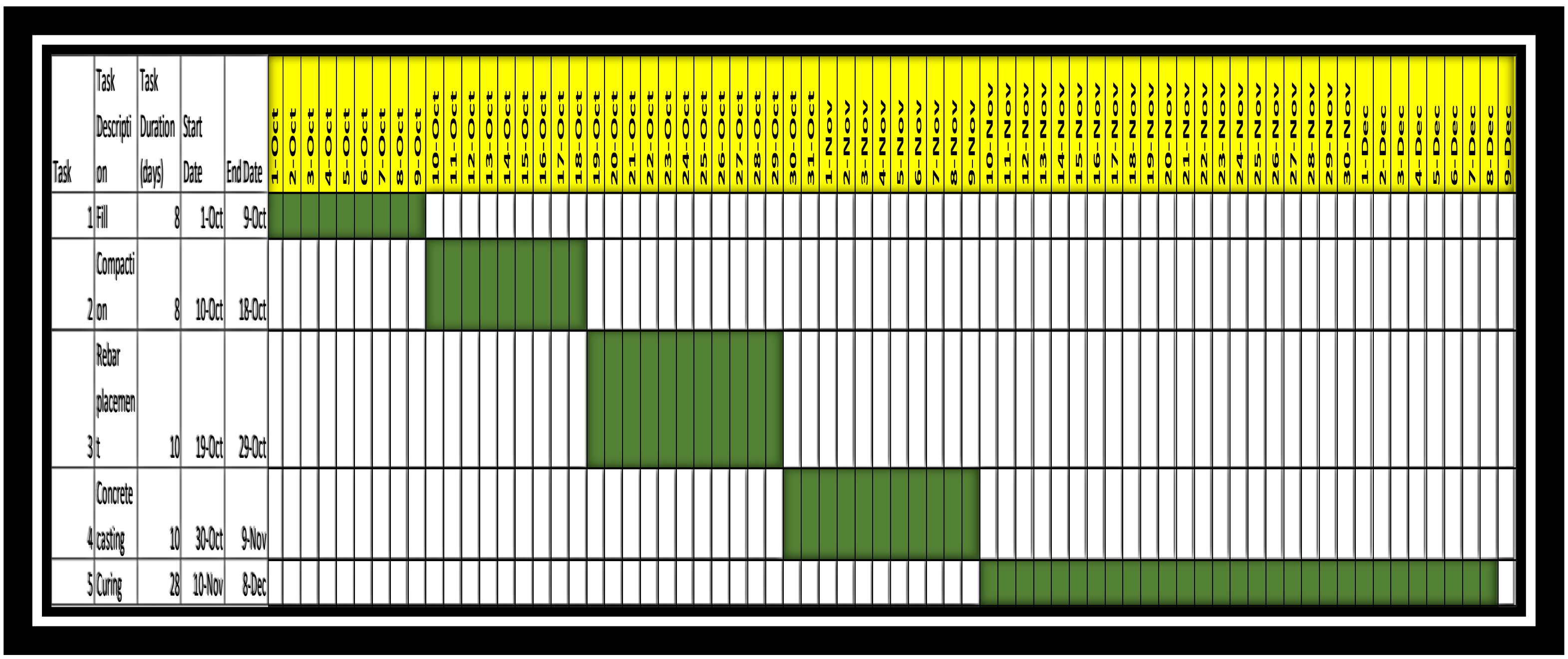
Table: Flexible Pavement

Cost/Benefit Type	Cost/Benefit in BDT	Weightage Type	Weightage	Weighted Amount in BDT
Accident Benefit	1298207516.20	Safety	3	3894622549
VOC	146909646.6	User Cost/Benefit	2	293819293.2
TTC	305818457.4			611636914.7
Fuel Benefit	8567542.15	Environmental Cost/Benefit	3	25702626.45
Noise Benefit	487373484.1			1462120452
Total Benefit	2246876646.46			6287901835.42
Cost	131848319.6	Construction and Maintenance Cost	4	527393278.3
Earth Fill	45203004			180812016
Maintenance	301770095.6			1207080382

Total Cost	478821419.2			1915285677
B/C ratio				3.283009899

With the defined weightage, it could be noted that Rigid pavement was more beneficial than the rigid pavement. So, rigid pavement with thickness 8.5 in was decided for this study.

Project Timeline:



Project Timeline:

There will be two different works. One is filling earth on the embankment, the other is constructing the pavement. However, before filling the embankment, it will be difficult to construct the pavement as most of the pavement will be built over the filled embankment. So, the 5 tasks are fill, compaction, rebar placement, concrete casting, and curing. None of the work can start before the other gets done.

Total project duration will be 68 days. Among them, all the works have been tentatively set for 8-10 days. The total length of the road is 8.508 km. So, 1 km each day was the idea to make this project timeline.

Feasibility Study Timeline:

Task	Task Description	Task Duration (days)	Start Date	End Date	14-Jun	15-Jun	16-Jun	17-Jun	18-Jun	19-Jun	20-Jun	21-Jun	22-Jun	23-Jun	24-Jun	25-Jun	26-Jun	27-Jun	28-Jun	29-Jun	30-Jun	1-Jul	2-Jul	3-Jul	4-Jul	5-Jul	6-Jul	7-Jul	8-Jul	9-Jul	10-Jul	11-Jul	12-Jul	13-Jul	14-Jul	15-Jul	16-Jul	17-Jul	18-Jul	19-Jul	20-Jul	21-Jul	22-Jul	23-Jul	24-Jul	25-Jul	26-Jul	27-Jul	28-Jul	29-Jul	30-Jul	31-Jul	1-Aug	2-Aug	3-Aug	4-Aug	5-Aug	6-Aug	7-Aug	8-Aug	9-Aug	10-Aug	11-Aug	12-Aug	13-Aug	14-Aug	15-Aug	16-Aug	17-Aug	18-Aug	19-Aug	20-Aug	21-Aug	22-Aug	23-Aug	24-Aug	25-Aug	26-Aug	27-Aug	28-Aug	29-Aug	30-Aug	31-Aug	1-Sep	2-Sep	3-Sep	4-Sep	5-Sep	6-Sep	7-Sep
1	AADT	7	14-Jun	21-Jun																																																																																		
2	LOS	14	22-Jun	6-Jul																																																																																		
3	Geometric Design	7	7-Jul	14-Jul																																																																																	
4	Structural Design	7	15-Jul	22-Jul																																																																																	
5	Ethics	7	23-Jul	30-Jul																																																																																	
6	User cost	14	31-Jul	14-Aug																																																																																	
7	Health Cost	7	15-Aug	22-Aug																																																																																	
8	Design Comparison	7	23-Aug	30-Aug																																																																																	
9	Autocad Drawing	7	31-Aug	7-Sep																																																																																	

Mode of financing with source: (BDT)

Mode	Gob(FE)	PA (RPA)	Own Fund	Others	PA source
Loan/Credit	0	0	0	0	0
Grant	778821419.2	0	0	0	0
Equity	0	0	0	0	0
Others	0	0	0	0	0
Total	778821419.2	0	0	0	0

Chapter 11

Ethics

To continue a project perfectly and in diciplened way ethics is a topic that should obey by all mandatorily. From the very beginning of a project to the finishing ethical issues come.

Some issues that cannot be excluded when the topic ethics comes in are quality of work, the tender process, accountability of expense, corruption, etc.

First ethical issue occurred in tendering . tendering is the first process of any project. Tender is the process of any entity inviting suppliers to provide a formal written submission for goods or services. By this process entity can select a contractor for construction work on the basis of best value for money. Since entity select a contractor in this process , entity face a lot of difficulty here. Like he can be threated. Many of the times threat come from political involved persons, even law enforcement agencies can not do anything here. Sometimes it happens that tender selection committee member get influenced by money of a candidate and wrong person get choose which is a serious ethical issue for a contraction site.

Then it comes substandard quality of construction work. A well organized construction site build with well educated workers, errorless perfect number of machines, workers with perfect safety tools, well graded construction material. If any of these get short then it is called substandard quality of contraction work. After getting choose in tendering process it is up to contractor to manage all of these. But sometimes it seen that to theft money he do not ensure all standard needs. It is seen that he use less educated, less experienced worker at working site to theft money. Even he use low quality construction material. This is an serious ethical issue to continue perfectly a construction site perfectly.

In a contraction site it is mandatory to obey all safety measures. Firstly a contractor has to manage all safety tools for his workers and he has to ensure that all workers are using those all all time at working time. Then they have to be the most aware of contraction tools that no one of civil people get hurt. If possible it is high recommended to manage fence around the construction site so that none of a civil people can come in the area. Even security has to be hired for this.

From the contractor to the workers it is most important that they get their money in time. Everyone here do their work for money so that they can manage their life. So it very ethical to give their money in time.

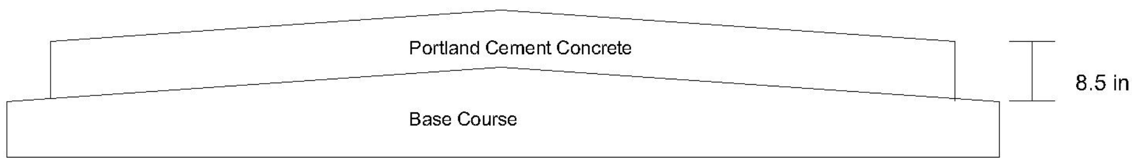
In a project the most threating part is corruption. Corruption is a topic you will see from the very starting of a project to the finish. As we spoke earlier, tender selection committee choose wrong tenderer for money. After that contractor do rest of the damage as we have mentioned earlier. Most of the time we have seen that they give low quality product and less in number. They theft a lot of money from their. Engineers get involved here for money. Sometimes it is seen that contractor, engineer gang use bamboo stick rather than reinforcement. Which is a very serious ethical issue. We see they use low quality and less quantity cement which is suicidal decision. It is sure that accident will occur and we can see lots of accidents in road for road quality. Corruption is a serious ethical issue for a construction side.

Construction project like constructing a road or any big project it is important that everyone become honest and they have to be accountable. In the government project mass people are the main source of investment. So it is responsibility for all the members who are connected with the work to manage media, mass people with proper ethics.

To over overcome all these issues ethics should be taught mandatorily. Everyone related to the project have to know the codes of ethics. Government personnel, tenderer, contractor, workers everyone have to know about the codes of ethics. After then if any one disobey any rule then law enforcement agencies have to be very strict against it.

Chapter 12

Cross Section of the Selected Pavement



Chapter 13

BOQ

Construction Cost for Rigid Pavement:

Description	**Unit**	**Quantity**	**Rate in BDT**	**Amount in BDT**
ROAD WAY AND BORROW EXCAVATION				
Capping Layer compacted to 95% MDD,AASHTO T-180	m^3	19,966.40	205.2359	4097822.1
SUBBASE				
Gravel Sub-base layer,97%MDD,AASHTO T-180	m 3	12,937.40	333.221	4311013.4
: RIGID PAVEMENT				
Concrete Pavement				
Concrete Trial Pavement				
Manual Construction	m2	300	2581.205	774361.44
Concrete Pavement 216	m2	60	2581.205	154872.29
Concrete Pavement 216 mm		70,027.80	2581.205	180756093
Texturing and Curing the Concrete pavement				0
Burlap dragged and / or grooved texture	m2	69,931.90	18.1	1265767.4
Curing	m2	80,064.20	108.6	8694972.1
Joints				0
Expansion Joint complete (except Dowels and end caps)	m	14	514.5468	7203.6552

Longitudinal joints complete (except tie bars	m	9,933.70	42.8789	425946.13
Sealed transverse contraction joints as per the drawing (except Dowels)	m	2,779.40	48.4537	134672.21
Dowel bars (mild steel plain bars, epoxy coated) (25 mm diameter and 400 mm long at 300 mm spacing):	no	9,565.40	145.9403	1395977.3
Tie Bars (Ø 12 mm high strength deformed bars ,1000 mm long @ 600mm spacing, with 15cm long protective coating as per the drawing)	no	16,689.10	84.0564	1402825.7
End caps for dowels at expansion joints with compressible fill	no	48	72.4	3475.2
Steel Reinforcement in Concrete Pavement				0
High tensile steel bars (Ø14 and Ø 12 mm deformed bars for the concrete reinforcement and 39 Anchors(keys) as per the drawing)	Ton	429.24	94681.1	40640915
Separation Membrane				
Impermeable plastic sheeting 125 microns thick	m2	69,931.80		

OR MC-30 prime coat material to be used in the absence of impermeable plastic sheeting,application rate of 1.25lit/m2	lit	87,414.84	72.5629	6343074.3
Rigid Pavement Total				250408992
Grand total of the bills without contingency				255054756
Add 10% for contingency				25505476
Add 15% VAT				42084035
Total contract amount (including VAT)				322644266

Construction Cost for Flexible Pavement:

Description	Unit	Quantity	Rate	Amount in BDT
5000 SUBBASE, ROAD BASE AND GRAVEL WEARING COURSE				
5100: SUB-BASES				
Sub-base layer constructed from gravel or Crushed stone:	m 3	7,377.00	333.221	2458171.3
a) Gravel sub-base (unstabilized gravel) compacted to:				
(i) 95% of modified AASHTO density				
5200: ROAD BASES				

Base layer construction a) Gravel base taken from cut or borrow, Gravel base (unstabilized gravel) compacted to:	m 3	29,239.00	725.9548	21226192
(i) 95% of modified AASHTO density				
6000 BITUMINOUS SURFACINGS AND ROAD BASES				
6100 BITUMINOUS PRIME COAT				
Prime coat				
(a) MC-30 cutback bitumen	Lt	40,955.90	72.5629	2971878.9
Tack Coat				
RC -70 Cut back bitumenapplied at 1lit per sq.m	Lt	205,852.51	69.1239	14229328
6300C: DOUBLE SURFACE TREATMENTS				
Double surface treatment using				
(c) Double surface treatment using 20	m 2	80,882.68	198.6113	16064214

mm and 10 mm chippings (with MC 3000 cutback)				
Variations in the rate of application of Bituminous Binder,with MC 3000 cutback	Lt			
(h) MC 3000 cutback bitumen	Lt	5,877.00	85.7578	503998.59
Variations in the rate of application of Chippings				
(a) 20 mm chippings	m 3	1,273.38	971.5899	1237203.1
Variations in the rate of application of Chippings				
(b) 10 mm chippings	m 3	587.71		
BITUMINOUS Road Bases and Surfacing				
Asphalt Surfacing				
(iii)(a)50mm A sphaltic Surfacing with pentration grade 80/100 Bitemen	m2	50,746.31	385.5481	19565143
(b) Dense Bitumen Macadam	m 3	9,098.77	5890.048	53592189

Total	131848320

Routine Maintenance Cost for Pavements:

Flexible pavement needs to be maintained time to time. If not, the surface may get deteriorated. Once that occurs, the level of service worsen in very short period of time.

Table 3.6: Agency Cost of Flexible pavement

S/No	Activity	Cost (ETB)	Remarks
1	Construction Cost	6,301,638.47	
2	Routine Maintenance Cost	673,176.26	Twice every year
3	Periodic Maintenance Cost	681,856.38	Once every three years
4	Rehabilitation Cost	2,558,500.84	At 15th and 30th years
5	Salvage Value	1,705,667.23	After 40th years

Yonus et al. (2016) provided this table for the estimated time period for flexible pavement maintenance. Based on this table, a tentative maintenance schedule and related cost was calculated. The rehabilitation cost has been modified as this projects life cycle is 33 years.

Table:

Year	Routine cost	Periodic Cost	Rehabilitation Cost	Reconstruction Cost
1	1361280			
2	1361280			
3	1361280	4202952		
4	1361280			
5	1361280			
6	1361280	4202952		

7	1361280			
8	1361280			
9	1361280	4202952		
10	1361280			
11	1361280			
12	1361280	4202952		
13	1361280			
14	1361280			
15	1361280	4202952	39383532	
16	1361280			
17	1361280			
18	1361280	4202952		
19	1361280			
20	1361280			
21	1361280	4202952		
22	1361280			
23	1361280			
24	1361280	4202952		
25	1361280		39383532	
26	1361280			
27	1361280	4202952		
28	1361280			
29	1361280			
30	1361280	4202952		
31	1361280			
32	1361280			
33	1361280	4202952		49907928
Total	219829704			

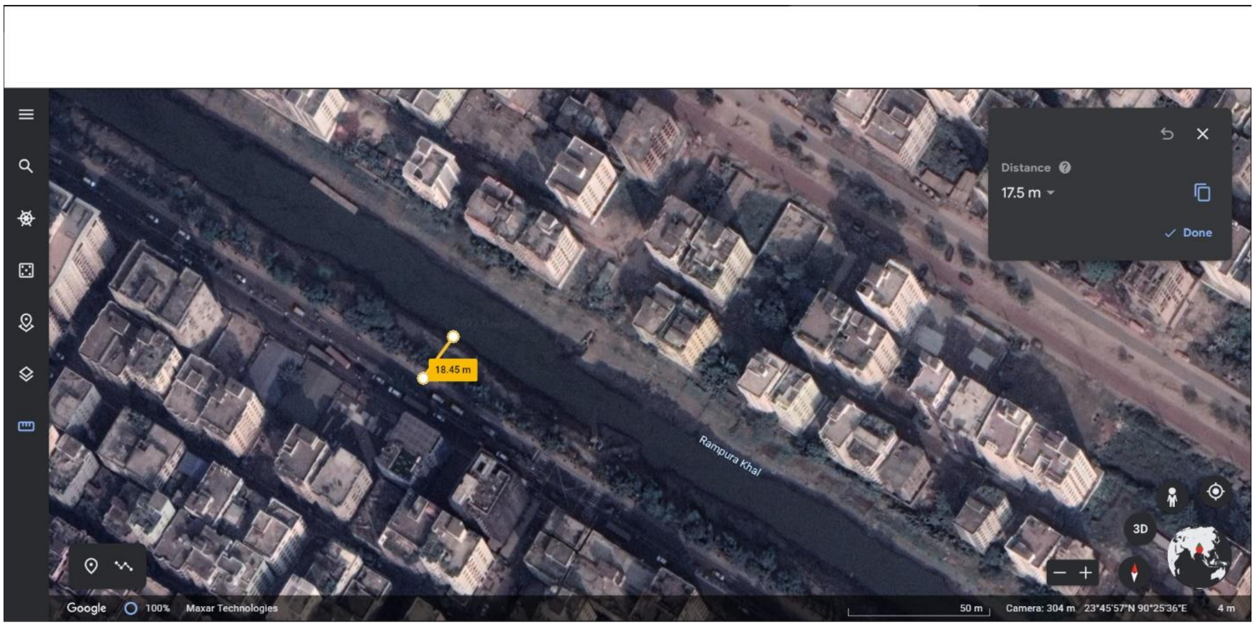
The total cost for maintenance, rehabilitation, and reconstruction was found to be 219829704 bdt.

In terms of rigid pavement, it does not require any maintenance cost. Once the construction of rigid pavement is completed, it does not require any major maintenance. Thus, the pavement is known as “Fit and Forget”.

Chapter 14

Legal Issue and Water Resource

Many project report published by the JICA, ADB, and RHD mentioned that the right of way is already owned by the government. On the R112 road, all of the houses, shops, mosque, etc. were built leaving the right of way. So, implementing this project will not produce any legal issue or settlement cost.



As shown in the picture, there are 17.5 m distance left before the water body starts. The road will be only 7.3m. Those embankments will be filled with soil and a retaining wall will be built before the waterbody. So, the waterbody will remain unchanged.

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