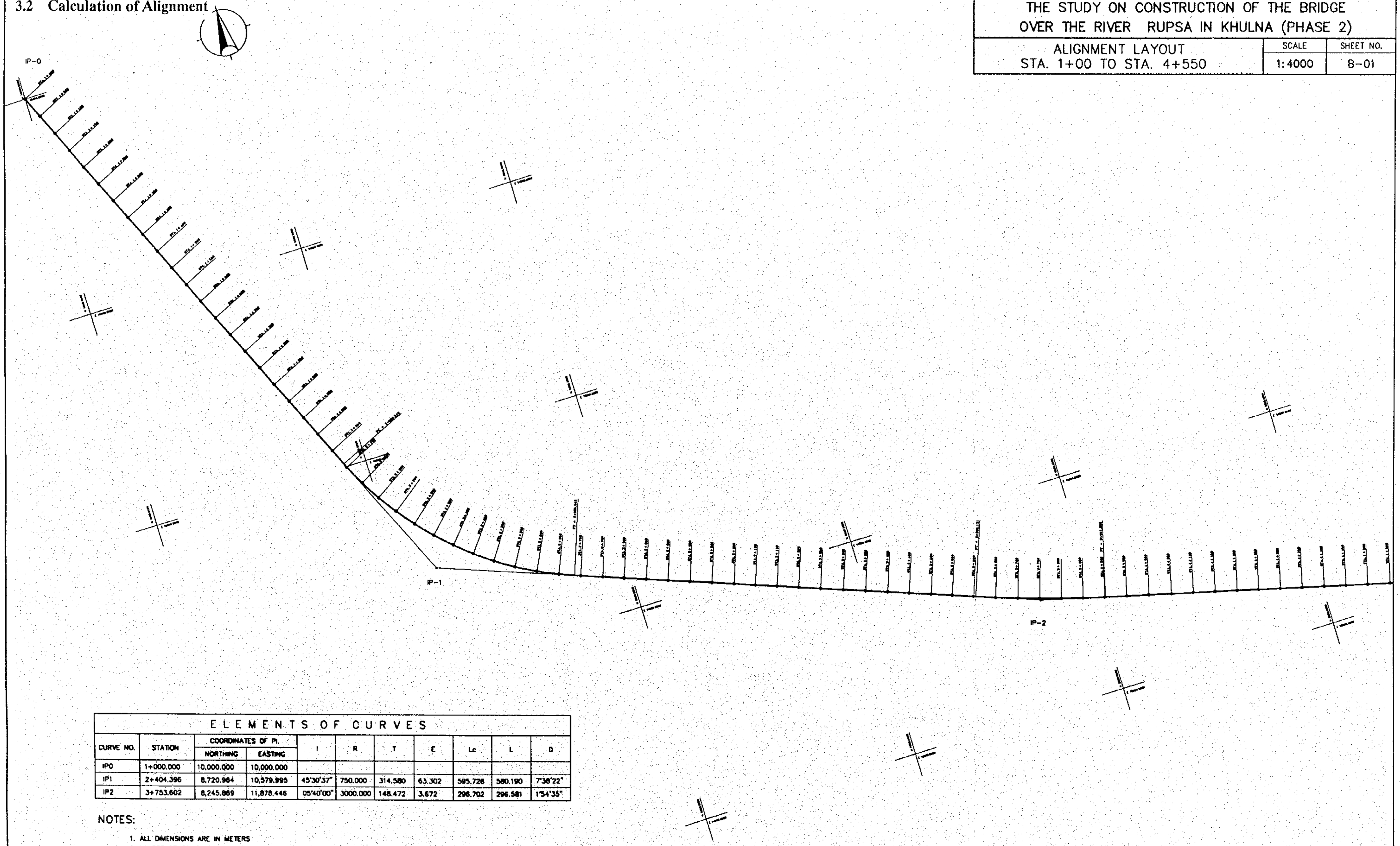
3.2 Calculation of Alignment

THE STUDY ON CONSTRUCTION OF THE BRIDGE OVER THE RIVER RUPSA IN KHULNA (PHASE 2)		
ALIGNMENT LAYOUT STA. 1+00 TO STA. 4+550	SCALE 1:4000	SHEET NO. B-01



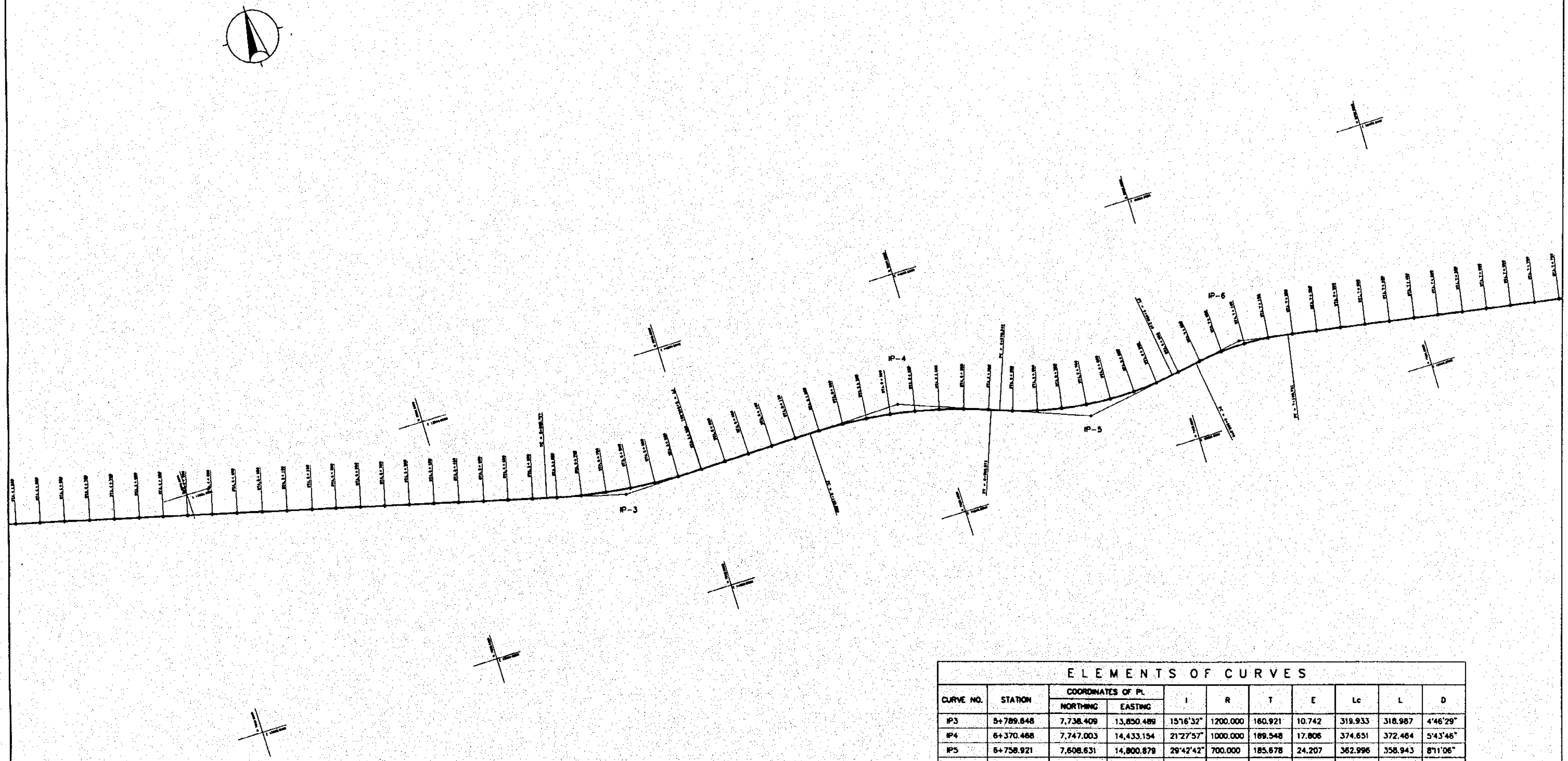
ELEMENTS OF CURVES										
CURVE NO.	STATION	COORDINATES OF PI.		I	R	T	E	Lc	L	D
		NORTHING	EASTING							
IP0	1+000.000	10,000.000	10,000.000							
IP1	2+404.396	8,720.964	10,579.995	45°30'37"	750.000	314.580	63.302	595.728	580.190	7°38'22"
IP2	3+753.602	8,245.869	11,878.446	05°40'00"	3000.000	148.472	3.672	296.702	296.581	1°54'35"

NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SHOWN.

B-01

THE STUDY ON CONSTRUCTION OF THE BRIDGE OVER THE RIVER RUPSA IN KHULNA (PHASE 2)		
ALIGNMENT LAYOUT STA. 4+550 TO 7+750	SCALE 1:4000	SHEET NO. B-02



ELEMENTS OF CURVES										
CURVE NO.	STATION	COORDINATES OF PI.		I	R	T	E	Lc	L	D
		NORTHING	EASTING							
IP3	5+789.648	7,738.409	13,850.489	15°16'32"	1200.000	160.921	10.742	319.933	318.987	4°46'29"
IP4	6+370.468	7,747.003	14,433.154	21°27'57"	1000.000	189.548	17.806	374.651	372.464	5°43'46"
IP5	6+758.921	7,608.631	14,800.879	29°42'42"	700.000	185.678	24.207	362.996	358.943	8°11'06"
IP6	7+091.787	7,662.544	15,137.818	19°04'31"	600.000	100.810	08.410	199.755	198.834	9°32'57"

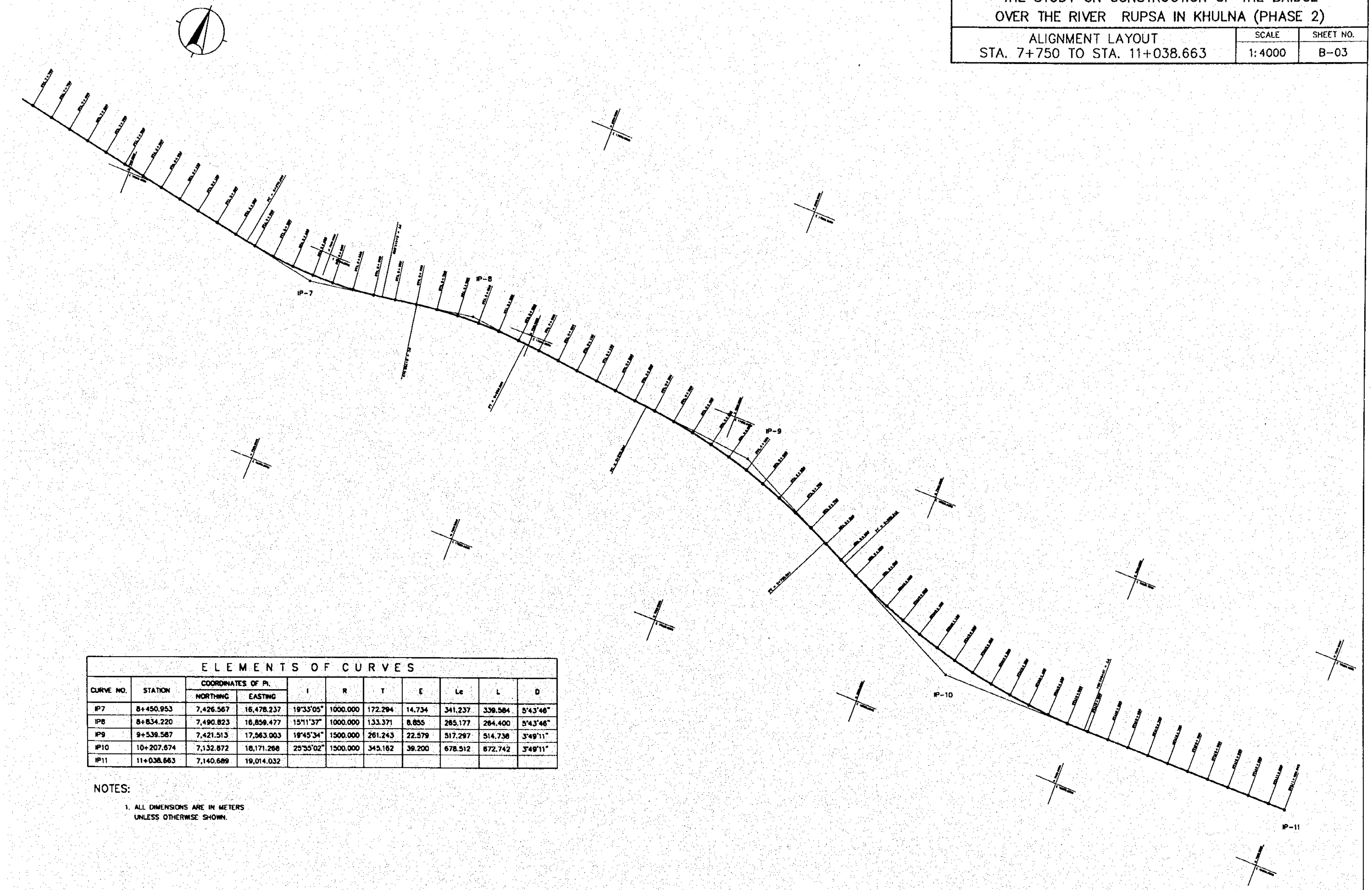
NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SHOWN.

B-02

THE STUDY ON CONSTRUCTION OF THE BRIDGE
OVER THE RIVER RUPSA IN KHULNA (PHASE 2)

ALIGNMENT LAYOUT STA. 7+750 TO STA. 11+038.663	SCALE	SHEET NO.
	1:4000	B-03



ELEMENTS OF CURVES										
CURVE NO.	STATION	COORDINATES OF PI.		I	R	T	E	Le	L	D
		NORTHING	EASTING							
IP7	8+450.953	7,426.567	16,478.237	19°33'05"	1000.000	172.294	14.734	341.237	339.584	5°43'46"
IP8	8+834.220	7,490.823	16,859.477	15°11'37"	1000.000	133.371	8.855	265.177	264.400	5°43'46"
IP9	9+539.587	7,421.513	17,563.003	19°45'34"	1500.000	261.243	22.579	517.297	514.738	3°49'11"
IP10	10+207.674	7,132.872	18,171.268	25°35'02"	1500.000	345.162	39.200	678.512	672.742	3°49'11"
IP11	11+038.663	7,140.689	19,014.032							

NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SHOWN.

B-03

THE STUDY ON CONSTRUCTION OF THE BRIDGE
OVER THE RIVER RUPSA IN KHULNA (PHASE 2)

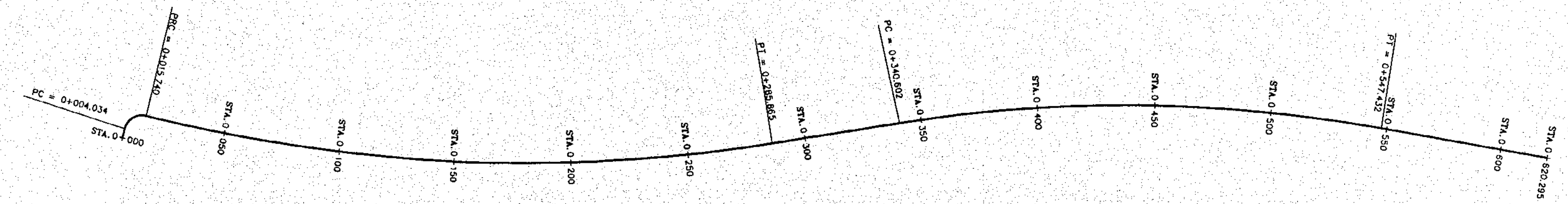
ALIGNMENT LAYOUT OF ACCESS ROAD WEST BANK NORTH SIDE	SCALE	SHEET NO.
	1:1000	B-04

ELEMENTS OF CURVES

CURVE NO.	STATION	COORDINATES OF PI.		I	R	T	E	Lc	L	D
		NORTHING	EASTING							
IP0	0+000.000	7,660.426	14,702.687							
IP1	0+011.460	7,671.529	14,705.525	89°25'49"	7.500	7.426	3.054	11.706	10.554	763°56'37"
IP2	0+152.613	7,637.329	14,845.713	22°47'46"	678.934	136.873	13.659	270.125	268.347	08°26'21"
IP3	0+444.983	7,684.091	15,137.986	19°04'31"	621.250	104.381	8.708	206.830	205.876	09°13'22"
IP4	0+620.295	7,653.381	15,312.545							

NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SHOWN.



1 / B-04 ALIGNMENT LAYOUT OF ACCESS ROAD WEST BANK NORTH SIDE (STA.0+00 TO STA. 0+620.295)
SCALE 1:1000

B-04

THE STUDY ON CONSTRUCTION OF THE BRIDGE OVER THE RIVER RUPSA IN KHULNA (PHASE 2)

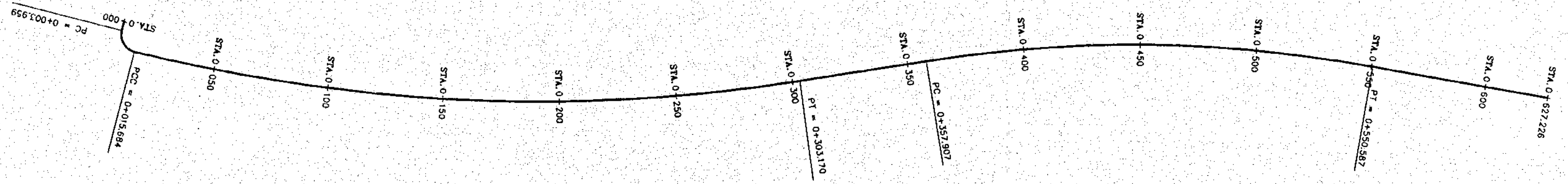
ALIGNMENT LAYOUT OF ACCESS ROAD WEST BANK SOUTH SIDE	SCALE	SHEET NO.
	1:1000	B-05

ELEMENTS OF CURVES

CURVE NO.	STATION	COORDINATES OF PI.		I	R	T	E	Lc	L	D
		NORTHING	EASTING							
IP0	0+000.000	7,841.533	14,697.858							
IP1	0+011.401	7,830.487	14,695.036	89°31'40"	7.503	7.442	3.065	11.724	10.567	763°36'19"
IP2	0+161.361	7,593.968	14,843.734	22°50'16"	721.250	145.677	14.565	287.486	285.587	07°56'38"
IP3	0+455.147	7,640.997	15,137.649	19°04'31"	578.750	97.240	8.112	192.680	191.792	09°54'00"
IP4	0+627.226	7,610.849	15,308.895							

NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SHOWN.



1 / B-05 ALIGNMENT LAYOUT OF ACCESS ROAD WEST BANK SOUTH SIDE (STA.0+000 TO STA.0+627.226)

SCALE 1:1000

B-05

THE STUDY ON CONSTRUCTION OF THE BRIDGE
OVER THE RIVER RUPSA IN KHULNA (PHASE 2)

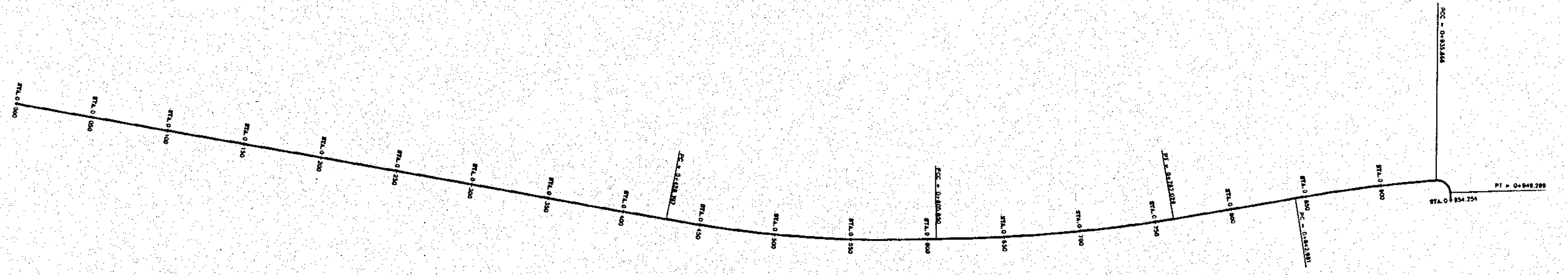
ALIGNMENT LAYOUT OF ACCESS ROAD EAST BANK NORTH SIDE	SCALE	SHEET NO.
	1:1500	B-06

ELEMENTS OF CURVES

CURVE NO.	STATION	COORDINATES OF PI.		I	R	T	E	Lc	L	D
		NORTHING	EASTING							
IP0	0+000	7,551.643	15,890.328							
IP1	0+517.505	7,460.928	16,399.815	12°58'23"	783.727	89.108	5.049	177.453	177.074	07°18'36"
IP2	0+684.106	7,465.122	16,567.102	09°09'41"	976.750	78.256	3.130	156.179	156.012	05°51'57"
IP3	0+889.456	7,499.307	16,769.925	05°12'04"	1023.250	46.474	1.055	92.885	92.853	05°35'58"
IP4	0+994.438	7,503.498	16,824.811	90°28'48"	8.500	8.572	3.571	13.423	12.071	674°04'05"
IP5	0+954.254	7,489.993	16,825.728							

NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SHOWN.



1 B-06 ALIGNMENT OF ACCESS ROAD EAST BANK NORTH SIDE (STA.0+000 TO STA.0+954.254)
SCALE 1:1500

B-06

THE STUDY ON CONSTRUCTION OF THE BRIDGE
OVER THE RIVER RUPSA IN KHULNA (PHASE 2)

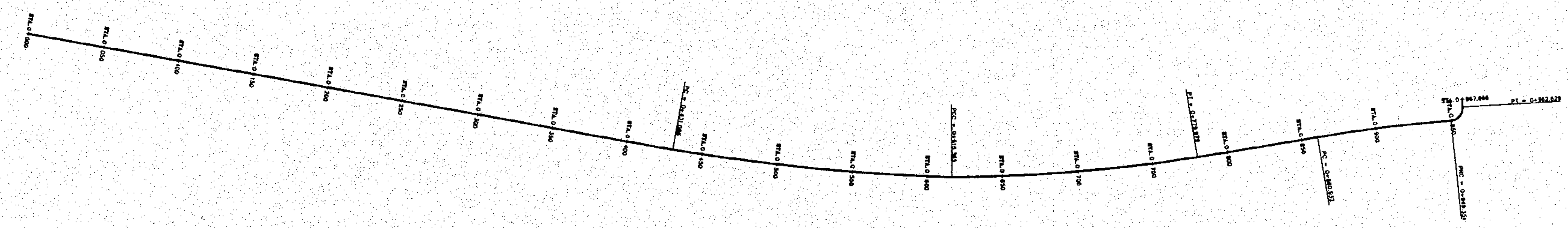
ALIGNMENT LAYOUT OF ACCESS ROAD EAST BANK SOUTH SIDE	SCALE	SHEET NO.
	1:1500	B-07

ELEMENTS OF CURVES

CURVE NO.	STATION	COORDINATES OF PI.		I	R	T	E	Lc	L	D
		NORTHING	EASTING							
IP0	0+000	7,510.253	15,880.312							
IP1	0+523.873	7,420.412	16,396.419	07°55'10"	1340.456	92.788	3.208	185.280	185.132	04°16'28"
IP2	0+698.347	7,418.650	16,571.157	09°09'41"	1023.250	81.982	3.297	163.614	163.440	05°35'56"
IP3	0+905.172	7,453.082	16,775.449	05°11'12"	976.750	44.240	1.001	88.419	88.389	05°51'57"
IP4	0+957.778	7,457.105	16,827.963	89°30'20"	8.500	8.427	3.469	13.278	11.969	674°04'05"
IP5	0+967.666	7,470.538	16,827.050							

NOTES:

1. ALL DIMENSIONS ARE IN METERS
UNLESS OTHERWISE SHOWN.



1
B-07
ALIGNMENT OF ACCESS ROAD EAST BANK SOUTH SIDE (STA.0+000 TO STA.0+967.666)
SCALE 1:1500

B-07

CALCULATION OF ALIGNMENT

(1) SOUTHERN SECTION OF KHULNA BYPASS (1/7)

Sation		Northing	Easting	Remark
1+	000.000	10,000.000	10,000.000	BP
1+	050.000	9,954.463	10,020.649	
1+	100.000	9,908.926	10,041.299	
1+	150.000	9,863.389	10,061.948	
1+	200.000	9,817.852	10,082.597	
1+	250.000	9,772.316	10,103.246	
1+	300.000	9,726.779	10,123.896	
1+	350.000	9,681.242	10,144.545	
1+	400.000	9,635.705	10,165.194	
1+	450.000	9,590.168	10,185.843	
1+	500.000	9,544.631	10,206.493	
1+	550.000	9,499.094	10,227.142	
1+	600.000	9,453.557	10,247.791	
1+	650.000	9,408.021	10,268.441	
1+	700.000	9,362.484	10,289.090	
1+	750.000	9,316.947	10,309.739	
1+	800.000	9,271.410	10,330.388	
1+	850.000	9,225.873	10,351.038	
1+	900.000	9,180.336	10,371.687	
1+	950.000	9,134.799	10,392.336	
2+	000.000	9,089.262	10,412.985	
2+	050.000	9,043.725	10,433.635	
2+	089.816	9,007.464	10,450.078	BC1
2+	100.000	8,998.218	10,454.347	
2+	150.000	8,953.707	10,477.105	
2+	200.000	8,910.812	10,502.777	
2+	250.000	8,869.722	10,531.250	
2+	300.000	8,830.621	10,562.397	
2+	350.000	8,793.681	10,596.079	
2+	387.680	8,767.371	10,623.048	SP1
2+	437.680	8,759.067	10,632.148	
2+	487.680	8,726.932	10,670.443	
2+	537.680	8,697.421	10,710.793	
2+	587.680	8,670.662	10,753.019	
2+	637.680	8,646.776	10,796.934	
2+	687.680	8,625.869	10,842.343	

CALCULATION OF ALIGNMENT

(1) SOUTHERN SECTION OF KHULNA BYPASS (2/7)

Sation		Northing	Easting	Remark
2+	685.543	8,612.870	10,875.420	EC1
2+	700.000	8,607.902	10,888.997	
2+	750.000	8,590.722	10,935.952	
2+	800.000	8,573.541	10,982.908	
2+	850.000	8,556.360	11,029.863	
2+	900.000	8,539.179	11,076.819	
2+	950.000	8,521.999	11,123.774	
3+	000.000	8,504.818	11,170.730	
3+	050.000	8,487.637	11,217.685	
3+	100.000	8,470.456	11,264.641	
3+	150.000	8,453.276	11,311.596	
3+	200.000	8,436.095	11,358.552	
3+	250.000	8,418.914	11,405.508	
3+	300.000	8,401.733	11,452.463	
3+	350.000	8,384.553	11,499.419	
3+	400.000	8,367.372	11,546.374	
3+	450.000	8,350.191	11,593.330	
3+	500.000	8,333.011	11,640.285	
3+	550.000	8,315.830	11,687.241	
3+	600.000	8,298.649	11,734.196	
3+	605.131	8,296.886	11,739.015	BC2
3+	650.000	8,281.784	11,781.266	
3+	700.000	8,265.702	11,828.608	
3+	750.000	8,250.410	11,876.212	
3+	703.481	8,249.375	11,879.536	SP2
3+	800.000	8,235.915	11,924.064	
3+	850.000	8,222.219	11,972.151	
3+	900.000	8,209.326	12,020.459	
3+	851.832	8,208.869	12,022.233	EC2
3+	950.000	8,196.865	12,068.882	
4+	000.000	8,184.404	12,117.304	
4+	050.000	8,171.944	12,165.727	
4+	100.000	8,159.483	12,214.149	
4+	150.000	8,147.023	12,262.572	
4+	200.000	8,134.563	12,310.994	
4+	250.000	8,122.102	12,359.417	

CALCULATION OF ALIGNMENT

(1) SOUTHERN SECTION OF KHULNA BYPASS (3/7)

Sation	Northing	Easting	Remark
4+ 300.000	8,109.642	12,407.839	
4+ 350.000	8,097.181	12,456.262	
4+ 400.000	8,084.721	12,504.684	
4+ 450.000	8,072.261	12,553.107	
4+ 500.000	8,059.800	12,601.529	
4+ 550.000	8,047.340	12,649.952	
4+ 600.000	8,034.879	12,698.374	
4+ 650.000	8,022.419	12,746.797	
4+ 700.000	8,009.958	12,795.219	
4+ 750.000	7,997.498	12,843.642	
4+ 800.000	7,985.038	12,892.064	
4+ 850.000	7,972.577	12,940.487	
4+ 900.000	7,960.117	12,988.909	
4+ 950.000	7,947.656	13,037.332	
5+ 000.000	7,935.196	13,085.754	
5+ 050.000	7,922.736	13,134.177	
5+ 100.000	7,910.275	13,182.599	
5+ 150.000	7,897.815	13,231.022	
5+ 200.000	7,885.354	13,279.444	
5+ 250.000	7,872.894	13,327.867	
5+ 300.000	7,860.433	13,376.289	
5+ 350.000	7,847.973	13,424.712	
5+ 400.000	7,835.513	13,473.134	
5+ 450.000	7,823.052	13,521.557	
5+ 500.000	7,810.592	13,569.979	
5+ 550.000	7,798.131	13,618.402	
5+ 600.000	7,785.671	13,666.824	
5+ 628.727	7,778.512	13,694.645	BC3
5+ 650.000	7,773.393	13,715.292	
5+ 700.000	7,762.810	13,764.156	
5+ 750.000	7,754.271	13,813.418	
5+ 788.694	7,749.075	13,851.760	SP3
5+ 800.000	7,747.791	13,862.992	
5+ 850.000	7,743.382	13,912.794	
5+ 900.000	7,741.051	13,962.736	
5+ 948.661	7,740.782	14,011.393	EC3

CALCULATION OF ALIGNMENT
(1) SOUTHERN SECTION OF KHULNA BYPASS (4/7)

Sation		Northing	Easting	Remark
5+	950.000	7,740.802	14,012.732	
6+	000.000	7,741.539	14,062.726	
6+	050.000	7,742.277	14,112.721	
6+	100.000	7,743.014	14,162.715	
6+	150.000	7,743.752	14,212.710	
6+	180.920	7,744.208	14,243.627	BC4
6+	200.000	7,744.307	14,262.706	
6+	250.000	7,742.841	14,312.679	
6+	300.000	7,738.879	14,362.517	
6+	350.000	7,732.431	14,412.094	
6+	368.246	7,729.462	14,430.096	SP4
6+	400.000	7,723.513	14,461.287	
6+	450.000	7,712.148	14,509.973	
6+	500.000	7,698.364	14,558.030	
6+	550.000	7,682.195	14,605.338	
6+	555.572	7,680.247	14,610.558	EC4
6+	573.243	7,674.024	14,627.097	BC5
6+	600.000	7,665.081	14,652.314	
6+	650.000	7,650.980	14,700.273	
6+	700.000	7,640.338	14,749.117	
6+	750.000	7,633.208	14,798.595	
6+	754.741	7,632.716	14,803.311	SP5
6+	800.000	7,629.628	14,848.456	
6+	850.000	7,629.616	14,898.445	
6+	900.000	7,633.171	14,948.308	
6+	936.240	7,637.968	14,984.225	EC5
6+	950.000	7,640.142	14,997.812	
6+	990.976	7,646.616	15,038.274	BC6
7+	000.000	7,647.975	15,047.195	
7+	050.000	7,653.062	15,096.921	
7+	090.854	7,654.134	15,137.752	SP6
7+	100.000	7,653.993	15,146.897	
7+	150.000	7,650.761	15,196.778	
7+	190.731	7,645.065	15,237.102	EC6
7+	200.000	7,643.458	15,246.230	
7+	250.000	7,634.789	15,295.473	

CALCULATION OF ALIGNMENT

(1) SOUTHERN SECTION OF KHULNA BYPASS (5/7)

Sation	Northing	Easting	Remark
7+ 300.000	7,626.120	15,344.715	
7+ 350.000	7,617.451	15,393.958	
7+ 400.000	7,608.782	15,443.201	
7+ 450.000	7,600.113	15,492.444	
7+ 500.000	7,591.444	15,541.686	
7+ 550.000	7,582.775	15,590.929	
7+ 600.000	7,574.106	15,640.172	
7+ 650.000	7,565.437	15,689.415	
7+ 700.000	7,556.768	15,738.657	
7+ 750.000	7,548.099	15,787.900	
7+ 800.000	7,539.430	15,837.143	
7+ 850.000	7,530.761	15,886.385	
7+ 900.000	7,522.092	15,935.628	
7+ 950.000	7,513.423	15,984.871	
8+ 000.000	7,504.754	16,034.114	
8+ 050.000	7,496.085	16,083.356	
8+ 100.000	7,487.416	16,132.599	
8+ 150.000	7,478.747	16,181.842	
8+ 200.000	7,470.077	16,231.085	
8+ 250.000	7,461.408	16,280.327	
8+ 278.659	7,456.439	16,308.553	BC7
8+ 300.000	7,452.964	16,329.608	
8+ 350.000	7,446.586	16,379.194	
8+ 400.000	7,442.694	16,429.037	
8+ 449.278	7,441.301	16,478.291	SP7
8+ 450.000	7,441.299	16,479.013	
8+ 500.000	7,442.402	16,528.995	
8+ 550.000	7,446.003	16,578.860	
8+ 600.000	7,452.091	16,628.483	
8+ 619.896	7,455.202	16,648.134	EC7
8+ 650.000	7,460.206	16,677.819	
8+ 700.000	7,468.516	16,727.124	
8+ 700.849	7,468.657	16,727.961	BC8
8+ 750.000	7,475.631	16,776.610	
8+ 800.000	7,480.266	16,826.389	
8+ 833.437	7,481.974	16,859.781	SP8

CALCULATION OF ALIGNMENT
(1) SOUTHERN SECTION OF KHULNA BYPASS (6/7)

Sation		Northing	Easting	Remark
8+	850.000	7,482.406	16,876.338	
8+	900.000	7,482.047	16,926.332	
8+	950.000	7,479.190	16,976.245	
8+	966.026	7,477.747	16,992.205	EC8
9+	000.000	7,474.416	17,026.016	
9+	050.000	7,469.514	17,075.775	
9+	100.000	7,464.612	17,125.534	
9+	150.000	7,459.709	17,175.293	
9+	200.000	7,454.807	17,225.052	
9+	250.000	7,449.905	17,274.811	
9+	278.344	7,447.126	17,303.019	BC9
9+	300.000	7,444.847	17,324.554	
9+	350.000	7,438.400	17,374.135	
9+	400.000	7,430.305	17,423.473	
9+	450.000	7,420.569	17,472.513	
9+	500.000	7,409.205	17,521.202	
9+	536.993	7,399.755	17,556.967	SP9
9+	550.000	7,396.224	17,569.485	
9+	600.000	7,381.641	17,617.309	
9+	650.000	7,365.472	17,664.620	
9+	700.000	7,347.736	17,711.366	
9+	750.000	7,328.452	17,757.495	
9+	795.641	7,309.515	17,799.021	EC9
9+	800.000	7,307.646	17,802.959	
9+	850.000	7,286.211	17,848.131	
9+	862.512	7,280.847	17,859.435	BC10
9+	900.000	7,265.200	17,893.500	
9+	950.000	7,245.665	17,939.524	
10+	000.000	7,227.675	17,986.173	
10+	050.000	7,211.250	18,033.395	
10+	100.000	7,196.407	18,081.139	
10+	150.000	7,183.164	18,129.351	
10+	200.000	7,171.535	18,177.977	
10+	201.768	7,171.154	18,179.704	SP10
10+	250.000	7,161.533	18,226.964	
10+	300.000	7,153.169	18,276.257	

CALCULATION OF ALIGNMENT

(1) SOUTHERN SECTION OF KHULNA BYPASS (7/7)

Sation	Northing	Easting	Remark
10+ 350.000	7,146.453	18,325.802	
10+ 400.000	7,141.391	18,375.543	
10+ 450.000	7,137.990	18,425.425	
10+ 500.000	7,136.254	18,475.392	
10+ 541.024	7,136.073	18,516.415	EC10
10+ 550.000	7,136.157	18,525.390	
10+ 600.000	7,136.620	18,575.388	
10+ 650.000	7,137.084	18,625.386	
10+ 700.000	7,137.548	18,675.384	
10+ 750.000	7,138.012	18,725.381	
10+ 800.000	7,138.475	18,775.379	
10+ 850.000	7,138.939	18,825.377	
10+ 900.000	7,139.403	18,875.375	
10+ 950.000	7,139.867	18,925.373	
11+ 000.000	7,140.330	18,975.371	
11+ 038.663	7,140.689	19,014.032	EP

COORDINATE OF IP

(1) SOUTHERN SECTION OF KHULNA BYPASS

IP No.	Northing	Easting	Remark
BP	10,000.000	10,000.000	
IP-1	8,720.964	10,579.995	
IP-2	8,245.869	11,878.446	
IP-3	7,738.409	13,850.489	
IP-4	7,747.003	14,433.154	
IP-5	7,608.631	14,800.879	
IP-6	7,662.544	15,137.818	
IP-7	7,426.567	16,478.237	
IP-8	7,490.823	16,859.477	
IP-9	7,421.513	17,563.003	
IP-10	7,132.872	18,171.268	
EP	7,140.689	19,014.032	

CALCULATION OF ALIGNMENT

(2) WEST ACCESS ROAD NORTH SIDE

Station	Northing	Easting	Tangential Direction
0 + 0	7,660.426	14,702.688	N 14-20-18 E
0 + 50	7,662.487	14,746.213	S 79-11-03 E
0 + 100	7,654.920	14,795.626	S 83-24-14 E
0 + 150	7,651.010	14,845.461	S 87-37-24 E
0 + 200	7,650.777	14,895.449	N 88-09-26 E
0 + 250	7,654.223	14,945.319	N 83-56-15 E
0 + 300	7,661.184	14,994.824	N 80-54-33 E
0 + 350	7,669.014	15,044.207	N 81-46-34 E
0 + 400	7,674.168	15,093.927	N 86-23-14 E
0 + 450	7,675.308	15,143.901	S 89-00-05 E
0 + 500	7,672.427	15,193.804	S 84-23-24 E
0 + 550	7,665.548	15,243.315	S 80-00-56 E
0 + 600	7,656.879	15,292.558	S 80-00-56 E

CALCULATION OF ALIGNMENT

(3) WEST ACCESS ROAD SOUTH SIDE

Station	Northing	Easting	Tangential Direction
0 + 0	7,641.534	14,697.859	S 14-20-18 W
0 + 50	7,621.227	14,735.745	S 78-58-44 E
0 + 100	7,613.377	14,785.115	S 82-57-04 E
0 + 150	7,608.965	14,834.910	S 86-55-23 E
0 + 200	7,608.013	14,884.891	N 89-06-18 E
0 + 250	7,610.526	14,934.818	N 85-07-59 E
0 + 300	7,616.491	14,984.451	N 81-09-40 E
0 + 350	7,624.384	15,033.824	N 80-54-33 E
0 + 400	7,630.767	15,083.401	N 85-04-35 E
0 + 450	7,632.903	15,133.340	S 89-58-25 E
0 + 500	7,630.721	15,183.276	S 85-01-25 E
0 + 550	7,624.239	15,232.839	S 80-04-25 E
0 + 600	7,615.570	15,282.082	S 80-00-56 E

CALCULATION OF ALIGNMENT

(4) EAST ACCESS ROAD NORTH SIDE

Station	Northing	Easting	Tangential Direction
0 + 0	7,551.644	15,890.328	S 80-00-56 E
0 + 50	7,542.974	15,939.571	S 80-00-56 E
0 + 100	7,534.305	15,988.814	S 80-00-56 E
0 + 150	7,525.636	16,038.057	S 80-00-56 E
0 + 200	7,516.967	16,087.299	S 80-00-56 E
0 + 250	7,508.298	16,136.542	S 80-00-56 E
0 + 300	7,499.629	16,185.785	S 80-00-56 E
0 + 350	7,490.960	16,235.028	S 80-00-56 E
0 + 400	7,482.291	16,284.270	S 80-00-56 E
0 + 450	7,473.675	16,333.522	S 80-56-52 E
0 + 500	7,467.388	16,383.116	S 84-36-12 E
0 + 550	7,464.276	16,433.011	S 88-15-31 E
0 + 600	7,464.352	16,483.002	N 88-05-10 E
0 + 650	7,465.879	16,532.975	N 87-00-16 E
0 + 700	7,469.768	16,582.818	N 84-04-18 E
0 + 750	7,476.203	16,632.397	N 81-08-19 E
0 + 800	7,484.440	16,681.713	N 80-25-59 E
0 + 850	7,492.726	16,731.022	N 80-49-34 E
0 + 900	7,499.489	16,780.557	N 83-37-33 E
0 + 950	7,494.237	16,825.440	S 03-53-10 E

CALCULATION OF ALIGNMENT

(5) EAST ACCESS ROAD SOUTH SIDE

Station	Northing	Easting	Tangential Direction
0 + 0	7,510.253	15,880.312	S 80-00-56 E
0 + 50	7,501.584	15,929.555	S 80-00-56 E
0 + 100	7,492.915	15,978.797	S 80-00-56 E
0 + 150	7,484.246	16,028.040	S 80-00-56 E
0 + 200	7,475.577	16,077.283	S 80-00-56 E
0 + 250	7,466.908	16,126.526	S 80-00-56 E
0 + 300	7,458.239	16,175.768	S 80-00-56 E
0 + 350	7,449.570	16,225.011	S 80-00-56 E
0 + 400	7,440.901	16,274.254	S 80-00-56 E
0 + 450	7,432.565	16,323.552	S 81-26-34 E
0 + 500	7,426.049	16,373.123	S 83-34-48 E
0 + 550	7,421.386	16,422.902	S 85-43-02 E
0 + 600	7,418.583	16,472.820	S 87-51-16 E
0 + 650	7,418.861	16,522.801	N 87-42-40 E
0 + 700	7,422.077	16,572.693	N 84-54-41 E
0 + 750	7,427.727	16,622.368	N 82-06-42 E
0 + 800	7,435.603	16,671.741	N 80-25-59 E
0 + 850	7,443.913	16,721.045	N 80-25-59 E
0 + 900	7,451.451	16,770.470	N 82-43-29 E
0 + 950	7,456.536	16,820.205	N 81-14-38 E

3.3 Toll Gate

2.3.1 Required Number of Lanes

1) Design Conditions

(1) Type of Toll Gate

The toll gate is set on SSKB because a toll is imposed only on Rupsa Bridge.

(2) Toll Levying System

The flat tariff system is adopted because a toll is imposed only on Rupsa Bridge.

2) Analysis

(1) Daily Traffic Volume

Daily traffic volume by type of vehicle in 2015 was 11,094 as shown Table 1.

Table 1 Daily Traffic Volume

Unit: Vehcle/Day

Year	M.cycle	A.rickshaw	Car	Bus	Truck	Total
2005	664	1,409	627	2,060	1,484	6,243
2006	701	1,486	661	2,173	1,585	6,606
2007	739	1,568	697	2,293	1,693	6,990
2008	780	1,654	736	2,419	1,808	7,396
2009	823	1,745	776	2,551	1,931	7,827
2010	868	1,841	819	2,692	2,062	8,282
2011	920	1,951	868	2,845	2,186	8,779
2012	976	2,069	920	3,025	2,317	9,306
2013	1,034	2,193	975	3,206	2,456	9,864
2014	1,096	2,324	1,034	3,399	2,603	10,456
2015	1,163	2,466	1,097	3,606	2,762	11,094

(2) Design Traffic Volume

K-Value is 8.0 %

D-Value is 50.0 %

Then,

DHV = ADT x K x D

= 11,094 x 0.08 x 0.50

= 444

(3) Service Time

The service time is set 8 seconds because a toll gate is the flat tariff system.

(4) Service Level

The service level (average waiting vehicle) is 1 vehicle.

Table 2 Relations Number of Lanes, Service Time, Average Waiting Vehicle and Capacity

Service Time / Average Waiting / Lanes	8 sec.	
	1.0	3.0
1	230	340
2	640	780
3	1,070	1,230
4	1,500	1,670
5	1,940	2,120
6	2,380	2,570
7	2,830	3,020
8	3,270	3,470
9	3,720	3,920
10	4,170	4,370

3) Determination of Number of Lanes at a Toll Plaza

Number of booths to be provided at a toll plaza for the year 2015 is determined from traffic volume (interval of arrival), service time per vehicle and service level provided (planned length of queue).

Two (2) lanes are required based on the basic hourly traffic volume (444 veh./hr), the service time per vehicle (8 second) and the service level (1 veh./lane), and additional one lane at the center is provided as reversible lane for high peak hours because commuter traffic might increase beyond forecast.

3.4 Pavement Design

3.4.1 Southern Section of Khulna Bypass

1. Background

It was confirmed by the Interim Report for the Study that the Southern Section of Khulna Bypass (SSKB) is planned to have a flexible pavement in all the stretch except a toll plaza where a rigid pavement is planned due to high resistance against rutting and oil leakage. Accordingly, this working paper is prepared to show the justification of pavement structure as well as to reveal formulation and parameters used for computation.

2. Characteristics of Pavement, Flexible and Rigid

	Flexible Pavement	Rigid pavement
Target Design Performance Period	15 years extendible by stage overlay or projected rehabilitation works	20 years
Transformation-proof Wear-proof	Compared with rigid pavement, slight transformation proof and wear proof causing rutting.	Seldom rutting and more proof.
Noise and Vibration	Little noise and small vibration.	Joints and grooves cause vibration and noise.
Brightness of Road Surface	Weak reflection from road surface.	Brighter than flexible pavement in the dark.
Construction Aspects	Short construction period enabling early opening to traffic.	1. Generally, the composition of construction machinery is a longer line than that of flexible pavement and it causes a longer construction period than that of flexible pavement. 2. The curing period and /or construction of joints may cause delay in opening to traffic.

Maintenance Works	Easy maintenance work by simple maintenance methods.	Maintenance is seldom necessary except when placed on soft ground areas where subgrade or subbase is damaged by consolidation or sliding, and it may yield large-scale maintenance.
Construction Cost and Maintenance Cost	Initially cheaper construction cost but costly periodic maintenance. Costs over 20 years period may result in the same level as that of rigid pavement.	Initially higher construction cost but usually little maintenance. It may be liable to huge reconstruction cost as pointed out above.

3. Pavement Design

3.1 Design Approach

The pavement design procedure prevailing in Japan "Manual for Asphalt Pavement 1989", which includes the structure design method for rigid pavement, is applied to the study from following technical viewpoints;

1) It will accommodate considerable road traffic comprising heavy vehicles of large buses and trucks including 40 ft. container truck in future;
2) Loading conditions of heavy vehicles and their axle load distribution are deemed equivalent; and
3) Natural conditions such as high ground water level and annual rainfall are similar.

However, the proposed pavement structures are examined by design procedures presented in "AASHTO Guide for Design of Pavement Structures 1993".

3.2 Design Procedure

3.2.1 Classification of Roadway by Traffic Flow Volume

A pavement standard should be determined from five classifications as shown in Table 3.1 on the basis of the estimation of one-way daily traffic volume of heavy vehicles in the fifth year of operation. Heavy vehicles denote cargo trucks, buses, construction machines and special large-size motor vehicles.

Table 3.1 Road Classification by Traffic Volume

Classification	One-Way Daily Traffic Volume Of Heavy Vehicles
L	100 or less
A	101 to 250
B	251 to 1,000
C	1,001 to 3,000
D	more than 3,000

Forecasted traffic volume of the SSKB at the highest section is as shown in Table 3.2, and the estimation of one-way daily traffic volume of heavy vehicles in the fifth year of operation is 2,377 veh./day. Thus, the road classification of the SSKB is determined as "C".

Table 3.2 Forecasted Traffic Volume

Unit: Vehicles/day

Year	M.cycle	A.rickshaw	Car	Bus	Truck	Total	Bus/Truck Total
2005	664	1,409	627	2,060	1,484	6,243	3,544
2006	701	1,486	661	2,173	1,585	6,606	3,758
2007	739	1,568	697	2,293	1,693	6,990	3,985
2008	780	1,654	736	2,419	1,808	7,396	4,226
2009	823	1,745	776	2,552	1,931	7,827	4,482
2010	868	1,841	819	2,692	2,062	8,282	4,754
2011	920	1,951	868	2,854	2,186	8,779	5,039
2012	976	2,069	920	3,025	2,317	9,306	5,342
2013	1,034	2,193	975	3,206	2,456	9,864	5,662
2014	1,096	2,324	1,034	3,399	2,603	10,456	6,002
2015	1,163	2,466	1,097	3,606	2,762	11,094	6,368

3.2.2 Design CBR Value

(1) Preliminary Investigation and CBR Value

The design CBR value should be determined by sampling subgrade soils to design the thickness of the pavement.

The embankment structure of the SSKB comprises Lower Roadbed, Upper Roadbed and Improved Subgrade, and a subgrade refers to the soil about one (1) meter under the pavement. The lower roadbed will be built by side borrow materials of which CBR value may remain in a range of 2 by a normal compaction method, while the upper roadbed will be also built by the same materials but the CBR value will be increased up to 2 – 4 by a special compaction method. 30cm thick improved subgrade will be constructed by improved soils mixed side borrow materials and imported fill materials such as dredged sand, and the CBR value normally is expected more than 10.

(2) Determination of Design CBR Value

The average CBR value of the soils within 1m depth from the subgrade level should taken as the CBR value. The average CBR value is calculated according to the following formula:

$$CBR_m = \left(\frac{h_1 * CBR_1^{1/3} + h_2 * CBR_2^{1/3} \cdots\cdots + h_n * CBR_n^{1/3}}{100} \right)^3$$

where:

CBR_m : average CBR value

CBR_1, CBR_2 ...CBR_n : CBR value of soil layers No. 1, 2 ...n

h_1, h_2 .... h_n : thickness of soil layers No. 1, 2....n (cm)

$h_1 + h_2 \ldots + h_n = 100$cm

Using the formula and applying h_1 = 70cm CBR_1 = 3, h_2 = 30cm CBR_2 = 10, the design CBR value is calculated 4.

(3) Design of Pavement Thickness

Using the design CBR value and the road classification, the pavement thickness of each layer is designed so that the desirable T_A value is assured, and the total thickness H should be larger than 80% of the target value in Table 3.3.

Table 3.3 Target Value for T_A and Total Thickness H

Design CBR	Target Value (cm)									
	L Traffic		A Traffic		B Traffic		C Traffic		D Traffic	
	T_A	H	T_A	H	T_A	H	T_A	H	T_A	H
2	17	52	21	61	29	74	39	90	51	105
3	15	41	19	48	26	58	35	70	45	90
4	14	35	18	41	24	49	32	59	41	70
6	12	27	16	32	21	38	28	47	37	55
8	11	23	14	27	19	32	26	39	34	46
12	-	-	13	21	17	26	23	31	30	36
20	-	-	-	-	-	-	20	23	26	27

(4) Determination of Pavement Structure

The following equations are used to determine a pavement structure.

$$T_A = a_1 * T_1 + a_2 * T_2 + \cdots + a_n * T_n$$

$$H = T_1 + T_2 + \cdots + T_n$$

where :

$a_1, a_2, \cdots a_n$: Conversion coefficient shown in Table 3.4 for reference.

$T_1, T_2 \cdots T_n$: Thickness of each layer (cm)

Table 3.4 additionally contains conversion coefficients for local materials commonly used in Bangladesh, which is referred to "Fig. 2.7 Various in Granular Subbase Layer Coefficient" contained in the AASHTO.

The minimum combined thickness of binder and surface courses excluding wearing course is specified in Table 3.5.

Table 3.5 Minimum Combined Thickness of Binder and Surface Courses

Road Classification	Minimum Combined Thickness (cm)
L, A	5
B	10 (5)
C	15 (10)
D	20 (15)

Note: Figures in parentheses indicate the minimum thickness applicable to pavement with a base course using the bituminous stabilization.

A final structure may be determined if it satisfy the required values shown in Tables 3.3 and 3.5.

Table 3.4 (1) Conversion Coefficient for TA

Course	ethod and Mateerial of Constructio	Conditions	Coefficient a_n	
			per inch	per cm
Surface & Binder	Plant mixed dense asphalt concrete		0.44	1.00
Base	Bituminous stabilization	Stability: 350kgf or more	0.34	0.85
		Stability: 250kgf or more	0.22	0.55
	Cement stabilization	UC strength (7days): 30kgf/sq.cm or m	0.22	0.55
	Lime stabilization	UC strength (10days): 10kgf/sq.cm or	0.18	0.45
	Crushed stone for mechanical stabili	Modified CBR: 80 or more	0.14	0.35
	Slag for mechanical stabilization	Modified CBR: 80 or more	0.22	0.55
	Hydraukic slag	UC strength (14days): 12kgf/sq.cm or	0.22	0.55
Subbase	Crusheer-run, slag, sand, etc.	Modified CBR: 30 or more	0.10	0.25
		Modified CBR: 20 - 30	0.08	0.20
	Cement stabilization	UC strength (7days): 10kgf/sq.cm or m	0.10	0.25
	Lime stabilization	UC strength (10days): 7kgf/sq.cm or m	0.10	0.25

Table 3.4 (2) Conversion Coefficient for TA

Description of Material	Soaked CBR	Coefficient a_n	
		per inch	per cm
Hand crushed bricks (with 0 to 20% local sand)	60	0.12	0.30
Well graded plant crushed bricks (0/37.5 mm)	150	0.14	0.35
Hand/Plant crushed bricks with 30%-50% local	30	0.11	0.28
Mixture of crushed boulders (30%), shingles(30%), pea-gravel (20%), sand (20%)	100~60	0.14	0.35
Mixture of Coarse (Sylhet)sand (40%) and local sand (60%)	30	0.11	0.28
Hand crushed boulder (60%), pea-gravel (20%), sand (20%)	80	0.13	0.33
Well graded plandt crushed boulders (0/37.5 m	150	0.14	0.35
Hand/ Plant crushed boulders with 50% local sa	30	0.11	0.28
Soil stabilized with lime	45~60	0.12	0.30
Sand/clay mixture mechanically stabilized	15	0.09	0.23
Local river sand and sandy silt	15	0.09	0.23

(5) Recommended Pavement Structure

The pavement structure is proposed as follows.

Surface & Binder Course: Plant-mixed Asphalt Concrete	10cm
Upper Base Course: Asphalt Treated Base (ATB)	10cm
Lower Base Course: Hand crushed bricks (with 0 to 20% local sand)	20cm
Subbase Course: Sand/clay mixture mechanically stabilized	35cm

The proposed pavement structure has the design factors of T_A = 32.6 cm and H = 75cm to satisfy fully the required values.

4. Proposed Pavement Structure Examined by the AASHTO

(1) Cumulative 18-kip Equivalent Single Axle Loads (ESAL): W_{18}

$$W_{18} = D_D * D_L * w_{18} = 0.56 * 10^6 * \{(1+0.09)^t - 1\}/0.09$$

where:

- D_D : A directional distribution factor, expressed as a ratio, that it accounts for the distribution of ESAL units by direction.
- D_L : A lane distribution factor, expressed as a ratio, that it accounts for distribution of traffic if two lanes or more are available in one direction.
- w_{18} : The cumulative two-directional 18-kip ESAL units predicted for a specific section of highway during the analysis period
- t : time (years)

(2) Precedent Design Parameters

1) Estimated 10-year Total 18-kip Equivalent Single Axle Load Applications W18 : 8.5 million units
2) Reliability (initial pavement plus one overlay): 95%
3) Standard Normal Deviate Value Z_R = -1.645
4) Overall Standard Deviation S_O = 0.35
5) Effective Roadbed Resilient Modulus M_R = 5,000 psi
6) Design serviceability Loss Δ PSI = 2.1

(3) Design Total Structure Number (SN)

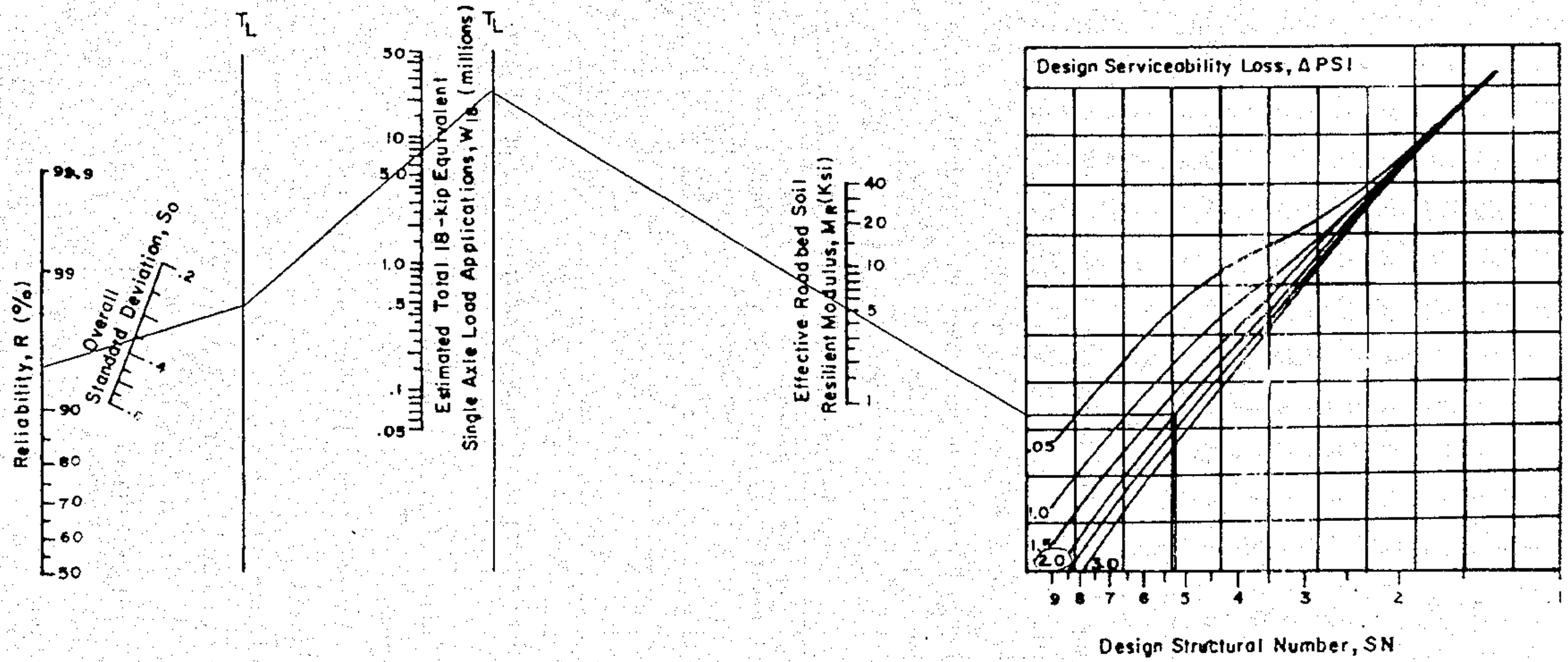
Using Fig. 4.1 with above input parameters, Design Total Structure Number (SN) is determined to be 5.21.

(4) Conclusion

The proposed pavement structure has T_A = 32.6 cm equivalent to SN = 5.26, and it is warranted even if the AASHTO design procedure is applied.

NOMOGRAPH SOLVES:

$$\log_{10} W_{18} = Z_R^* S_0 + 9.36 * \log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left[\frac{\Delta PSI}{4.2-1.5}\right]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32 * \log_{10} M_R - 8.07$$



THE STUDY ON CONSTRUCTION OF THE BRIDGE OVER THE RIVER RUPSA IN KHULNA (Phase-2)

Fig. 4.1 Design Chart for flexible pavement based on using mean values for each input

5. Initial Performance Period

1) Condition

Initial SN = 5.21, Maximum Possible Performance Period = 10 years, PI = 50%, Swell Probability Ps = 100 %, Swell Rate Constants ϕ = 0.14.

2) Potential Vertical Rise; V_R

Using Fig. 5.1 with input parameter PI = 50%, the Potential Vertical Rise; V_R was determined as 0.83 inches.

1) Iteration to determine the Initial Performance Period

Three Trial Performance Priods were set as 7, 8.5 and 9 years. And, using Fig. 5.2 with input parameter t, ϕ and V_R, each ΔPSI_{swall} was determined.

Using Fig. 4.1 with input parameter above data, The Initial Performance Period was determined as below.

Table 5.1 Reduction in Performance Period (Service Life) Arising Swelling Consideration

Iteration No.	Trial Performance Priod (years)	Serviceability Loss Due to Swelling ΔPSI_{swall}	Corresponding Serviceability Loss Due to Traffic ΔPSI_{tr}	Allowable Cumulative Traffic (18-Kip ESAL)	Corresponding Performance Period (years)
1	7	0.1737	1.9263	7.18×10^6	8.9
2	8.5	0.1935	1.9065	7.03×10^6	8.8
3	9	0.1992	1.9008	6.98×10^6	8.7

The Initial Performance Period was determined to be 8.5 years.

6. Development of Overlay Design

1) Conditions

Traffic between 7 years to 14 years =9.41×10^6 ESAL

Reliability = 0.95

Standard Normal Deviate, Z_R = -1.645

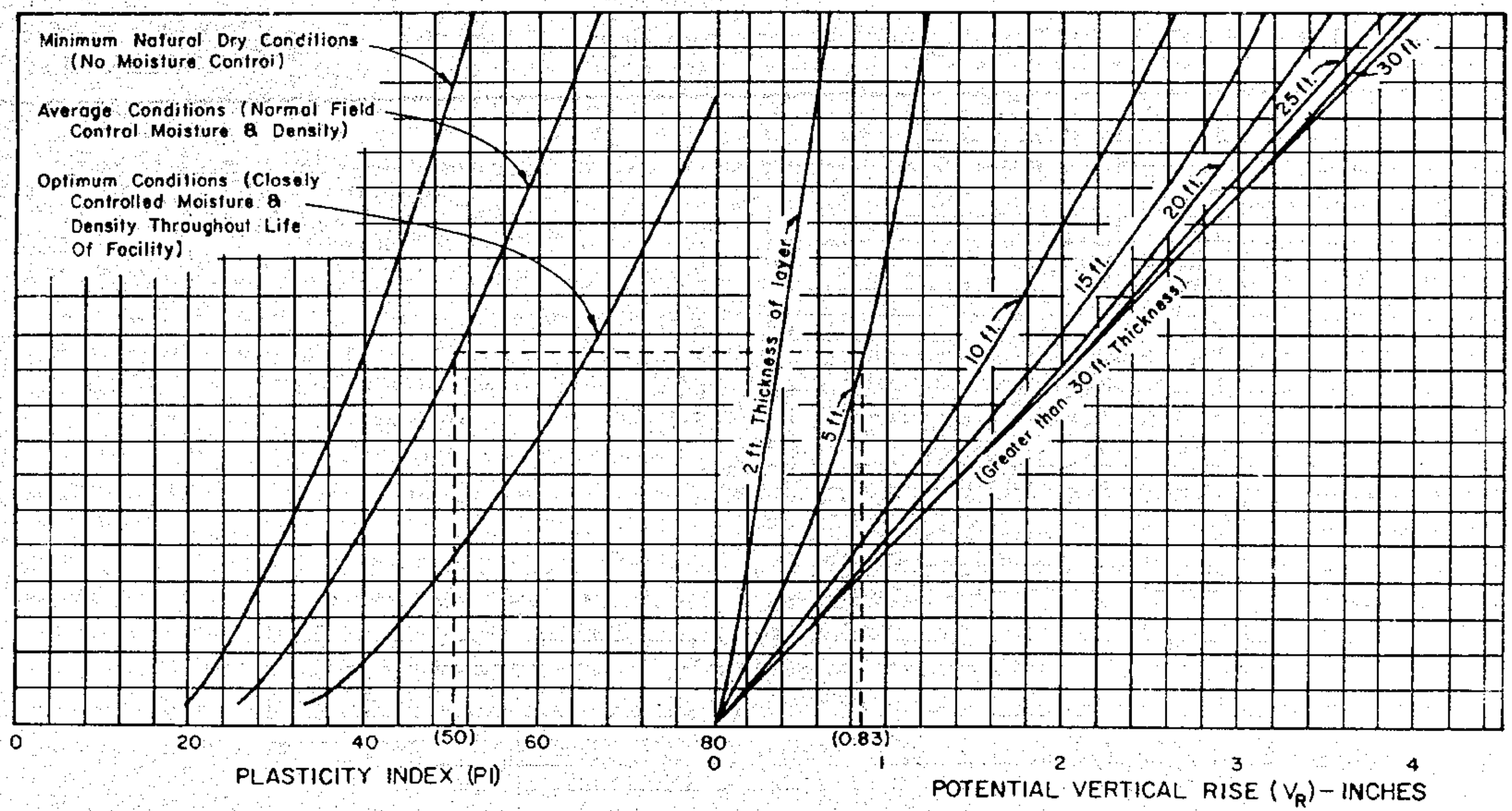
Overall Standard Deviation, S_o = 0.35

Roadbed Resilient Modulus, M_R = 5,000 psi

Serviceability Loss due to Traffic, ΔPSI_{tr} = 2.035

2) Equation

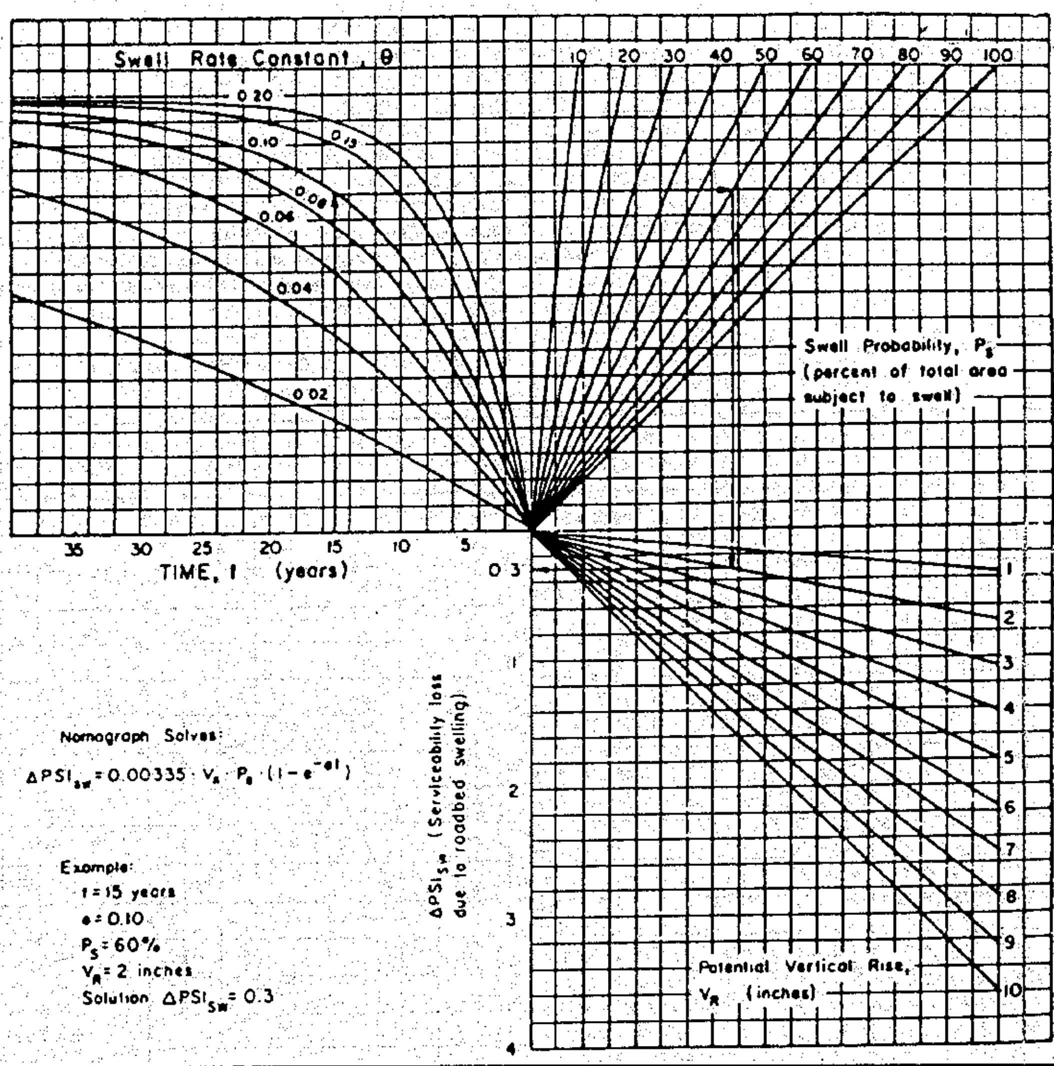
$$D_{ol} = SN_{ol} / a_{ol} = (SN_f - SN_{eff}) / a_{ol} = (SN_f - CF \times SN_0) / a_{ol}$$



NOTES:
1. This figure is predicated upon the following assumptions:
   a. The subgrade soils for the thickness shown all are passing the No. 40 mesh sieve.
   b. The subgrade soil has a uniform moisture content and plasticity index throughout the layer thickness for the conditions shown.
   c. A surcharge pressure from 20 inches of overburden (± 10 inches will have no material effect).
2. Calculations are required to determine V_R for other surcharge pressures.

THE STUDY ON CONSTRUCTION OF THE BRIDGE OVER THE RIVER RUPSA IN KHULNA (Phase-2)

Fig. 5.1 Chart for Estimating the Approximate Potential Vertical Rise of Natural Soils



THE STUDY ON CONSTRUCTION OF THE BRIDGE OVER THE RIVER RUPSA IN KHULNA (Phase-2)

Fig. 5.2 Chart for Estimating Serviceability Loss Due to Roadbed Swelling

Where:

D_{ol} = Required overlay thickness, inches
SN_{ol} = Required overlay structual number
a_{ol} = Structural coefficient for the AC overlay
SN_f = Structural number for future traffic
SN_{eff} = Effective structural number of the existing pavement
CF = Condition Factor
SN_0 = Structural number of the pavement if it were newly constructed.

3) Determination of SN_f

Using Fig. 6.1 with input parameter described in 1) above, SN_f is determined to be 5.33.

4) Determination of CF

Using below equation with input parameter $N_p = 6.7 \times 10^6$ and $N_{1.5} = 16.0 \times 10^6$, the Remaining Life; RL was determined as 58 %.

$RL = 100 \times (1 - N_p / N_{1.5})$

Where:

RL = Remaining life, percent
N_p = Total traffic to date, ESALs
$N_{1.5}$ = Total traffic to pavement "failure", ESALs

Using Fig. 6.2 with input parameter RL = 58 %, the Condition Factor; CF was determined as 0.91.

5) Determination of SN_{eff}

The Effective structural number; SN_{eff} is calculated using CF and SN_0 to be 4.74.

6) Determination of Required Overlay Thickness

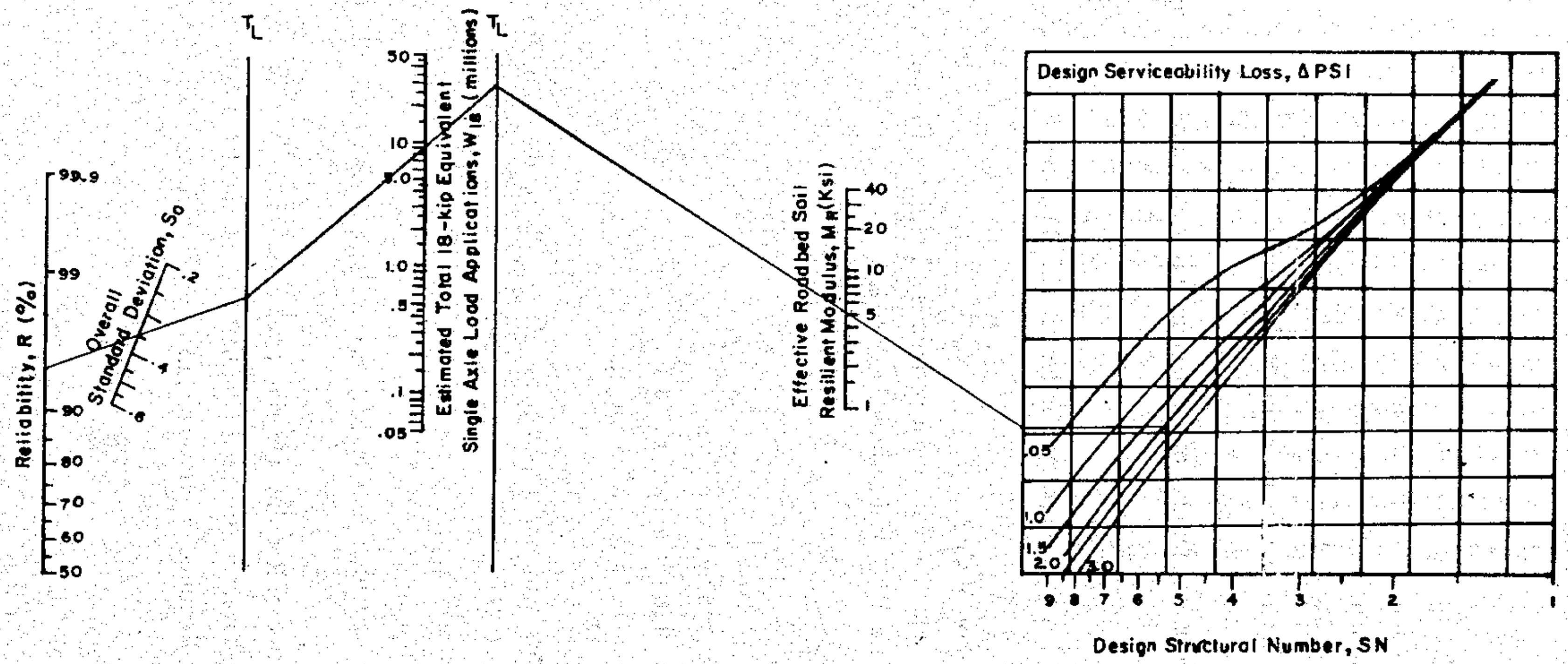
The Required Overlay Structural Number; SN_{ol} is calculated using SN_f and SN_{eff} to be 0.59. And the Required Overlay Thickness; D_{ol} is calculated using SN_{ol} and $a_{ol} = 0.44$:

Thus,

D_{ol} = 0.59 / 0.44
= 1.34 inches
≒ 3.4 cm

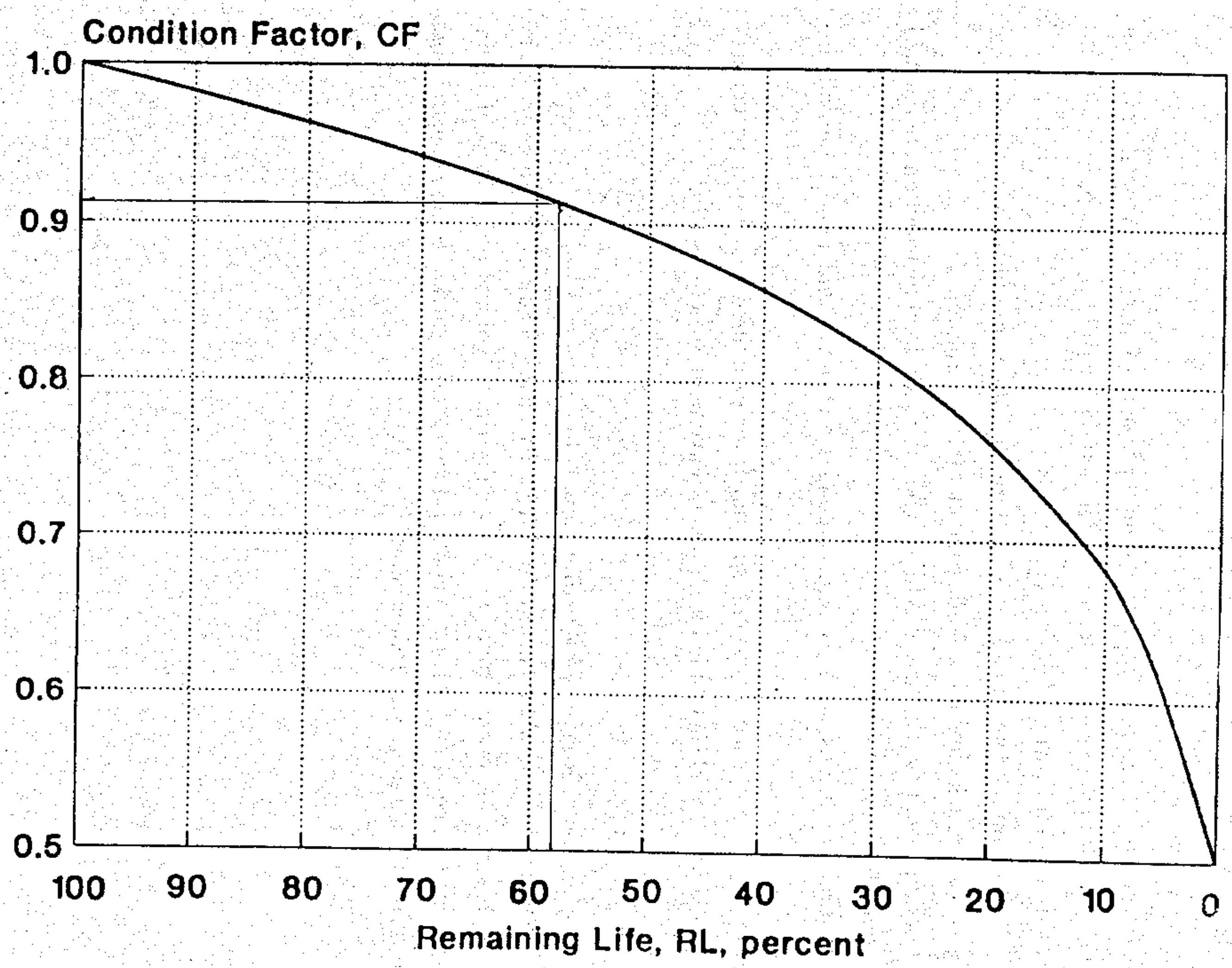
NOMOGRAPH SOLVES:

$$\log_{10} W_{18} = Z_R^{*} S_0 + 9.36^{*}\log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left[\frac{\Delta PSI}{4.2-1.5}\right]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32^{*}\log_{10} M_R - 8.07$$



THE STUDY ON CONSTRUCTION OF THE BRIDGE OVER THE RIVER RUPSA IN KHULNA (Phase-2)

Fig. 6.1 Design Chart for flexible pavement based on using mean values for each input



THE STUDY ON CONSTRUCTION OF THE BRIDGE OVER THE RIVER RUPSA IN KHULNA (Phase-2)

Fig. 6.2 Relationship Between Condition Factor and Remaining Life