EVALUATION OF PAVEMENT DESIGN PARAMETERS FOR NATIONAL HIGHWAYS OF BANGLADESH

By

Mohammad Ahad Ullah

MASTER OF SCIENCE IN ENGINEERING
(CIVIL AND TRANSPORTATION)

DEPARTMENT OF CIVIL ENGINEERING

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY
DHAKA, BANGLADESH

NOVEMBER 2012

Evaluation of Pavement Design Parameters for National Highways of Bangladesh

BY
MOHAMMAD AHAD ULLAH

A Thesis Submitted to the Department of Civil Engineering, Bangladesh University of Engineering and Technology, Dhaka, in partial fulfillment of the requirements for the degree of

Master of Science in Engineering
(Civil & Transportation)

NOVEMBER 2012

The Thesis Titled "Evaluation of Pavement Design Parameters for National Highways of Bangladesh", Submitted by: Mohammad Ahad Ullah, Roll No: 0409042411P, Session: April/2009; has been accepted as satisfactory in partial fulfillment of the requirement for the degree of Master of Science in Civil Engineering (Transportation) on 10th November, 2012.

BOARD OF EXAMINERS

______________________________ Dr. Md. Shamsul Hoque Professor Department of Civil Engineering BUET, Dhaka-1000.	Chairman (Supervisor)
______________________________ Dr. Md. Mujibur Rahman Professor and Head Department of Civil Engineering BUET, Dhaka-1000.	Member (Ex-Officio)
______________________________ Dr. Tanweer Hasan Professor Department of Civil Engineering BUET, Dhaka-1000.	Member
______________________________ Dr. Saiyid Hassan Sikder Deputy Chief Planning Commission, Bangladesh.	Member (External)

It is hereby declared that except for the contents where specific reference have been made to the work of others, the studies contained in this thesis is the result of investigation carried out by the author. No part of this thesis has been submitted to any other University or educational establishment for a Degree, Diploma or other qualification (except for publication).

Signature of the Candidate

____

(Mohammad Ahad Ullah)

CONTENTS

ACKNOWLEDGMENT

Thanks to Almighty Allah for His graciousness, unlimited kindness and with the blessings of Whom the good deeds are fulfilled.

The author wishes to express his deepest gratitude to Dr. Md. Shamsul Hoque, Professor, Department of Civil Engineering, BUET, Dhaka, for his continuous guidance, invaluable suggestions and affectionate encouragement at every stage of this study.

A very special debt of deep gratitude is offered to the author's parents, wife and children for their continuous encouragement and cooperation during this study.

ABSTRACT

This study is performed to evaluate the pavement design parameters in different National Highways of Bangladesh. National Highways like N-1, N-2, N-5, and N-8 are selected for this purpose based on availability of daily flow and axle load data. Traffic flow related parameters such as daily, weekly, seasonal variations, directional distribution, traffic composition, traffic growth pattern, expansion factors and regression models are extensively analyzed to ascertain if any commonality exists among different design flow parameters in these selected National Highways as well as to assess if there is any need for improvement of the existing pavement design parameters. Besides, the axle load characteristics are also evaluated to observe the actual wheel load damaged factor against the current pavement design practices.

From the time series analyses of pavement design parameters, it is found that like any other stabilized corridors, the basic traffic flow patterns of these highways are repetitive in nature. It is observed that there are significant differences in various traffic flow parameters among the four studied highways, viz. N-1 corridors carries almost double traffic (190.50%) than N-5 corridors and almost two and a half times traffic (265.46%) than N-2 corridors. With regards to annual average traffic growth rate, a wide range of variations (11.17 to 21.03%) are also observed along the selected corridors. These values are found to be much higher than the standard growth factor of 10% as considered to the RHD pavement design guide (PDG, 2005). Similarly, comparison of other important traffic parameters viz. DD, truck percentage and expansion factors among different corridors also revealed dissimilarities and wide range of variations. This essentially implies that updating of existing pavement design parameters are essential and for rational pavement design, corridor specific parameters should be used instead of using common parametric values.

Moreover, detailed vehicle overloading investigations disclosed that there is a strong need for immediate revision of existing pavement design parameters like 85th percentile design truck weight, equivalent ESAL value, axle damage factor, etc. due to presence of significant proportion of exceptionally heavily laden trucks in the RHD network. For instance, the 85th percentile design truck weight and the average

ESAL per six wheeler trucks are found 26.50 tons and 32.41 tons respectively along Dhaka-Aricha corridor which are much higher than the current legal gross vehicle weight of 15.5 tons. Similarly, the presence of significant number of grossly overloaded vehicles, particularly 2-axle medium trucks, disclosed much higher equivalency factor (>200) as compared to PGD recommended design value of 4.62.

Thicker asphalt concrete layers can resist excessive deformation under heavily loaded traffic volumes and prolong the life of the pavement. But, permitting the uncontrolled plying of grossly overloaded vehicles must be economically unsustainable since it would result either in high capital costs for heavily over designed pavements to cater for the illegal overloads or early deterioration of pavements designed for a normal/legal range of vehicle loading leading to heavy premature periodic maintenance and/or rehabilitation costs. As such, it is essential that effective monitoring and control measures be introduced and implemented, as soon as possible, to curb the ever increasing axle load along with some structural design improvements for all National Highways to meet the present need for carrying bulk freights.

APPENDIX A

SAMPLES OF TYPICAL TRAFFIC FLOW DATA TABLES

Table A1: Daily Traffic Flow Volume in 2005 on Jamuna Bridge (East Toll Plaza)

Date	Day	Motor Cycle	Light Vehicle	Small Bus	Large Bus	Small Truck	Medium Truck	Large Truck	Total Traffic
1-Jan-05	Saturday	67	391	50	829	177	1073	34	2621
2-Jan-05	Sunday	32	366	49	822	163	1197	39	2668
3-Jan-05	Monday	41	422	45	811	203	1282	36	2840
4-Jan-05	Tuesday	45	376	41	844	203	1336	36	2881
5-Jan-05	Wednesday	30	389	46	798	208	1332	36	2839
6-Jan-05	Thursday	56	490	55	859	205	1374	51	3090
7-Jan-05	Friday	67	507	52	858	200	1343	56	3083
8-Jan-05	Saturday	42	176	13	300	132	980	24	1667
9-Jan-05	Sunday	34	409	41	827	185	1149	51	2696
10-Jan-05	Monday	29	428	45	817	191	1463	55	3028
11-Jan-05	Tuesday	32	398	43	800	190	1452	51	2966
12-Jan-05	Wednesday	39	393	63	834	182	1511	54	3076
13-Jan-05	Thursday	52	473	50	865	212	1560	68	3280
14-Jan-05	Friday	47	485	45	850	184	1493	46	3150
15-Jan-05	Saturday	46	399	40	846	181	1422	56	2990
16-Jan-05	Sunday	41	438	46	855	218	1628	77	3303
17-Jan-05	Monday	32	448	36	914	220	2024	68	3742
18-Jan-05	Tuesday	39	573	50	1052	223	1752	64	3753
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
1-Aug-05	Monday	47	389	49	856	187	1099	43	2670
2-Aug-05	Tuesday	39	376	39	844	215	1107	36	2656
3-Aug-05	Wednesday	50	357	39	858	213	1174	33	2724
4-Aug-05	Thursday	68	428	50	895	198	1114	27	2780
5-Aug-05	Friday	88	421	48	891	174	942	28	2592
6-Aug-05	Saturday	57	308	46	872	168	801	26	2278
7-Aug-05	Sunday	57	345	42	859	179	1014	25	2521
8-Aug-05	Monday	44	370	44	855	192	990	27	2522
9-Aug-05	Tuesday	44	339	42	853	189	996	37	2500
10-Aug-05	Wednesday	57	340	45	848	177	891	25	2383
11-Aug-05	Thursday	66	424	52	947	143	936	23	2591
12-Aug-05	Friday	62	407	48	876	159	781	23	2356
13-Aug-05	Saturday	79	339	39	905	170	787	21	2340
14-Aug-05	Sunday	39	387	41	914	212	1037	22	2652
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
23-Dec-05	Friday	72	617	38	880	190	1145	36	2978
24-Dec-05	Saturday	63	447	37	846	177	1150	35	2755
25-Dec-05	Sunday	43	502	41	831	206	1201	37	2861
26-Dec-05	Monday	47	414	34	871	182	1243	35	2826
27-Dec-05	Tuesday	42	429	38	833	169	1333	39	2883
28-Dec-05	Wednesday	47	457	53	1167	224	1237	40	3225
29-Dec-05	Thursday	47	424	37	807	225	1261	45	2846
30-Dec-05	Friday	50	485	40	830	226	1285	52	2968
31-Dec-05	Saturday	57	374	36	814	194	1214	38	2727

** Data Source: Marga Net One Limited (MNOL)*

** Toll free vehicles not included*

Table A2: Daily Traffic Flow Volume in 2005 on Jamuna Bridge (West Toll Plaza)

Date	Day	Motor Cycle	Light Vehicle	Small Bus	Large Bus	Small Truck	Medium Truck	Large Truck	Total Traffic
1-Jan-05	Saturday	44	370	44	804	154	1191	23	2630
2-Jan-05	Sunday	71	380	61	890	188	1403	41	3034
3-Jan-05	Monday	46	380	48	825	190	1300	36	2825
4-Jan-05	Tuesday	38	410	43	803	205	1275	35	2809
5-Jan-05	Wednesday	49	387	53	832	203	1571	46	3141
6-Jan-05	Thursday	65	452	46	831	189	1291	43	2917
7-Jan-05	Friday	55	595	50	852	181	1331	58	3122
8-Jan-05	Saturday	53	207	11	326	136	986	24	1743
9-Jan-05	Sunday	50	432	41	833	175	1540	62	3133
10-Jan-05	Monday	38	355	44	802	213	1467	60	2979
11-Jan-05	Tuesday	37	361	54	817	181	1426	51	2927
12-Jan-05	Wednesday	43	410	60	870	201	1694	51	3329
13-Jan-05	Thursday	64	429	44	835	194	1436	59	3061
14-Jan-05	Friday	50	524	46	861	181	1567	53	3282
15-Jan-05	Saturday	45	455	43	830	173	1474	50	3070
16-Jan-05	Sunday	41	435	39	889	264	1896	61	3625
17-Jan-05	Monday	27	429	48	965	233	2017	83	3802
18-Jan-05	Tuesday	40	483	55	1163	211	2060	78	4090
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
1-Aug-05	Monday	48	345	45	851	200	988	28	2505
2-Aug-05	Tuesday	46	339	39	829	190	1026	30	2499
3-Aug-05	Wednesday	43	336	50	849	218	1073	32	2601
4-Aug-05	Thursday	84	360	44	888	176	866	35	2453
5-Aug-05	Friday	88	436	47	937	186	869	33	2596
6-Aug-05	Saturday	54	360	43	845	167	878	33	2380
7-Aug-05	Sunday	53	341	43	867	166	1087	41	2598
8-Aug-05	Monday	49	356	45	877	197	953	23	2500
9-Aug-05	Tuesday	41	321	38	830	145	871	28	2274
10-Aug-05	Wednesday	57	340	54	863	163	994	26	2497
11-Aug-05	Thursday	69	349	39	858	141	851	30	2337
12-Aug-05	Friday	66	462	52	979	155	926	29	2669
13-Aug-05	Saturday	76	354	42	886	171	892	23	2444
14-Aug-05	Sunday	51	354	40	890	199	1085	23	2642
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
23-Dec-05	Friday	76	525	42	876	156	1192	27	2894
24-Dec-05	Saturday	52	469	41	811	193	1175	43	2784
25-Dec-05	Sunday	65	614	42	897	179	1417	45	3259
26-Dec-05	Monday	47	414	30	839	177	1133	37	2677
27-Dec-05	Tuesday	47	443	43	1009	221	1216	36	3015
28-Dec-05	Wednesday	46	447	54	1032	208	1507	30	3324
29-Dec-05	Thursday	57	370	35	819	260	1236	51	2828
30-Dec-05	Friday	58	496	35	809	192	1185	40	2815
31-Dec-05	Saturday	52	437	36	797	194	1220	49	2785

** Data Source: Marga Net One Limited (MNOL)*

** Toll free vehicles not included*

Table A3: Daily Traffic Flow Volume in 2007 on Jamuna Bridge (West Toll Plaza)

Date	Day	Motor Cycle	Light Vehicle	Small Bus	Large Bus	Small Truck	Medium Truck	Large Truck	Total Traffic
1-Jan-07	Monday	86	285	8	495	17	65	1	957
2-Jan-07	Tuesday	143	595	25	900	57	138	1	1859
3-Jan-07	Wednesday	194	915	50	1205	129	390	9	2892
4-Jan-07	Thursday	129	946	42	1619	164	726	18	3644
5-Jan-07	Friday	296	1460	78	2944	239	1240	33	6290
6-Jan-07	Saturday	169	1585	63	2243	279	1037	29	5405
7-Jan-07	Sunday	46	185	2	76	114	332	13	768
8-Jan-07	Monday	81	250	2	26	174	444	10	987
9-Jan-07	Tuesday	70	368	8	722	257	1394	42	2861
10-Jan-07	Wednesday	93	863	65	1730	285	1510	36	4582
11-Jan-07	Thursday	62	504	49	1366	269	1413	53	3716
12-Jan-07	Friday	65	567	50	1248	263	1303	42	3538
13-Jan-07	Saturday	36	572	40	1117	268	1297	35	3365
14-Jan-07	Sunday	38	348	30	964	229	1189	49	2847
15-Jan-07	Monday	36	350	34	946	237	1186	40	2829
16-Jan-07	Tuesday	24	380	27	929	241	1220	43	2864
17-Jan-07	Wednesday	23	391	38	939	269	1222	58	2940
18-Jan-07	Thursday	37	413	29	924	241	1117	55	2816
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
1-Aug-07	Wednesday	19	478	32	899	328	1200	26	2982
2-Aug-07	Thursday	41	482	30	959	349	1155	25	3041
3-Aug-07	Friday	61	570	32	965	346	1139	25	3138
4-Aug-07	Saturday	43	598	32	1021	302	1193	22	3211
5-Aug-07	Sunday	34	452	28	928	334	1141	27	2944
6-Aug-07	Monday	37	406	35	946	376	1164	22	2986
7-Aug-07	Tuesday	22	430	20	909	370	1285	25	3061
8-Aug-07	Wednesday	36	410	40	946	376	1384	27	3219
9-Aug-07	Thursday	47	504	29	997	403	1252	26	3258
10-Aug-07	Friday	64	526	31	1014	366	1172	22	3195
11-Aug-07	Saturday	35	488	32	984	347	1180	17	3083
12-Aug-07	Sunday	48	499	27	996	365	1237	20	3192
13-Aug-07	Monday	27	414	30	948	391	1142	25	2977
14-Aug-07	Tuesday	37	452	29	972	366	1190	31	3077
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
23-Dec-07	Sunday	232	1005	35	1333	240	538	21	3404
24-Dec-07	Monday	228	1053	44	1954	369	1165	13	4826
25-Dec-07	Tuesday	323	1785	80	2742	378	1375	6	6689
26-Dec-07	Wednesday	164	1088	48	1818	395	1339	16	4868
27-Dec-07	Thursday	106	821	37	1483	394	1438	11	4290
28-Dec-07	Friday	154	877	45	1672	371	1303	20	4442
29-Dec-07	Saturday	83	788	39	1481	397	1369	29	4186
30-Dec-07	Sunday	67	602	30	1361	418	1521	18	4017
31-Dec-07	Monday	65	612	39	1296	446	1553	27	4038

** Data Source: Marga Net One Limited (MNOL)*

** Toll free vehicles not included*

Table A4: Daily Traffic Flow Volume in 2008 on Jamuna Bridge (East Toll Plaza)

Date	Day	Motor Cycle	Light Vehicle	Small Bus	Large Bus	Small Truck	Medium Truck	Large Truck	Total Traffic
1-Jan-08	Tuesday	32	441	38	1213	440	1505	26	3695
2-Jan-08	Wednesday	42	504	43	1182	431	1553	22	3777
3-Jan-08	Thursday	51	533	32	1179	440	1604	46	3885
4-Jan-08	Friday	68	703	35	1163	465	1554	37	4025
5-Jan-08	Saturday	60	504	33	1138	419	1378	25	3557
6-Jan-08	Sunday	40	539	27	1130	417	1482	32	3667
7-Jan-08	Monday	46	498	20	1089	400	1449	20	3522
8-Jan-08	Tuesday	48	534	28	1070	404	1429	28	3541
9-Jan-08	Wednesday	43	517	34	1064	427	1330	21	3436
10-Jan-08	Thursday	59	558	32	1122	389	1355	25	3540
11-Jan-08	Friday	61	644	28	1072	391	1264	21	3481
12-Jan-08	Saturday	57	471	26	1075	319	1282	21	3251
13-Jan-08	Sunday	37	465	25	1086	347	1340	22	3322
14-Jan-08	Monday	34	497	23	1044	366	1383	24	3371
15-Jan-08	Tuesday	41	468	41	1073	414	1498	24	3559
16-Jan-08	Wednesday	29	551	32	1008	376	1466	19	3481
17-Jan-08	Thursday	63	644	33	1091	385	1502	24	3742
18-Jan-08	Friday	69	764	32	1020	366	1217	22	3490
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
15-Mar-08	Saturday	58	516	30	1080	483	1404	14	3585
16-Mar-08	Sunday	46	529	27	1097	528	1770	34	4031
17-Mar-08	Monday	41	548	28	1083	528	1657	30	3915
18-Mar-08	Tuesday	60	531	31	1022	534	1546	31	3755
19-Mar-08	Wednesday	54	498	37	1010	536	1478	35	3648
20-Mar-08	Thursday	63	636	39	1141	499	1599	37	4014
21-Mar-08	Friday	102	723	34	1119	477	1507	26	3988
22-Mar-08	Saturday	50	526	27	1071	461	1362	28	3525
23-Mar-08	Sunday	51	469	26	1049	437	1461	21	3514
24-Mar-08	Monday	47	540	24	1048	474	1476	16	3625
25-Mar-08	Tuesday	49	607	32	1137	517	1580	19	3941
26-Mar-08	Wednesday	74	699	43	1052	454	1617	22	3961
27-Mar-08	Thursday	55	599	34	1084	488	1433	14	3707
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
10-Sep-08	Wednesday	41	439	33	853	501	1336	24	3227
11-Sep-08	Thursday	47	514	29	931	547	1536	17	3621
12-Sep-08	Friday	50	516	29	895	522	1436	16	3464
13-Sep-08	Saturday	49	474	27	879	434	1254	14	3131
14-Sep-08	Sunday	49	506	16	899	492	1488	19	3469
15-Sep-08	Monday	35	487	18	859	504	1342	28	3273
16-Sep-08	Tuesday	38	520	23	863	566	1496	28	3534
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
30-Dec-08	Tuesday	26	380	28	749	233	471	14	1901
31-Dec-08	Wednesday	42	533	38	1120	490	901	22	3146

** Data Source: Marga Net One Limited (MNOL)*

** Toll free vehicles not included*

Table A5: Daily Traffic Flow Volume in March 2006 on Jamuna Bridge (Both Direction)

Date	Day	MC	LV	SB	LB	ST	MT	LT	Tot Veh
1-Mar-06	Wednesday	121	937	118	2073	410	2294	77	**6030**
2-Mar-06	Thursday	149	881	81	1479	373	2144	74	**5181**
3-Mar-06	Friday	197	1085	87	1852	315	2084	77	**5697**
4-Mar-06	Saturday	127	884	92	1855	331	2018	73	**5380**
5-Mar-06	Sunday	169	774	77	1814	344	2311	74	**5563**
6-Mar-06	Monday	116	794	88	1810	347	2190	61	**5406**
7-Mar-06	Tuesday	116	827	80	1787	329	2190	76	**5405**
8-Mar-06	Wednesday	127	815	92	1838	347	2340	85	**5644**
9-Mar-06	Thursday	142	977	91	1905	350	2185	85	**5735**
10-Mar-06	Friday	169	1068	85	1887	310	2084	72	**5675**
11-Mar-06	Saturday	121	895	84	1824	293	1985	73	**5275**
12-Mar-06	Sunday	136	908	83	1845	329	2208	81	**5590**
13-Mar-06	Monday	152	637	38	1156	304	2075	67	**4429**
14-Mar-06	Tuesday	121	826	89	1843	338	2219	85	**5521**
15-Mar-06	Wednesday	119	830	106	1830	327	2178	74	**5464**
16-Mar-06	Thursday	153	906	87	1869	373	2112	82	**5582**
17-Mar-06	Friday	203	1003	88	1854	321	1989	88	**5546**
18-Mar-06	Saturday	175	877	81	1831	357	2045	68	**5434**
19-Mar-06	Sunday	129	691	65	1813	323	2235	86	**5342**
20-Mar-06	Monday	111	799	74	1821	321	2288	76	**5490**
21-Mar-06	Tuesday	91	730	78	1753	309	2157	68	**5186**
22-Mar-06	Wednesday	130	699	86	1782	336	2214	93	**5340**
23-Mar-06	Thursday	168	940	96	1924	383	2129	66	**5706**
24-Mar-06	Friday	212	1215	87	1837	301	2052	72	**5776**
25-Mar-06	Saturday	160	894	80	1629	282	1915	56	**5016**
26-Mar-06	Sunday	187	1067	87	1900	307	1827	68	**5443**
27-Mar-06	Monday	156	770	73	1840	315	1884	72	**5110**
28-Mar-06	Tuesday	97	763	74	1792	350	2114	79	**5269**
29-Mar-06	Wednesday	105	757	89	1756	378	2004	77	**5166**
30-Mar-06	Thursday	138	837	87	1857	352	1983	58	**5312**
31-Mar-06	Friday	207	1012	98	1926	315	2013	70	**5641**
TOTAL		**4504**	**27098**	**2621**	**55982**	**10370**	**65466**	**2313**	**168354**

** Data Source: Marga Net One Limited (MNOL)*

** Toll free vehicles not included*

Table A6: Daily Traffic Flow Volume in September 2007 on Jamuna Bridge (Both Direction)

Date	Day	MC	LV	SB	LB	ST	MT	LT	Tot Veh
1-Sep-07	Saturday	109	1145	76	2230	708	2114	39	6421
2-Sep-07	Sunday	57	966	62	2085	738	2503	32	6443
3-Sep-07	Monday	63	961	63	2053	750	2438	47	6375
4-Sep-07	Tuesday	79	1011	68	2022	710	2468	39	6397
5-Sep-07	Wednesday	71	891	79	1967	735	2250	46	6039
6-Sep-07	Thursday	90	1080	65	1953	700	2169	49	6106
7-Sep-07	Friday	92	1228	69	1944	657	2070	42	6102
8-Sep-07	Saturday	60	1074	66	2013	650	2067	35	5965
9-Sep-07	Sunday	60	938	50	2011	641	2397	43	6140
10-Sep-07	Monday	41	969	63	2016	737	2490	45	6361
11-Sep-07	Tuesday	67	1062	60	2023	830	2700	46	6788
12-Sep-07	Wednesday	58	1063	74	2136	836	2762	47	6976
13-Sep-07	Thursday	87	969	66	2052	850	2578	51	6653
14-Sep-07	Friday	82	756	52	1916	762	2554	40	6162
15-Sep-07	Saturday	56	711	54	1874	737	2267	55	5754
16-Sep-07	Sunday	44	785	50	1891	803	2868	52	6493
17-Sep-07	Monday	53	775	48	1787	813	2767	51	6294
18-Sep-07	Tuesday	59	723	59	1746	805	2722	62	6176
19-Sep-07	Wednesday	48	725	55	1775	808	2865	67	6343
20-Sep-07	Thursday	87	832	57	1809	808	2807	53	6453
21-Sep-07	Friday	76	836	53	1739	783	2671	46	6204
22-Sep-07	Saturday	67	745	53	1735	780	2550	58	5988
23-Sep-07	Sunday	42	792	46	1704	778	2741	62	6165
24-Sep-07	Monday	51	756	52	1632	787	2736	45	6059
25-Sep-07	Tuesday	48	800	63	1647	755	2825	67	6205
26-Sep-07	Wednesday	43	855	52	1702	817	2929	52	6450
27-Sep-07	Thursday	56	928	59	1723	825	2730	49	6370
28-Sep-07	Friday	73	873	58	1676	767	2593	37	6077
29-Sep-07	Saturday	90	807	47	1667	712	2566	36	5925
30-Sep-07	Sunday	63	769	46	1699	782	2870	48	6277
TOTAL		**1972**	**26825**	**1765**	**56227**	**22864**	**77067**	**1441**	**188161**

** Data Source: Marga Net One Limited (MNOL)*

** Toll free vehicles not included*

Table A7: Daily Traffic Flow Volume in February 2009 on Jamuna Bridge (Both Direction)

Date	Day	MC	LV	SB	LB	ST	MT	LT	Tot Veh
1-Feb-09	Sunday	112	1213	73	2543	1104	2888	39	7972
2-Feb-09	Monday	94	1262	65	2219	1185	2949	37	7811
3-Feb-09	Tuesday	92	1272	68	2123	1199	3106	50	7910
4-Feb-09	Wednesday	102	1337	76	2162	1275	3268	51	8271
5-Feb-09	Thursday	112	1413	60	2316	1197	2945	34	8077
6-Feb-09	Friday	158	1761	75	2269	1180	3006	38	8487
7-Feb-09	Saturday	123	1425	60	2196	1144	2896	36	7880
8-Feb-09	Sunday	93	1211	61	2198	1269	3505	42	8379
9-Feb-09	Monday	106	1266	72	2170	1360	3333	43	8350
10-Feb-09	Tuesday	98	1242	83	2158	1253	3302	51	8187
11-Feb-09	Wednesday	92	1214	93	2193	1300	3258	52	8202
12-Feb-09	Thursday	139	1465	65	2283	1243	2999	52	8246
13-Feb-09	Friday	136	1551	67	2291	1174	2820	30	8069
14-Feb-09	Saturday	201	1358	55	2188	1149	2837	62	7850
15-Feb-09	Sunday	96	1179	44	2186	1278	3026	44	7853
16-Feb-09	Monday	115	1239	54	2138	1305	3092	47	7990
17-Feb-09	Tuesday	145	1165	68	2149	1232	3026	52	7837
18-Feb-09	Wednesday	93	1279	77	2267	1449	3362	61	8588
19-Feb-09	Thursday	178	1586	72	2435	1314	2921	55	8561
20-Feb-09	Friday	194	1844	80	2265	1293	2782	70	8528
21-Feb-09	Saturday	234	1480	70	2356	1169	2400	43	7752
22-Feb-09	Sunday	170	1328	50	2294	1209	2774	59	7884
23-Feb-09	Monday	114	1263	61	2183	1388	3161	57	8227
24-Feb-09	Tuesday	95	1236	66	2142	1284	3034	51	7908
25-Feb-09	Wednesday	115	1162	75	2107	1293	3077	55	7884
26-Feb-09	Thursday	112	1177	53	1871	1067	2423	58	6761
27-Feb-09	Friday	126	1293	68	2011	1107	2394	46	7045
28-Feb-09	Saturday	121	1107	49	2151	1115	2483	40	7066
TOTAL		**3566**	**37328**	**1860**	**61864**	**34535**	**83067**	**1355**	**223575**

** Data Source: Bangabandhu Bridge Special Organization (BBSO)*

** Toll free vehicles not included*

Table A8: Daily Traffic Flow Volume in December 2009 on Jamuna Bridge

(Both Direction)

Date	Day	MC	LV	SB	LB	ST	MT	LT	Tot Veh
1-Dec-09	Tuesday	606	2690	36	3991	698	1282	27	**9330**
2-Dec-09	Wednesday	452	2635	72	4692	936	1963	39	**10789**
3-Dec-09	Thursday	354	2450	34	4409	1102	2405	65	**10819**
4-Dec-09	Friday	679	2968	43	5277	995	2455	58	**12475**
5-Dec-09	Saturday	351	2473	36	3826	1065	2591	62	**10404**
6-Dec-09	Sunday	212	1803	24	3248	1149	3034	64	**9534**
7-Dec-09	Monday	191	1831	23	3036	1156	3157	68	**9462**
8-Dec-09	Tuesday	136	1564	26	2722	1139	2873	62	**8522**
9-Dec-09	Wednesday	159	1657	34	2670	1230	3352	69	**9171**
10-Dec-09	Thursday	152	1814	27	2694	1300	3271	51	**9309**
11-Dec-09	Friday	218	2051	30	2752	1289	3102	59	**9501**
12-Dec-09	Saturday	149	1557	27	2670	1201	2979	63	**8646**
13-Dec-09	Sunday	138	1533	17	2536	1297	3460	42	**9023**
14-Dec-09	Monday	146	1515	18	2396	1233	3204	59	**8571**
15-Dec-09	Tuesday	148	1631	28	2480	1268	2970	66	**8591**
16-Dec-09	Wednesday	191	1605	27	2344	1105	2805	66	**8143**
17-Dec-09	Thursday	141	1568	16	2437	1206	2629	62	**8059**
18-Dec-09	Friday	191	1743	26	2501	1175	2844	75	**8555**
19-Dec-09	Saturday	178	1553	27	2466	1090	2763	51	**8128**
20-Dec-09	Sunday	151	1394	12	2394	1201	3044	57	**8253**
21-Dec-09	Monday	131	1543	12	2392	1241	3099	77	**8495**
22-Dec-09	Tuesday	121	1579	27	2307	1187	3166	89	**8476**
23-Dec-09	Wednesday	128	1578	27	2320	1245	3254	74	**8626**
24-Dec-09	Thursday	131	1832	22	2363	1303	3003	81	**8735**
25-Dec-09	Friday	155	2059	23	2353	1280	2980	96	**8946**
26-Dec-09	Saturday	134	1685	20	2402	1174	2878	58	**8351**
27-Dec-09	Sunday	105	1548	20	2297	1260	3291	72	**8593**
28-Dec-09	Monday	146	1668	15	2262	1287	3323	46	**8747**
29-Dec-09	Tuesday	109	1503	29	2330	1303	3264	59	**8597**
30-Dec-09	Wednesday	98	1603	29	2341	1263	3058	60	**8452**
31-Dec-09	Thursday	138	1705	16	2381	1281	3022	72	**8615**
TOTAL		**3,324**	**6339**	**56338**	**823**	**87289**	**36659**	**90521**	**1949**

** Data Source: Bangabandhu Bridge Special Organization (BBSO)*

** Toll free vehicles not included*

Table A9: Daily Traffic Flow Volume in May 2009 on Nalka-Hatikamrul-Bonpara Link Road (Both Direction)

Date	Day	Pickup Van/ Trailor Trucktor	Car/Jeep /Micro Bus/ Station Wagon	Mini Bus/ Coster/ Mini Truck	Bus/ Truck (Up to 2 Axle)	Crain/ Grader/ Pay-Loader/ Bulldoser	Vehicle More Than 2 Axle/ Truck & Container	Toll Free Vehicle	Total Vehicle
1-May-09	Friday	80	343	381	1231	1	32	21	**2089**
2-May-09	Saturday	89	303	443	1194	1	29	5	**2064**
3-May-09	Sunday	76	256	499	1380	0	32	12	**2255**
4-May-09	Monday	78	282	465	1419	0	35	13	**2292**
5-May-09	Tuesday	78	278	459	1406	0	52	9	**2282**
6-May-09	Wednesday	75	266	469	1321	1	57	15	**2204**
7-May-09	Thursday	71	338	449	1304	0	57	21	**2240**
8-May-09	Friday	67	394	458	1266	0	26	7	**2218**
9-May-09	Saturday	52	352	398	1223	1	41	17	**2084**
10-May-09	Sunday	78	296	458	1315	0	29	10	**2186**
11-May-09	Monday	75	282	505	1232	0	47	14	**2155**
12-May-09	Tuesday	101	259	523	1333	1	34	16	**2267**
13-May-09	Wednesday	100	222	529	1374	1	45	15	**2286**
14-May-09	Thursday	89	325	536	1420	1	29	14	**2414**
15-May-09	Friday	89	428	540	1391	2	40	8	**2498**
16-May-09	Saturday	69	324	489	1294	0	48	17	**2241**
17-May-09	Sunday	91	277	561	1517	0	35	11	**2492**
18-May-09	Monday	102	329	472	1500	0	63	14	**2480**
19-May-09	Tuesday	83	291	491	1394	0	43	20	**2322**
20-May-09	Wednesday	87	307	510	1562	1	37	13	**2517**
21-May-09	Thursday	102	335	513	1537	0	39	7	**2533**
22-May-09	Friday	63	480	501	1611	3	64	16	**2738**
23-May-09	Saturday	67	339	443	1390	0	36	16	**2291**
24-May-09	Sunday	84	276	506	1664	0	59	12	**2601**
25-May-09	Monday	76	371	482	1595	0	49	8	**2581**
26-May-09	Tuesday	98	385	547	1796	1	44	13	**2884**
27-May-09	Wednesday	87	308	574	1651	1	38	25	**2684**
28-May-09	Thursday	92	401	559	1608	0	69	7	**2736**
29-May-09	Friday	93	590	575	1472	0	48	9	**2787**
30-May-09	Saturday	85	380	510	1385	0	44	16	**2420**
31-May-09	Sunday	109	327	582	1471	0	59	16	**2564**
Month Total		**2586**	**10344**	**15427**	**44256**	**15**	**1360**	**417**	**74405**

** Data Source: MBEL-ATT JV Ltd.*

Table A10: Daily Traffic Flow Volume in December 2009 on Nalka-Hatikamrul-Bonpara Link Road (Both Direction)

Date	Day	Pickup Van/ Trailor Trucktor	Car/Jeep/Micro Bus/ Station Wagon	Mini Bus/ Coster/ Mini Truck	Bus/ Truck (Up to 2 Axle)	Crain/ Grader/ Pay-Loader/ Bulldoser	Vehicle More Than 2 Axle/ Truck & Container	Toll Free Vehicle	Total Vehicle
1-Dec-09	Tuesday	110	771	457	1117	0	24	31	**2510**
2-Dec-09	Wednesday	154	751	617	1408	0	36	27	**2993**
3-Dec-09	Thursday	174	667	612	1427	0	52	25	**2957**
4-Dec-09	Friday	170	737	638	1479	0	71	26	**3121**
5-Dec-09	Saturday	229	597	655	1326	0	58	15	**2880**
6-Dec-09	Sunday	182	421	597	1510	1	69	26	**2806**
7-Dec-09	Monday	184	450	582	1648	1	63	22	**2950**
8-Dec-09	Tuesday	236	434	575	1612	0	67	23	**2947**
9-Dec-09	Wednesday	260	414	618	1544	0	50	24	**2910**
10-Dec-09	Thursday	248	466	624	1560	0	56	14	**2968**
11-Dec-09	Friday	249	662	669	1615	2	48	18	**3263**
12-Dec-09	Saturday	195	401	535	1597	1	58	36	**2823**
13-Dec-09	Sunday	163	386	578	2124	0	75	30	**3356**
14-Dec-09	Monday	159	387	556	2018	0	82	14	**3216**
15-Dec-09	Tuesday	135	388	544	1743	3	102	35	**2950**
16-Dec-09	Wednesday	120	380	487	1678	3	87	13	**2768**
17-Dec-09	Thursday	150	348	439	1564	2	70	18	**2591**
18-Dec-09	Friday	93	495	512	1680	2	106	16	**2904**
19-Dec-09	Saturday	111	408	471	1555	2	57	10	**2614**
20-Dec-09	Sunday	108	348	526	1600	2	76	21	**2681**
21-Dec-09	Monday	113	391	564	1607	0	93	31	**2799**
22-Dec-09	Tuesday	105	409	489	1722	0	93	31	**2849**
23-Dec-09	Wednesday	148	464	532	1724	1	97	24	**2990**
24-Dec-09	Thursday	163	502	535	1662	0	87	24	**2973**
25-Dec-09	Friday	184	616	551	1733	0	108	20	**3212**
26-Dec-09	Saturday	95	413	442	1510	0	66	6	**2532**
27-Dec-09	Sunday	112	411	543	1704	0	54	22	**2846**
28-Dec-09	Monday	140	424	552	1649	2	67	24	**2858**
29-Dec-09	Tuesday	102	397	506	1596	0	66	32	**2699**
30-Dec-09	Wednesday	162	408	543	1601	2	80	73	**2869**
31-Dec-09	Thursday	133	456	526	1564	0	83	89	**2851**
Month Total		**4887**	**14802**	**17075**	**49877**	**24**	**2201**	**820**	**89686**

** Data Source: MBEL-ATT JV Ltd.*

Table A11: Daily Traffic Flow Volume in 2007 on Bhairab Bridge (West to East)

Date	Day	Class I	Class II	Class III	Class IV	Class V	Class VI	Class VII	Class VIII	Class IX	Total Vehicle
1-Jan-07	Monday	269	97	313	8	76	1087	25	1	48	**1924**
2-Jan-07	Tuesday	310	64	272	7	90	1010	19	0	52	**1824**
3-Jan-07	Wednesday	280	80	249	9	90	1018	23	0	47	**1796**
4-Jan-07	Thursday	310	81	289	11	88	1081	19	2	53	**1934**
5-Jan-07	Friday	322	86	313	7	81	917	21	1	32	**1780**
6-Jan-07	Saturday	356	82	365	8	78	889	22	3	37	**1840**
7-Jan-07	Sunday	215	77	420	5	69	947	11	0	35	**1779**
8-Jan-07	Monday	282	105	223	10	76	973	16	3	40	**1728**
9-Jan-07	Tuesday	236	91	245	8	87	1001	10	1	32	**1711**
10-Jan-07	Wednesday	260	98	386	11	92	1046	13	4	38	**1948**
11-Jan-07	Thursday	435	91	441	12	91	1190	10	3	43	**2316**
12-Jan-07	Friday	406	101	424	8	86	1193	9	3	39	**2269**
13-Jan-07	Saturday	373	92	336	10	81	1072	6	11	42	**2023**
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
16-Jun-07	Saturday	285	77	372	11	61	838	10	5	35	**1694**
17-Jun-07	Sunday	249	80	346	9	71	953	11	1	34	**1754**
18-Jun-07	Monday	319	114	359	9	88	970	13	1	34	**1907**
19-Jun-07	Tuesday	308	90	349	12	92	904	12	3	47	**1817**
20-Jun-07	Wednesday	318	97	396	6	109	984	20	2	39	**1971**
21-Jun-07	Thursday	367	116	488	11	91	1095	14	3	50	**2235**
22-Jun-07	Friday	374	101	600	6	78	969	10	3	40	**2181**
23-Jun-07	Saturday	362	103	388	10	77	949	18	4	48	**1959**
24-Jun-07	Sunday	282	88	412	10	74	1028	15	13	52	**1974**
25-Jun-07	Monday	319	94	399	12	95	1064	24	2	47	**2056**
26-Jun-07	Tuesday	315	106	325	8	82	977	19	2	53	**1887**
27-Jun-07	Wednesday	313	101	386	15	85	1020	13	1	32	**1966**
28-Jun-07	Thursday	354	101	537	11	86	1085	12	4	37	**2227**
29-Jun-07	Friday	381	89	569	8	86	1065	21	6	35	**2260**
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
6-Dec-07	Thursday	372	144	486	12	85	1177	17	1	52	**2346**
7-Dec-07	Friday	404	175	687	10	87	1170	30	5	35	**2603**
8-Dec-07	Saturday	358	190	429	7	56	1031	23	4	34	**2132**
9-Dec-07	Sunday	335	174	421	8	77	1215	15	6	38	**2289**
10-Dec-07	Monday	334	171	467	5	70	1194	33	3	49	**2326**
11-Dec-07	Tuesday	361	132	463	7	103	1194	24	7	37	**2328**
12-Dec-07	Wednesday	362	175	574	8	101	1228	31	3	51	**2533**
13-Dec-07	Thursday	399	318	655	9	85	1385	27	7	27	**2912**
14-Dec-07	Friday	437	290	881	8	96	1337	33	4	31	**3117**

** Data Source: Sigma-RCL JV.*

** Class I= Motor Cycle /Baby Taxi/ Mishuk, Class II= Maxi/ Pick-up/ Tampo, ClassIII= Car/Jeep/Station Wagon/ Micro, Class IV= Coaster/Tractor/Tractor with Trailer, Class V=Mini Bus/Mini Truck, Class VI=Bus/Truck/Covered Truck 2 Axle, Class VII= Bus/Truck/Covered Truck 3 Axle, Class VIII=Trailer Truck/Construction Equipment, Class IX=Toll Free Vehicles.*

Table A12: Daily Traffic Flow Volume in 2007 on Bhairab Bridge (East to West)

Date	Day	Class I	Class II	Class III	Class IV	Class V	Class VI	Class VII	Class VIII	Class IX	Total Vehicle
1-Jan-07	Monday	418	49	281	55	56	310	0	0	22	**1191**
2-Jan-07	Tuesday	564	42	446	7	38	446	0	0	29	**1572**
3-Jan-07	Wednesday	540	49	578	2	35	567	0	4	44	**1819**
4-Jan-07	Thursday	470	65	546	5	44	667	0	6	44	**1847**
5-Jan-07	Friday	652	136	682	5	56	770	0	8	32	**2341**
6-Jan-07	Saturday	635	159	735	15	67	851	4	7	53	**2526**
7-Jan-07	Sunday	235	51	96	10	34	232	2	1	31	**692**
8-Jan-07	Monday	331	54	148	8	43	261	1	0	36	**882**
9-Jan-07	Tuesday	262	59	166	2	41	370	1	2	43	**946**
10-Jan-07	Wednesday	268	72	308	8	51	631	2	6	21	**1367**
11-Jan-07	Thursday	440	103	338	9	88	974	3	2	40	**1997**
12-Jan-07	Friday	422	95	472	8	86	992	4	3	38	**2120**
13-Jan-07	Saturday	386	96	369	11	93	893	3	5	31	**1887**
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
16-Jun-07	Saturday	286	82	445	12	56	811	11	2	34	**1739**
17-Jun-07	Sunday	253	81	354	9	72	756	8	0	38	**1571**
18-Jun-07	Monday	334	113	333	8	74	852	4	3	33	**1754**
19-Jun-07	Tuesday	311	96	316	9	84	870	5	0	43	**1734**
20-Jun-07	Wednesday	335	95	433	11	102	846	9	1	37	**1869**
21-Jun-07	Thursday	386	120	438	9	87	912	12	2	37	**2003**
22-Jun-07	Friday	378	105	577	7	84	868	9	5	37	**2070**
23-Jun-07	Saturday	357	104	471	11	65	860	1	5	40	**1914**
24-Jun-07	Sunday	295	89	413	11	79	826	11	2	40	**1766**
25-Jun-07	Monday	314	100	390	13	80	915	13	1	41	**1867**
26-Jun-07	Tuesday	326	110	345	7	92	891	15	3	43	**1832**
27-Jun-07	Wednesday	311	103	417	11	88	910	13	2	39	**1894**
28-Jun-07	Thursday	361	105	431	10	93	968	13	5	36	**2022**
29-Jun-07	Friday	385	87	558	9	93	998	4	4	31	**2169**
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
6-Dec-07	Thursday	370	141	440	14	80	1005	11	4	74	**2139**
7-Dec-07	Friday	415	176	674	10	87	1082	12	4	51	**2511**
8-Dec-07	Saturday	367	211	529	7	68	998	9	1	33	**2223**
9-Dec-07	Sunday	341	174	486	6	60	981	21	5	39	**2113**
10-Dec-07	Monday	341	164	437	5	77	1114	15	3	49	**2205**
11-Dec-07	Tuesday	372	137	454	6	87	1067	16	5	36	**2180**
12-Dec-07	Wednesday	363	175	573	8	78	1174	26	2	48	**2447**
13-Dec-07	Thursday	393	316	556	8	94	1191	18	0	36	**2612**
14-Dec-07	Friday	448	295	793	10	103	1312	27	6	34	**3028**

** Data Source: Sigma-RCL JV.*

** Class I= Motor Cycle /Baby Taxi/ Mishuk, Class II= Maxi/ Pick-up/ Tampo, ClassIII= Car/Jeep/Station Wagon/ Micro, Class IV= Coaster/Tractor/Tractor with Trailer, Class V=Mini Bus/Mini Truck, Class VI=Bus/Truck/Covered Truck 2 Axle, Class VII= Bus/Truck/Covered Truck 3 Axle, Class VIII=Trailer Truck/Construction Equipment, Class IX=Toll Free Vehicles.*

Table A13: Daily Traffic Flow Volume in 2009 on Bhairab Bridge (West to East)

Date	Day	Class I	Class II	Class III	Class IV	Class V	Class VI	Class VII	Class VIII	Class IX	Total Vehicle
1-Jan-09	Thursday	747	360	628	8	75	1164	23	2	42	**3049**
2-Jan-09	Friday	756	371	798	14	90	1091	32	1	35	**3188**
3-Jan-09	Saturday	709	327	565	6	76	1070	28	1	41	**2823**
4-Jan-09	Sunday	692	302	573	12	82	1236	22	2	33	**2954**
5-Jan-09	Monday	682	341	603	7	89	1250	23	5	44	**3044**
6-Jan-09	Tuesday	516	219	569	13	89	1241	24	1	31	**2703**
7-Jan-09	Wednesday	603	200	706	9	79	1239	20	7	38	**2901**
8-Jan-09	Thursday	190	585	728	69	53	1024	8	30	43	**2730**
9-Jan-09	Friday	570	175	820	8	81	1150	25	2	25	**2856**
10-Jan-09	Saturday	547	179	563	9	77	1108	18	4	25	**2530**
11-Jan-09	Sunday	500	156	560	13	82	1259	23	1	40	**2634**
12-Jan-09	Monday	509	161	559	13	96	1274	26	3	40	**2681**
13-Jan-09	Tuesday	523	205	521	4	63	1171	23	3	32	**2545**
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
11-Aug-09	Tuesday	698	215	702	15	127	1303	21	2	22	**3105**
12-Aug-09	Wednesday	794	214	886	25	115	1287	19	0	28	**3368**
13-Aug-09	Thursday	877	260	1428	26	132	1287	14	1	32	**4057**
14-Aug-09	Friday	885	217	1157	20	128	1274	20	1	24	**3726**
15-Aug-09	Saturday	792	145	750	9	97	1038	15	0	35	**2881**
16-Aug-09	Sunday	748	169	737	20	113	1152	21	0	30	**2990**
17-Aug-09	Monday	688	166	692	10	134	1201	37	0	33	**2961**
18-Aug-09	Tuesday	610	183	708	12	130	1171	18	0	40	**2872**
19-Aug-09	Wednesday	726	176	771	22	133	1254	31	2	34	**3149**
20-Aug-09	Thursday	816	214	908	20	144	1242	32	0	29	**3405**
21-Aug-09	Friday	813	188	924	9	152	1244	31	2	34	**3397**
22-Aug-09	Saturday	734	182	533	21	130	1105	13	0	33	**2751**
23-Aug-09	Sunday	527	150	438	15	104	1096	26	0	29	**2385**
24-Aug-09	Monday	533	171	493	17	130	1096	36	1	26	**2503**
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
17-Nov-09	Tuesday	585	168	655	14	143	1394	43	3	39	**3044**
18-Nov-09	Wednesday	540	164	654	12	119	1423	41	0	33	**2986**
19-Nov-09	Thursday	649	207	685	18	130	1544	33	1	31	**3298**
20-Nov-09	Friday	798	166	816	15	138	1459	45	1	20	**3458**
21-Nov-09	Saturday	691	178	630	15	127	1307	33	2	23	**3006**
22-Nov-09	Sunday	696	177	694	18	141	1492	32	1	30	**3281**
23-Nov-09	Monday	733	202	691	9	143	1521	43	0	24	**3366**
24-Nov-09	Tuesday	788	219	762	16	163	1427	28	7	42	**3452**
25-Nov-09	Wednesday	813	216	945	26	156	1429	17	1	44	**3647**

** Data Source: Sigma-RCL JV.*

** Class I= Motor Cycle /Baby Taxi/ Mishuk, Class II= Maxi/ Pick-up/ Tampo, ClassIII= Car/Jeep/Station Wagon/ Micro, Class IV= Coaster/Tractor/Tractor with Trailer, Class V=Mini Bus/Mini Truck, Class VI=Bus/Truck/Covered Truck 2 Axle, Class VII= Bus/Truck/Covered Truck 3 Axle, Class VIII=Trailer Truck/Construction Equipment, Class IX=Toll Free Vehicles.*

Table A14: Daily Traffic Flow Volume in 2009 on Bhairab Bridge (East to West)

Date	Day	Class I	Class II	Class III	Class IV	Class V	Class VI	Class VII	Class VIII	Class IX	Total Vehicle
1-Jan-09	Thursday	758	363	562	6	83	906	21	0	46	**2745**
2-Jan-09	Friday	761	376	766	11	79	943	9	3	32	**2980**
3-Jan-09	Saturday	729	341	717	4	75	937	8	0	40	**2851**
4-Jan-09	Sunday	686	312	631	11	72	926	18	2	32	**2690**
5-Jan-09	Monday	692	338	611	4	76	1021	16	7	39	**2804**
6-Jan-09	Tuesday	524	208	607	11	84	990	22	1	27	**2474**
7-Jan-09	Wednesday	638	195	667	10	74	1058	23	3	28	**2696**
8-Jan-09	Thursday	553	183	953	7	73	1293	33	1	30	**3126**
9-Jan-09	Friday	584	175	929	8	80	1038	30	4	22	**2870**
10-Jan-09	Saturday	546	173	784	10	68	982	18	2	45	**2628**
11-Jan-09	Sunday	492	159	599	13	86	910	20	3	28	**2310**
12-Jan-09	Monday	435	161	563	10	94	1076	22	2	26	**2389**
13-Jan-09	Tuesday	528	203	538	3	67	1021	34	1	27	**2422**
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
11-Aug-09	Tuesday	719	195	760	19	126	1124	15	0	27	**2985**
12-Aug-09	Wednesday	777	209	770	21	143	1181	19	1	27	**3148**
13-Aug-09	Thursday	901	233	943	22	137	1129	22	1	19	**3407**
14-Aug-09	Friday	871	230	1200	17	132	1107	10	0	24	**3591**
15-Aug-09	Saturday	804	154	1315	13	111	1171	32	2	33	**3635**
16-Aug-09	Sunday	758	171	819	14	97	1014	22	0	19	**2914**
17-Aug-09	Monday	701	159	693	10	124	1037	23	0	24	**2771**
18-Aug-09	Tuesday	630	176	698	15	125	1126	30	1	28	**2829**
19-Aug-09	Wednesday	724	175	724	10	126	1110	27	0	31	**2927**
20-Aug-09	Thursday	786	217	839	11	129	1137	20	0	28	**3167**
21-Aug-09	Friday	813	192	972	11	148	1090	14	0	26	**3266**
22-Aug-09	Saturday	733	176	693	21	133	1065	26	0	23	**2870**
23-Aug-09	Sunday	541	140	465	13	117	1056	29	0	18	**2379**
24-Aug-09	Monday	524	181	508	13	125	989	24	1	16	**2381**
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
17-Nov-09	Tuesday	579	180	673	12	130	1237	26	5	25	**2867**
18-Nov-09	Wednesday	550	171	642	12	114	1196	49	1	24	**2759**
19-Nov-09	Thursday	669	201	614	20	140	1234	35	0	20	**2933**
20-Nov-09	Friday	789	184	845	9	139	1273	36	1	30	**3306**
21-Nov-09	Saturday	688	172	736	22	106	1257	46	2	20	**3049**
22-Nov-09	Sunday	700	174	673	13	118	1257	33	1	24	**2993**
23-Nov-09	Monday	719	214	707	11	134	1388	41	0	34	**3248**
24-Nov-09	Tuesday	789	212	743	12	164	1532	32	0	31	**3515**
25-Nov-09	Wednesday	826	242	861	24	172	1573	33	1	39	**3771**

** Data Source: Sigma-RCL JV.*

** Class I= Motor Cycle /Baby Taxi/ Mishuk, Class II= Maxi/ Pick-up/ Tampo, ClassIII= Car/Jeep/Station Wagon/ Micro, Class IV= Coaster/Tractor/Tractor with Trailer, Class V=Mini Bus/Mini Truck, Class VI=Bus/Truck/Covered Truck 2 Axle, Class VII= Bus/Truck/Covered Truck 3 Axle, Class VIII=Trailer Truck/Construction Equipment, Class IX=Toll Free Vehicles.*

Table A15: Daily Traffic Flow Volume in 2008 on Bhairab Bridge (Both Direction)

Date	Day	Class I	Class II	Class III	Class IV	Class V	Class VI	Class VII	Class VIII	Class IX	Total Vehicle
1-Jan-08	Tuesday	754	321	839	12	153	2144	48	14	77	**4362**
2-Jan-08	Wednesday	694	297	992	18	158	2073	37	9	82	**4360**
3-Jan-08	Thursday	807	299	995	28	189	2258	47	20	85	**4728**
4-Jan-08	Friday	854	488	1324	10	170	2162	52	6	66	**5132**
5-Jan-08	Saturday	765	508	1095	30	155	2039	60	11	70	**4733**
6-Jan-08	Sunday	796	500	976	13	168	2165	56	21	85	**4780**
7-Jan-08	Monday	707	393	1028	17	176	2116	64	20	81	**4602**
8-Jan-08	Tuesday	688	361	857	26	161	2085	57	12	61	**4308**
9-Jan-08	Wednesday	722	838	1108	16	151	2070	59	13	90	**5067**
10-Jan-08	Thursday	792	1445	1329	20	161	2149	49	12	93	**6050**
11-Jan-08	Friday	858	460	1282	17	139	2072	43	15	67	**4953**
12-Jan-08	Saturday	745	447	1130	11	121	1974	33	3	75	**4539**
13-Jan-08	Sunday	778	368	1042	30	179	2108	33	16	76	**4630**
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
1-Jun-08	Sunday	1030	783	2186	33	244	3504	52	5	86	**7923**
2-Jun-08	Monday	868	637	2186	22	244	3422	58	5	87	**7529**
3-Jun-08	Tuesday	1043	735	2189	29	233	3497	60	4	84	**7874**
4-Jun-08	Wednesday	921	690	2199	32	230	3293	61	8	69	**7503**
5-Jun-08	Thursday	1159	1010	2653	19	248	3538	60	4	95	**8786**
6-Jun-08	Friday	1134	726	3070	35	231	3386	60	4	78	**8724**
7-Jun-08	Saturday	1061	830	2256	33	250	3275	78	6	92	**7881**
8-Jun-08	Sunday	994	664	2251	28	292	4033	65	9	98	**8434**
9-Jun-08	Monday	1055	824	2106	25	293	3627	76	11	96	**8113**
10-Jun-08	Tuesday	974	898	1939	24	236	3164	75	5	81	**7396**
11-Jun-08	Wednesday	1033	790	2003	25	205	3116	84	10	60	**7326**
12-Jun-08	Thursday	1204	869	2184	42	260	3421	71	3	94	**8148**
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
24-Sep-08	Wednesday	1319	751	923	18	177	2256	43	8	60	**5555**
25-Sep-08	Thursday	1438	951	962	28	174	2405	38	16	71	**6083**
26-Sep-08	Friday	1405	826	1272	13	198	2263	48	7	54	**6086**
27-Sep-08	Saturday	1340	865	949	14	175	2105	28	5	72	**5553**
28-Sep-08	Sunday	1409	781	1072	17	173	2124	22	6	53	**5657**
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
23-Dec-08	Tuesday	1317	786	1041	10	177	2211	44	7	81	**5674**
24-Dec-08	Wednesday	1358	673	1065	14	162	2203	43	7	70	**5595**

** Data Source: Sigma-RCL JV.*

** Class I= Motor Cycle /Baby Taxi/ Mishuk, Class II= Maxi/ Pick-up/ Tampo, ClassIII= Car/Jeep/Station Wagon/ Micro, Class IV= Coaster/Tractor/Tractor with Trailer, Class V=Mini Bus/Mini Truck, Class VI=Bus/Truck/Covered Truck 2 Axle, Class VII= Bus/Truck/Covered Truck 3 Axle, Class VIII=Trailer Truck/Construction Equipment, Class IX=Toll Free Vehicles.*

Table A16: Daily Traffic Flow Volume in 2009 on Bhairab Bridge (Both Direction)

Date	Day	Class I	Class II	Class III	Class IV	Class V	Class VI	Class VII	Class VIII	Class IX	Total Vehicle
15-Jan-09	Thursday	1126	359	1378	15	163	2495	50	8	81	**5675**
16-Jan-09	Friday	1276	329	1588	12	133	2253	60	8	61	**5720**
17-Jan-09	Saturday	1139	384	1302	23	137	2101	65	12	62	**5225**
18-Jan-09	Sunday	973	323	1207	19	112	1845	348	8	74	**4909**
19-Jan-09	Monday	904	310	1108	18	162	2258	50	6	99	**4915**
20-Jan-09	Tuesday	929	309	987	64	177	2285	65	4	70	**4890**
21-Jan-09	Wednesday	894	285	1048	5	174	2164	325	14	80	**4989**
22-Jan-09	Thursday	424	74	675	4	83	1231	34	5	59	**2589**
23-Jan-09	Friday	1212	357	1558	23	106	1716	43	5	77	**5097**
24-Jan-09	Saturday	1081	324	1240	16	149	2005	47	3	75	**4940**
25-Jan-09	Sunday	1271	367	1477	35	209	2708	62	9	91	**6229**
26-Jan-09	Monday	952	308	1084	23	193	2282	66	10	87	**5005**
27-Jan-09	Tuesday	1003	311	1160	15	190	2288	69	13	60	**5109**
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
1-Aug-09	Saturday	1442	317	1433	25	257	2046	25	1	73	5619
2-Aug-09	Sunday	1328	410	1244	19	234	2186	23	0	70	5514
3-Aug-09	Monday	1188	415	1209	20	258	2195	38	1	70	5394
4-Aug-09	Tuesday	1369	351	1158	34	264	2258	19	2	71	5526
5-Aug-09	Wednesday	1286	359	1224	19	262	2295	30	0	51	5526
6-Aug-09	Thursday	1429	413	1251	39	230	2112	34	2	57	5567
7-Aug-09	Friday	1572	336	1524	23	176	1800	25	2	45	5503
8-Aug-09	Saturday	1511	362	1422	38	204	2128	27	1	52	5745
9-Aug-09	Sunday	1517	319	1320	32	210	2367	31	1	62	5859
10-Aug-09	Monday	1227	388	1602	39	225	2323	36	0	51	5891
11-Aug-09	Tuesday	1417	410	1462	34	253	2427	36	2	49	6090
12-Aug-09	Wednesday	1571	423	1656	46	258	2468	38	1	55	6516
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
20-Oct-09	Tuesday	1453	351	1137	17	223	2374	70	3	67	5695
21-Oct-09	Wednesday	1444	308	1070	24	211	2306	63	1	56	5483
22-Oct-09	Thursday	1368	411	1256	33	273	2387	49	4	70	5851
23-Oct-09	Friday	1579	328	1741	27	240	2301	66	4	66	6352
24-Oct-09	Saturday	1346	344	1273	27	208	2245	52	4	71	5570
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
30-Dec-09	Wednesday	1488	368	1602	17	232	2529	63	2	85	6386
31-Dec-09	Thursday	1613	435	1678	37	252	2536	72	8	60	6691

** Data Source: Sigma-RCL JV.*

** Class I= Motor Cycle /Baby Taxi/ Mishuk, Class II= Maxi/ Pick-up/ Tampo, ClassIII= Car/Jeep/Station Wagon/ Micro, Class IV= Coaster/Tractor/Tractor with Trailer, Class V=Mini Bus/Mini Truck, Class VI=Bus/Truck/Covered Truck 2 Axle, Class VII= Bus/Truck/Covered Truck 3 Axle, Class VIII=Trailer Truck/Construction Equipment, Class IX=Toll Free Vehicles.*

Table A17: Daily Traffic Flow Volume in May 2007 on Bhairab Bridge

(Both Direction)

Date	Day	Class I	Class II	Class III	Class IV	Class V	Class VI	Class VII	Class VIII	Class IX	Total Vehicle
1-May-07	Tuesday	693	173	797	22	153	1915	55	10	75	3893
2-May-07	Wednesday	598	160	721	15	123	1833	48	14	86	3598
3-May-07	Thursday	659	209	657	27	170	2061	33	12	71	3899
4-May-07	Friday	689	187	828	21	182	1933	41	6	63	3950
5-May-07	Saturday	664	201	610	5	179	1846	36	6	58	3605
6-May-07	Sunday	620	187	611	16	153	1881	36	2	66	3572
7-May-07	Monday	588	213	600	12	167	1950	26	3	79	3638
8-May-07	Tuesday	593	212	535	20	147	1916	33	6	101	3563
9-May-07	Wednesday	575	164	594	13	162	1919	37	1	120	3585
10-May-07	Thursday	650	195	615	17	204	2068	31	0	81	3861
11-May-07	Friday	726	209	850	19	160	1939	47	1	77	4028
12-May-07	Saturday	665	197	619	14	152	1894	46	2	92	3681
13-May-07	Sunday	661	176	719	19	153	2004	47	2	79	3860
14-May-07	Monday	557	203	606	25	151	1894	41	3	75	3555
15-May-07	Tuesday	535	191	565	17	140	1865	32	1	88	3434
16-May-07	Wednesday	620	206	621	22	169	1959	45	4	91	3737
17-May-07	Thursday	667	213	735	16	195	2112	32	4	83	4057
18-May-07	Friday	710	228	919	15	188	1904	29	3	62	4058
19-May-07	Saturday	680	190	689	6	179	1838	30	7	76	3695
20-May-07	Sunday	626	200	673	15	166	1886	21	5	76	3668
21-May-07	Monday	606	210	651	19	164	1793	24	3	81	3551
22-May-07	Tuesday	619	164	605	21	165	1862	39	3	87	3565
23-May-07	Wednesday	583	179	637	17	142	1915	27	8	82	3590
24-May-07	Thursday	677	224	773	14	163	1920	36	5	74	3886
25-May-07	Friday	701	186	979	3	164	1920	37	3	71	4064
26-May-07	Saturday	701	205	724	18	143	1806	27	1	82	3707
27-May-07	Sunday	604	201	636	13	173	1855	24	4	79	3589
28-May-07	Monday	610	243	657	19	192	1890	26	3	90	3730
29-May-07	Tuesday	603	219	526	21	163	1893	29	2	83	3539
30-May-07	Wednesday	608	223	590	10	173	1952	27	6	76	3665
31-May-07	Thursday	641	257	785	22	157	2013	35	11	72	3993
TOTAL		**19729**	**6225**	**21127**	**513**	**5092**	**59436**	**1077**	**141**	**2476**	**115816**

** Data Source: Sigma-RCL JV.*

** Class I= Motor Cycle /Baby Taxi/ Mishuk, Class II= Maxi/ Pick-up/ Tampo, ClassIII= Car/Jeep/Station Wagon/ Micro, Class IV= Coaster/Tractor/Tractor with Trailer, Class V=Mini Bus/Mini Truck, Class VI=Bus/Truck/Covered Truck 2 Axle, Class VII= Bus/Truck/Covered Truck 3 Axle, Class VIII=Trailer Truck/Construction Equipment, Class IX=Toll Free Vehicles.*

Table A18: Daily Traffic Flow Volume in August 2009 on Bhairab Bridge (Both Direction)

Date	Day	Class I	Class II	Class III	Class IV	Class V	Class VI	Class VII	Class VIII	Class IX	Total Vehicle
1-Aug-09	Saturday	1442	317	1433	25	257	2046	25	1	73	**5619**
2-Aug-09	Sunday	1328	410	1244	19	234	2186	23	0	70	**5514**
3-Aug-09	Monday	1188	415	1209	20	258	2195	38	1	70	**5394**
4-Aug-09	Tuesday	1369	351	1158	34	264	2258	19	2	71	**5526**
5-Aug-09	Wednesday	1286	359	1224	19	262	2295	30	0	51	**5526**
6-Aug-09	Thursday	1429	413	1251	39	230	2112	34	2	57	**5567**
7-Aug-09	Friday	1572	336	1524	23	176	1800	25	2	45	**5503**
8-Aug-09	Saturday	1511	362	1422	38	204	2128	27	1	52	**5745**
9-Aug-09	Sunday	1517	319	1320	32	210	2367	31	1	62	**5859**
10-Aug-09	Monday	1227	388	1602	39	225	2323	36	0	51	**5891**
11-Aug-09	Tuesday	1417	410	1462	34	253	2427	36	2	49	**6090**
12-Aug-09	Wednesday	1571	423	1656	46	258	2468	38	1	55	**6516**
13-Aug-09	Thursday	1778	493	2371	48	269	2416	36	2	51	**7464**
14-Aug-09	Friday	1756	447	2357	37	260	2381	30	1	48	**7317**
15-Aug-09	Saturday	1596	299	2065	22	208	2209	47	2	68	**6516**
16-Aug-09	Sunday	1506	340	1556	34	210	2166	43	0	49	**5904**
17-Aug-09	Monday	1389	325	1385	20	258	2238	60	0	57	**5732**
18-Aug-09	Tuesday	1240	359	1406	27	255	2297	48	1	68	**5701**
19-Aug-09	Wednesday	1450	351	1495	32	259	2364	58	2	65	**6076**
20-Aug-09	Thursday	1602	431	1747	31	273	2379	52	0	57	**6572**
21-Aug-09	Friday	1626	380	1896	20	300	2334	45	2	60	**6663**
22-Aug-09	Saturday	1467	358	1226	42	263	2170	39	0	56	**5621**
23-Aug-09	Sunday	1068	290	903	28	221	2152	55	0	47	**4764**
24-Aug-09	Monday	1057	352	1001	30	255	2085	60	2	42	**4884**
25-Aug-09	Tuesday	1143	272	973	30	219	2172	65	1	41	**4916**
26-Aug-09	Wednesday	1190	298	1049	16	221	2085	43	0	71	**4973**
27-Aug-09	Thursday	1136	343	1063	23	204	2114	49	0	66	**4998**
28-Aug-09	Friday	1258	307	1246	23	236	2077	56	0	49	**5252**
29-Aug-09	Saturday	1213	305	1129	16	217	2049	43	2	43	**5017**
30-Aug-09	Sunday	1089	274	1051	12	190	2135	63	2	52	**4868**
31-Aug-09	Monday	1206	337	1019	18	216	2094	61	0	48	**4999**
TOTAL		**42627**	**11064**	**43443**	**877**	**7365**	**68522**	**1315**	**30**	**1744**	**176987**

** Data Source: Sigma-RCL JV.*

** Class I= Motor Cycle /Baby Taxi/ Mishuk, Class II= Maxi/ Pick-up/ Tampo, ClassIII= Car/Jeep/Station Wagon/ Micro, Class IV= Coaster/Tractor/Tractor with Trailer, Class V=Mini Bus/Mini Truck, Class VI=Bus/Truck/Covered Truck 2 Axle, Class VII= Bus/Truck/Covered Truck 3 Axle, Class VIII=Trailer Truck/Construction Equipment, Class IX=Toll Free Vehicles.*

Table A19: Daily Traffic Flow Volume in 2006 on Meghna-Gomoti Bridge (Both Direction)

Date	Day	Motor Cycle	Scooter/ Tampo	Car/ Jeep	Micro/ Pickup	Mini bus/ Coaster	Bus	Truck	Trailer	Toll Free Vehicle	Total Traffic
1-Jan-06	saturday	8	36	843	1180	902	1020	3132	78	313	**7512**
2-Jan-06	sunday	10	38	828	1143	867	1037	3258	70	306	**7557**
3-Jan-06	monday	8	37	801	1091	900	998	3185	180	317	**7517**
4-Jan-06	tuesday	5	28	836	1053	768	951	3558	112	244	**7555**
5-Jan-06	wednesday	8	47	913	1103	953	1048	3763	119	328	**8282**
6-Jan-06	thursday	16	39	1133	1416	890	1068	3860	140	287	**8849**
7-Jan-06	friday	19	30	1217	1535	963	1235	3054	105	352	**8510**
8-Jan-06	saturday	29	41	1176	1543	1084	1334	3419	141	334	**9101**
9-Jan-06	sunday	46	67	2123	2105	1656	1441	3756	151	443	**11788**
10-Jan-06	monday	25	369	3640	2340	2605	1763	2647	71	488	**13948**
11-Jan-06	tuesday	25	62	1528	1106	905	838	337	5	264	**5070**
12-Jan-06	wednesday	39	91	1806	1149	888	1001	152	1	426	**5553**
13-Jan-06	thursday	62	43	1939	1317	1056	1180	180	5	374	**6156**
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
17-Apr-06	sunday	22	33	903	1039	1177	1216	3385	114	351	**8240**
18-Apr-06	monday	11	32	782	832	1236	1273	3323	157	290	**7936**
19-Apr-06	tuesday	24	28	949	999	1192	1388	3663	144	347	**8734**
20-Apr-06	wednesday	18	27	471	605	396	570	3081	126	205	**5499**
21-Apr-06	thursday	58	51	1806	1476	1205	1362	3083	182	430	**9653**
22-Apr-06	friday	36	58	1137	1072	1211	1426	2358	132	414	**7844**
23-Apr-06	saturday	26	31	433	515	435	570	3047	118	255	**5430**
24-Apr-06	sunday	24	42	959	1004	1173	1373	3192	141	344	**8252**
25-Apr-06	monday	27	35	872	873	1095	1239	3565	160	384	**8250**
26-Apr-06	tuesday	19	54	805	744	1024	1214	3554	159	262	**7835**
27-Apr-06	wednesday	14	32	906	835	1239	1397	3483	177	343	**8426**
28-Apr-06	thursday	27	80	1571	1286	1088	1262	3279	176	360	**9129**
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
15-Oct-06	saturday	24	35	1149	1346	1205	1499	4223	155	362	**9998**
16-Oct-06	sunday	26	22	1117	1585	1216	1506	4496	181	368	**10517**
17-Oct-06	monday	22	30	1058	1462	1250	1424	4642	246	389	**10523**
18-Oct-06	tuesday	14	38	1245	1517	1345	1518	4706	243	367	**10993**
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
25-Dec-06	sunday	28	26	1652	2034	1163	1471	4318	129	341	11162
26-Dec-06	monday	23	32	1644	2150	1355	1646	3728	112	339	11029
27-Dec-06	tuesday	20	34	1487	1864	1252	1523	4540	133	345	11198
28-Dec-06	wednesday	40	35	1609	1951	1379	1716	4639	166	374	11909
29-Dec-06	thursday	88	73	2728	2733	1622	1933	4834	240	419	14670
30-Dec-06	friday	95	135	3575	3411	2370	2291	4138	260	533	16808
31-Dec-06	saturday	97	578	4705	3478	3474	2596	2750	103	548	18329

** Data Source: RCL.*

Table A20: Daily Traffic Flow Volume in 2008 on Meghna-Gomoti Bridge (Both Direction)

Date	Day	Motor Cycle	Scooter/ Tampo	Car/ Jeep	Micro/ Pickup	Mini bus/ Coaster	Bus	Truck	Trailer	Toll Free Vehicle	Total Traffic
1-Jan-08	Tuesday	60	305	1364	1752	1612	2140	4455	265	495	**12448**
2-Jan-08	Wednesday	67	321	1512	2057	1580	2115	4629	232	516	**13029**
3-Jan-08	Thursday	68	275	1689	1876	1621	2068	4661	258	689	**13205**
4-Jan-08	Friday	119	313	2622	2737	1618	2182	4661	346	555	**15153**
5-Jan-08	Saturday	84	325	1879	2404	1631	2311	3908	184	556	**13282**
6-Jan-08	Sunday	59	290	1476	2102	1585	2161	4451	227	486	**12837**
7-Jan-08	Monday	55	256	1587	2288	1503	2123	4446	273	532	**13063**
8-Jan-08	Tuesday	55	333	1475	2191	1520	2062	4674	230	511	**13051**
9-Jan-08	Wednesday	58	273	1545	2232	1536	2091	5050	376	589	**13750**
10-Jan-08	Thursday	68	292	1723	2094	1600	2239	4721	320	575	**13632**
11-Jan-08	Friday	93	326	2784	3028	1544	2214	4808	331	571	**15699**
12-Jan-08	Saturday	79	309	1884	2199	1591	2290	3899	255	597	**13103**
13-Jan-08	Sunday	58	305	1603	2060	1554	2237	4718	289	517	**13341**
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
17-May-08	Saturday	107	51	335	453	1374	2129	3629	321	351	**8750**
18-May-08	Sunday	93	63	252	428	1304	1922	4054	321	337	**8774**
19-May-08	Monday	108	84	360	449	1320	1934	4221	310	271	**9057**
20-May-08	Tuesday	87	74	184	294	921	1293	3040	219	271	**6383**
21-May-08	Wednesday	81	91	199	218	497	365	3345	205	184	**5185**
22-May-08	Thursday	147	142	319	463	871	459	4791	316	264	**7772**
23-May-08	Friday	191	154	448	487	1139	1304	4553	348	301	**8925**
24-May-08	Saturday	143	82	365	508	1204	1750	3705	322	275	**8354**
25-May-08	Sunday	98	74	288	509	1177	1576	4385	334	303	**8744**
26-May-08	Monday	53	64	214	366	856	929	3487	231	230	**6430**
27-May-08	Tuesday	68	55	200	249	442	211	3605	209	195	**5234**
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
14-Sep-08	Sunday	69	673	1214	1604	1217	1692	4339	339	506	**11653**
15-Sep-08	Monday	56	711	1297	1814	1210	1684	4685	308	489	**12254**
16-Sep-08	Tuesday	65	688	1213	1803	1190	1637	5099	307	527	**12529**
17-Sep-08	Wednesday	68	757	1236	1789	1159	1660	4938	399	474	**12480**
18-Sep-08	Thursday	74	825	1527	1799	1243	1737	4993	392	534	**13124**
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
25-Dec-08	Thursday	134	816	3162	2391	1368	2223	5553	461	606	16714
26-Dec-08	Friday	127	789	3173	2225	1147	2018	4614	325	572	14990
27-Dec-08	Saturday	123	967	2835	1854	1159	2166	3123	224	661	13112
28-Dec-08	Sunday	36	1214	2803	1321	1335	2362	4014	310	684	14079
29-Dec-08	Monday	16	65	674	346	109	228	520	46	154	2158
30-Dec-08	Tuesday	69	696	2096	1803	1162	1694	1604	139	560	9823
31-Dec-08	Wednesday	98	711	1844	2175	1549	2090	3421	376	695	12959

* *Data Source: RCL.*

Table A21: Daily Traffic Flow Volume in May 2007 on Meghna-Gomoti Bridge (Both Direction)

Date	Day	Motor Cycle	Scooter/ Tampo	Car/ Jeep	Micro/ Pickup	Mini bus/ Coaster	Bus	Truck	Trailer	Toll Free Vehicle	Total Traffic
1-May-07	Tuesday	89	199	1894	1684	1467	1671	4333	277	428	**12042**
2-May-07	Wednesday	60	211	1679	1779	1476	1783	3139	169	463	**10759**
3-May-07	Thursday	53	190	1442	1666	1608	1892	3788	131	529	**11299**
4-May-07	Friday	121	212	2329	2237	1538	1826	4099	208	493	**13063**
5-May-07	Saturday	61	203	1580	1590	1612	1951	3214	166	550	**10927**
6-May-07	Sunday	60	181	1317	1576	1554	1852	4071	234	481	**11326**
7-May-07	Monday	39	160	1221	1525	1457	1718	4809	307	426	**11662**
8-May-07	Tuesday	54	165	1116	1358	1362	1661	5075	280	399	**11470**
9-May-07	Wednesday	40	200	1236	1622	1572	1748	5180	306	504	**12408**
10-May-07	Thursday	69	193	1488	1609	1727	1950	4741	265	535	**12577**
11-May-07	Friday	137	221	2347	2160	1619	1872	4716	314	502	**13888**
12-May-07	Saturday	76	191	1567	1547	1672	1928	3763	159	534	**11437**
13-May-07	Sunday	58	178	1141	1579	1505	1804	4737	214	464	**11680**
14-May-07	Monday	40	209	1268	1648	1553	1795	4423	223	416	**11575**
15-May-07	Tuesday	35	181	1224	1462	1500	1749	4312	313	396	**11172**
16-May-07	Wednesday	46	224	1330	1636	1538	1832	4528	316	508	**11958**
17-May-07	Thursday	57	246	1775	1799	1722	2051	4669	252	532	**13103**
18-May-07	Friday	114	267	2542	2525	1711	2031	4468	317	541	**14516**
19-May-07	Saturday	74	241	1703	1891	1625	1985	3354	214	537	**11624**
20-May-07	Sunday	38	179	1330	1649	1599	1976	4217	259	464	**11711**
21-May-07	Monday	62	208	1348	1832	1568	1897	4409	188	461	**11973**
22-May-07	Tuesday	35	227	1266	1432	1565	1886	4759	218	461	**11849**
23-May-07	Wednesday	42	236	1464	1687	1592	1835	4793	259	497	**12405**
24-May-07	Thursday	69	207	1594	1774	1688	2019	4378	332	567	**12628**
25-May-07	Friday	114	227	2728	2639	1687	1986	4390	314	548	**14633**
26-May-07	Saturday	77	217	1792	1893	1703	2015	3425	213	548	**11883**
27-May-07	Sunday	59	205	1396	1657	1633	1949	4212	243	487	**11841**
28-May-07	Monday	43	206	1253	1671	1505	1852	4425	233	448	**11636**
29-May-07	Tuesday	35	213	1213	1395	1535	1827	4445	251	477	**11391**
30-May-07	Wednesday	52	214	1229	1605	1583	1842	4786	183	496	**11990**
31-May-07	Thursday	65	222	1521	1837	1676	2014	4503	233	552	**12623**
TOTAL		**1974**	**6433**	**48333**	**53964**	**49152**	**58197**	**134161**	**7591**	**15244**	**375049**

** Data Source: RCL.*

Table A22: Daily Traffic Flow Volume in August 2008 on Meghna-Gomoti Bridge (Both Direction)

Date	Day	Motor Cycle	Scooter/ Tampo	Car/ Jeep	Micro/ Pickup	Mini bus/ Coaster	Bus	Truck	Trailer	Toll Free Vehicle	Total Traffic
1-Aug-08	Friday	146	882	2517	2736	1434	2070	4853	346	609	**15593**
2-Aug-08	Saturday	101	835	1823	2017	1482	2104	3479	179	643	**12663**
3-Aug-08	Sunday	71	744	1352	1895	1404	2051	4197	311	529	**12554**
4-Aug-08	Monday	81	745	1403	1920	1388	1897	4178	210	558	**12380**
5-Aug-08	Tuesday	61	734	1319	1850	1427	1880	4551	284	566	**12672**
6-Aug-08	Wednesday	79	803	1341	2065	1420	1955	5083	371	541	**13658**
7-Aug-08	Thursday	92	773	1716	2331	1542	2150	5028	392	551	**14575**
8-Aug-08	Friday	145	851	2686	2980	1482	2105	4719	367	583	**15918**
9-Aug-08	Saturday	87	792	1820	1843	1471	2129	3706	220	587	**12655**
10-Aug-08	Sunday	48	743	1382	1828	1348	1986	4255	303	488	**12381**
11-Aug-08	Monday	62	721	1419	1886	1279	1938	4530	331	470	**12636**
12-Aug-08	Tuesday	83	728	1373	1823	1330	1920	4852	359	514	**12982**
13-Aug-08	Wednesday	62	766	1374	1882	1375	1961	5174	377	537	**13508**
14-Aug-08	Thursday	128	867	1719	1974	1647	2257	5129	376	670	**14767**
15-Aug-08	Friday	149	920	2742	2936	1619	2240	5240	428	587	**16861**
16-Aug-08	Saturday	116	782	1498	1786	1363	1883	3516	186	558	**11688**
17-Aug-08	Sunday	108	682	1836	1939	1287	1980	2608	205	578	**11223**
18-Aug-08	Monday	51	690	1307	1816	1557	2194	2384	136	524	**10659**
19-Aug-08	Tuesday	70	758	1158	1725	1397	2008	3970	256	508	**11850**
20-Aug-08	Wednesday	60	891	1349	1760	1443	2032	4677	331	403	**12946**
21-Aug-08	Thursday	110	893	1817	2251	1587	2211	5274	370	611	**15124**
22-Aug-08	Friday	156	986	2958	3042	1558	2138	5085	378	650	**16951**
23-Aug-08	Saturday	101	827	1931	2003	1502	2079	3723	193	645	**13004**
24-Aug-08	Sunday	94	855	2214	2231	1415	2158	4266	376	629	**14238**
25-Aug-08	Monday	69	822	1567	2018	1465	2157	3741	216	595	**12650**
26-Aug-08	Tuesday	69	800	1485	1936	1393	2017	4562	317	601	**13180**
27-Aug-08	Wednesday	65	860	1550	1976	1406	2013	5509	296	628	**14303**
28-Aug-08	Thursday	96	866	1683	2233	1567	2171	5166	426	643	**14851**
29-Aug-08	Friday	120	932	2872	3117	1537	2148	4882	364	644	**16616**
30-Aug-08	Saturday	110	936	1995	2242	1602	2187	3786	204	674	**13736**
31-Aug-08	Sunday	85	835	1607	2125	1542	2112	4636	417	617	**13976**
TOTAL		**2875**	**25319**	**54813**	**66166**	**45269**	**64131**	**136759**	**9525**	**17941**	**422798**

** Data Source: RCL.*

Table A23: Daily Traffic Flow Volume in December 2009 on Meghna-Gomoti Bridge (Both Direction)

Date	Day	Motor Cycle	Scooter/ Tampo	Car/ Jeep	Micro/ Pickup	Mini bus/ Coaster	Bus	Truck	Trailer	Toll Free Vehicle	Total Traffic
1-Dec-09	Tuesday	141	921	3089	3761	1532	2430	6061	495	625	**19055**
2-Dec-09	Wednesday	113	757	2441	3086	1379	2299	3390	230	699	**14394**
3-Dec-09	Thursday	85	760	1919	3051	1363	2151	4640	208	681	**14858**
4-Dec-09	Friday	73	709	1767	2700	1392	2064	5285	257	627	**14874**
5-Dec-09	Saturday	88	761	1601	2457	1356	1865	6019	388	535	**15070**
6-Dec-09	Sunday	82	758	1905	2924	1405	2090	6268	378	572	**16382**
7-Dec-09	Monday	121	942	2141	2898	1534	2085	6174	413	667	**16975**
8-Dec-09	Tuesday	143	1062	3395	3966	1570	2148	6031	392	698	**19405**
9-Dec-09	Wednesday	145	885	2541	3242	1559	2189	4049	277	818	**15705**
10-Dec-09	Thursday	109	789	1969	3279	1558	2269	5343	256	633	**16205**
11-Dec-09	Friday	128	790	1842	2855	1473	2120	5546	337	631	**15722**
12-Dec-09	Saturday	74	775	1796	2649	1446	2080	6031	367	588	**15806**
13-Dec-09	Sunday	38	777	1866	2848	1454	2104	6354	474	675	**16590**
14-Dec-09	Monday	121	843	2120	2915	1558	2232	5702	330	710	**16531**
15-Dec-09	Tuesday	197	1033	3371	3762	1535	2340	5799	404	731	**19172**
16-Dec-09	Wednesday	127	803	2436	3131	1394	2216	3946	252	701	**15006**
17-Dec-09	Thursday	74	861	1981	3122	1562	2194	4777	196	356	**15123**
18-Dec-09	Friday	86	743	1892	2759	1479	2094	5359	234	424	**15070**
19-Dec-09	Saturday	95	716	1723	2619	1402	2037	5441	333	413	**14779**
20-Dec-09	Sunday	70	770	1944	2704	1632	2257	5909	441	425	**16152**
21-Dec-09	Monday	107	845	1943	2643	1698	2338	5389	416	545	**15924**
22-Dec-09	Tuesday	186	971	3017	3701	1577	2365	5808	412	601	**18638**
23-Dec-09	Wednesday	125	793	2344	3092	1456	2233	4039	242	657	**14981**
24-Dec-09	Thursday	118	879	1748	2810	1693	2293	4712	232	374	**14859**
25-Dec-09	Friday	95	838	1796	2683	1785	2331	5013	306	211	**15058**
26-Dec-09	Saturday	109	832	1764	2870	1677	2030	5849	386	168	**15685**
27-Dec-09	Sunday	91	801	1955	2993	1698	2073	6186	418	150	**16365**
28-Dec-09	Monday	128	810	1960	2737	1772	2221	5740	355	134	**15857**
29-Dec-09	Tuesday	170	910	3426	3839	1850	2254	5881	422	168	**18920**
30-Dec-09	Wednesday	129	773	2108	2888	1649	2190	4002	224	172	**14135**
31-Dec-09	Thursday	131	721	1782	2907	1657	2275	4903	262	162	**14800**
TOTAL		**3499**	**25628**	**67582**	**93891**	**48095**	**67867**	**165646**	**10337**	**15551**	**498096**

** Data Source: MBBL-ATT JV.*

Table A24: Daily Traffic Flow Volume in January 2010 on First Dhaleshari Bridge (Dhaka-Mawa Direction)

Date	Day	Truck	Bus	Mini Bus	Micro/ Pickup	Jeep/ Car	Tempo/ Auto Rickshaw	Motor Cycle	Van/ Bicycle	Total Traffic
1-Jan-10	Friday	194	201	866	625	1269	151	110	51	**3467**
2-Jan-10	Saturday	250	195	905	410	579	95	85	70	**2589**
3-Jan-10	Sunday	216	207	980	240	561	132	70	50	**2456**
4-Jan-10	Monday	224	190	862	400	503	114	59	40	**2392**
5-Jan-10	Tuesday	266	190	701	410	600	127	72	53	**2419**
6-Jan-10	Wednesday	250	190	836	350	476	110	65	50	**2327**
7-Jan-10	Thursday	281	205	1060	376	744	140	72	45	**2923**
8-Jan-10	Friday	190	203	990	533	1094	150	85	55	**3300**
9-Jan-10	Saturday	256	204	917	384	641	127	73	47	**2649**
10-Jan-10	Sunday	275	203	932	331	534	110	60	45	**2490**
11-Jan-10	Monday	269	201	788	466	600	127	75	56	**2582**
12-Jan-10	Tuesday	250	200	884	350	440	115	71	60	**2370**
13-Jan-10	Wednesday	279	201	799	350	610	127	72	44	**2482**
14-Jan-10	Thursday	280	205	1038	447	716	115	75	62	**2938**
15-Jan-10	Friday	158	207	871	633	1387	148	105	52	**3561**
16-Jan-10	Saturday	250	190	913	350	625	95	70	55	**2548**
17-Jan-10	Sunday	264	190	776	400	522	132	82	54	**2420**
18-Jan-10	Monday	245	185	792	345	558	115	75	55	**2370**
19-Jan-10	Tuesday	266	180	708	425	425	122	71	48	**2245**
20-Jan-10	Wednesday	270	203	772	415	525	120	70	57	**2432**
21-Jan-10	Thursday	305	210	1010	371	692	139	74	55	**2856**
22-Jan-10	Friday	215	208	925	527	1060	125	70	51	**3181**
23-Jan-10	Saturday	288	202	908	495	320	180	50	40	**2483**
24-Jan-10	Sunday	201	225	1159	301	602	152	75	46	**2761**
25-Jan-10	Monday	275	205	1010	450	550	168	72	60	**2790**
26-Jan-10	Tuesday	302	190	1159	410	520	180	48	49	**2858**
27-Jan-10	Wednesday	298	230	955	430	825	175	81	53	**3047**
28-Jan-10	Thursday	310	225	1060	550	800	170	80	62	**3257**
29-Jan-10	Friday	235	208	1320	742	1007	202	51	45	**3810**
30-Jan-10	Saturday	296	205	908	353	1080	125	68	43	**3078**
31-Jan-10	Sunday	290	205	999	410	525	110	75	46	**2660**
TOTAL		**7948**	**6263**	**28803**	**13279**	**21390**	**4198**	**2261**	**1599**	**85741**

** Data Source: Keraniganj Road Sub-Division, RHD.*

Table A25: Daily Traffic Flow Volume in January 2010 on Second Dhaleshari Bridge (Mawa-Dhaka Direction)

Date	Day	Truck	Bus	Mini Bus	Micro/ Pickup	Jeep/ Car	Tempo/ Auto Rickshaw	Motor Cycle	Van/ Bicycle	Total Traffic
1-Jan-10	Friday	205	185	805	600	746	154	80	23	**2798**
2-Jan-10	Saturday	170	186	801	580	472	165	60	25	**2459**
3-Jan-10	Sunday	140	150	700	406	511	150	100	27	**2184**
4-Jan-10	Monday	141	151	700	400	558	140	80	42	**2212**
5-Jan-10	Tuesday	155	180	750	425	400	150	80	34	**2174**
6-Jan-10	Wednesday	160	185	775	405	696	160	75	42	**2498**
7-Jan-10	Thursday	166	180	775	405	861	162	75	42	**2666**
8-Jan-10	Friday	200	190	825	650	1105	160	80	49	**3259**
9-Jan-10	Saturday	182	170	724	403	803	160	46	78	**2566**
10-Jan-10	Sunday	181	167	726	402	787	166	60	52	**2541**
11-Jan-10	Monday	182	171	725	404	791	157	75	49	**2554**
12-Jan-10	Tuesday	150	170	768	404	777	170	70	55	**2564**
13-Jan-10	Wednesday	150	170	768	414	777	170	70	53	**2572**
14-Jan-10	Thursday	201	188	864	476	580	201	40	31	**2581**
15-Jan-10	Friday	254	190	869	550	760	230	40	32	**2925**
16-Jan-10	Saturday	175	188	785	440	548	152	32	32	**2352**
17-Jan-10	Sunday	168	178	750	425	405	150	80	34	**2190**
18-Jan-10	Monday	174	175	767	420	400	150	81	33	**2200**
19-Jan-10	Tuesday	182	175	760	420	420	148	80	34	**2219**
20-Jan-10	Wednesday	200	180	758	370	600	180	50	42	**2380**
21-Jan-10	Thursday	204	175	841	464	570	192	47	29	**2522**
22-Jan-10	Friday	210	200	878	600	1100	100	40	33	**3161**
23-Jan-10	Saturday	205	185	860	500	634	190	50	41	**2665**
24-Jan-10	Sunday	204	175	841	464	570	192	47	30	**2523**
25-Jan-10	Monday	222	203	712	637	678	203	40	26	**2721**
26-Jan-10	Tuesday	225	205	775	600	617	200	50	41	**2713**
27-Jan-10	Wednesday	169	190	900	525	1283	165	40	34	**3306**
28-Jan-10	Thursday	170	190	900	525	1277	165	40	34	**3301**
29-Jan-10	Friday	225	220	950	625	1296	225	70	52	**3663**
30-Jan-10	Saturday	170	190	900	525	1102	165	40	33	**3125**
31-Jan-10	Sunday	200	198	777	601	680	190	30	24	**2700**
TOTAL		**5740**	**5660**	**24729**	**15065**	**22804**	**5262**	**1848**	**1186**	**82294**

** Data Source: Keraniganj Road Sub-Division, RHD.*

Table A26: Daily Traffic Flow Volume in March 2010 on First & Second Dhaleshari Bridge (Both Direction)

Date	Day	Truck	Bus	Mini Bus	Micro/ Pickup	Jeep/ Car	Tempo/ Auto Rickshaw	Motor Cycle	Van/ Bicycle	Total Traffic
1-Mar-10	Monday	510	388	1838	945	1102	397	128	77	**5385**
2-Mar-10	Tuesday	523	377	1732	1020	1219	420	120	69	**5480**
3-Mar-10	Wednesday	615	410	1721	935	1186	482	95	76	**5520**
4-Mar-10	Thursday	520	352	1768	1029	1149	408	89	71	**5386**
5-Mar-10	Friday	440	385	1508	1558	2400	410	83	67	**6851**
6-Mar-10	Saturday	550	395	1584	1155	1632	540	102	92	**6050**
7-Mar-10	Sunday	483	397	1824	1109	1155	394	110	98	**5570**
8-Mar-10	Monday	485	390	1569	1258	1285	390	95	71	**5543**
9-Mar-10	Tuesday	494	380	1780	1050	1037	375	117	81	**5314**
10-Mar-10	Wednesday	519	368	1652	883	1426	410	130	85	**5473**
11-Mar-10	Thursday	502	400	1939	1186	1493	405	140	117	**6182**
12-Mar-10	Friday	335	421	2138	1620	2369	490	105	79	**7557**
13-Mar-10	Saturday	463	384	1649	1129	1526	396	122	98	**5767**
14-Mar-10	Sunday	440	390	1717	1205	1050	393	90	78	**5363**
15-Mar-10	Monday	408	405	1972	820	992	490	84	69	**5240**
16-Mar-10	Tuesday	458	398	1672	1249	1294	411	103	84	**5669**
17-Mar-10	Wednesday	472	386	1617	1256	1510	404	85	81	**5811**
18-Mar-10	Thursday	516	415	1787	1270	1556	515	85	80	**6224**
19-Mar-10	Friday	436	394	2013	1398	2467	377	122	93	**7300**
20-Mar-10	Saturday	480	375	1649	1165	1591	380	90	75	**5805**
21-Mar-10	Sunday	552	425	1731	900	1131	495	95	84	**5413**
22-Mar-10	Monday	439	341	1603	853	967	330	111	80	**4724**
23-Mar-10	Tuesday	458	381	1609	1164	1045	376	80	61	**5174**
24-Mar-10	Wednesday	454	391	1832	922	1337	398	102	70	**5506**
25-Mar-10	Thursday	509	400	1778	1251	1662	415	126	102	**6243**
26-Mar-10	Friday	461	412	1818	1689	2271	422	97	73	**7243**
27-Mar-10	Saturday	454	420	1913	774	1838	470	107	74	**6050**
28-Mar-10	Sunday	485	378	1894	958	1174	371	115	98	**5473**
29-Mar-10	Monday	471	384	1919	970	1092	364	93	77	**5370**
30-Mar-10	Tuesday	490	400	1865	1160	1756	1400	115	84	**7270**
31-Mar-10	Wednesday	517	398	1566	1178	1151	414	127	130	**5481**
TOTAL		**14939**	**12140**	**54657**	**35059**	**44863**	**13942**	**3263**	**2574**	**181437**

** Data Source: Keraniganj Road Sub-Division, RHD.*

Table A27: Daily Traffic Flow Volume in July 2010 on First & Second Dhaleshari Bridge (Both Direction)

Date	Day	Truck	Bus	Mini Bus	Micro/ Pickup	Jeep/ Car	Tempo/ Auto Rickshaw	Motor Cycle	Van/ Bicycle	Total Traffic
1-Jul-10	Thursday	390	210	299	490	677	290	55	44	**2455**
2-Jul-10	Friday	456	390	1620	1130	2112	379	98	60	**6245**
3-Jul-10	Saturday	455	295	1095	1034	1451	281	102	96	**4809**
4-Jul-10	Sunday	481	310	1451	851	1119	289	77	55	**4633**
5-Jul-10	Monday	486	342	1518	827	1066	333	85	61	**4718**
6-Jul-10	Tuesday	514	284	1704	797	895	276	102	82	**4654**
7-Jul-10	Wednesday	517	293	1686	805	955	271	94	60	**4681**
8-Jul-10	Thursday	555	377	1636	835	1710	421	98	56	**5688**
9-Jul-10	Friday	422	376	1604	1302	2437	410	107	80	**6738**
10-Jul-10	Saturday	497	324	1552	815	1230	231	75	60	**4784**
11-Jul-10	Sunday	511	343	1515	815	921	305	59	44	**4513**
12-Jul-10	Monday	353	302	1616	853	1137	285	104	85	**4735**
13-Jul-10	Tuesday	501	305	1357	852	1017	250	70	53	**4405**
14-Jul-10	Wednesday	530	349	1514	625	893	335	78	50	**4374**
15-Jul-10	Thursday	522	302	1013	1182	1400	388	104	71	**4982**
16-Jul-10	Friday	446	359	1556	1250	2170	358	72	50	**6261**
17-Jul-10	Saturday	495	347	1562	774	1108	347	80	47	**4760**
18-Jul-10	Sunday	452	317	1411	1041	1162	276	102	72	**4833**
19-Jul-10	Monday	456	320	1459	1041	1052	264	67	34	**4693**
20-Jul-10	Tuesday	479	329	1468	775	966	307	68	46	**4438**
21-Jul-10	Wednesday	406	300	1323	861	1176	296	107	81	**4550**
22-Jul-10	Thursday	456	310	1464	972	1245	270	80	56	**4853**
23-Jul-10	Friday	390	335	1517	1297	2099	324	83	52	**6097**
24-Jul-10	Saturday	406	327	1441	927	1280	306	82	69	**4838**
25-Jul-10	Sunday	445	300	1475	817	1041	270	80	63	**4491**
26-Jul-10	Monday	492	327	1554	771	1103	348	87	48	**4730**
27-Jul-10	Tuesday	508	360	1442	1009	1407	404	87	55	**5272**
28-Jul-10	Wednesday	375	313	1549	794	1307	338	95	57	**4828**
29-Jul-10	Thursday	485	328	1463	965	1672	384	88	43	**5428**
30-Jul-10	Friday	472	407	1321	1049	2011	416	110	59	**5845**
31-Jul-10	Saturday	435	280	1128	950	1022	300	85	69	**4269**
TOTAL		**14388**	**10061**	**44313**	**28506**	**40841**	**9952**	**2681**	**1858**	**152600**

** Data Source: Keraniganj Road Sub-Division, RHD.*

Table A28: Axle Load Control Station Batholi, Manikgonj
Monthly Overload Truck Status report (Manikgonj Side)
For the month of February 2012

Towards SL No.	Date	Towards	Vehicle Number	Weight-As per Axle Number										Total Weight
				1	2	3	4	5	6	7	8	9	10	
1	February 1, 2012	Manikgonj	DHA-MA-TA--12-4159	7.5	14.6	0	0	0	0	0	0	0	0	22.1
2	February 1, 2012	Manikgonj	DHA-MA-TA-14-3003	9.6	20.5	0	0	0	0	0	0	0	0	30.1
3	February 1, 2012	Manikgonj	JESS-TA-11-1202	5.8	15.1	0	0	0	0	0	0	0	0	20.9
4	February 1, 2012	Manikgonj	DHA-MA-TA-11-1208	6.4	15.9	0	0	0	0	0	0	0	0	22.3
5	February 1, 2012	Manikgonj	KUS-TA-11-1250	8.2	13.5	0	0	0	0	0	0	0	0	21.7
6	February 1, 2012	Manikgonj	KUS-TA-11-1132	7.1	15.1	0	0	0	0	0	0	0	0	22.2
7	February 1, 2012	Manikgonj	DHA-MA-O-14-2001	6.5	13.8	0	0	0	0	0	0	0	0	20.3
8	February 1, 2012	Manikgonj	JESS-TA-11-1149	8.9	21.2	0	0	0	0	0	0	0	0	30.1
9	February 1, 2012	Manikgonj	JHE-TA-11-4161	9.5	23.7	0	0	0	0	0	0	0	0	33.2
10	February 1, 2012	Manikgonj	JHE-TA-11-4153	9.7	21.4	0	0	0	0	0	0	0	0	31.1
11	February 1, 2012	Manikgonj	JHE-TA-11-4151	6.6	14.4	0	0	0	0	0	0	0	0	21
12	February 1, 2012	Manikgonj	JESS-TA-11-3900	6.5	20.6	0	0	0	0	0	0	0	0	27.1
13	February 1, 2012	Manikgonj	DHA-MA-TA-14-0030	9.1	20.2	0	0	0	0	0	0	0	0	29.3
14	February 1, 2012	Manikgonj	DHA-MA-O-11-3007	5.8	15.1	0	0	0	0	0	0	0	0	20.9
15	February 1, 2012	Manikgonj	DHA-MA-TA-14-2091	6.9	19.2	0	0	0	0	0	0	0	0	26.1
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2096	February 11, 2012	Manikgonj	CHITT-TA-11-0395	6.7	16	0	0	0	0	0	0	0	0	22.7
2097	February 11, 2012	Manikgonj	CHITT-TA-11-0416	5.7	14.6	0	0	0	0	0	0	0	0	20.3
2098	February 11, 2012	Manikgonj	DHA-MA-TA-11-2055	7.2	14.8	0	0	0	0	0	0	0	0	22.0
2099	February 11, 2012	Manikgonj	DHA-MA-TA-16-1171	5.9	17.2	0	0	0	0	0	0	0	0	23.1
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4523	February 22, 2012	Manikgonj	DHA-MA-TA-16-0916	5.7	20.8	0	0	0	0	0	0	0	0	26.5
4524	February 22, 2012	Manikgonj	DHA-MA-TA-14-5611	5.3	17	0	0	0	0	0	0	0	0	22.3
4525	February 22, 2012	Manikgonj	DHA-MA-TA-14-9139	6.1	21.4	0	0	0	0	0	0	0	0	27.5
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6225	February 29, 2012	Manikgonj	DHA TA-14-1765	6.9	16.5	0	0	0	0	0	0	0	0	23.4
6226	February 29, 2012	Manikgonj	JES TA-11-0147	8.5	13.6	0	0	0	0	0	0	0	0	22.1
6227	February 29, 2012	Manikgonj	JES TA-11-1950	5.3	21	0	0	0	0	0	0	0	0	26.3
6228	February 29, 2012	Manikgonj	DHA TA-16-6612	10.5	21.5	0	0	0	0	0	0	0	0	32

** Data Source: Regnum Resource Ltd.*

Table A29: Axle Load Control Station Batholi, Manikgonj
Monthly Overload Truck Status report (Dhaka Side)
For the month of February 2012

Towards SL No.	Date	Towards	Vehicle Number	Weight-As per Axle Number										Total/ Weight
				1	2	3	4	5	6	7	8	9	10	
1	February 1, 2012	Dhaka	DHA-TA-14-4520	7.7	15.7	0	0	0	0	0	0	0	0	23.4
2	February 1, 2012	Dhaka	DHA-TA-14-2442	8.8	17.4	0	0	0	0	0	0	0	0	26.2
3	February 1, 2012	Dhaka	DHA-TA-11-1542	7.5	13.3	0	0	0	0	0	0	0	0	20.8
4	February 1, 2012	Dhaka	JHE-TA-11-2089	7.7	20.6	0	0	0	0	0	0	0	0	28.3
5	February 1, 2012	Dhaka	DHA-TA-11-2025	8.3	18.2	0	0	0	0	0	0	0	0	26.5
6	February 1, 2012	Dhaka	JES-TA-02-6091	9.6	18.3	0	0	0	0	0	0	0	0	27.9
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1708	February 10,2012	Dhaka	JHI-TA-11-1080	6.2	15.8	0	0	0	0	0	0	0	0	22
1709	February 10,2012	Dhaka	JES-TA-11-1935	6.3	17.5	0	0	0	0	0	0	0	0	23.8
1710	February 10,2012	Dhaka	DHA-TA-11-3577	5.9	15.8	0	0	0	0	0	0	0	0	21.7
1711	February 10,2012	Dhaka	DHA-TA-14-28-36	6.5	17.5	0	0	0	0	0	0	0	0	24
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2800	February 16, 2012	Dhaka	DHA-TA-11-4513	5.4	18	0	0	0	0	0	0	0	0	23.4
2801	February 16, 2012	Dhaka	DHA-TA-11-3489	8.7	14.7	0	0	0	0	0	0	0	0	23.4
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4114	February 21, 2012	Dhaka	DHA-TA-16-0910	6.5	19.9	0	0	0	0	0	0	0	0	26.4
4115	February 21, 2012	Dhaka	DHA-TA-14-5638	5.8	22.8	0	0	0	0	0	0	0	0	28.6
4116	February 21, 2012	Dhaka	JES-TA-11-1940	8.8	19.4	0	0	0	0	0	0	0	0	28.2
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5157	February 25, 2012	Dhaka	DHA-TA-16-6569	7.3	18.9	0	0	0	0	0	0	0	0	26.2
5158	February 25, 2012	Dhaka	DHA-TA-16-6282	5.6	15.9	0	0	0	0	0	0	0	0	21.5
5159	February 25, 2012	Dhaka	DHA-TA-16-2226	7.6	22.4	0	0	0	0	0	0	0	0	30
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6261	February 29, 2012	Dhaka	JES.TA-11-0923	6.4	16.6	0	0	0	0	0	0	0	0	23
6262	February 29, 2012	Dhaka	JES.TA-11-0769	5.3	17	0	0	0	0	0	0	0	0	22.3
6263	February 29, 2012	Dhaka	KUS.TA-11-1109	6.5	15.4	0	0	0	0	0	0	0	0	21.9
6264	February 29, 2012	Dhaka	DHA-TA-16-2123	5.6	15.6	0	0	0	0	0	0	0	0	21.2

** Data Source: Regnum Resource Ltd.*

Table A30: Axle Load Control Station Batholi, Manikgonj
Monthly Overload Truck Status report (Both Side)
For the month of February 2012

SL No.	Date	Vehicle Number	Weight-As per Axle Number										Total/Weight
			1	2	3	4	5	6	7	8	9	10	
1	February 1, 2012	DHA-TA-14-4520	7.7	15.7	0	0	0	0	0	0	0	0	23.4
2	February 1, 2012	DHA-TA-14-2442	8.8	17.4	0	0	0	0	0	0	0	0	26.2
3	February 1, 2012	DHA-TA-11-1542	7.5	13.3	0	0	0	0	0	0	0	0	20.8
4	February 1, 2012	JHE-TA-11-2089	7.7	20.6	0	0	0	0	0	0	0	0	28.3
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
1429	February 05,2012	DHA-TA-16-2712	8	15.1	0	0	0	0	0	0	0	0	23.1
1430	February 05,2012	SAT-TA-11-0131	5.6	15	0	0	0	0	0	0	0	0	20.6
-	-	-	-	-	-	-	-	-	-	-	-	-	-
2386	February 07,2012	KUS TA-02-0153	5.6	15.4	0	0	0	0	0	0	0	0	21
2387	February 07,2012	JES TA-11-1667	7.2	17.8	0	0	0	0	0	0	0	0	25
2388	February 07,2012	DHA TA-14-5948	6.4	16.3	0	0	0	0	0	0	0	0	22.7
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
3671	February 10,2012	JHE-TA-11-0744	5.9	18.8	0	0	0	0	0	0	0	0	24.7
3672	February 10,2012	JESS-TA-11-2691	9.8	18.5	0	0	0	0	0	0	0	0	28.3
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
4931	February 13,2012	JHE-TA-11-0886	5.9	14.3	0	0	0	0	0	0	0	0	20.2
4932	February 13,2012	JHE-TA-11-0885	6.9	18.5	0	0	0	0	0	0	0	0	25.4
4933	February 13,2012	JES-TA-11-1465	6.4	16.6	0	0	0	0	0	0	0	0	23
4934	February 13,2012	JES-TA-11-1532	7.8	20.6	0	0	0	0	0	0	0	0	28.4
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
5874	February 16,2012	DHA-TA-16-2525	8	12.7	0	0	0	0	0	0	0	0	20.7
5875	February 16,2012	JES-TA-11-1388	5.6	16	0	0	0	0	0	0	0	0	21.6
5876	February 16,2012	DHA-TA-11-1410	6.3	14.2	0	0	0	0	0	0	0	0	20.5
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
6100	February 16,2012	DHA TA-11-1851	6.3	16.3	0	0	0	0	0	0	0	0	22.6
6101	February 16,2012	DHA TA-14-5661	7	22.5	0	0	0	0	0	0	0	0	29.5
6102	February 16,2012	JHI TA-11-0856	5.6	21.2	0	0	0	0	0	0	0	0	26.8
6103	February 16,2012	DHA TA-16-6104	7.3	15.9	0	0	0	0	0	0	0	0	23.2

** Data Source: Regnum Resource Ltd.*

Table A31: Axle Load Control Station Batholi, Manikgonj
Monthly Overload Truck Status report (Both Side)
For the month of February 2012

SL No.	Date	Vehicle Number	Weight-As per Axle Number										Total/Weight
			1	2	3	4	5	6	7	8	9	10	
6985	February 18,2012	CTI TA-02-0138	6	16	0	0	0	0	0	0	0	0	22
6986	February 18,2012	DHA TA-16-1678	5.6	18	0	0	0	0	0	0	0	0	23.6
6987	February 18,2012	DHA TA-11-1575	5.4	19.8	0	0	0	0	0	0	0	0	25.2
6988	February 18,2012	JHE TA-11-0158	6.1	20.6	0	0	0	0	0	0	0	0	26.7
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
7786	February 20,2012	JES-TA-11-1017	5.6	23.3	0	0	0	0	0	0	0	0	28.9
7787	February 20,2012	JHE-TA-11-0478	8.5	17.8	0	0	0	0	0	0	0	0	26.3
-	-	-	-	-	-	-	-	-	-	-	-	-	-
8125	February 21,2012	DHA-TA-11-3165	7.6	21.5	0	0	0	0	0	0	0	0	29.1
8126	February 21,2012	JESS-TA-11-0061	6.5	21.3	0	0	0	0	0	0	0	0	27.8
8127	February 21,2012	DHA-TA-16-2161	6.4	16.1	0	0	0	0	0	0	0	0	22.5
8128	February 21,2012	DHA-TA-16.5901	6.9	14.9	0	0	0	0	0	0	0	0	21.8
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
9137	February 23,2012	NAR-TA-11-0417	7.5	12.5	0	0	0	0	0	0	0	0	20
9138	February 23,2012	DHA-TA-14-4079	8.2	13.8	0	0	0	0	0	0	0	0	22
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
10000	February 24,2012	DHA TA-14-9226	6.7	17.5	0	0	0	0	0	0	0	0	24.2
10001	February 24,2012	DHA TA-16-3185	9.4	19.2	0	0	0	0	0	0	0	0	28.6
10002	February 24,2012	DHA TA-16-4299	5.8	22.1	0	0	0	0	0	0	0	0	27.9
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
11024	February 26,2012	KUS TA-02-0099	6.1	16.2	0	0	0	0	0	0	0	0	22.3
11025	February 26,2012	KHU T5A-11-1816	5.6	15.8	0	0	0	0	0	0	0	0	21.4
11026	February 26,2012	DHA TA-11-2836	7.8	20.9	0	0	0	0	0	0	0	0	28.7
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
12489	February 29,2012	DHA TA-14-1765	6.9	16.5	0	0	0	0	0	0	0	0	23.4
12490	February 29,2012	JES TA-11-0147	8.5	13.6	0	0	0	0	0	0	0	0	22.1
12491	February 29,2012	JES TA-11-1950	5.3	21	0	0	0	0	0	0	0	0	26.3
12492	February 29,2012	DHA TA-16-6612	10.5	21.5	0	0	0	0	0	0	0	0	32

** Data Source: Regnum Resource Ltd.*

Table A32: Axle Load Control Station, Narayangonj
Meghna Bridge Toll Plaza (Dhaka-Chittagong Direction)
For the month of February 2012

Sl. No.	WeighDate	Reg Number	Gross Weight	Legal Gross MaxWeight	Axle Weight 1	Axle Weight 2	Axle Weight 3	Axle Weight 4
635	2/1/2012 18:03	6546	19180	16000	4710	14470	0	0
636	2/1/2012 18:04	8938	21400	16000	7110	14290	0	0
637	2/1/2012 18:05	213	25200	16000	5910	19290	0	0
638	2/1/2012 18:05	549	18740	16000	5540	13200	0	0
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
2031	2/4/2012 17:34	125	22360	16000	16420	5940	0	0
2032	2/4/2012 17:35	4221	37260	20000	17140	7370	12750	0
2033	2/4/2012 17:36	6287	9330	6000	3950	5380	0	0
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
2584	2/5/2012 19:30	456	21250	16000	7360	13890	0	0
2585	2/5/2012 19:35	02-5298	40900	20000	14500	6420	19980	0
2586	2/5/2012 19:36	45878	24890	16000	7190	17700	0	0
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
3232	2/7/2012 3:52	114545	23140	16000	7200	15940	0	0
3233	2/7/2012 3:53	17852	17990	16000	4590	13400	0	0
3234	2/7/2012 3:54	14547	21350	16000	6450	14900	0	0
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
4135	2/8/2012 21:05	123	24420	16000	8470	15950	0	0
4136	2/8/2012 21:07	52648	35520	18000	15450	4390	15680	0
4137	2/8/2012 21:10	75521	12190	16000	4380	7810	0	0
4138	2/8/2012 21:11	30264	9470	6000	3780	5690	0	0
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
5241	2/11/2012 14:41	112456	25340	16000	7200	18140	0	0
5242	2/11/2012 14:47	4512	50250	22000	6310	15170	8170	20600
5243	2/11/2012 14:49	11225	22790	16000	7300	15490	0	0

** Data Source: Asian Traffic Technology (ATT) Ltd.*

Table A33: Axle Load Control Station, Narayangonj
Meghna Bridge Toll Plaza (Dhaka-Chittagong Direction)
For the month of February 2012

Sl. No.	WeighDate	Reg Number	Gross Weight	Legal Gross MaxWeight	Axle Weight 1	Axle Weight 2	Axle Weight 3	Axle Weight 4
6021	2/13/2012 8:12	24519	22330	16000	6030	16300	0	0
6022	2/13/2012 8:20	192446	23630	16000	6980	16650	0	0
6023	2/13/2012 8:21	112436	24420	16000	8420	16000	0	0
6024	2/13/2012 8:21	027812	23880	16000	8210	15670	0	0
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
6985	2/15/2012 8:50	123	21530	16000	7000	14530	0	0
6986	2/15/2012 8:53	123	23400	16000	7010	16390	0	0
6987	2/15/2012 8:55	123	23660	16000	7440	16220	0	0
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
7755	2/17/2012 20:28	123	20380	16000	5670	14710	0	0
7756	2/17/2012 20:36	123	49900	20000	5010	20030	5010	19850
7757	2/17/2012 20:37	123	19710	16000	6000	13710	0	0
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
8045	2/18/2012 20:27	321	23930	16000	7570	16360	0	0
8046	2/18/2012 20:33	123	21570	16000	5650	15920	0	0
8047	2/18/2012 20:38	123	22670	16000	5570	17100	0	0
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
10961	2/26/2012 14:43	12549	23190	16000	7720	15470	0	0
10962	2/26/2012 14:45	54320	23630	16000	7660	15970	0	0
10963	2/26/2012 15:01	87523	23670	16000	7410	16260	0	0
10964	2/26/2012 15:03	2154	22740	16000	7270	15470	0	0
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
12097	2/29/2012 12:28	15321	23920	16000	7110	16810	0	0
12098	2/29/2012 12:30	14235	20420	16000	6910	13510	0	0
12099	2/29/2012 12:34	19246	20630	16000	5290	15340	0	0

** Data Source: Asian Traffic Technology (ATT) Ltd.*

Table A34: Axle Load Control Station, Narayangonj Gomoti Bridge Toll Plaza (Chittagong-Dhaka Direction) For the month of February 2012

Sl. No.	WeighDate	Reg Number	Gross Weight	Axle Number	Legal Gross MaxWeight
1	February 25, 2012	11-2612	37750	3	26000
2	February 25, 2012	11-0603	31790	2	16000
3	February 25, 2012	14-7797	23740	2	16000
4	February 25, 2012	11-0701	23140	2	16000
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
161	February 26, 2012	10-1075	24650	2	16000
162	February 26, 2012	14-9191	27240	2	16000
163	February 26, 2012	14-4959	29810	2	16000
-	-	-	-	-	-
-	-	-	-	-	-
230	February 28, 2012	18-2654	29220	2	16000
231	February 28, 2012	11-63328	26840	2	16000
232	February 28, 2012	11-1227	34440	3	21000
-	-	-	-	-	-
-	-	-	-	-	-
547	February 23, 2012	11-1334	24460	2	16000
548	February 23, 2012	16-5243	27070	4	31000
549	February 23, 2012	16-1012	25070	2	16000
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
885	February 19, 2012	110935	31000	2	16000
886	February 19, 2012	110921	27870	2	16000
887	February 19, 2012	110474	26509	2	16000
888	February 19, 2012	110744	26070	2	16000
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
1169	February 24, 2012	14-8697	24940	2	16000
1170	February 24, 2012	11-1197	23780	2	16000
1171	February 24, 2012	16-0327	25490	2	16000

** Data Source: Asian Traffic Technology (ATT) Ltd.*

APPENDIX B

SUMMARIZED DATA TABLES AND CHARTS

Table B1: Day-wise ADT on Jamuna Bridge (Averaged Over 2005 to 2009)

Day	Average Daily Volume of Traffic		
	East to West	West to East	Bothway
Saturday	3,066	3,236	6,302
Sunday	3,210	3,225	6,436
Monday	3,229	3,219	6,448
Tuesday	3,240	3,278	6,518
Wednesday	3,280	3,367	6,647
Thursday	3,448	3,266	6,714
Friday	3,433	3,397	6,830
Avg. Weekly Vol.	**22,907**	**22,988**	**45,894**
Weekly ADT	**3,272**	**3,284**	**6,556**

**Data Source: Marga Net One Limited (MNOL), BBSO.*

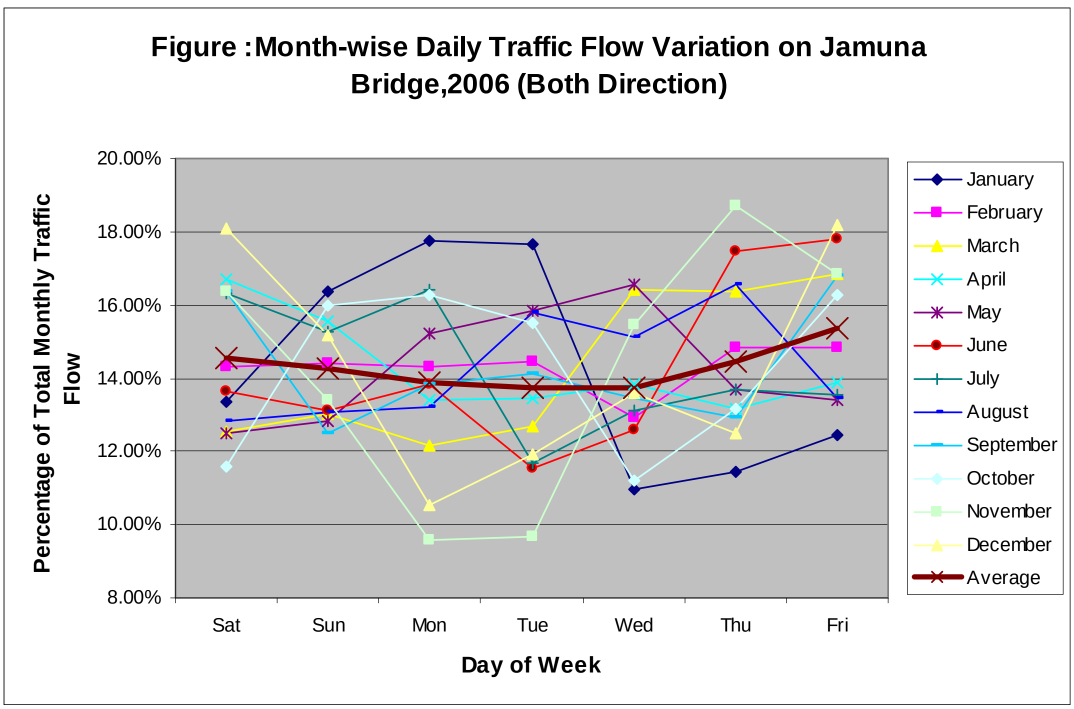


Figure B1: Month-wise Daily Flow Fluctuation on Jamuna Bridge, 2006

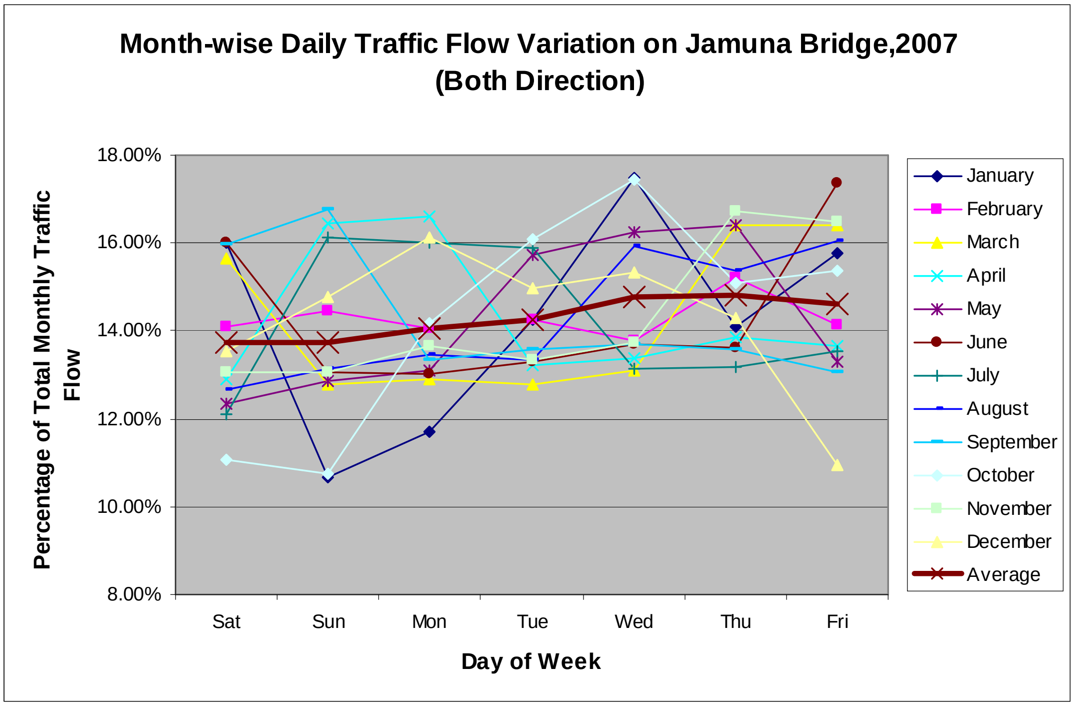


Figure B2: Month-wise Daily Flow Fluctuation on Jamuna Bridge, 2007

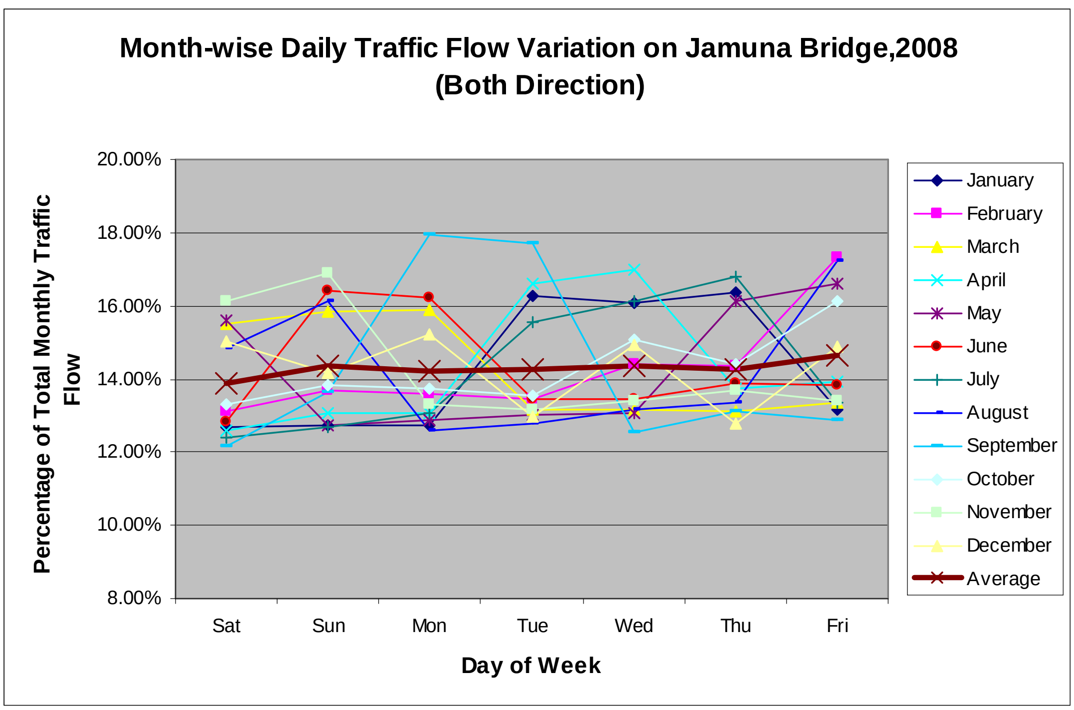


Figure B3: Month-wise Daily Flow Fluctuation on Jamuna Bridge, 2008

Table B2: Day-wise Yearly Traffic Flow on Jamuna Bridge

Day \ Year	2005		2006		2007		2008		2009	
	East to West	West to East	East to West	West to East	East to West	West to East	East to West	West to East	East to West	West to East
Saturday	121,760	125,683	147,640	155,266	157,955	165,197	178,039	189,789	194,106	207,683
Sunday	132,694	138,209	151,068	145,552	160,961	161,732	187,861	191,731	204,986	204,120
Monday	136,296	136,931	145,838	143,428	165,776	164,959	191,325	185,337	203,403	209,437
Tuesday	139,993	141,555	144,969	140,905	165,525	169,850	189,054	188,643	206,319	214,955
Wednesday	143,450	147,882	140,724	144,752	172,276	175,069	188,505	191,568	211,471	219,758
Thursday	147,621	134,311	152,328	148,370	179,514	168,865	192,543	185,627	228,901	215,939
Friday	140,659	143,269	157,663	161,991	172,059	171,071	193,936	193,981	228,208	212,906
TOTAL	**962,473**	**967,840**	**1,040,230**	**1,040,264**	**1,174,066**	**1,176,743**	**1,321,263**	**1,326,676**	**1,477,394**	**1,484,798**
TOTAL - BOTH DIRECTION	**1,930,313**		**2,080,494**		**2,350,809**		**2,647,939**		**2,962,192**	

Source Data: Marga Net One Limited (MNOL), BBSO.

Table B3: Average Daily Volume of Three Pre-dominant Vehicle Classes on Jamuna Bridge (2005 to 2009)

Day	Average Daily Volume of Traffic								
	Large Bus			**Medium Truck**			**Light Vehicle**		
	East to West	**West to East**	**Bothway**	**East to West**	**West to East**	**Bothway**	**East to West**	**West to East**	**Bothway**
Saturday	1,020	1,032	**2,052**	1,092	1,149	**2,241**	491	594	**1,085**
Sunday	1,005	996	**2,002**	1,239	1,229	**2,468**	497	511	**1,007**
Monday	997	995	**1,991**	1,254	1,230	**2,484**	505	491	**996**
Tuesday	996	992	**1,988**	1,263	1,289	**2,552**	497	496	**993**
Wednesday	1,006	1,023	**2,029**	1,271	1,312	**2,583**	511	508	**1,019**
Thursday	1,057	1,032	**2,089**	1,268	1,174	**2,442**	609	525	**1,134**
Friday	1,059	1,096	**2,155**	1,196	1,163	**2,358**	673	647	**1,320**
Avg. Weekly Vol.	**7,140**	**7,166**	**14,306**	**8,583**	**8,546**	**17,128**	**3,783**	**3,771**	**7,554**

Source Data: Marga Net One Limited (MNOL), BBSO.

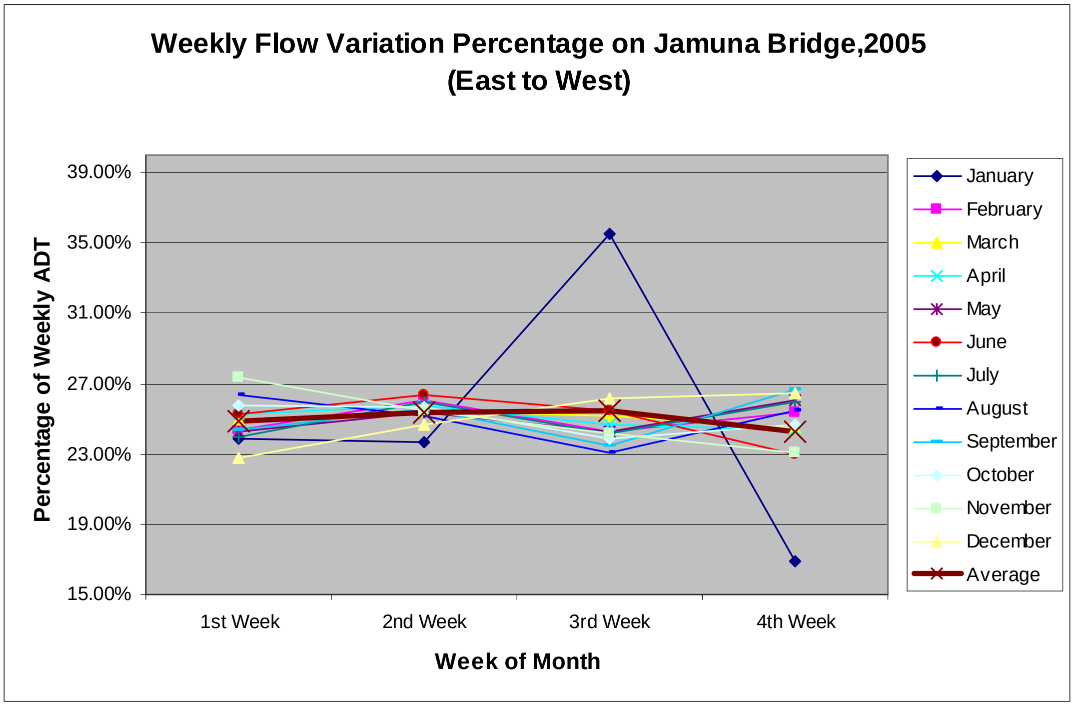


Figure B4: Weekly Traffic Flow Variation Pattern on Jamuna Bridge (East to West), 2005

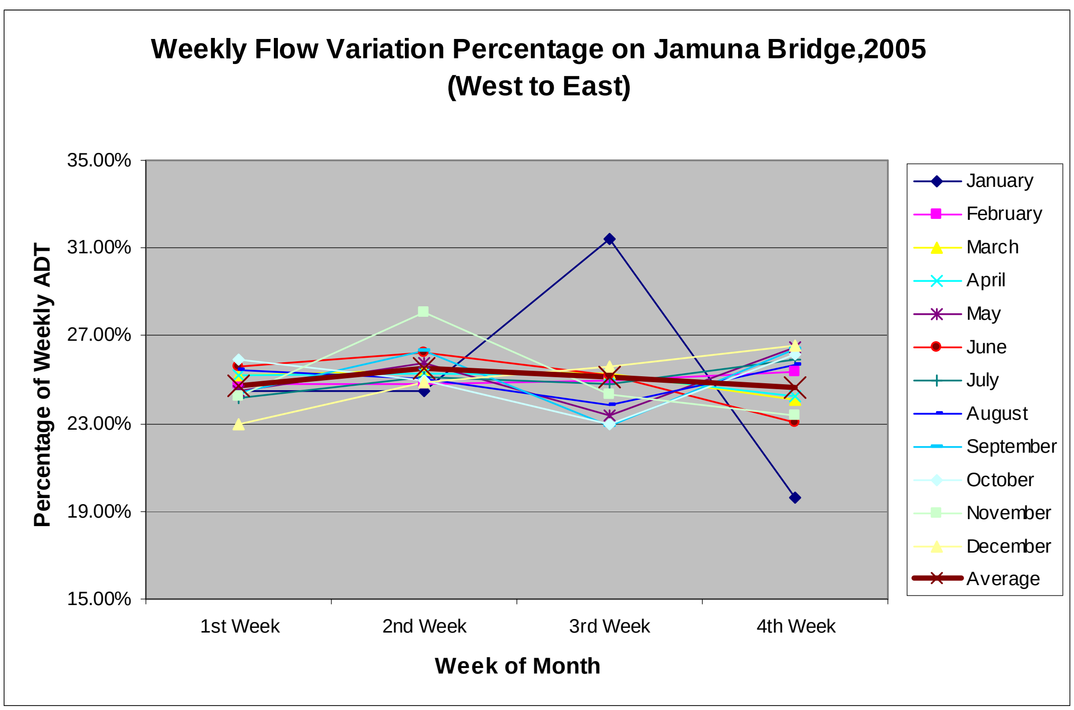


Figure B5: Weekly Traffic Flow Variation Pattern on Jamuna Bridge (West to East), 2005

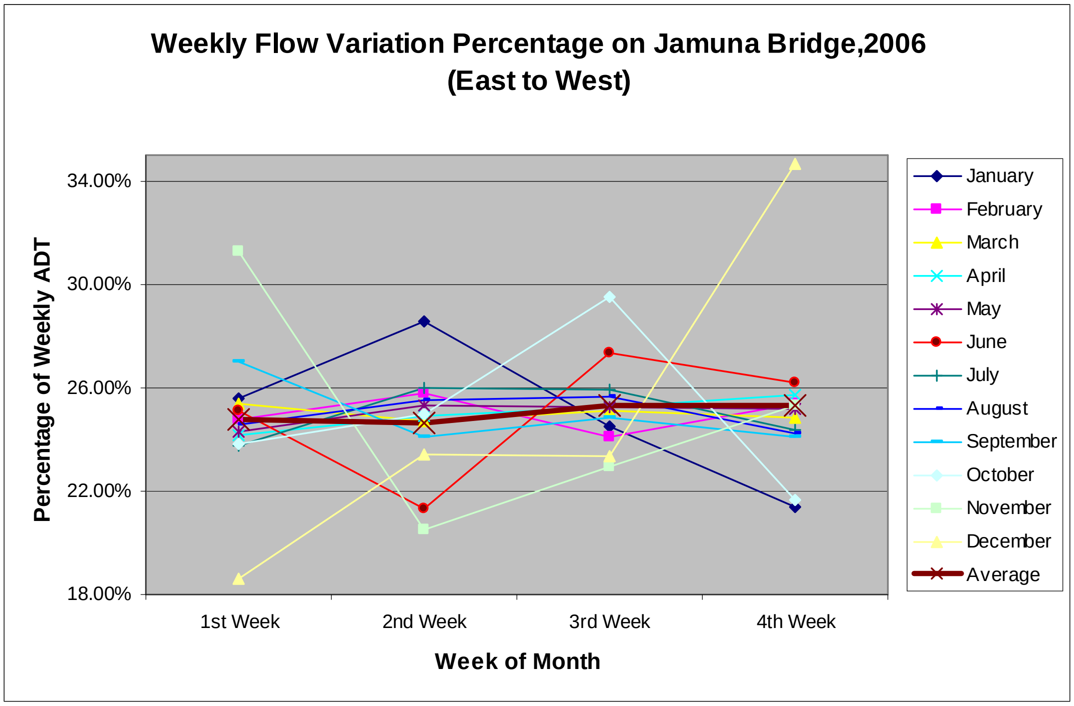


Figure B6: Weekly Traffic Flow Variation Pattern on Jamuna Bridge (East to West), 2006

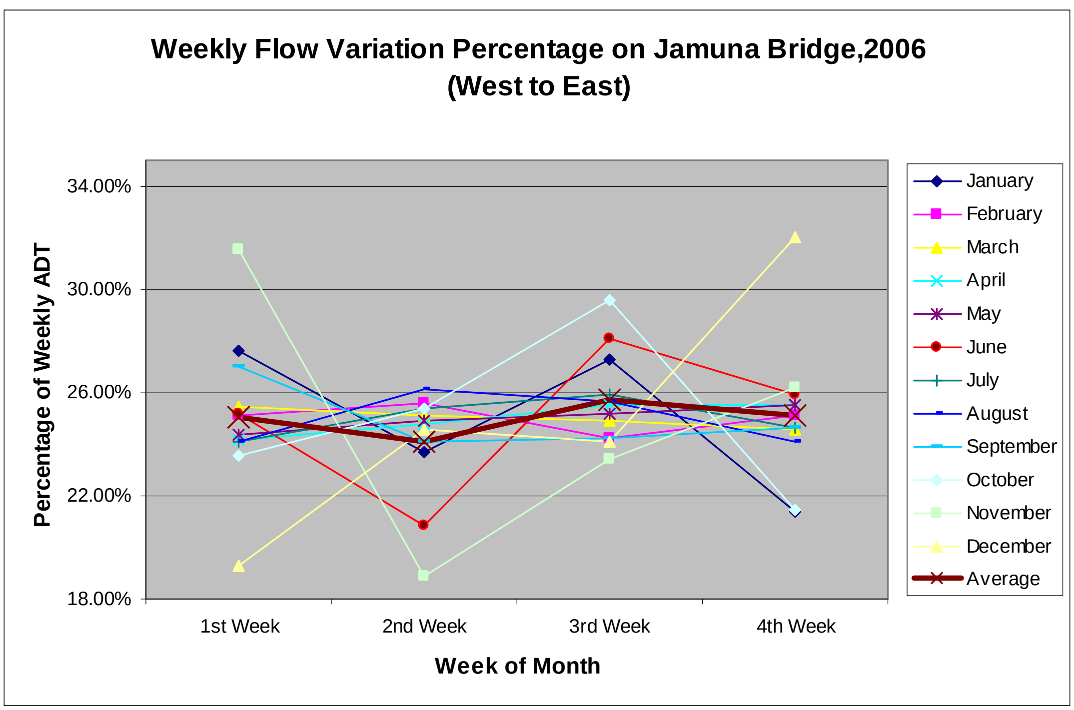


Figure B7: Weekly Traffic Flow Variation Pattern on Jamuna Bridge (West to East), 2006

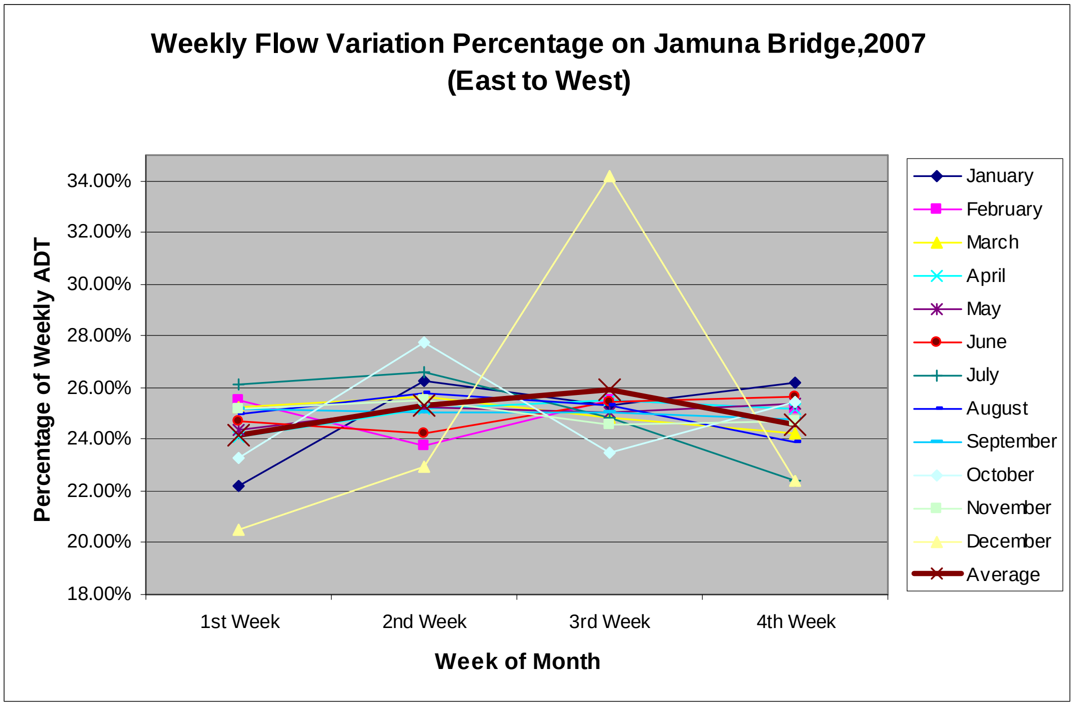


Figure B8: Weekly Traffic Flow Variation Pattern on Jamuna Bridge (East to West), 2007

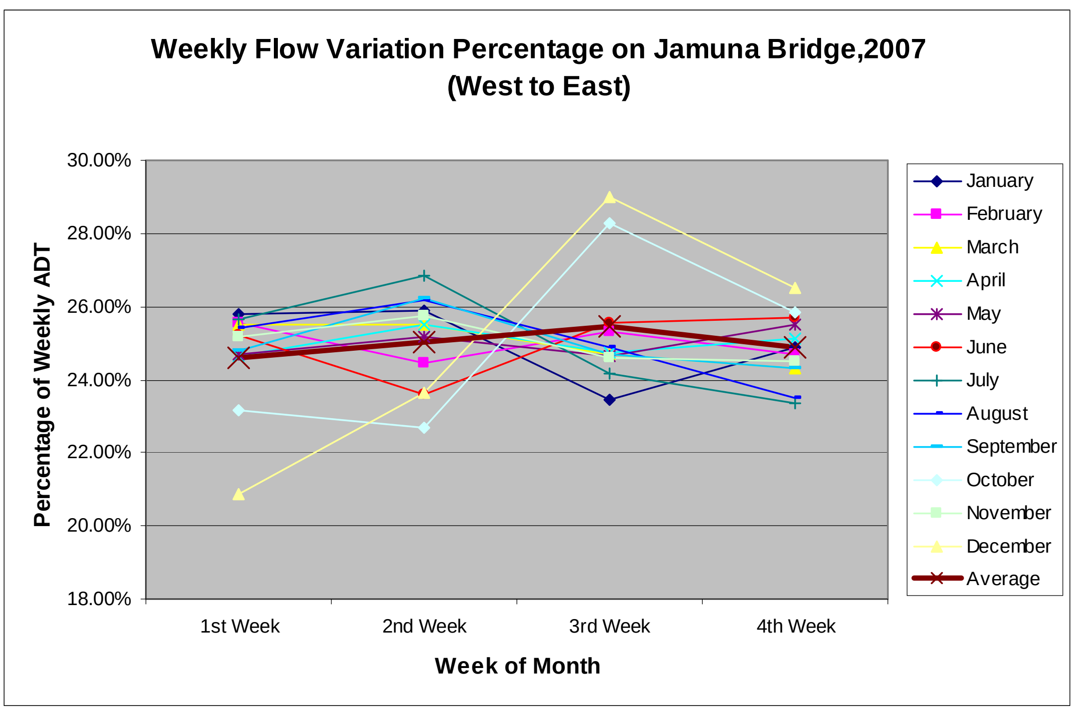


Figure B9: Weekly Traffic Flow Variation Pattern on Jamuna Bridge (West to East), 2007

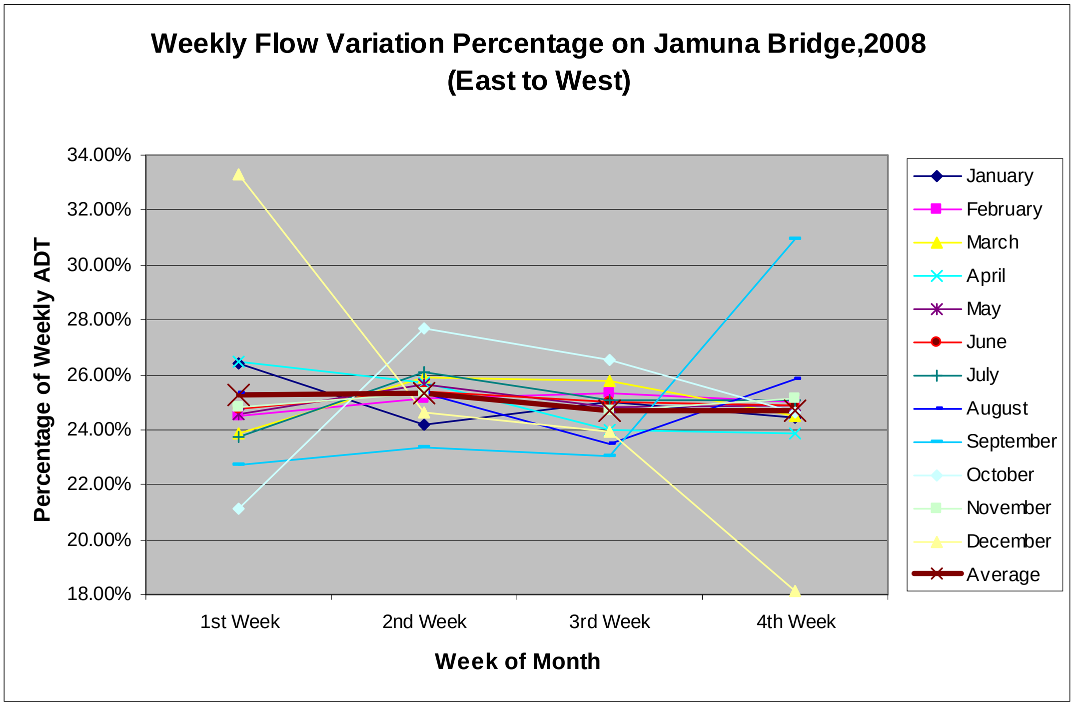


Figure B10: Weekly Traffic Flow Variation Pattern on Jamuna Bridge (East to West), 2008

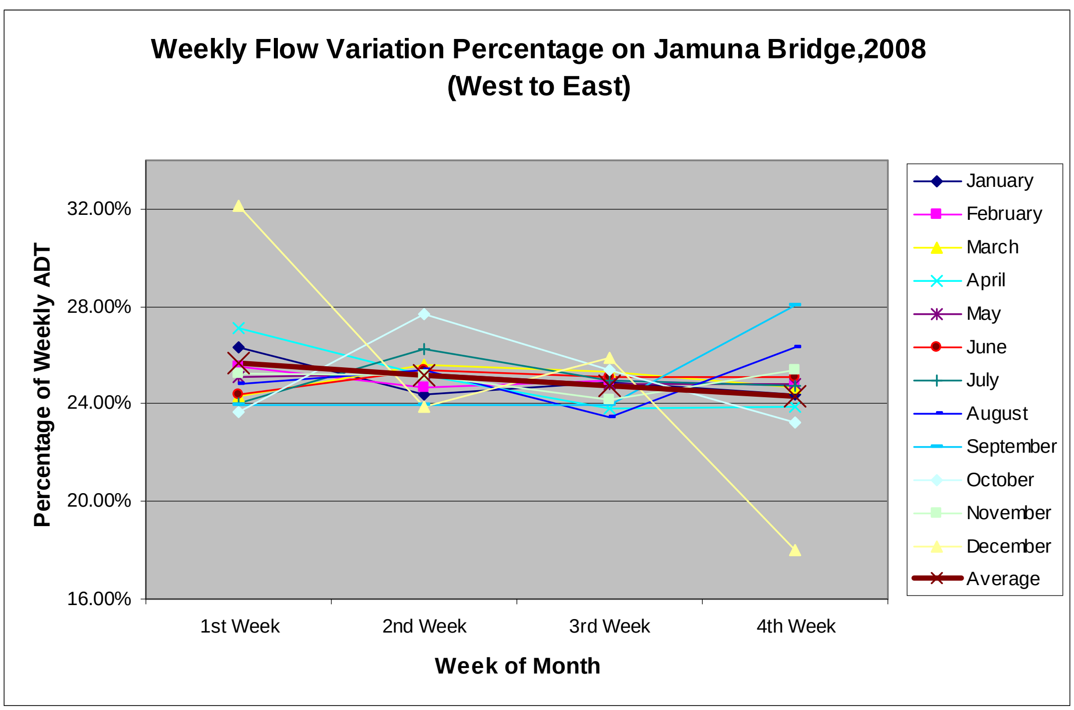


Figure B11: Weekly Traffic Flow Variation Pattern on Jamuna Bridge (West to East), 2008

Table B4: Monthly Bi-Directional Traffic Volume on Jamuna Bridge

Month\Year	2005	2006	2007	2008	2009
Jan	180,426	196,278	182,787	219,713	237,308
Feb	147,964	154,703	176,282	208,812	223,575
Mar	167,355	168,354	190,420	232,404	234,368
Apr	158,215	162,053	185,136	209,366	222,787
May	157,247	170,153	192,508	217,671	239,455
Jun	160,719	178,056	194,433	221,612	253,497
Jul	158,730	174,472	192,399	214,606	259,745
Aug	153,591	179,494	186,088	212,331	236,128
Sep	157,462	168,778	188,161	216,116	247,680
Oct	152,113	171,521	212,973	214,256	249,826
Nov	165,180	154,014	199,045	222,333	277,905
Dec	171,311	202,618	250,577	258,719	279,918
Yearly Volume	**1,930,313**	**2,080,494**	**2,350,809**	**2,647,939**	**2,962,192**

Source Data: Marga Net One Limited (MNOL), BBSO.

Table B5: Monthly Bi-Directional Traffic Flow, in Percentage of Yearly Volume

Month\Year	2005	2006	2007	2008	2009	**Average**
Jan	9.35%	9.43%	7.78%	8.30%	8.01%	**8.57%**
Feb	7.67%	7.44%	7.50%	7.89%	7.55%	**7.61%**
Mar	8.67%	8.09%	8.10%	8.78%	7.91%	**8.31%**
Apr	8.20%	7.79%	7.88%	7.91%	7.52%	**7.86%**
May	8.15%	8.18%	8.19%	8.22%	8.08%	**8.16%**
Jun	8.33%	8.56%	8.27%	8.37%	8.56%	**8.42%**
Jul	8.22%	8.39%	8.18%	8.10%	8.77%	**8.33%**
Aug	7.96%	8.63%	7.92%	8.02%	7.97%	**8.10%**
Sep	8.16%	8.11%	8.00%	8.16%	8.36%	**8.16%**
Oct	7.88%	8.24%	9.06%	8.09%	8.43%	**8.34%**
Nov	8.56%	7.40%	8.47%	8.40%	9.38%	**8.44%**
Dec	8.87%	9.74%	10.66%	9.77%	9.45%	**9.70%**
Total	100.00%	100.00%	100.00%	100.00%	100.00%	**100.00%**
Maximum	9.35%	9.74%	10.66%	9.77%	9.45%	9.70%
Minimum	7.67%	7.40%	7.50%	7.89%	7.52%	7.61%

Source Data: Marga Net One Limited (MNOL), BBSO.

Table B6: Monthly Bi-Directional Traffic Flow on Jamuna Bridge, 2005

Month	Motor Cycle	Light Vehicle	Small Bus	Large Bus	Small Truck	Medium Truck	Large Truck	Total Traffic	Percentage
Jan-05	4234	28939	3210	58693	9903	73007	2440	**180426**	**9.35**
Feb-05	2776	21080	2403	47000	8795	63779	2131	**147964**	**7.67**
Mar-05	3001	23373	2669	53009	10172	72459	2672	**167355**	**8.67**
Apr-05	3151	22442	2612	51747	10820	64638	2805	**158215**	**8.20**
May-05	3305	22650	2182	51454	12426	62426	2804	**157247**	**8.15**
Jun-05	2930	24080	2684	53388	11673	63337	2627	**160719**	**8.33**
Jul-05	3532	24141	2648	53625	11767	60865	2152	**158730**	**8.22**
Aug-05	3401	22633	2525	52960	11502	58781	1789	**153591**	**7.96**
Sep-05	3763	23899	2358	49850	13027	62374	2191	**157462**	**8.16**
Oct-05	2963	21558	2401	48520	12856	61408	2407	**152113**	**7.88**
Nov-05	5775	28429	2648	60903	10301	55254	1870	**165180**	**8.56**
Dec-05	3324	26686	2380	51789	11467	73172	2493	**171311**	**8.87**
TOTAL	**42155**	**289910**	**30720**	**632938**	**134709**	**771500**	**28381**	**1930313**	**100.00**
Percentage	2.18	15.02	1.59	32.79	6.98	39.97	1.47	100	

Source Data: Marga Net One Limited (MNOL), BBSO.

Table B7: Monthly Bi-Directional Traffic Flow on Jamuna Bridge, 2006

Month	Motor Cycle	Light Vehicle	Small Bus	Large Bus	Small Truck	Medium Truck	Large Truck	Total Traffic	Percentage
Jan-06	5600	33825	3092	69809	10888	70980	2084	**196278**	**9.43**
Feb-06	3930	25315	2377	49761	9781	61431	2108	**154703**	**7.44**
Mar-06	4504	27098	2621	55982	10370	65466	2313	**168354**	**8.09**
Apr-06	4403	24409	2286	53899	10619	64191	2246	**162053**	**7.79**
May-06	4243	26137	2336	57170	13342	64234	2691	**170153**	**8.18**
Jun-06	3346	25969	2329	56733	15887	71102	2690	**178056**	**8.56**
Jul-06	3505	26695	1879	57497	15301	67439	2156	**174472**	**8.39**
Aug-06	3389	26643	2215	57020	17113	70859	2255	**179494**	**8.63**
Sep-06	3017	24685	2075	54605	16783	65274	2339	**168778**	**8.11**
Oct-06	5573	29266	2235	61748	14482	56248	1969	**171521**	**8.24**
Nov-06	3016	22398	1593	47407	14189	63296	2115	**154014**	**7.40**
Dec-06	3552	33130	2338	61439	16036	83551	2572	**202618**	**9.74**
TOTAL	**48078**	**325570**	**27376**	**683070**	**164791**	**804071**	**27538**	**2080494**	**100.00**
Percentage	2.31	15.65	1.32	32.83	7.92	38.65	1.32	100	

Source Data: Marga Net One Limited (MNOL), BBSO.

Table B8: Monthly Bi-Directional Traffic Flow on Jamuna Bridge, 2007

Month	Motor Cycle	Light Vehicle	Small Bus	Large Bus	Small Truck	Medium Truck	Large Truck	Total Traffic	Percentage
Jan-07	3586	31816	2242	64737	13632	64936	1838	**182787**	**7.78**
Feb-07	1890	26225	2199	57010	15069	71823	2066	**176282**	**7.50**
Mar-07	2565	28352	2288	62024	16649	76216	2326	**190420**	**8.10**
Apr-07	2593	26193	1982	59259	17874	75904	1331	**185136**	**7.88**
May-07	2919	28647	2147	60142	22105	75405	1143	**192508**	**8.19**
Jun-07	2385	30467	2263	62258	21510	74093	1457	**194433**	**8.27**
Jul-07	2492	31207	2081	63152	20559	71462	1446	**192399**	**8.18**
Aug-07	2655	28259	1900	57255	21940	72591	1488	**186088**	**7.92**
Sep-07	1972	26825	1765	56227	22864	77067	1441	**188161**	**8.00**
Oct-07	5149	36792	2168	75122	21071	71436	1235	**212973**	**9.06**
Nov-07	2585	29342	1900	58447	24643	80860	1268	**199045**	**8.47**
Dec-07	5589	43415	2427	78503	25850	93420	1373	**250577**	**10.66**
TOTAL	**36380**	**367540**	**25362**	**754136**	**243766**	**905213**	**18412**	**2350809**	**100.00**
Percentage	1.55	15.63	1.08	32.08	10.37	38.51	0.78	100	

Source Data: Marga Net One Limited (MNOL), BBSO.

Table B9: Monthly Bi-Directional Traffic Flow on Jamuna Bridge, 2008

Month	Motor Cycle	Light Vehicle	Small Bus	Large Bus	Small Truck	Medium Truck	Large Truck	Total Traffic	Percentage
Jan-08	2825	32978	1924	68250	24053	88225	1458	**219713**	**8.30**
Feb-08	2966	34094	1952	61639	23502	83243	1416	**208812**	**7.89**
Mar-08	3511	35068	2026	67340	28920	94025	1514	**232404**	**8.78**
Apr-08	3759	31720	1867	63628	28186	79160	1046	**209366**	**7.91**
May-08	3839	34526	2108	66657	31060	78268	1213	**217671**	**8.22**
Jun-08	3373	36018	2340	68157	30799	79475	1450	**221612**	**8.37**
Jul-08	3025	34822	2243	65839	29404	77881	1392	**214606**	**8.10**
Aug-08	3587	36400	2122	64628	29031	75059	1504	**212331**	**8.02**
Sep-08	4030	35916	1872	62777	30153	79828	1540	**216116**	**8.16**
Oct-08	6097	41123	1598	73119	28238	62805	1276	**214256**	**8.09**
Nov-08	3395	37915	1755	59754	34495	83547	1472	**222333**	**8.40**
Dec-08	6813	52927	2160	84203	31002	80227	1387	**258719**	**9.77**
TOTAL	**47220**	**443507**	**23967**	**805991**	**348843**	**961743**	**16668**	**2647939**	**100.00**
Percentage	1.78	16.75	0.91	30.44	13.17	36.32	0.63	100	

Source Data: Marga Net One Limited (MNOL), BBSO.

Table B10: Monthly Bi-Directional Traffic Flow on Jamuna Bridge, 2009

Month	Motor Cycle	Light Vehicle	Small Bus	Large Bus	Small Truck	Medium Truck	Large Truck	Total Traffic	Percentage
Jan-09	3447	40850	1989	67859	33729	87858	1576	**237308**	**8.01**
Feb-09	3566	37328	1860	61864	34535	83067	1355	**223575**	**7.55**
Mar-09	4266	41312	1949	68716	33560	83080	1485	**234368**	**7.91**
Apr-09	4053	38414	1666	64767	32933	79273	1681	**222787**	**7.52**
May-09	4405	45022	1863	67393	35976	82928	1868	**239455**	**8.08**
Jun-09	4552	44046	1719	70951	36873	93222	2134	**253497**	**8.56**
Jul-09	4433	45516	1459	70842	37123	98332	2040	**259745**	**8.77**
Aug-09	4160	41214	699	66829	35116	86573	1537	**236128**	**7.97**
Sep-09	8697	52581	762	81164	30276	72723	1477	**247680**	**8.36**
Oct-09	5096	44743	447	73293	38472	85832	1943	**249826**	**8.43**
Nov-09	6998	56468	789	74423	37885	99339	2003	**277905**	**9.38**
Dec-09	6339	56338	823	87289	36659	90521	1949	**279918**	**9.45**
TOTAL	**60012**	**543832**	**16025**	**855390**	**423137**	**1042748**	**21048**	**2962192**	**100.00**
Percentage	2.03	18.36	0.54	28.88	14.28	35.20	0.71	100	

Source Data: Marga Net One Limited (MNOL), BBSO.

Table B11: Day-wise ADT on Bhairab Bridge
(Averaged Over 2007 to 2009)

Day	Average Daily Volume of Traffic		
	Bhairab Toll Plaza	Ashuganj Toll Plaza	Bothway
Saturday	2,506	2,596	5,102
Sunday	2,582	2,477	5,059
Monday	2,609	2,467	5,076
Tuesday	2,548	2,445	4,993
Wednesday	2,610	2,509	5,119
Thursday	2,874	2,629	5,503
Friday	2,906	2,885	5,791
Avg. Weekly Vol.	**18,634**	**18,009**	**36,643**
Weekly ADT	**2,662**	**2,573**	**5,235**

**Data Source: Sigma-RCL JV.*

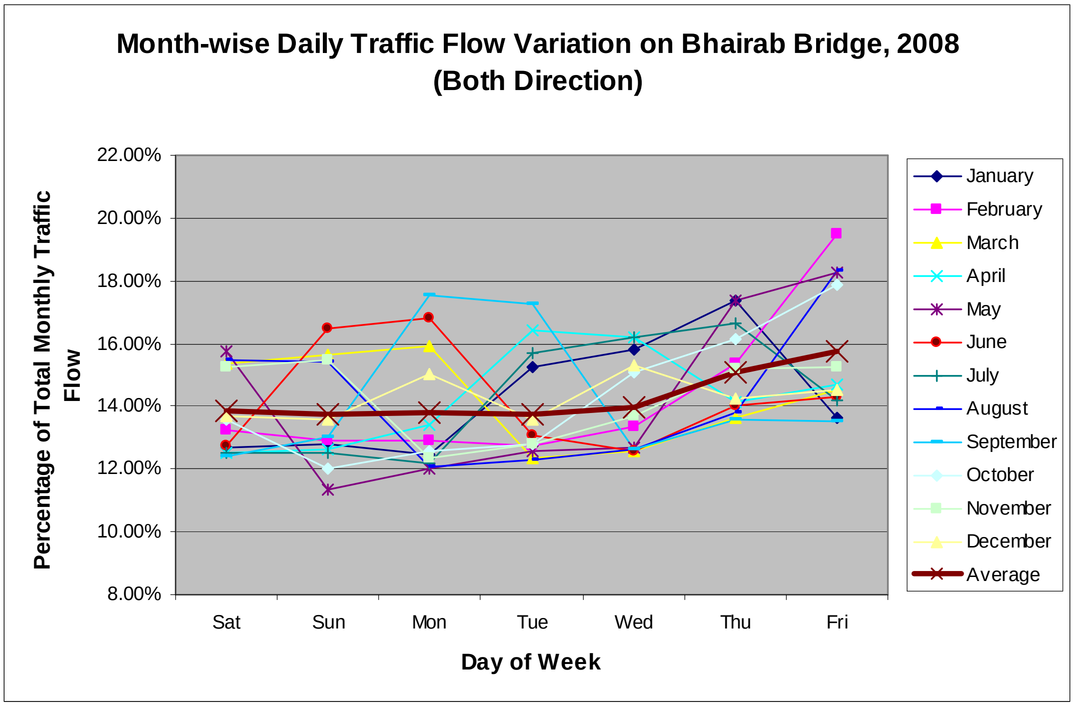


Figure B12: Month-wise Daily Flow Fluctuation on Bhairab Bridge, 2008

Table B12: Day-wise Yearly Traffic Flow on Bhairab Bridge

Day \ Year	2007		2008		2009	
	East to West	West to East	East to West	West to East	East to West	West to East
Saturday	157,955	165,197	178,039	189,789	194,106	207,683
Sunday	160,961	161,732	187,861	191,731	204,986	204,120
Monday	165,776	164,959	191,325	185,337	203,403	209,437
Tuesday	165,525	169,850	189,054	188,643	206,319	214,955
Wednesday	172,276	175,069	188,505	191,568	211,471	219,758
Thursday	179,514	168,865	192,543	185,627	228,901	215,939
Friday	172,059	171,071	193,936	193,981	228,208	212,906
TOTAL	**1,174,066**	**1,176,743**	**1,321,263**	**1,326,676**	**1,477,394**	**1,484,798**
TOTAL - BOTH DIRECTION	**2,350,809**		**2,647,939**		**2,962,192**	

Source Data: Sigma-RCL JV.

Table B13: Average Daily Volume of Three Pre-dominant Vehicle Classes on Bhairab Bridge (2007 to 2009)

Day	**Average Daily Volume of Traffic**					
	Large Bus and Medium Truck			**Light Vehicle**		
	Bhairab Toll Plaza	**Ashuganj Toll Plaza**	**Bothway**	**Bhairab Toll Plaza**	**Ashuganj Toll Plaza**	**Bothway**
Saturday	1,055	1,003	**2,058**	766	911	**1,677**
Sunday	1,154	1,001	**2,156**	750	798	**1,547**
Monday	1,152	1,019	**2,171**	780	775	**1,555**
Tuesday	1,150	1,031	**2,180**	738	754	**1,492**
Wednesday	1,167	1,062	**2,228**	781	787	**1,568**
Thursday	1,213	1,082	**2,295**	943	829	**1,772**
Friday	1,113	1,084	**2,197**	1,030	1,032	**2,062**
Avg. Weekly Vol.	**8,004**	**7,282**	**15,286**	**5,788**	**5,886**	**11,673**
Weekly ADT	**1,143**	**1,040**	**2,184**	**827**	**841**	**1,668**

Source Data: Sigma-RCL JV.

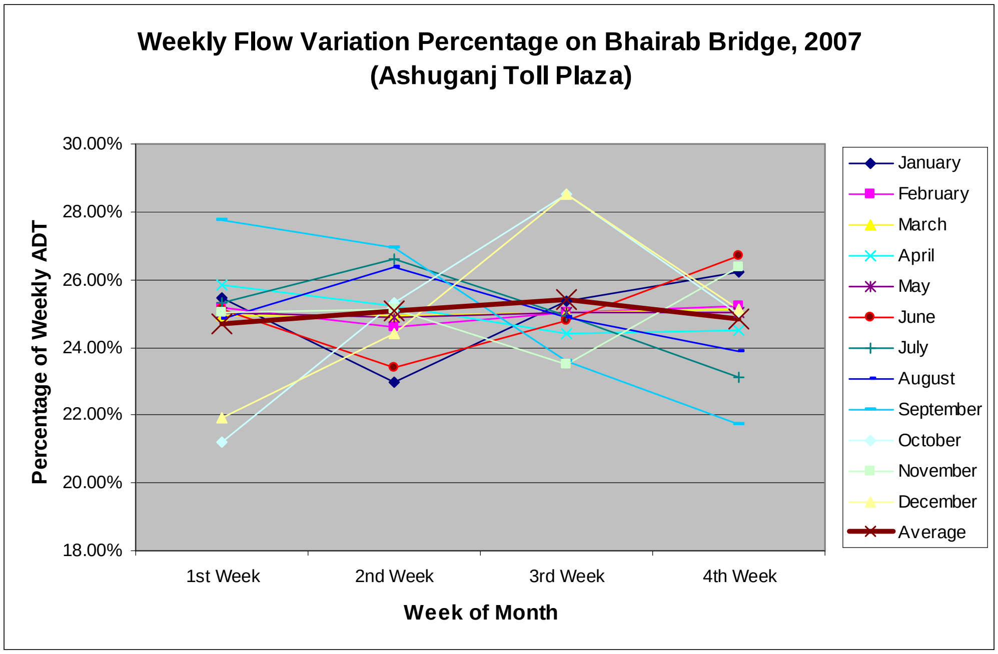


Figure B13: Weekly Traffic Flow Variation Pattern on Bhairab Bridge (Ashuganj Toll Plaza), 2007

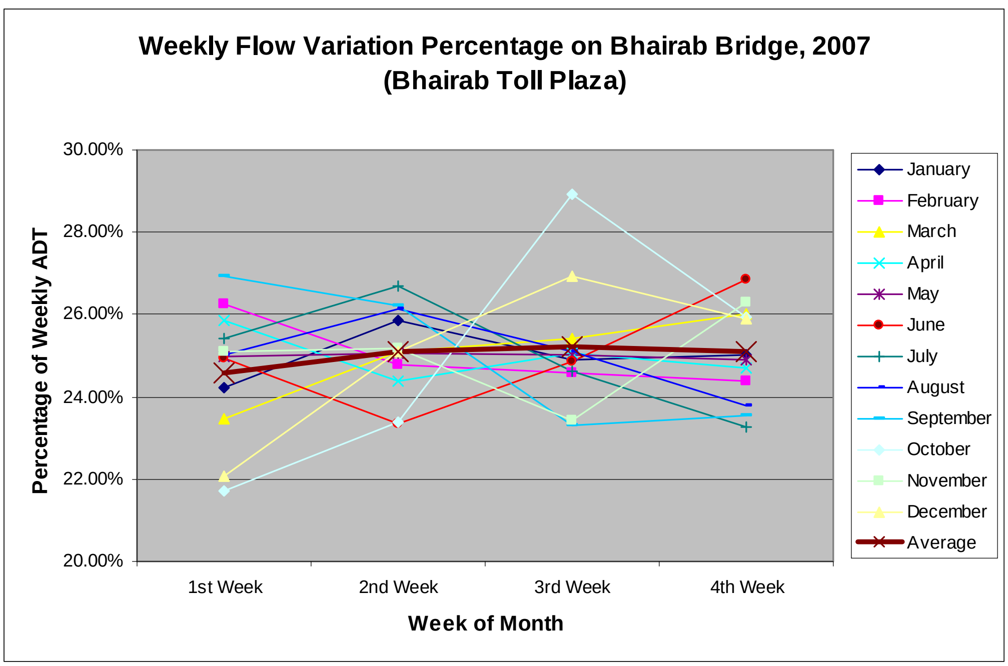


Figure B14: Weekly Traffic Flow Variation Pattern on Bhairab Bridge (Bhairab Toll Plaza), 2007

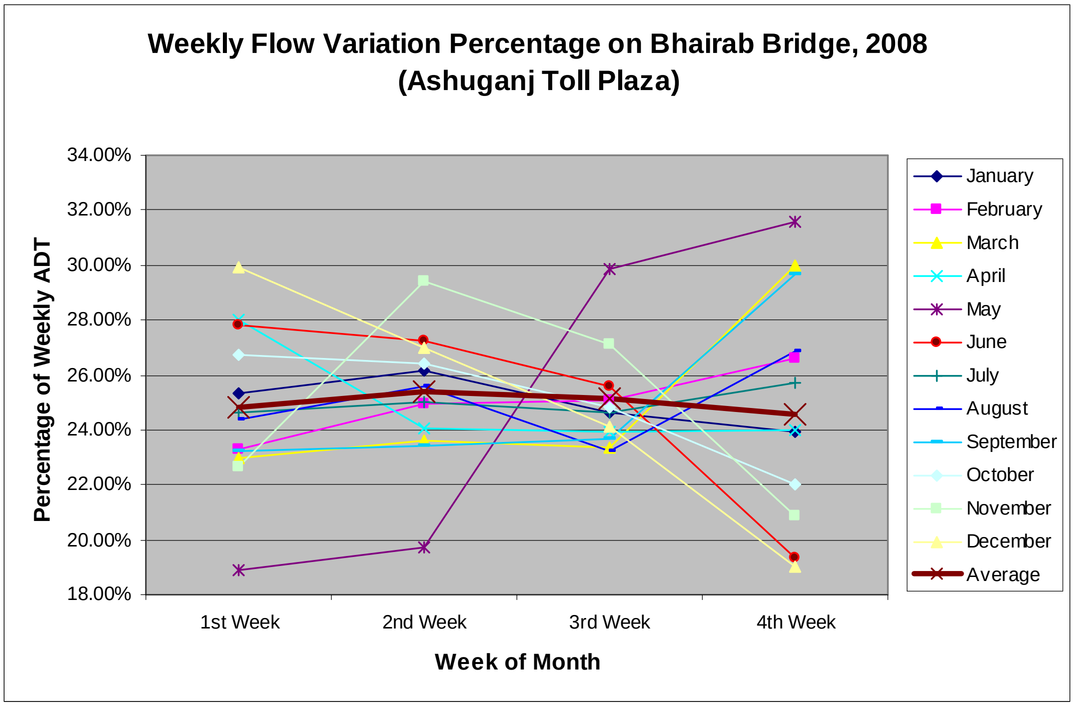


Figure B15: Weekly Traffic Flow Variation Pattern on Bhairab Bridge (Ashuganj Toll Plaza), 2008

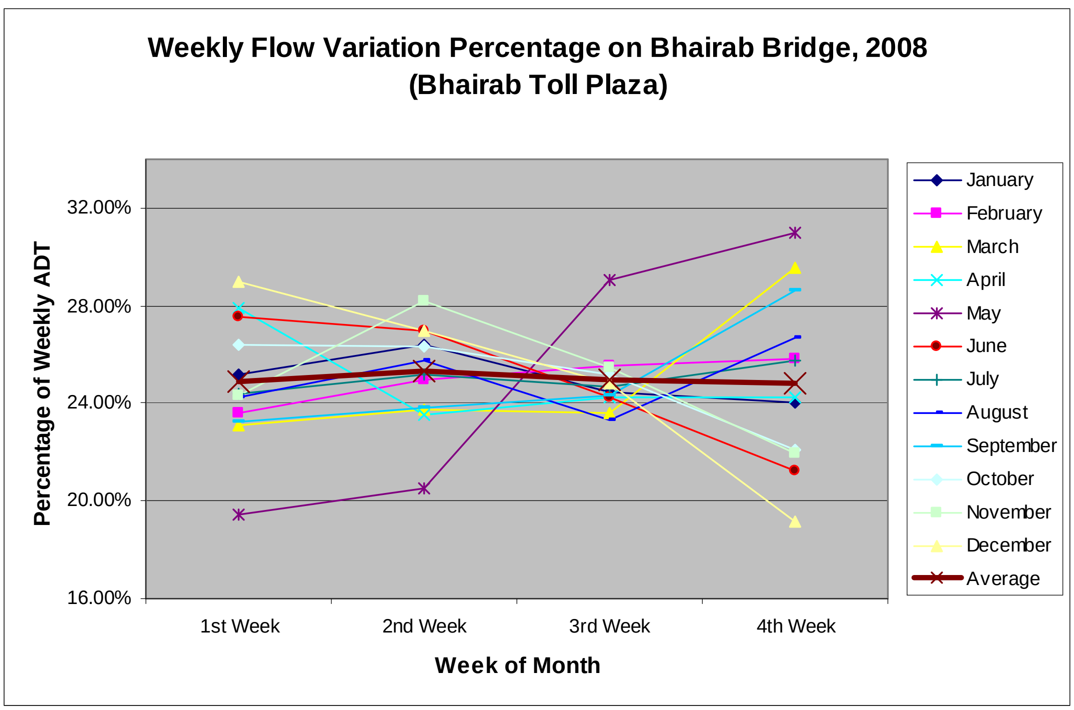


Figure B16: Weekly Traffic Flow Variation Pattern on Bhairab Bridge (Bhairab Toll Plaza), 2008

Table B14: Monthly Bi-Directional Traffic Volume on Bhairab Bridge

Month\Year	2007	2008	2009
Jan	111,264	142,849	165,147
Feb	108,794	143,810	160,869
Mar	119,673	178,453	175,773
Apr	112,696	153,613	162,958
May	115,816	204,053	173,608
Jun	112,770	214,629	172,284
Jul	125,261	166,635	180,520
Aug	118,221	178,741	176,987
Sep	109,984	157,233	175,972
Oct	130,364	189,231	182,337
Nov	129,286	236,827	193,099
Dec	154,420	198,370	204,986
Yearly Volume	**1,448,549**	**2,164,444**	**2,124,540**

Source Data: Sigma-RCL JV.

Table B15: Monthly Bi-Directional Traffic Flow, in Percentage of Yearly Volume on Bhairab Bridge

Month\Year	2007	2008	2009	**Average**
Jan	7.68%	6.60%	7.77%	**7.35%**
Feb	7.51%	6.64%	7.57%	**7.24%**
Mar	8.26%	8.24%	8.27%	**8.26%**
Apr	7.78%	7.10%	7.67%	**7.52%**
May	8.00%	9.43%	8.17%	**8.53%**
Jun	7.79%	9.92%	8.11%	**8.60%**
Jul	8.65%	7.70%	8.50%	**8.28%**
Aug	8.16%	8.26%	8.33%	**8.25%**
Sep	7.59%	7.26%	8.28%	**7.71%**
Oct	9.00%	8.74%	8.58%	**8.77%**
Nov	8.93%	10.94%	9.09%	**9.65%**
Dec	10.66%	9.16%	9.65%	**9.82%**
Total	100.00%	100.00%	100.00%	**100.00%**
Maximum	10.66%	10.94%	9.65%	9.82%
Minimum	7.51%	6.60%	7.57%	7.24%

Source Data: Sigma-RCL JV.

Table B16: Monthly Bi-Directional Traffic Flow on Bhairab Bridge, 2007

Month	Class I	Class II	Class III	Class IV	Class V	Class VI	Class VII	Class VIII	Class IX	Total Traffic	Percentage
Jan-07	19631	4792	22447	554	4468	55810	876	213	2473	**111264**	**7.68**
Feb-07	17290	4177	21243	611	4247	57520	1188	243	2275	**108794**	**7.51**
Mar-07	19077	5185	22049	564	5054	63631	1424	198	2491	**119673**	**8.26**
Apr-07	18687	5031	19711	554	4686	60228	1072	316	2411	**112696**	**7.78**
May-07	19729	6225	21127	513	5092	59436	1077	141	2476	**115816**	**8.00**
Jun-07	19131	5875	23795	608	4798	55202	763	153	2445	**112770**	**7.79**
Jul-07	20552	6745	28662	597	4998	60302	902	360	2143	**125261**	**8.65**
Aug-07	20967	5105	25582	526	5133	57616	1145	143	2004	**118221**	**8.16**
Sep-07	18990	5592	21916	516	4845	54841	1094	73	2117	**109984**	**7.59**
Oct-07	27335	10005	28093	445	4688	56494	863	76	2365	**130364**	**9.00**
Nov-07	22629	9427	26601	601	4604	61687	1153	190	2394	**129286**	**8.93**
Dec-07	27415	16178	35702	544	4971	65764	1108	221	2517	**154420**	**10.66**
TOTAL	**251433**	**84337**	**296928**	**6633**	**57584**	**708531**	**12665**	**2327**	**28111**	**1448549**	**100.00**
Percentage	17.36	5.82	20.50	0.46	3.98	48.91	0.87	0.16	1.94	100	

** Source Data: Marga Net One Limited (MNOL), BBSO.*

** Class I= Motor Cycle /Baby Taxi/ Mishuk, Class II= Maxi/ Pick-up/ Tampo, ClassIII= Car/Jeep/Station Wagon/ Micro, Class IV= Coaster/Tractor/Tractor with Trailer, Class V=Mini Bus/Mini Truck, Class VI=Bus/Truck/Covered Truck 2 Axle, Class VII= Bus/Truck/Covered Truck 3 Axle, Class VIII=Trailer Truck/Construction Equipment, Class IX=Toll Free Vehicles.*

Table B17: Monthly Bi-Directional Traffic Flow on Bhairab Bridge, 2008

Month	Class I	Class II	Class III	Class IV	Class V	Class VI	Class VII	Class VIII	Class IX	Total Traffic	Percentage
Jan-08	**23058**	**12864**	**32460**	**589**	**4853**	**64822**	**1354**	**360**	**2489**	**142849**	**6.60**
Feb-08	24183	13752	33264	539	4350	63600	1441	229	2452	**143810**	**6.64**
Mar-08	28792	33143	35963	578	5089	70617	1561	277	2433	**178453**	**8.24**
Apr-08	28853	20679	30310	571	5219	63878	1733	149	2221	**153613**	**7.10**
May-08	31968	22163	58957	635	7241	78671	1695	140	2583	**204053**	**9.43**
Jun-08	31517	23046	55372	988	7065	92079	1849	212	2501	**214629**	**9.92**
Jul-08	30813	25906	35254	825	5853	64395	685	120	2784	**166635**	**7.70**
Aug-08	36309	27494	38934	701	5731	66040	940	91	2501	**178741**	**8.26**
Sep-08	37230	20766	27484	539	5073	63303	772	160	1906	**157233**	**7.26**
Oct-08	48338	33754	38898	444	4679	60468	566	108	1976	**189231**	**8.74**
Nov-08	42617	28888	54431	571	6923	95520	1869	4277	1731	**236827**	**10.94**
Dec-08	49246	30034	45551	534	4936	64837	881	134	2217	**198370**	**9.16**
TOTAL	**412924**	**292489**	**486878**	**7514**	**67012**	**848230**	**15346**	**6257**	**27794**	**2164444**	**100.00**
Percentage	19.08	13.51	22.49	0.35	3.10	39.19	0.71	0.29	1.28	100	

**Source Data: Marga Net One Limited (MNOL), BBSO.*

** Class I= Motor Cycle /Baby Taxi/ Mishuk, Class II= Maxi/ Pick-up/ Tampo, ClassIII= Car/Jeep/Station Wagon/ Micro, Class IV= Coaster/Tractor/Tractor with Trailer, Class V=Mini Bus/Mini Truck, Class VI=Bus/Truck/Covered Truck 2 Axle, Class VII= Bus/Truck/Covered Truck 3 Axle, Class VIII=Trailer Truck/Construction Equipment, Class IX=Toll Free Vehicles.*

Table B18: Monthly Bi-Directional Traffic Flow on Bhairab Bridge, 2009

Month	Class I	Class II	Class III	Class IV	Class V	Class VI	Class VII	Class VIII	Class IX	Total Traffic	Percentage
Jan-09	34013	12395	40146	661	5265	68119	2126	242	2180	165147	7.77
Feb-09	34914	9543	37768	594	5620	68617	2057	161	1595	160869	7.57
Mar-09	39134	11236	40455	699	5720	74848	1716	237	1728	175773	8.27
Apr-09	39630	11269	35212	665	5812	67281	1378	164	1547	162958	7.67
May-09	43194	14517	39161	633	6251	67116	970	144	1622	173608	8.17
Jun-09	40890	14248	39528	913	7303	66539	1004	126	1733	172284	8.11
Jul-09	42190	12592	46596	819	7245	67997	1006	69	2006	180520	8.50
Aug-09	42627	11064	43443	877	7365	68522	1315	30	1744	176987	8.33
Sep-09	51503	9920	41806	690	6416	62454	1348	34	1801	175972	8.28
Oct-09	47135	10392	41042	782	6688	72558	1774	74	1892	182337	8.58
Nov-09	48383	11186	47152	1024	7300	74437	1662	76	1879	193099	9.09
Dec-09	53767	11093	52071	905	7281	76032	1675	114	2048	204986	9.65
TOTAL	517380	139455	504380	9262	78266	834520	18031	1471	21775	2124540	100.00
Percentage	24.35	6.56	23.74	0.44	3.68	39.28	0.85	0.07	1.02	100	

**Source Data: Marga Net One Limited (MNOL), BBSO.*

** Class I= Motor Cycle /Baby Taxi/ Mishuk, Class II= Maxi/ Pick-up/ Tampo, ClassIII= Car/Jeep/Station Wagon/ Micro, Class IV= Coaster/Tractor/Tractor with Trailer, Class V=Mini Bus/Mini Truck, Class VI=Bus/Truck/Covered Truck 2 Axle, Class VII= Bus/Truck/Covered Truck 3 Axle, Class VIII=Trailer Truck/Construction Equipment, Class IX=Toll Free Vehicles.*

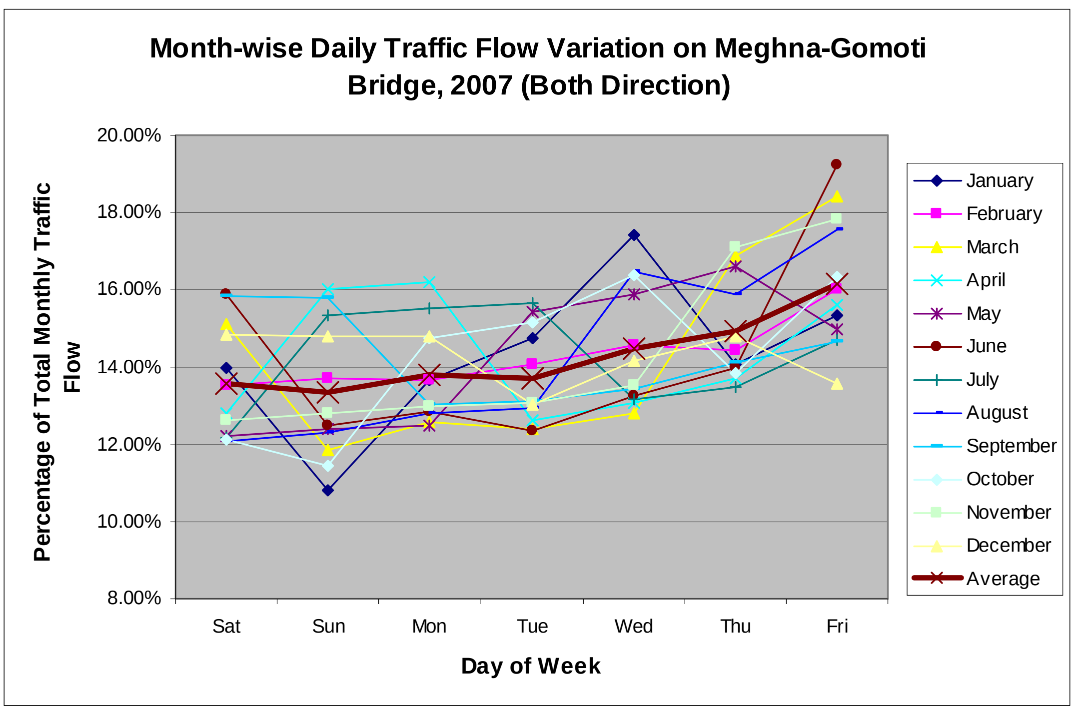


Figure B17: Month-wise Daily Flow Fluctuation on Meghna-Gomoti Bridge, 2007

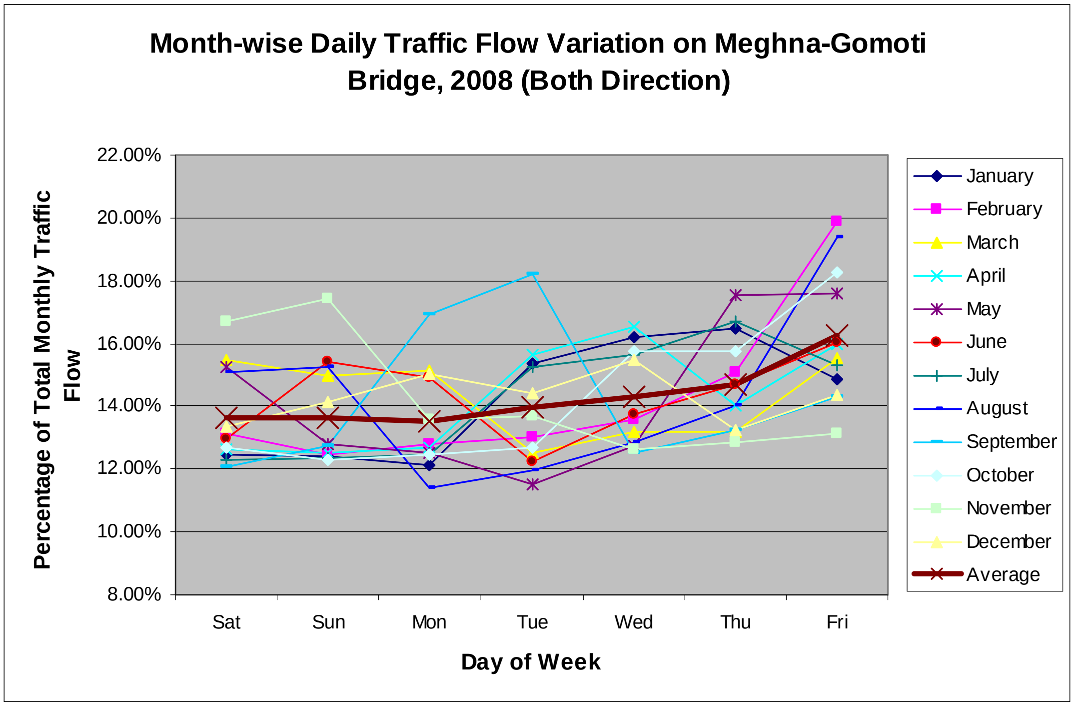


Figure B18: Month-wise Daily Flow Fluctuation on Meghna-Gomoti Bridge, 2008

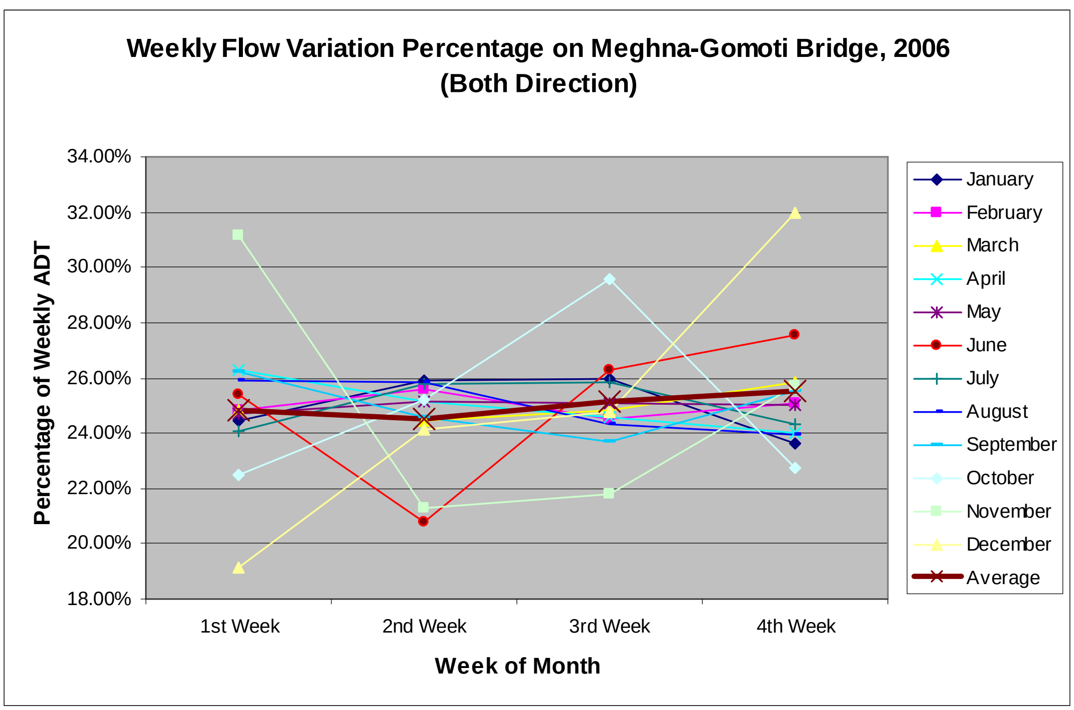


Figure B19: Weekly Flow Variation Percentage on Meghna-Gomoti Bridge, 2006 (Both Direction)

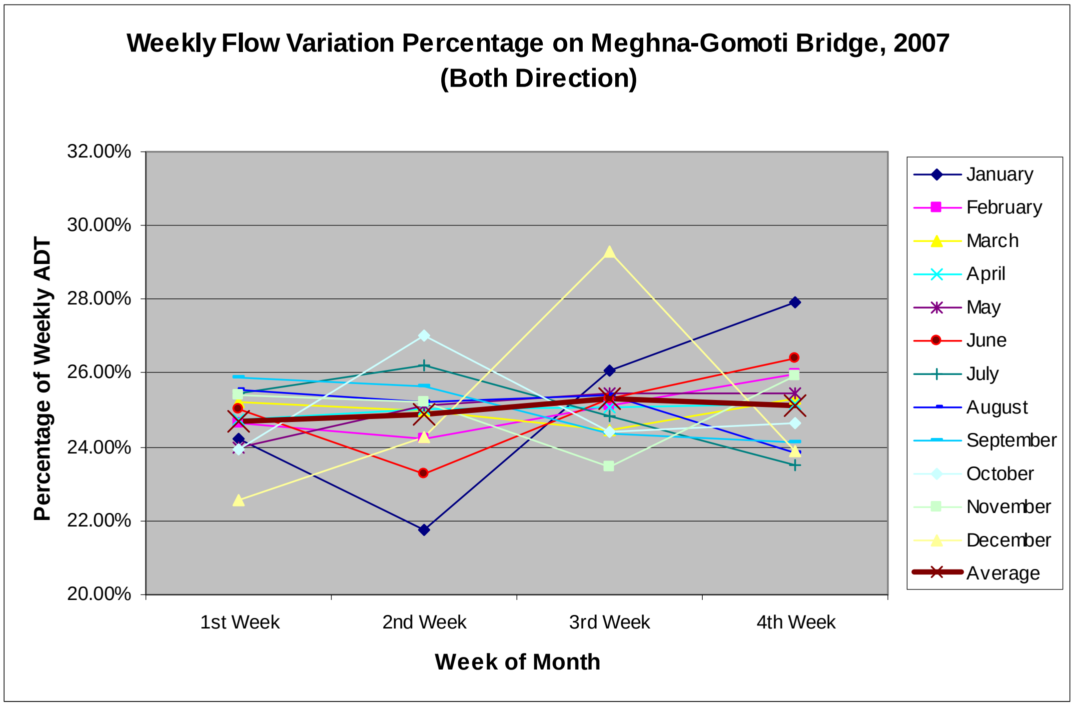


Figure B20: Weekly Flow Variation Percentage on Meghna-Gomoti Bridge, 2007 (Both Direction)

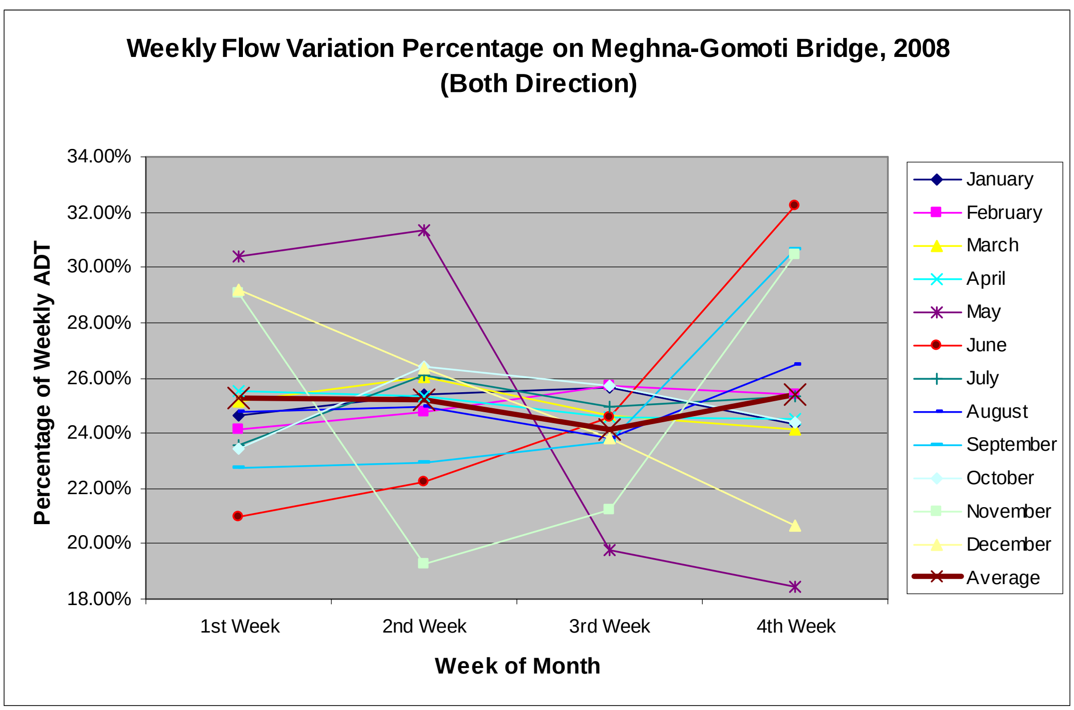


Figure B21: Weekly Flow Variation Percentage on Meghna-Gomoti Bridge, 2008 (Both Direction)

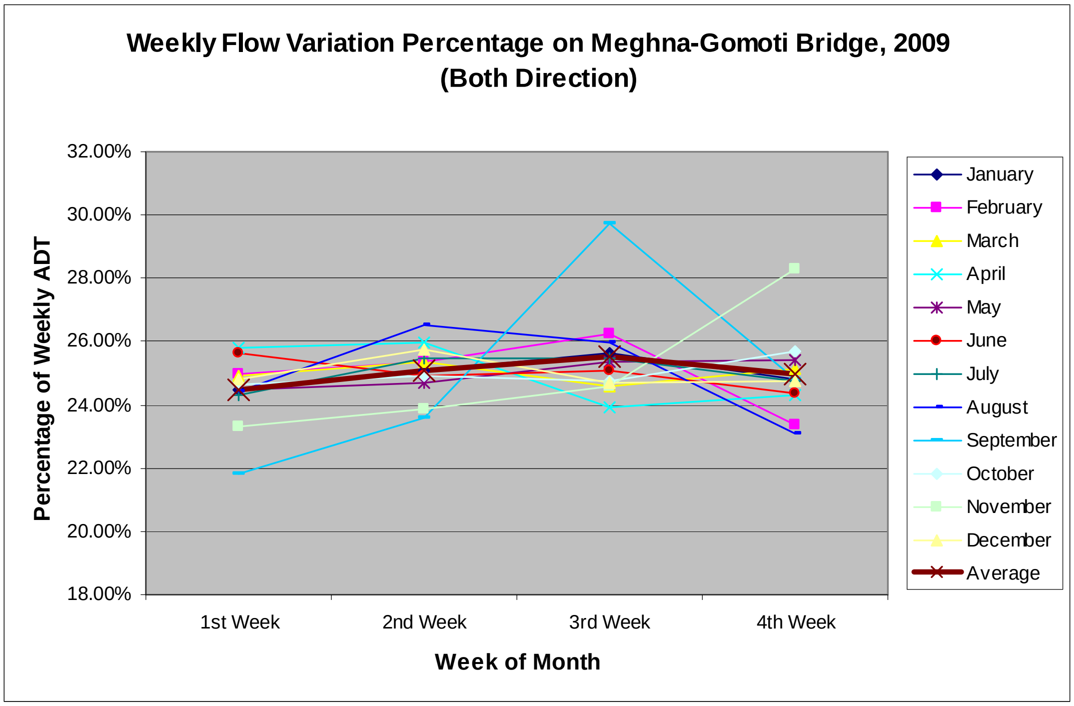


Figure B22: Weekly Flow Variation Percentage on Meghna-Gomoti Bridge, 2009 (Both Direction)

Table B19: Monthly Bi-Directional Traffic Volume on Meghna-Gomoti Bridge

Month\Year	2006	2007	2008	2009
Jan	250,988	295,193	416,396	453,185
Feb	238,820	312,740	403,447	424,170
Mar	265,789	360,112	429,778	464,702
Apr	243,965	345,105	402,048	444,537
May	266,474	375,049	326,242	472,871
Jun	261,144	359,441	292,239	457,681
Jul	288,475	369,120	415,725	467,515
Aug	277,259	352,299	422,798	452,142
Sep	263,283	346,617	409,367	470,306
Oct	298,482	393,615	427,631	503,949
Nov	240,141	366,653	319,814	523,644
Dec	315,590	437,893	467,464	498,096
Yearly Volume	**3,210,410**	**4,313,837**	**4,732,949**	**5,632,798**

Source Data: RCL, MBEL-ATT JV.

Table B20: Monthly Bi-Directional Traffic Flow, in Percentage of Yearly Volume on Meghna-Gomoti Bridge

Month\Year	2006	2007	2008	2009	Average
Jan	7.82%	6.84%	8.80%	8.05%	**7.88%**
Feb	7.44%	7.25%	8.52%	7.53%	**7.69%**
Mar	8.28%	8.35%	9.08%	8.25%	**8.49%**
Apr	7.60%	8.00%	8.49%	7.89%	**8.00%**
May	8.30%	8.69%	6.89%	8.39%	**8.07%**
Jun	8.13%	8.33%	6.17%	8.13%	**7.69%**
Jul	8.99%	8.56%	8.78%	8.30%	**8.66%**
Aug	8.64%	8.17%	8.93%	8.03%	**8.44%**
Sep	8.20%	8.04%	8.65%	8.35%	**8.31%**
Oct	9.30%	9.12%	9.04%	8.95%	**9.10%**
Nov	7.48%	8.50%	6.76%	9.30%	**8.01%**
Dec	9.83%	10.15%	9.88%	8.84%	**9.68%**
Total	100.00%	100.00%	100.00%	100.00%	**100.00%**
Maximum	9.83%	10.15%	9.88%	9.30%	9.68%
Minimum	7.44%	6.84%	6.17%	7.53%	7.69%

Source Data: RCL, MBEL-ATT JV.

Table B21: Monthly Bi-Directional Traffic Flow on Meghna-Gomoti Bridge, 2006

Month	Motor Cycle	Scooter/ Tampo	Car/ Jeep	Micro/ Pickup	Mini bus/ Coaster	Bus	Truck	Trailer	Toll Free Vehicle	Total Traffic	Percentage
Jan-06	771	1633	39317	39192	35791	39430	80294	2909	11651	**250988**	**7.82**
Feb-06	594	1309	32989	34834	31197	37241	85890	3543	11223	**238820**	**7.44**
Mar-06	719	1409	35119	35168	35527	41736	99433	4323	12355	**265789**	**8.28**
Apr-06	741	1210	30171	30415	33617	39100	93910	3872	10929	**243965**	**7.60**
May-06	745	1146	34330	34163	36560	43116	100827	3974	11613	**266474**	**8.30**
Jun-06	712	1144	32736	35279	35528	40261	101248	3830	10406	**261144**	**8.13**
Jul-06	765	1074	36245	39348	39104	46117	110651	3861	11310	**288475**	**8.99**
Aug-06	737	972	35034	37696	37719	44523	105047	4296	11235	**277259**	**8.64**
Sep-06	715	968	33019	36914	35857	41908	99327	3571	11004	**263283**	**8.20**
Oct-06	1434	2301	47441	48128	41501	45669	95899	4083	12026	**298482**	**9.30**
Nov-06	736	1213	29369	34594	30467	34123	96837	4330	8472	**240141**	**7.48**
Dec-06	1032	1768	48054	52858	38971	44714	112974	4899	10320	**315590**	**9.83**
TOTAL	**9701**	**16147**	**433824**	**458589**	**431839**	**497938**	**1182337**	**47491**	**132544**	**3210410**	**100.00**
Percentage	0.30	0.50	13.51	14.28	13.45	15.51	36.83	1.48	4.13	100	

Source Data: RCL, MBEL-ATT JV.

Table B22: Monthly Bi-Directional Traffic Flow on Meghna-Gomoti Bridge, 2007

Month	Motor Cycle	Scooter/ Tampo	Car/ Jeep	Micro/ Pickup	Mini bus/ Coaster	Bus	Truck	Trailer	Toll Free Vehicle	Total Traffic	Percentage
Jan-07	1224	1451	46251	48313	40907	47212	93145	4672	12018	**295193**	**6.84**
Feb-07	1115	2155	42302	48238	43333	51373	106317	6100	11807	**312740**	**7.25**
Mar-07	1746	2856	46987	52035	50165	57540	127266	8357	13160	**360112**	**8.35**
Apr-07	1679	5857	42266	46769	47602	54511	123594	8232	14595	**345105**	**8.00**
May-07	1974	6433	48333	53964	49152	58197	134161	7591	15244	**375049**	**8.69**
Jun-07	1849	6906	45737	53806	48040	55662	125170	6906	15365	**359441**	**8.33**
Jul-07	1526	6910	46096	54714	49525	57307	130501	7008	15533	**369120**	**8.56**
Aug-07	1841	7726	42397	51434	46299	55240	123976	7929	15457	**352299**	**8.17**
Sep-07	1421	7902	38983	50423	43657	54136	126721	8820	14554	**346617**	**8.04**
Oct-07	3200	9918	57335	67445	51910	63751	114430	8318	17308	**393615**	**9.12**
Nov-07	1844	7920	44672	57898	44678	56832	128117	9509	15183	**366653**	**8.50**
Dec-07	3310	10462	67903	81999	55583	68652	126091	6358	17535	**437893**	**10.15**
TOTAL	**22729**	**76496**	**569262**	**667038**	**570851**	**680413**	**1459489**	**89800**	**177759**	**4313837**	**100.00**
Percentage	0.53	1.77	13.20	15.46	13.23	15.77	33.83	2.08	4.12	100	

Source Data: RCL, MBEL-ATT JV.

Table B23: Monthly Bi-Directional Traffic Flow on Meghna-Gomoti Bridge, 2008

Month	Motor Cycle	Scooter/ Tampo	Car/ Jeep	Micro/ Pickup	Mini bus/ Coaster	Bus	Truck	Trailer	Toll Free Vehicle	Total Traffic	Percentage
Jan-08	**1922**	**8890**	**54610**	**69125**	**48632**	**67279**	**140186**	**8755**	**16997**	**416396**	**8.80**
Feb-08	2112	7588	57106	68967	46248	65945	129399	7977	18105	**403447**	**8.52**
Mar-08	2620	9080	58056	67968	49787	69996	144124	8329	19818	**429778**	**9.08**
Apr-08	2793	9107	51018	60790	47880	64917	138746	8809	17988	**402048**	**8.49**
May-08	3430	6079	30817	37509	40671	52059	133692	9043	12942	**326242**	**6.89**
Jun-08	3275	14873	24973	33603	36867	29420	129807	8393	11028	**292239**	**6.17**
Jul-08	2479	23770	49754	61893	43925	60882	145267	10633	17122	**415725**	**8.78**
Aug-08	2875	25319	54813	66166	45269	64131	136759	9525	17941	**422798**	**8.93**
Sep-08	2909	24043	50650	66276	41687	56124	140838	9772	17068	**409367**	**8.65**
Oct-08	4558	26417	63860	74838	44917	69332	116625	8393	18691	**427631**	**9.04**
Nov-08	2958	23571	30951	48436	29563	45110	120372	4594	14259	**319814**	**6.76**
Dec-08	5044	28129	83151	86578	48564	70423	118691	7647	19237	**467464**	**9.88**
TOTAL	**36975**	**206866**	**609759**	**742149**	**524010**	**715618**	**1594506**	**101870**	**201196**	**4732949**	**100.00**
Percentage	0.78	4.37	12.88	15.68	11.07	15.12	33.69	2.15	4.25	100	

Source Data: RCL, MBEL-ATT JV.

Table B24: Monthly Bi-Directional Traffic Flow on Meghna-Gomoti Bridge, 2009

Month	Motor Cycle	Scooter/ Tampo	Car/ Jeep	Micro/ Pickup	Mini bus/ Coaster	Bus	Truck	Trailer	Toll Free Vehicle	Total Traffic	Percentage
Jan-09	**3482**	**20445**	**65970**	**76828**	**43283**	**65505**	**146805**	**11966**	**18901**	**453185**	**8.05**
Feb-09	3467	18988	57480	71968	42396	64022	138144	9415	18290	**424170**	**7.53**
Mar-09	3636	22694	62797	77292	46225	68116	154634	9377	19931	**464702**	**8.25**
Apr-09	3607	22126	56148	71433	42956	63910	155362	10013	18982	**444537**	**7.89**
May-09	3985	23209	67127	80171	44262	69097	154829	10938	19253	**472871**	**8.39**
Jun-09	3539	23041	60470	76811	43139	65824	154940	10078	19839	**457681**	**8.13**
Jul-09	3501	24632	60371	81355	43652	64446	161375	8420	19763	**467515**	**8.30**
Aug-09	3534	25491	56637	76074	43188	62180	157427	8844	18767	**452142**	**8.03**
Sep-09	5481	29521	70320	93529	46194	65661	132695	7196	19709	**470306**	**8.35**
Oct-09	4104	26281	59672	88962	44823	67669	181290	10701	20447	**503949**	**8.95**
Nov-09	5061	29024	71625	106254	47757	63852	173051	8710	18310	**523644**	**9.30**
Dec-09	3499	25628	67582	93891	48095	67867	165646	10337	15551	**498096**	**8.84**
TOTAL	**46896**	**291080**	**756199**	**994568**	**535970**	**788149**	**1876198**	**115995**	**227743**	**5632798**	**100.00**

Source Data: RCL, MBEL-ATT JV.

Table B25: Day-wise ADT on Jamuna Bridge (From Oct'09-Sep'10))

Day	Average Daily Volume of Traffic		
	Dhaka to Mawa	**Mawa to Dhaka**	**Bothway**
Saturday	2,663	2,550	5,213
Sunday	2,568	2,472	5,040
Monday	2,618	2,503	5,120
Tuesday	2,592	2,535	5,128
Wednesday	2,629	2,539	5,168
Thursday	2,952	2,666	5,617
Friday	3,397	3,130	6,528
Avg. Weekly Vol.	**19,419**	**18,395**	**37,814**
Weekly ADT	**2,774**	**2,628**	**5,402**

**Data Source: Keraniganj Road Sub-Division (RHD).*

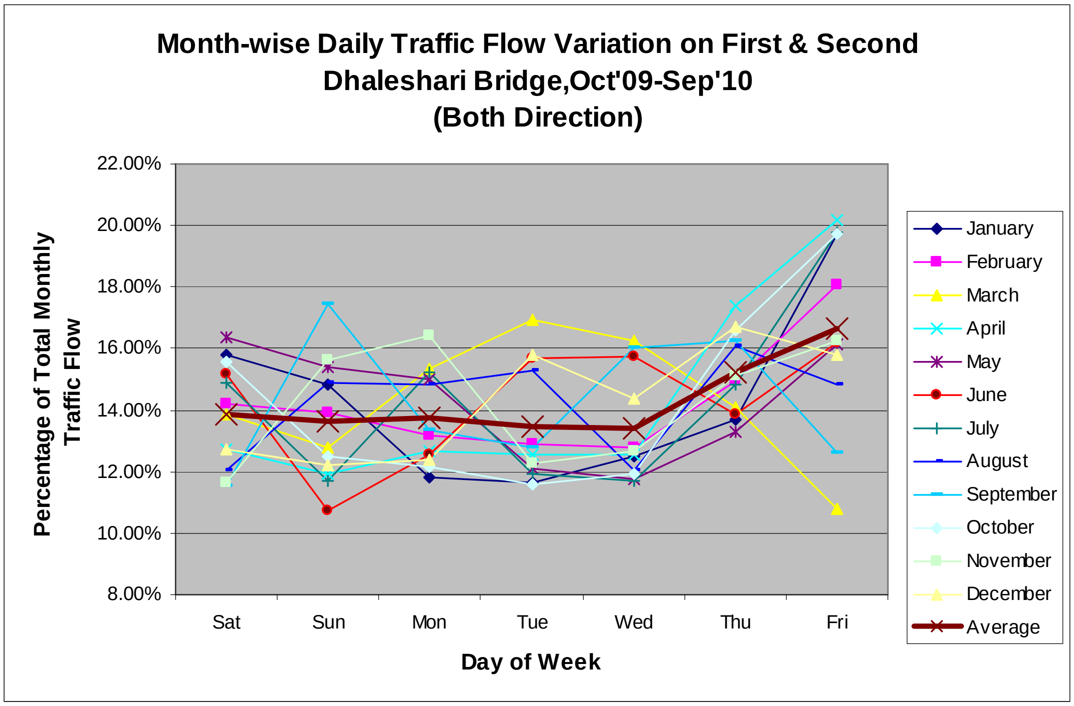


Figure B23: Month-wise Daily Flow Fluctuation on First and Second Dhaleshari Bridge (Both Direction) (From October 2009-September 2010)

Table B26: Day-wise Yearly Traffic Flow on First and Second Dhaleshari Bridge

Day \ Year	2009	
	Dhaka to Mawa	Mawa to Dhaka
Saturday	2,663	2,550
Sunday	2,568	2,472
Monday	2,618	2,503
Tuesday	2,592	2,535
Wednesday	2,629	2,539
Thursday	2,952	2,666
Friday	3,397	3,130
TOTAL	**19,419**	**18,395**
TOTAL - BOTH DIRECTION	**37,814**	

**Data Source: Keraniganj Road Sub-Division (RHD).*

Table B27: Average Daily Volume of Three Pre-dominant Vehicle Classes on First and Second Dhaleshari Bridge, 2009

Day	Average Daily Volume of Traffic								
	Truck			Bus			Mini Bus		
	Dhaka to Mawa	Mawa to Dhaka	Bothway	Dhaka to Mawa	Mawa to Dhaka	Bothway	Dhaka to Mawa	Mawa to Dhaka	Bothway
Saturday	258	195	**452**	201	168	**369**	872	734	**1,606**
Sunday	271	191	**462**	195	163	**359**	905	732	**1,637**
Monday	280	191	**471**	196	168	**364**	882	744	**1,625**
Tuesday	285	192	**477**	195	169	**364**	875	732	**1,607**
Wednesday	282	198	**480**	203	166	**368**	861	737	**1,598**
Thursday	297	202	**498**	209	175	**384**	925	743	**1,668**
Friday	232	206	**438**	210	182	**392**	924	804	**1,727**
Avg. Weekly Vol.	**1,904**	**1,374**	**3,278**	**1,409**	**1,190**	**2,599**	**6,242**	**5,227**	**11,469**

**Data Source: Keraniganj Road Sub-Division (RHD).*

Table B28: Monthly Bi-Directional Traffic Volume on First and Second Dhaleshari Bridge, 2009

Month\Year	October 2009-September 2010
Jan	168,035
Feb	164,866
Mar	181,437
Apr	173,394
May	175,349
Jun	153,826
Jul	152,600
Aug	141,108
Sep	155,820
Oct	160,481
Nov	165,413
Dec	177,949
Yearly Volume	**1,970,278**

**Data Source: Keraniganj Road Sub-Division (RHD).*

Table B29: Monthly Bi-Directional Traffic Flow, in Percentage of Yearly Volume on First and Second Dhaleshari Bridge, 2009

Month\Year	October 2009-September 2010
Jan	8.53%
Feb	8.37%
Mar	9.21%
Apr	8.80%
May	8.90%
Jun	7.81%
Jul	7.75%
Aug	7.16%
Sep	7.91%
Oct	8.15%
Nov	8.40%
Dec	9.03%
Total	100.00%
Maximum	9.21%
Minimum	7.16%

**Data Source: Keraniganj Road Sub-Division (RHD).*

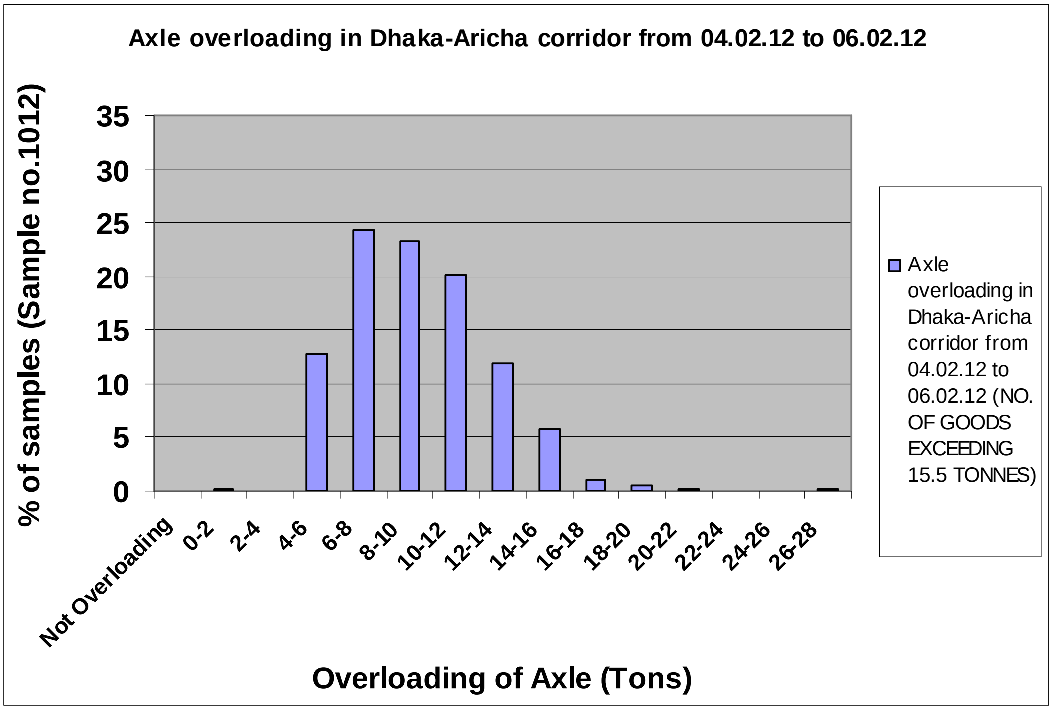


Figure B24: Axle Overloading in Dhaka-Aricha Corridor from 04.02.12 to 06.02.12

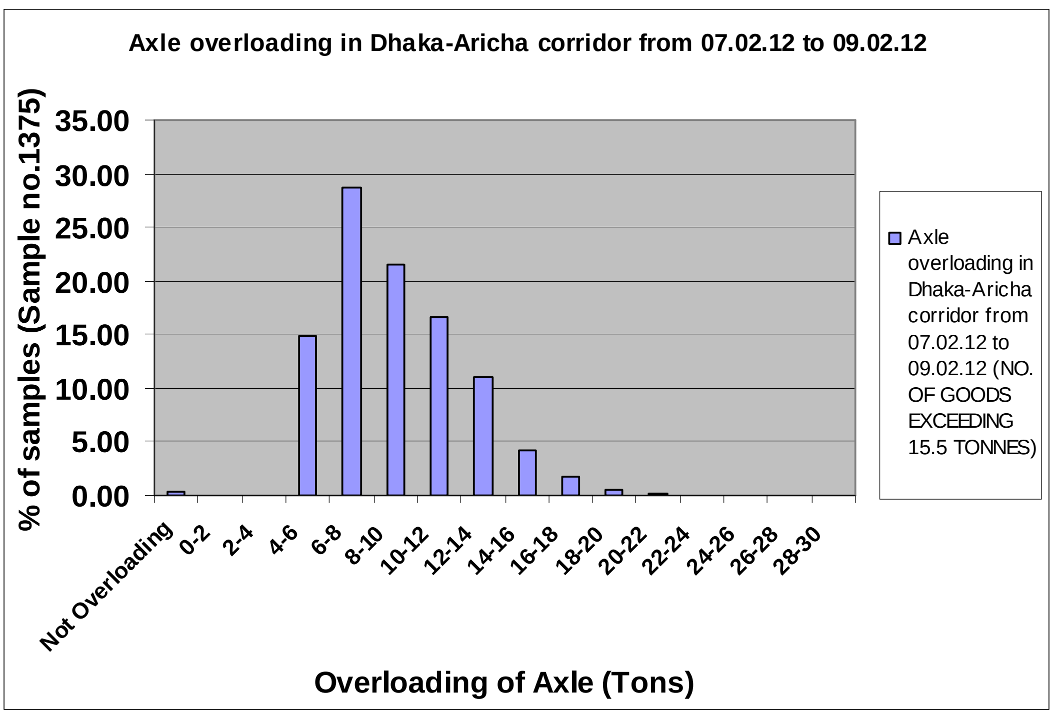


Figure B25: Axle Overloading in Dhaka-Aricha Corridor from 07.02.12 to 09.02.12

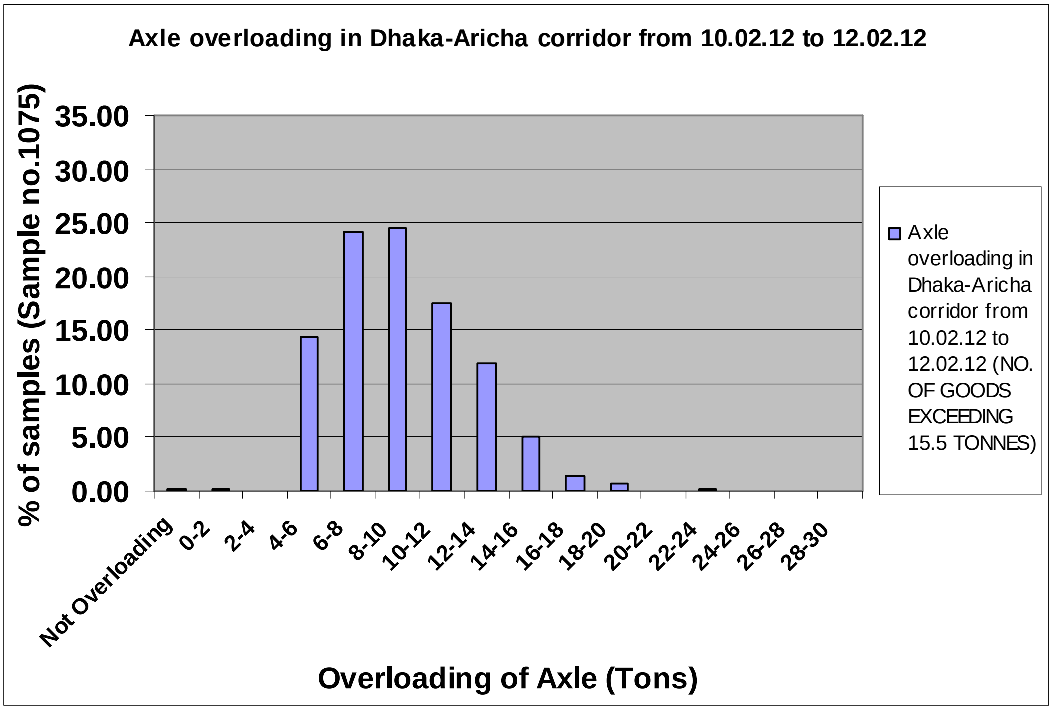


Figure B26: Axle Overloading in Dhaka-Aricha Corridor from 10.02.12 to 12.02.12

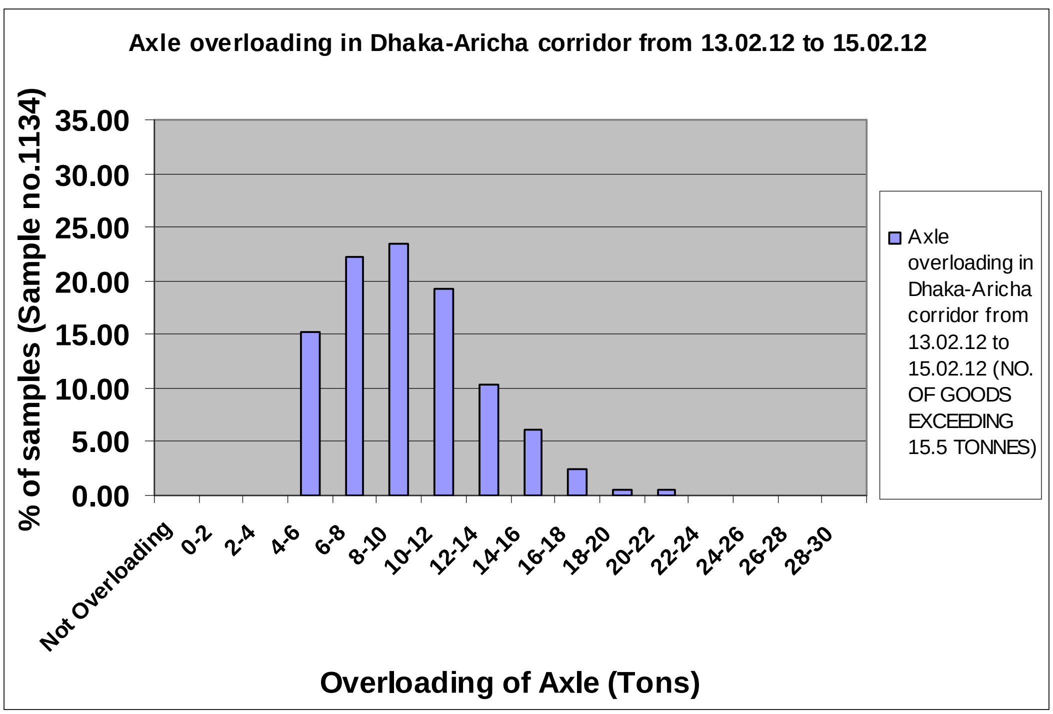


Figure B27: Axle Overloading in Dhaka-Aricha Corridor from 13.02.12 to 15.02.12

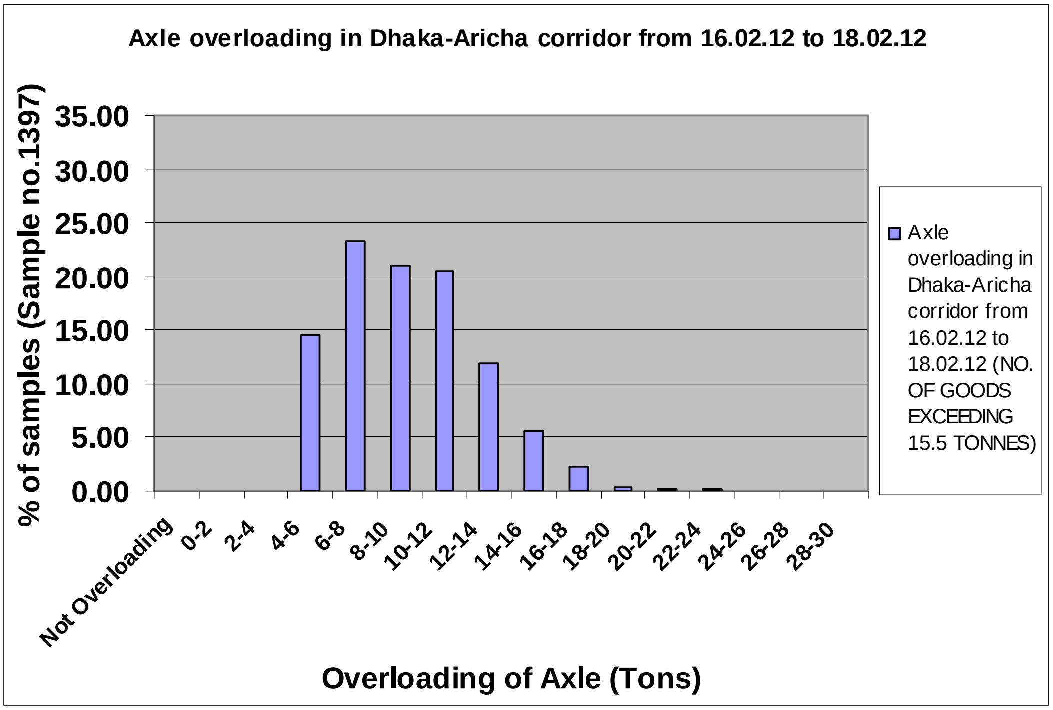


Figure B28: Axle Overloading in Dhaka-Aricha Corridor from 16.02.12 to 18.02.12

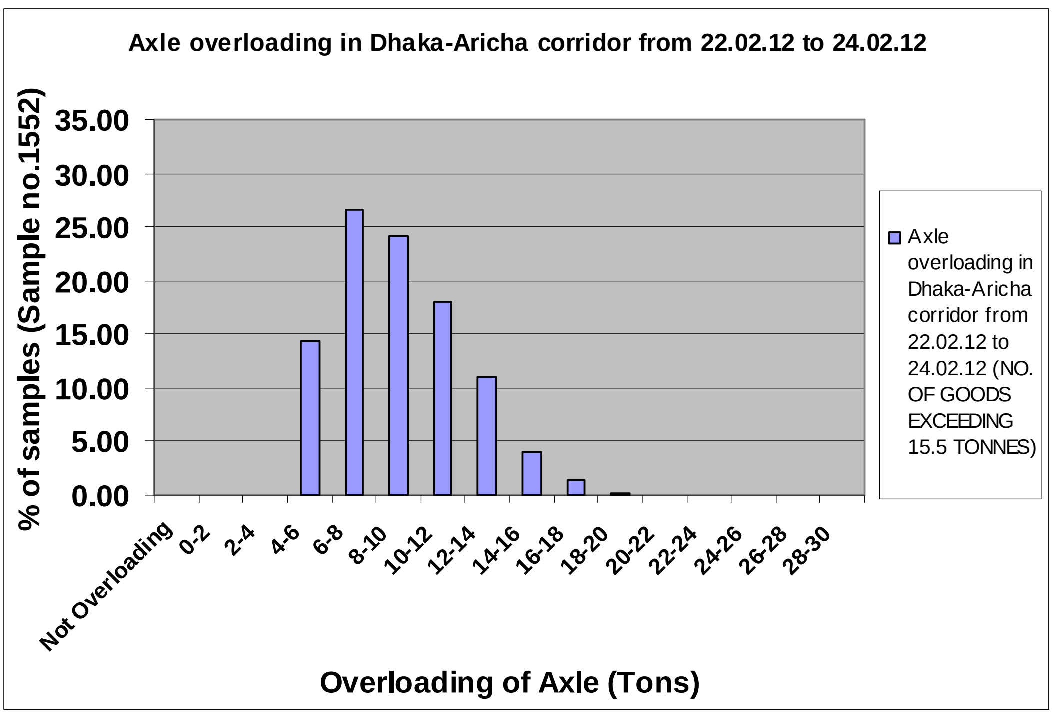


Figure B29: Axle Overloading in Dhaka-Aricha Corridor from 22.02.12 to 24.02.12

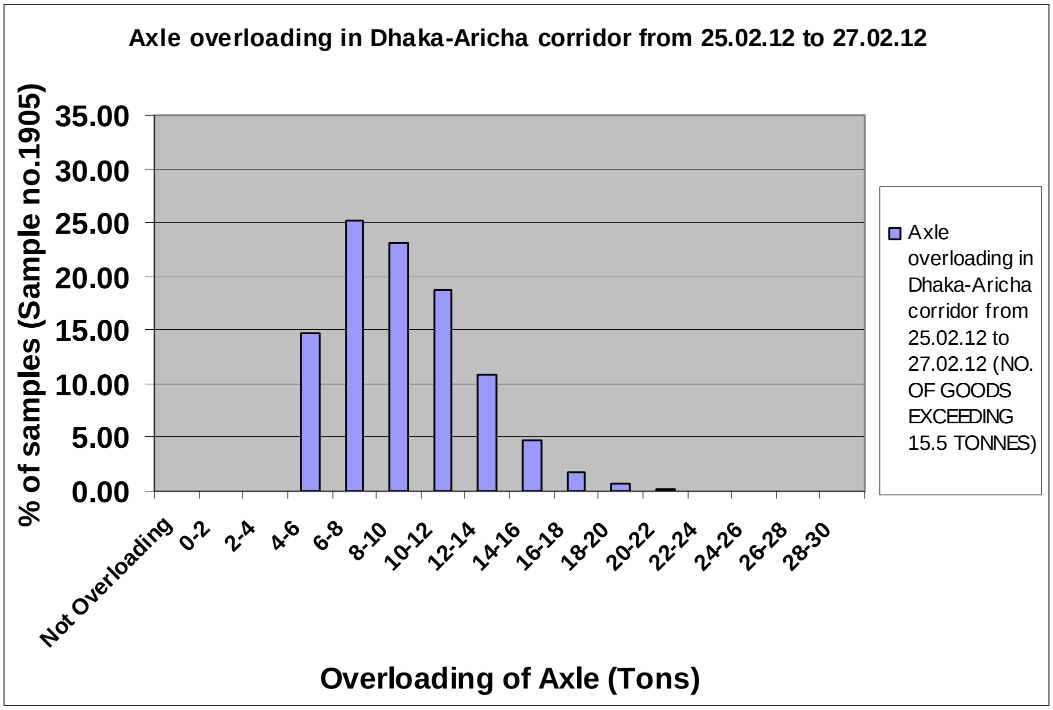


Figure B30: Axle Overloading in Dhaka-Aricha Corridor from 25.02.12 to 27.02.12

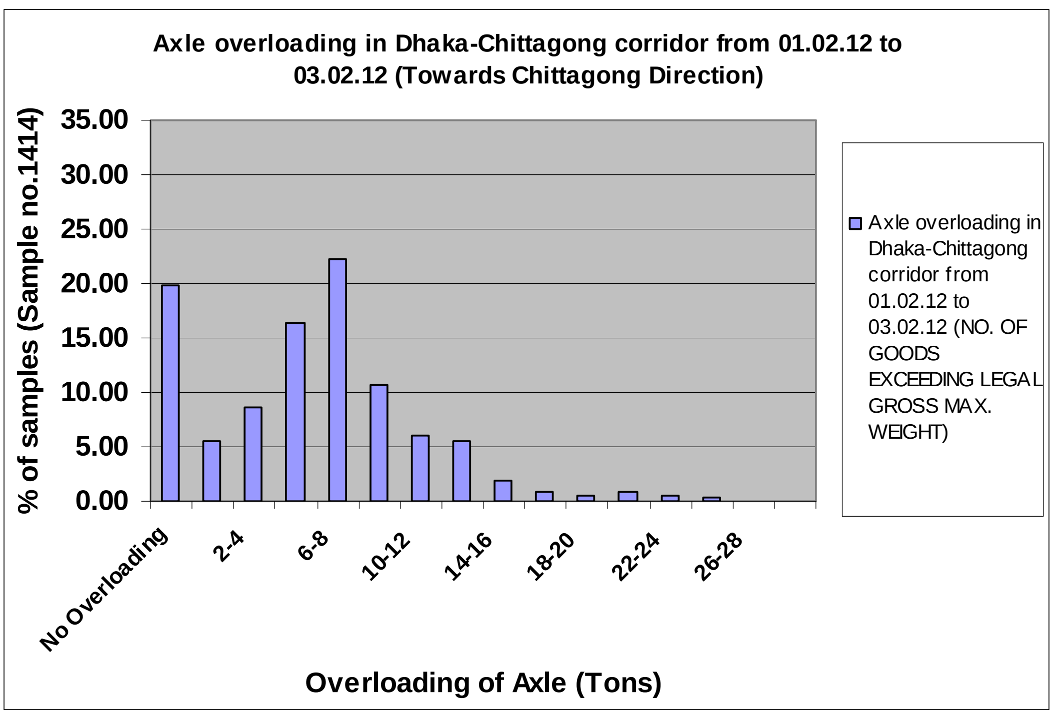


Figure B31: Axle Overloading in Dhaka-Chittagong Corridor from 01.02.12 to 03.02.12

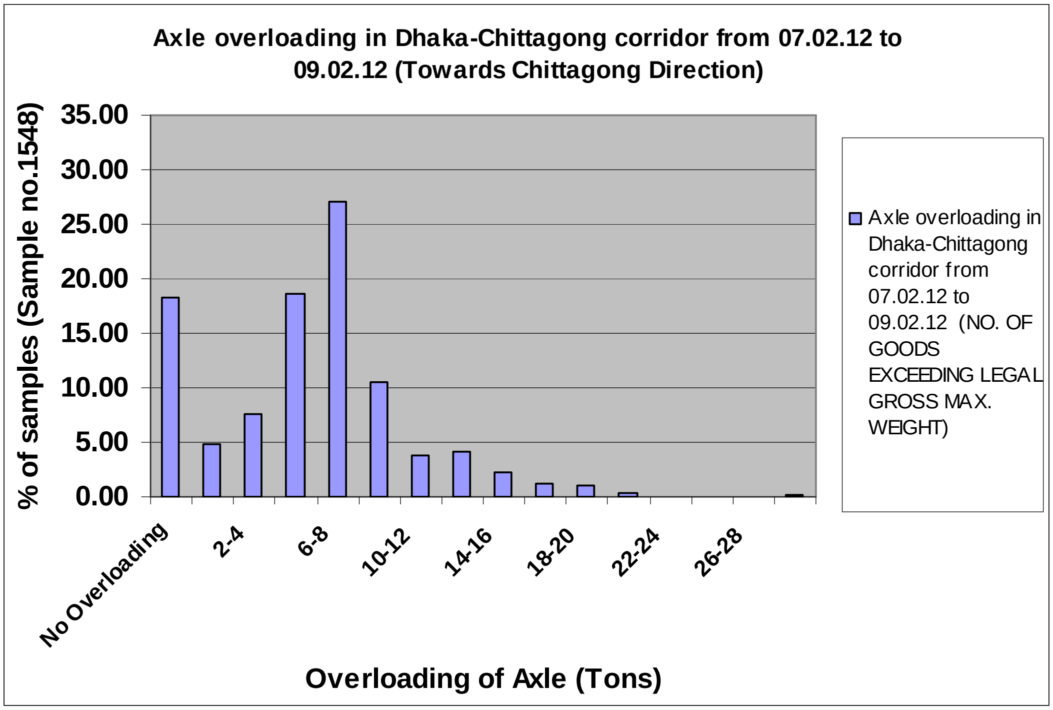


Figure B32: Axle Overloading in Dhaka-Chittagong Corridor from 07.02.12 to 09.02.12

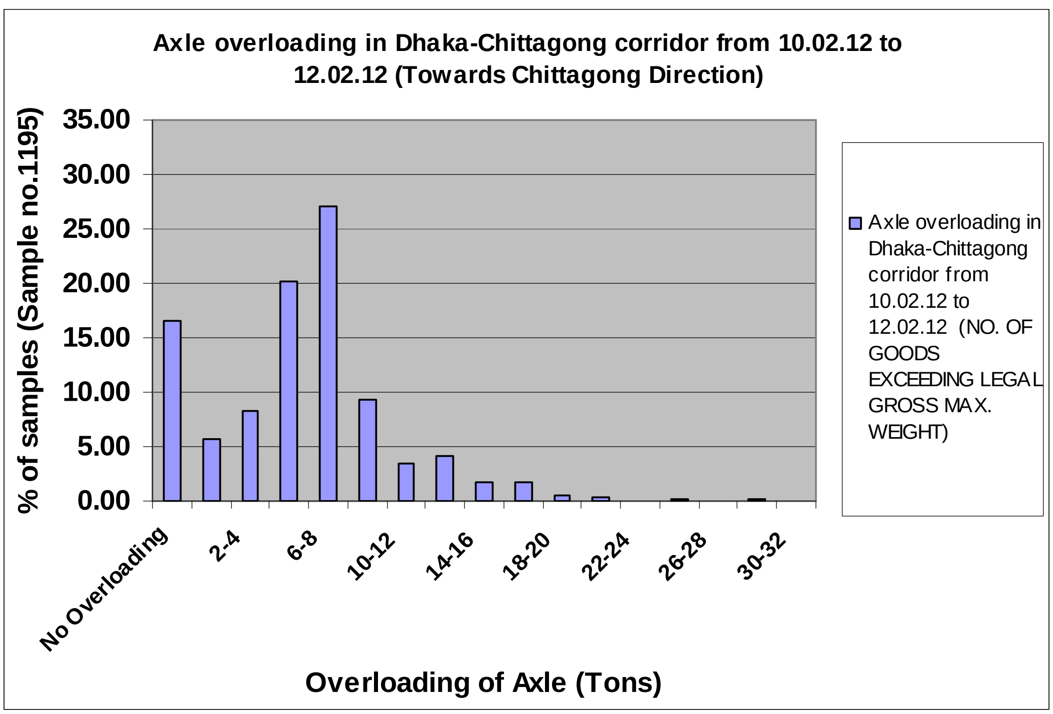


Figure B33: Axle Overloading in Dhaka-Chittagong Corridor from 10.02.12 to 12.02.12

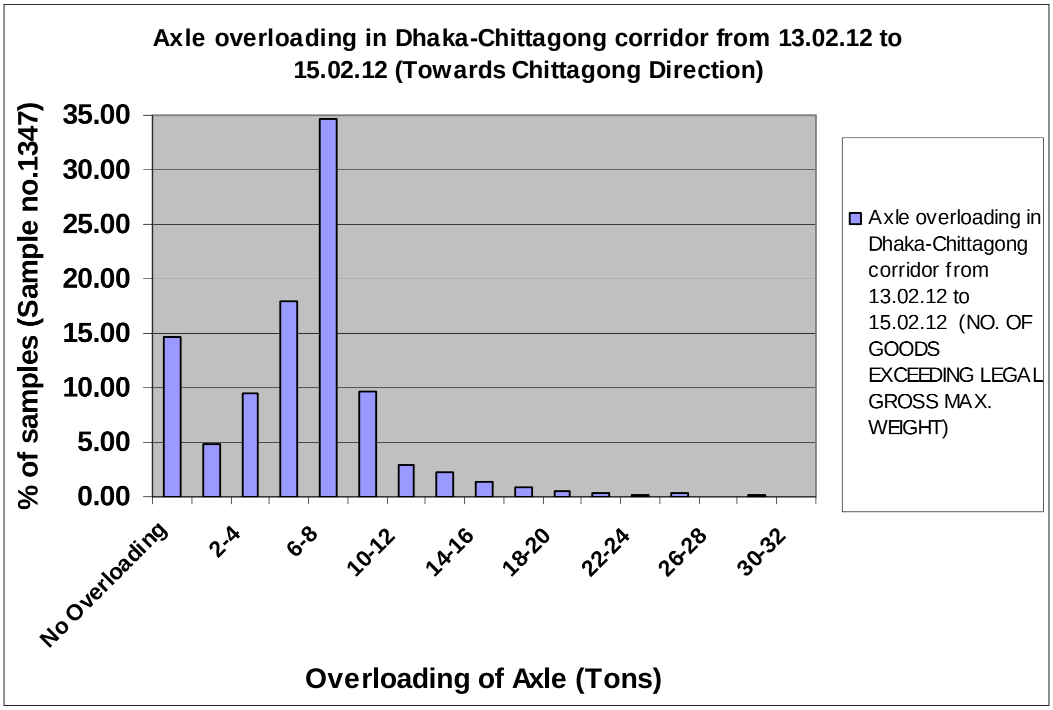


Figure B34: Axle Overloading in Dhaka-Chittagong Corridor from 10.02.12 to 12.02.12

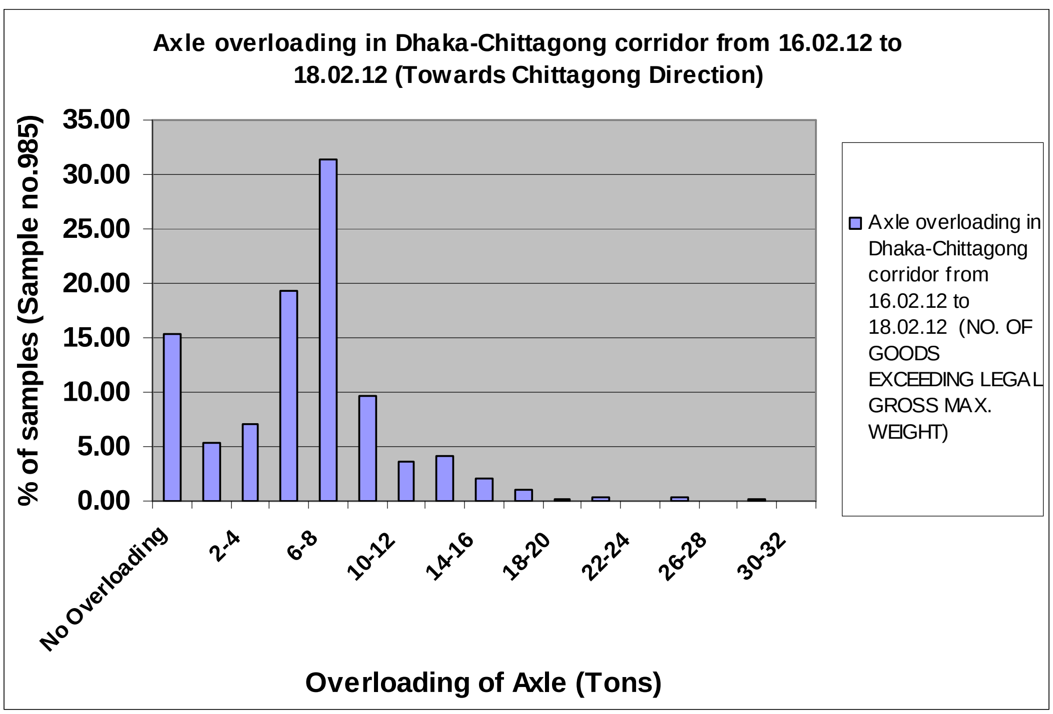


Figure B35: Axle Overloading in Dhaka-Chittagong Corridor from 16.02.12 to 18.02.12

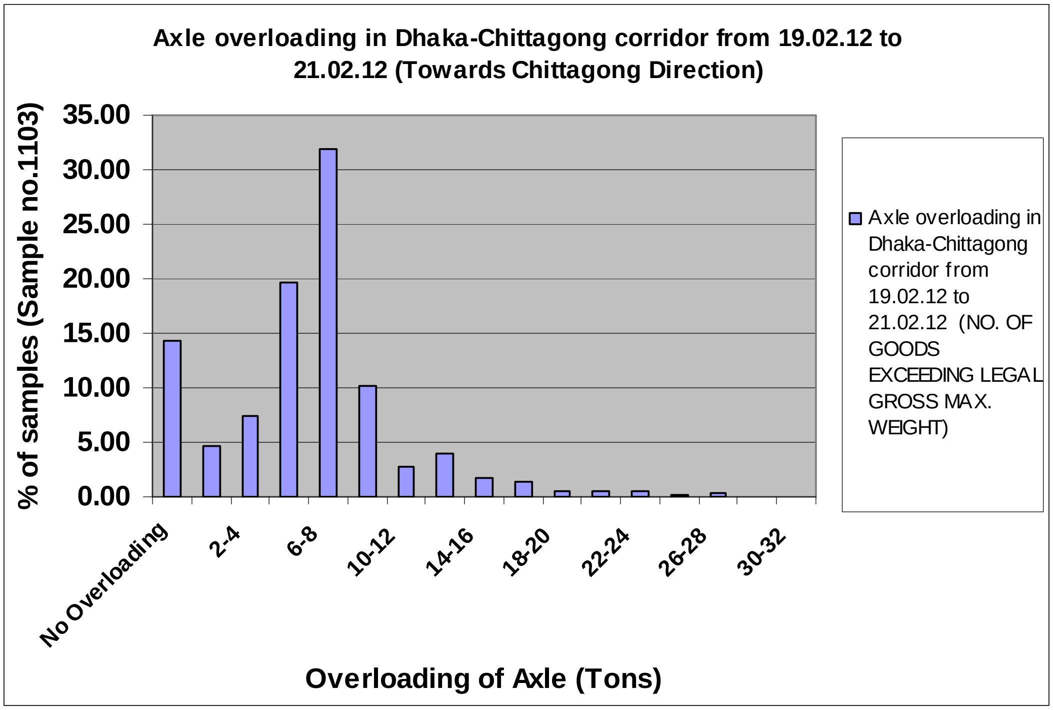


Figure B36: Axle Overloading in Dhaka-Chittagong Corridor from 19.02.12 to 21.02.12

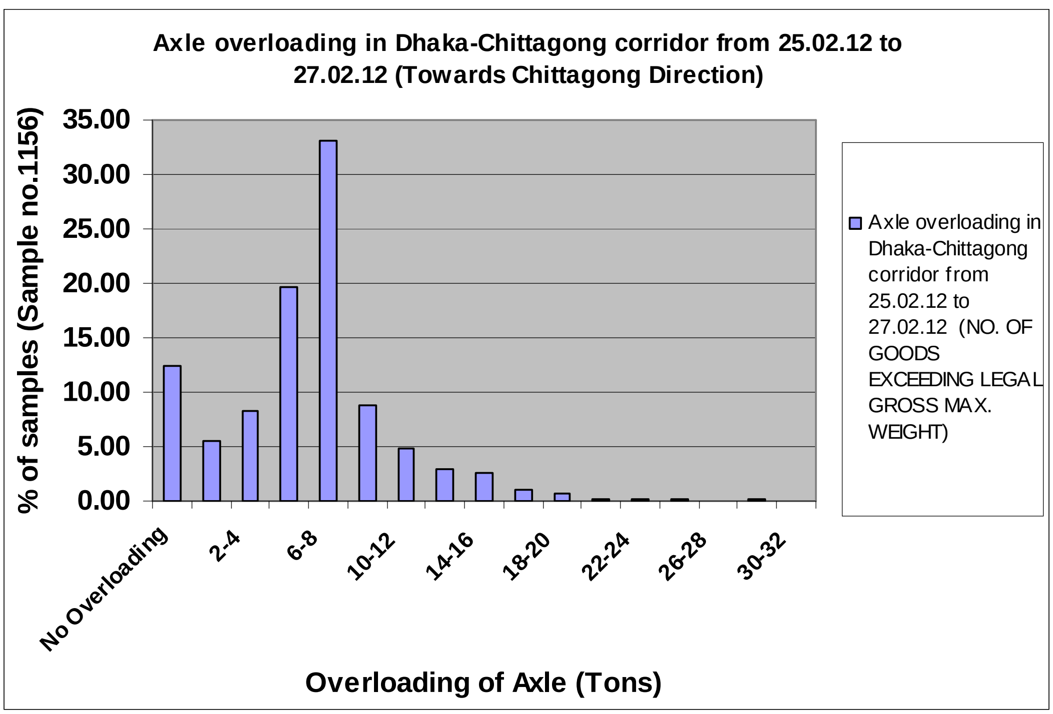


Figure B37: Axle Overloading in Dhaka-Chittagong Corridor from 25.02.12 to 27.02.12

APPENDIX C

SAMPLE OF CORRESPONDENCE FOR DATA COLLECTION

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

The pavement design process is the technique of developing a combination of top layers of different materials in the most economical manner to cater for the total axle load over the design life of a highway. In other words the purpose of pavement design is to ensure that the stresses as induced in the top layers of a highway due to movement of heavy wheel loads are disseminated and minimized to safe level through selection of different types and appropriate thickness of pavement layers. Commonly used pavement design methods are based on empirical studies, mechanistic analysis or a combination of both (AASHTO 1990).

The study of vehicular flow characteristics is very useful for developing highway and transportation plans, performing economic analyses, evaluating the performance of transportation facilities and establishing geometric criteria etc. Geometric design of highway requires previously established control parameters like design hourly volume (DHV), peak hour factor (PHF), directional distribution (DD), growth rate and percentage of trucks in the traffic stream. DHV is the economic hourly flow of future year, which is chosen in such a way that during the design period it should not be exceeded too often or too much. According to AAHSTO geometric design guidelines, it is usually taken as the 30th highest hourly volume of the design year in case of long duration count or availability of annual average daily traffic (AADT) data. Whereas in case of short duration count or ADT (average daily traffic), it is may be determined by multiplying the ADT by a percent representative of the amount of traffic occurring during the peak hour in an average weekday. The percentage, K is known as the peak factor and is typically 8 to 12% for urban facilities and 12 to 18% for rural facilities.

Directional distribution (DD) is the one-way volume in the predominant direction of travel, expressed as a percentage of the two-way design hour volume. DD ranges from 55 to 80% for rural road and typically is about 67% (AASHTO 1990). In the developed countries, in general, traffic tends to be more equally divided by the direction near the city center, where a value of 55% is common. Then in the outer fringe of the city, where the value of 67% or even 70% occur with considerable frequency. Moreover, for reliable forecast of future traffic needs corridor wise growth factors and expansion factors as well as percentage of truck is needed for estimation of design axle load. In Bangladesh, usually these above parameters are assumed on the basis of standard values established for the developed country situation. So far no attempt has been made yet to establish these values for the local traffic conditions, though there is a crying need to establish these parameters as it leads to economical design of road.

The ever increasing vehicle population and heavy axle loads has caused substantial damage to Bangladeshi roads. Trucks carry loads much in excess of legal limits and are largely responsible for poor road condition in addition to the inadequate structural capacity of pavements and diminishing allocation of funds year after year for maintenance and rehabilitation.Very huge capital investments are now needed to upgrade and rehabilitate the existing road network to make it capable to withstand high stresses and tyre pressure caused by heavy wheel loads. However, responsible departments of Bangladesh are not properly aware of the severe effect of heavy axle load. An attempt is made by this research to illustrate the harsh effect of axle load upon pavements in Bangladesh.

1.2 STATEMENT OF THE PROBLEM

One of the main reasons why attempts were not made earlier in Bangladesh to establish pavement design basic parameters is the lack of long term reliable data. Long duration data collection and preservation is very expensive, as it requires extra logistics like permanent counting stations and manpower. Necessary allocation for this purpose is very difficult to provide in country like Bangladesh where there is acute shortage of money for maintaining existing roadway infrastructures and as well as for expansion of road network. Besides, there is a lack of consciousness and inability to understand the importance of these parameters for engineering use. As such, there is a great need to study and research in this area.

Major tolled bridges in Bangladesh are Jamuna Multipurpose Bridge (JMB), Bhairab bridge, Lalonsha Pakshi bridge, Rupsha bridge, Meghna and Gomoti bridges, First and Second Dhaleshari bridges etc. These tolled bridges collect revenue for the Government and preserve data, which is a good source for traffic flow analysis. Gaining access to these databases will give the opportunity to establish the basic pavement design parameters for the major corridors of Bangladesh. If these parameters can be established, they can also give a basic idea about the parameters in other major corridors in Bangladesh.

Prediction of flow for design year is also important for the geometric and structural design of highway. For reliable assessment of average annual traffic as well as future demand, it is desirable that traffic counts are undertaken throughout the year to take account of seasonal variations in traffic flows. In the absence of long duration count, there are two approaches for the estimation of AADT from short counts, either by using regression model or by applying previously established expansion factors for the similar facilities (Garber and Hoel 1999).

Several studies carried out in developed countries have shown that if continuous flow data is available for a particular road segment of a highway, model could be built considering recursive pattern of traffic flow in order to predict AADT from short count (i.e. less 24 hours) data that is very important parameter for pavement design purpose (Erhunmwunsee 1991, Sharma 1989, Kaub 1988). In India, attempt is also made to establish trend in traffic volumes pertaining to daily, weekly, monthly and yearly flow patterns and to use these particulars for forecasting of traffic volumes (Highway Research Record 1981). Though, these studies were carried out in developed and developing country like India many years ago, so far no such effort in this subject is made in Bangladesh. One of the main reasons is stated earlier that is lack of long duration round the clock flow data.

Fast economic growth brings with it an increase in the demands on road transportation as well as in the numbers of vehicles that are frequently overloaded as a result of the effort to achieve more effective vehicle use. This leads to a situation in which road management bodies are more and more often faced with the accelerated degradation of road pavements with increasing requirements for repairs, maintenance and traffic quality assurance. The presence of overloading is indicated by the width area of rutting which is more than 60% of total road structural distress per km and by real maximum axle load of the heavy vehicle which is larger than its standard Maximum Axle Load. The loss cost of road pavement distress due to overloading is calculated based on damage factor and deficit design life. Damage factor due to overloading is not duly recognized in pavement design considerations in Bangladesh mainly due to lack of data and initiative, resulting severe distress are being observed in most of the National Highways recently. The vehicle equivalency factors (damaging factors) should be upgraded in urgent basis. For instance, according to RHD pavement design guide, 2005 vehicle equivalency factor is 4.62 for medium truck. Correct identification of vehicle loading pattern is very necessary for sustainable pavement design.

RHD pavement design guide, 2005 also suggested that traffic growth rate is 10% per annum for all National Highways in Bangladesh. In addition, AADT estimation technique and detail traffic flow characteristics of highways are ignored in RHD pavement design guide. Hence, there is need for comprehensive study for rationalizing corridor wise different pavement design parameters viz. vehicular flow fluctuation and characteristics (DD, ADT, AADT, expansion factor etc.), composition, annual growth rate of vehicles, percentage of heavy vehicles, frequency distribution of axle loads, damage factor etc.

1.3 OBJECTIVE OF THE STUDY

The main objectives of this research is to identify deficiencies associated with the existing pavement design method as followed by RHD and proposing rational design parameters for major corridors of Bangladesh. The specific objectives of the study are:

i. To review existing pavement design methodology to identify the scope of future improvement;

ii. To rationalize vehicular flow related input into pavement design;

iii. To collect axle load data for determining realistic damage factor to be consider in the pavement design;

iv. To propose rational pavement design parameters considering actual road traffic condition.

It is expected that outcome of this research work will facilitate identification of different vehicular flow characteristics in particular relation to geometric and structural design of pavement on different corridors of Bangladesh.

1.4 SCOPE OF THE STUDY

This thesis is to be performed using the traffic flow and axle load data on different corridors like Dhaka-Chittagong, Dhaka-Sylhet, Dhaka-North Bengal, Dhaka-Aricha and Dhaka-Mawa highways. An attempt has been made for updating the parameters of pavement design in Bangladesh.

The expansion factors and regression models for the estimation of AADT from short counts are established for N-1, N-2 and N-5 corridors. Similar analyses can be performed to established factors or models for the remaining other corridors of Bangladesh using flow data of particular corridors in future.

An extensive axle load data analyses has been done on Dhaka-Chittagong and Dhaka-Aricha corridor, which reveals the axle load related damage for those corridors. Axle load intensity on other corridors can be investigated in future for determining damage exerted by heavy freight movement.

It is expected that the following outcome can be made possible through this research:

- Traffic related pavement design parameters in different important corridors of Bangladesh can be established.
- Flow related parameters and expansion factors/equations for estimating AADT from short counts in different National Highways can be established.
- Daily, monthly and yearly traffic flow graph can be established for different National Highways in Bangladesh and flow pattern would be possible to understand in those corridors.
- By using the expansion factors or equations in the selected corridor, independent audit of toll collection would be possible.
- Traffic parameters in different corridors determined in this research can be used to design and upgrade National Highways of Bangladesh.
- Extensive axle load data analyses on two important National Highways are done in this study which will help to understand the recent overloading pattern in Bangladesh.

- Comparison of traffic flow between highways can be done.
- The framework developed in this research can be used as a model for developing traffic monitoring software.

1.5 OUTLINE OF METHODOLOGY

In order to achieve the first objective of the study detail review of the relevant literatures are made to broaden the understanding of existing design practice of pavement in Bangladesh. Literature review of RHD pavement design specifications, Road note 29, AASHTO pavement design manual, Austroad pavement design guide and browsing of internet have broadens the detail understanding. Moreover, review of literature gives an overview of the previous research works done on this topic in home and abroad. Review of literature also helps to make out future scope of pavement improvement in the context of Bangladesh.

The second objective is to the review different vehicular flow characteristics in particular relation to geometric and structural design of pavement. The detail general characteristics like vehicular flow, composition, directional distribution, hourly flow fluctuations, annual growth rate of vehicles, the design hour and peak hour volumes, percentage of heavy vehicles etc. are considered under investigation. It also helps to comprehend the fundamentals of flow prediction model and its related parameters. Then in order to study on the vehicular flow characteristics, data are collected from (1) Marga Net One Limited (MNOL) and Bangabandhu Bridge Special Organization (BBSO) for Jamuna Bridge, (2) Sigma-RCL JV for Bhairab and Ashuganj bridge, (3) RCL and MBEL-ATT for Meghna and Gomoti bridge, (4) Keranigonj Road Sub-division for First and Second Dhaleshari bridge, (4) MBEL for Bonpara-Hatikumrul road, etc.

When traffic data are collected continuously for a long period and presented for a number of consecutive days, weeks, months, years etc. then the repetitive nature of the variation is observed, since the pattern of the hourly, weekly, monthly variations are similar for all years, although the actual volumes may not necessary be the same. If there is any external factor, which may influence flow pattern, the cyclic property of yearly flow will not be observed distinctively. As such, before the analysis of vehicular flow, all unusual data will be eliminated from the database to ensure natural periodic variation of traffic stream flow. To achieve this objective, effort will be made to prepare an event calendar by gathering information related to hartal, transport strike, natural calamity like flood etc. which are very unpredictable in nature and have the potential to affect the normal pattern of traffic flow. In this regard, officials of various tolls collecting agency, Meteorological department of Bangladesh would be contacted and above all daily newspapers would be consulted.

The raw database is formatted in line with the objectives of the research and requirement of statistical software. The features that are analyzed including the determination of vehicular flow, composition, directional distribution, peak hour volume, design hour volume, vehicle wise growth rate, percentage of trucks, flow fluctuations with respect to daily, weekly, monthly, seasonally and yearly etc.

It is expected that, if the flow parameters along with the prediction models for the estimation of the ADT or AADT from short-interval counts could be established for the major corridor roads, the economic design of highways along with these corridors would be facilitated with more reliability and predictability. The models would be useful to independently verify the revenues collected by the toll operators. Moreover, the outcome of this research work would also give a benchmark for establishing future geometric design control parameters for those corridors of Bangladesh.

The third objective of this thesis is to collect axle load data from various sources to identify damage factor for pavement design, which is very essential for major roads in Bangladesh. The axle load data are collected from axle load control stations of Dhaka-Aricha highways and Dhaka-Chittagong highways. It is to be mentioned that, the ever increasing vehicle population and heavy axle loads has caused substantial damage to Bangladesh roads. Trucks carry loads much in excess of legal limits and are largely responsible for poor road conditions in addition to the adequate structural capacity of pavements and diminishing allocation of funds year after year for maintenance and rehabilitation. Very huge capital investments are now needed to upgrade and rehabilitate the existing road network to make it capable to withstand high stresses and tire pressure caused by heavy wheel loads. In view of very remote possibility of such large magnitude of funds ever becoming available in the near future, one of the best courses to remedy the situation would be to strictly enforce the legal axle limits.

Finally, the forth objective is to propose rational pavement design parameter considering road traffic condition of Bangladesh. Effective pavement design is the most important aspects for sustainable road infrastructure. The condition and adequacy of the road / highway is often judged by the smoothness or roughness of the pavement. Deficient pavement conditions can result in increased user costs, travel delays, braking and fuel consumption, vehicle maintenance repairs and probability of increased crashes. Road maintenance cost and accident rates are now increasing exponentially in Bangladesh. Correct pavement design parameters can decrease road maintenance cost, increase the life cycle of pavement and reduce accidents.

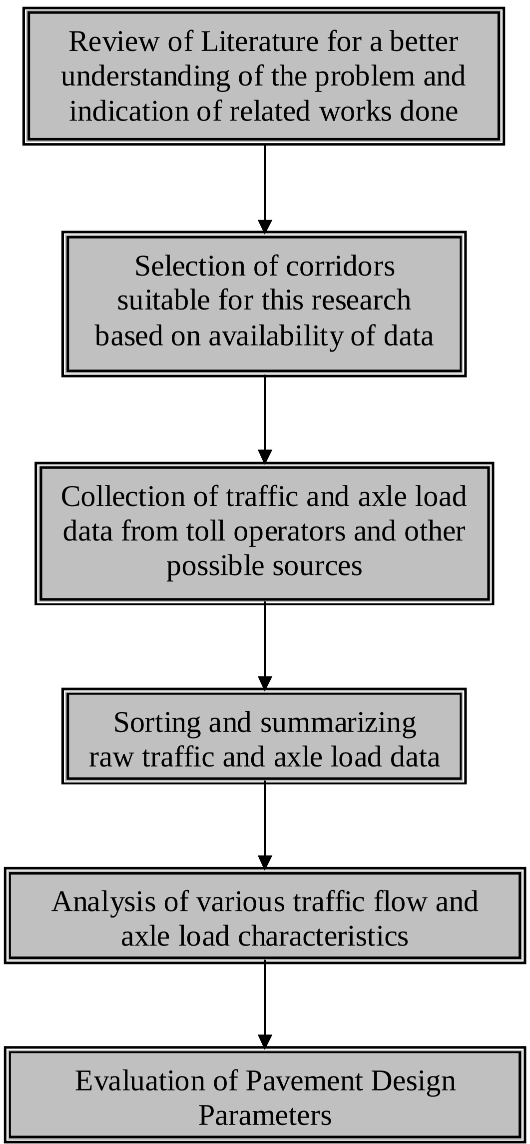


Figure 1.1: Flow chart of the research methodology

1.6 ORGANIZATION OF THE THESIS

The research works performed in this study are divided into different topics and presented in seven Chapters.

A brief introduction to the background and statement of the problem is presented in the first Chapter. The Chapter also contains the objective and scope of the thesis along with brief description of the research plan.

Chapter 2 presents the literature review of related topics. In this Chapter the definition of the related terms, guidelines for pavement design parameters and previously performed related works have been described.

In Chapter 3, the methodology of this research is described. This covers the corridor selection, data collection, data processing, and framework development processes used in this thesis.

Chapter 4 contains the traffic flow related characteristics analyses in different corridors of Bangladesh. In this Chapter the daily, weekly, monthly flow variations as well as directional distribution, traffic composition, truck percentage, eid factor, traffic growth pattern on the different corridors are described.

Chapter 5 includes the analyses of axle load data on different highways. A comparison is made between present and past axle load pattern in selected corridors of Bangladesh. In addition, axle load related histrogram, frequency distribution and damage factor are explained in the Chapter.

Chapter 6 presents the evaluation of expansion factors, regression analyses, determination of regression equations for estimation of AADT from short counts for different National Highways of Bangladesh.

The conclusion of the entire research along with summary of study results is presented in Chapter 7. This Chapter suggests the rational pavement design parameters for different corridors of Bangladesh. The Chapter also contains suggestions and recommendations for future study and limitations of this thesis.

An appendix is attached at the end of this report containing necessary data and graphs.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The pavement design process is the technique of developing a combination of top layers of different materials in the most economic manner to cater for the total axle load over the design life of a highway. In other words the purpose of pavement design is to ensure that the stresses as induced in the top layers of a highway due to movement of heavy wheel loads are disseminated and minimized to safe level through selection of different types and appropriate thicknesses of pavement layers.

The principal of pavement design consist of geometric and structural design of pavement. A wide range of parameters are included in the process of pavement design. Most of the parameters like reliability, layer co-efficient, weather factor, etc. need empirical observations, which is outside the scope of the work. In this research, only a few traffic flow and axle load related parameters are analyzed to focus some drawbacks in the existing RHD road design technique. Accurate pavement design is not possible without proper traffic analysis in a corridor. Corridor wise traffic data analyses have not done yet in Bangladesh except Jamuna Bridge corridor. An attempt has been made to present corridor wise traffic and axle load data analyses by this research.

It is to be mentioned that study on traffic flow pattern and its variability over time carries a great importance to understand the characteristics of a traffic stream. Analysis of traffic flow pattern from existing data is performed to determine important characteristics of traffic flow that are used in geometric and structural design of highways, traffic monitoring programs, roadway maintenance and operation, feasibility studies, economic evaluation, traffic flow prediction, highway financing, evaluation of safety programs and many other related decision making.

While transport authorities and agencies in many developed countries extensively record traffic flow data through short counting as well as continuous counting stations in order to monitor their trend of traffic growth, changes in traffic characteristics and evaluation of expansion factors and/or equations, not many studies have been performed in Bangladesh on traffic characteristics and determination of expansion factors from which AADT can be reliably estimated from short counts. During the literature review on previously performed studies in Bangladesh on related topic, it was revealed that a similar study was carried out by Roads and Highways Department, as a part of Development of Geometric Design Standards, in 1994, on some important highways. Capt. Sheikh Muhibur Rahman performed a study on Vehicular Flow Pattern on Jamuna Multipurpose Bridge Access Road in 2002 during his B.Sc. Engg. project work. Both of the reports have been studied and have been analyzed in this Chapter.

This Chapter also contains brief discussion on Traffic Monitoring Guidelines 2001, published by Federal Highway Administration of U.S. Department of Transport, where thorough guidelines are provided for analysis of traffic characteristics and evaluation of expansion factors, and an Assessment of Data Collection Techniques for Highway Agencies, which have been helpful as guidelines for this thesis.

2.2 DEFINITION OF THE RELATED TERMS

Before going into the detail of this research, it is important to get familiarized with the terms related to traffic flow and axle load characteristics and also computation of expansion factors or equations. Therefore, in this section, the important pavement design parameters of traffic flow and axle load, which are frequently used in this thesis, are stated in brief.

<u>Traffic Volume:</u> Traffic Volume is defined as the number of vehicles that pass a particular point along a roadway or traffic lane per unit of time. Volume is a measure to quantify the traffic flow and is commonly measured in units of vehicles per hour, vehicles per day and so on.

<u>ADT:</u> ADT stands for Annual Daily Traffic and is defined by the average number of vehicles that pass a particular point during a period greater than one day and less than one year. It is determined by dividing the total number of vehicles within a period by the number of days. ADT is a fundamental measurement of traffic that is used for the determination of the vehicle-kilometer of travel on the various categories of highway system. Vehicle-kilometers are important for the development

of highway financing or taxation schedules, the evaluation of safety programs, and as a measure of service provided by a highway transportation system.

AADT: Average Annual Daily Traffic is represented by the total number of vehicles passing a particular point, averaged over one year data. AADT is a very important factor for geometric design of highways.

Design Hourly Volume: The Design Hourly Volume (abbreviated as DHV) is a future hourly volume that is used for design. It is usually the 30th highest hourly volume of the design year. The DHV is the most significant measure of highly volume since traffic volumes are much heavier during certain hours of the day or year, and it is for these hours that the highway is designed.

Peak Hour Factor: The Peak Hour Factor is defined as the ratio of total hourly volume to the maximum rate of flow within the hour.

Truck Percentage: The percentage of truck among a traffic stream is an important factor used for geometric and structural design of highways. The percentage of truck traveling along a roadway may vary differently from total vehicle traveling over time and AASHTO recommends to classification-wise data collection and represent by which this important factor can be determined.

Directional Distribution: Directional distribution refers to the percentage of traffic flow in one direction during a particular time of day. This factor is particularly important in the case of commuter roads, where maximum flow occurs in one direction in the morning and the other in the evening. This also needs to be considered for efficient geometric design.

Axle load of vehicles: Fast economic growth brings with it an increase in the demands on road transportation as well as in the numbers of vehicles that are frequently overloaded as a result of the effort to achieve more effective vehicle use. This leads to a situation in which road management bodies are more and more often faced with the accelerated degradation of road pavements with increasing requirements for repair, maintenance and traffic quality assurance. The trend also has a negative impact on traffic safety. Results from the theoritical analysis of overloading trucks prove an extreme impact of overloads, albeit from a relatively small number of vehicles, on the life and defects of road pavements. The analysis should constitute an argument for the concern road authority to introduce the general concept of truck weighing and the possibility of high penalties being imposed if maximum axle load is exceeded.

Equivalent Single Axle Loads (ESAL): ESAL is the number and weight of all axle loads from the vehicles expected during the pavement design life expressed in 18-KIP. ESALs are a traffic estimate that is required by most pavement design procedures, including the American Association of State Highway and Transportation Officials (AASHTO) 1993 Pavement Design Guide. ESALs are influenced by pavement type (flexible or rigid), surface thickness, and type of distress or failure. However, even roadways with fairly constant loads and traffic volumes may produce significantly varying ESALs along their lengths, depending on the interaction of these factors. ESALs indicate the relative damage to a pavement structure due to various axle loads. Vehicular wheel loads of various magnitudes and repetitions can be converted to an equivalent number of "standard" loads. The most common standard load is the 80 KN (18,000 lbs) ESAL. The two standard U.S. ESAL equations (one each for flexible and rigid pavements) are derived from the AASHO Road Test results. Both these equations involve the same basic format; however the exponents are slightly different. The equation outputs are load equivalency factors (LEFs) or ESAL factors. This factor relates various axle load combinations to the standard 80 KN (18,000 lbs) single axle load. It should be noted that ESALs as calculated by the ESAL equations are dependent upon the pavement type (flexible or rigid) and the pavement structure (structural number for flexible and slab depth for rigid). However, The AASHTO load equivalency equation is quite cumbersome and certainly not easy to remember. Therefore, as a rule-of-thumb, the damage caused by a particular load is roughly related to the load by a power of four (for reasonably strong pavement surfaces).

Estimating ESALs: A basic element in pavement design is estimating the ESALs a specific pavement will encounter over its design life. This helps determine the pavement structural design. This is done by forecasting traffic the pavement will be subjected to over its design life then converting the traffic to a specific number of ESALs based on its makeup. A typical ESAL estimate consists of:

Traffic count: A traffic count is used as a starting point for ESAL estimation. Most urban areas have some amount of historical traffic count records. If not, simple traffic tube counts are relatively inexpensive and quick. In some cases, designers may have to use extremely approximate estimates if no count data can be obtained.

A count or estimate of the number of heavy vehicles: This usually requires some sort of vehicle classification within the traffic count. The simplest classifications divide vehicles into two categories: (1) heavy trucks and (2) others.

An estimated traffic growth rate over the design life of the pavement: A growth rate estimate is required to convert a single year traffic count into the total traffic experienced over the pavement design life. Typically, multiplying the original traffic count by the pavement design life (in years) will grossly underestimate total ESALs.

Select appropriate LEFs to convert truck traffic to ESALs: Different regions may experience different types of loads. For instance, a particular area may experience a high number of trucks but they may be mostly empty thus lowering their LEF.

An ESAL estimate: An ESAL estimate can be made based on the preceding steps. Depending upon different circumstances these estimates are accurate most of the times.

Portable WIM Stations: Two technologies, capacitance mats and Brass Linguini (BL)-style piezoelectric sensors, are commonly used in United States for high-speed (i.e., on-highway) portable WIM data collection. Both technologies involve mounting a sensor on top of existing pavement. These actions require a temporary lane closure and often work by more than one person. Because the sensor is physically mounted on top of roadway surface, a bump is created as the tire of each axle passes the weight sensor. This bump causes two physical effects, each of which is detrimental to WIM system accuracy. The first effect is the additional dynamic motion imparted on the vehicle being weighed. This motion makes it much harder for the WIM system to accurately estimate the static weight

applied by each axle. The second physical effect is that the need to climb over this bump causes the tire itself to flex, absorbing some of the horizontal force from impact with the bump. This tire flex force is transmitted to the weight sensor, causing additional bias and noise in the measurement process. Portable WIM rarely achieves the same level of accuracy as a correctly placed permanent scale. This does not mean that weights collected using portable scales are not useful in the traffic load estimation process. Highway agencies must be particularly careful to calibrate portable scales each time they are placed on the roadway and to monitor the data produced after scales have been calibrated to ensure that the system is producing reliable results. This type of site is less costly to operate than a continuously operated WIM site (because one set of data collection electronics is used for several data collection sites and also because permanent power and communications are not needed, and therefore do not need to be constructed). WIM sites should be monitored for no less than 24 consecutive hours to account for time-of-day differences in vehicle weights. Data collection sessions of longer than 24 hours are encouraged whenever practical. In particular, when in ground weight sensors are being used and the data collection electronics can be safely left to operate without on-site staff, a minimum of one-week counts are recommended at all measurement locations that are not being operated continuously. If the weight data collection period is only 24 or 48-hours long, it assumes that there is no day-of-week difference in the loading condition of trucks passing the site. In other words, trucks traveling on weekends carry the same distribution of payloads as trucks traveling on weekdays. In addition, it is presumed that there are no seasonal differences in truck loading patterns.

<u>Permanent WIM Stations:</u> The original intent of most continuous monitoring efforts is to understand seasonal, weekly, and yearly traffic volume patterns to help improve the accuracy of traffic estimates used in a variety of analyses. Because of the physical problems of portable equipment, the majority of research and development in WIM has been done for permanently installed weight sensors. Five technologies are currently in use throughout the United States. The most common permanently mounted weight sensors are bending plates, hydraulic load cells, piezoceramic cables, piezopolymer cables, and piezoquartz sensors. All of the systems are

designed to have sensors permanently installed in or under the roadway. This results in less dynamic vehicle motion and less impact force on sensors than for surface-mounted sensors, which results in more accurate weighing conditions and longer sensor life. The permanent installation of the sensors and frames is normally better for consistent and accurate weighing measurements. The use of permanently installed WIM sensors is recommended as a means of improving the quality of the data. Vehicle weights within each truck weight group should be measured by a number of WIM sites located within the truck group. For most truck weight roadway groups, a minimum of six sites should be monitored. At least one of the WIM sites within each group should operate continuously throughout the year to measure temporal changes in the loads carried by trucks operating on those roads. Where possible, more locations within each group should be monitored continuously to provide more reliable measure of seasonal change.

Vehicle Damage Factor: The vehicle damage factor is a multiplier for converting the number of commercial vehicles of different axle loads and axle configuration to the number of standard axle load repetitions. It is defined as equivalent number of standard axles per commercial vehicle. The VDF varies with the vehicle axle configuration, axle loadings, terrain, type of road and from region to region. The VDF is arrived at from axle load surveys on typical road sections so as to cover various influencing factors such as traffic mix, type of transportation, type of commodities carried, time of the year, road conditions and degree of enforcement. For designing a new pavement, the VDF should be arrived at carefully by carrying out specific axle load surveys. Some surveys have been carried out in the country on National Highways, Regional Highways and Major Zilla Roads, which reveal excessive overloading of commercial vehicles. Therefore, it is recommended that the designer should take the realistic values of VDF after conducting the axle load survey particularly in the case of major projects. On some sections there may be significant difference in axle loading in two directions of traffic. In such situations the VDF should be evaluated direction wise to determine the lanes which are heavily loaded for the purpose of design.

2.3 VARIABILITY IN TRAFFIC STREAM

Traffic Monitoring Guide 2001 by Federal Highway Administration of U.S. Department of Transport has given comprehensive guidelines on variability in traffic stream, computation and application of factors to short counts to obtain AADT. This article briefly discusses the variations in traffic stream and important issues related to expansion factors in light of Traffic Monitoring Guide 2001.

It is an obvious statement that traffic flow varies over time. These variations are observed over a number of time scales such as – time of day, day of week, season (month) of the year. Traffic also varies from place to place, facility to facility depending on numerous parameters viz. economic, agricultural cycles, cultural, religious, recreational activities, function of the facility, surrounding locality, purpose of trip and many other factors.

2.4 DAILY VARIATION OF TRAFFIC

Like hourly fluctuation of traffic flow, there are variations in flow within days of week. Day-of-week patterns also fall into either of two basic patterns. In the traditional urban pattern, volumes are fairly constant during weekdays and then decline slightly on the weekend. This pattern also exists on rural roads. The other pattern, usually found on rural areas that contain recreational travel, shows constant weekday volumes followed by an increased volume on weekend. Trucks also have two patterns, both driven by the need of businesses. The pattern may be different where percentage of through-traffic is high. Considering these, the Traffic Monitoring Guide suggests that, "These significant changes in traffic volumes during the course of the week have several effects on the traffic monitoring program". Most importantly, the monitoring program needs to collect data that allow a State to describe these variations. Second, the monitoring program must allow this knowledge to be shared with the users of the traffic data and applied to individual locations.

Without these two steps, many of the analyses performed with traffic monitoring data will be inaccurate. Pavement designers need to account for reductions in truck traffic on the weekends if they are to accurately predict annual loading rates.

Likewise, accident rate comparisons for different vehicle classifications are not realistic unless these differences are accounted for in estimates of vehicle-miles-travel by class.

2.5 SEASONAL VARIATION

Traffic flow also varies over seasons in a year. According to the Traffic Monitoring Guide 2001, most states in the USA track four or more seasonal pattern and they base the patterns being followed on some combination of functional classification of roadway and geographic location. Geography and functional classification are used as readily available substitute measures for describing roads that follow that basic pattern. Geographic stratification is particularly important when different parts of a state experience very different travel pattern. For example, travel in areas that experience heavy recreational movements follow different travel patterns than those in areas without such movements. The guide has observed that truck traffic has different seasonal patterns than other vehicles. Some truck movements are stable throughout the year while other truck movements are highly seasonal. For example, in agricultural areas weight carried by truck varies with season. Truck volume patterns can vary considerably from car volume patterns. Roads that carry significant volumes of through-trucks tend to have very different seasonal patterns than roads that carry predominately local freight traffic. Roads that carry large volumes of recreational traffic often do not experience similarly large increases in truck traffic, but do often experience major increases in the number of recreational vehicles which share many characteristics with trucks. Thus, it is highly recommended that States monitor and account for seasonal variation in truck traffic directly, and that these procedures be independent of the procedures used to account for variations in car volume.

In Bangladesh, seasonal variation of traffic is mainly governed by agricultural cycle, monsoon climate and religious festival Eid. In the case of Eid, the seasonal variation is more complex because of the rotation nature of Arabic calendar in comparison to the English calendar.

2.6 DIRECTIONAL VARIATION

Some roads such as urban commuter roads involve a heavy inbound traffic in the morning and an outbound movement in the afternoon. On many sub-urban roads this directional behaviour is replaced by heavy peak movements in both directions in both peak periods. The time-of-day pattern for traffic on a particular road on bothway can differ to those for inbound and outbound traffic, when directional variation is large.

In areas with high recreational traffic flows, directional movements change the day-of-week traffic patterns as much as the time-of-day patterns. Travelers often arrive in the area starting late Thursday night and depart on Sunday.

Truck volumes and characteristics can also change by direction. One "classic" example of directional differences in trucks is the movement of loaded trucks in one direction along a road, with a return movement of empty trucks. This is often the case in regions where mineral resources are extracted. Volumes by vehicle classification can also change from one direction to another, for example when loaded logging trucks (classified as 5-axle tractor semi-trailers) move in one direction, and unloaded logging trucks (which carry the trailer dollies on the tractor and are classified as 3-axle single units) move in the other. Tracking these directional movements as part of the statewide monitoring program is important not only for planning, design, and operation of existing roadways, but as an important supplement to the knowledge base needed to estimate the impacts that new development will generate in previously undeveloped, rural lands.

2.7 SHORT COUNT EXPANSION METHODS

Robichaud and Gordon performed a study for British Columbia Ministry of Transportation (BCMoT) to assess the accuracy of their existing traffic monitoring system and to compare it to the alternatives for estimating traffic volumes on their highway network. The study report was published in March 2002 and includes a review of findings from similar projects by the Brunswick Department of Transportation and the Prince Edward Island Department of Transportation and Public Works.

The following discussion is based on this study report and reveals the types of counts used in traffic monitoring programs as well as the expansions methods used to attain AADT from short counts.

Traffic Counts: Agencies in Canada and the United States use similar approaches for collecting traffic volume data on their highway networks. Basically, two types of counts are completed - continuous counts at a limited number of permanent counting sites and short-term counts at a greater number of temporary counting sites.

The permanent counting sites provide a measure of the variation in traffic volumes over the entire year. Volumes are typically recorded in 15 minute or hourly intervals, 7 days a week, 365 days a year. These counters are located in areas to capture the different traffic patterns such as urban, rural and recreational flows on the various classes of highways in a province or state.

Short-term counters collect data over a period typically ranging from 1 to 7 days in length. Volumes are recorded in 15 minute or hourly intervals over the sampling period. These counters provide samples of traffic volumes over a greater extent of the highway network and are often referred to as coverage counts.

Summary measures such as annual average daily traffic (AADT) volumes and summer average daily traffic (SADT) volumes are estimated from the short-term counts using the seasonal patterns from the permanent counters. This process is often referred to as expanding the short-term count. Many transportation agencies in Canada use variations of a method developed by the Ontario Ministry of Transportation for expanding short-term counts, which is based on regression analysis. State agencies use an approach commonly called the factoring method for expanding their short-term counts to AADT volumes.

Mainly two approaches are used to expand traffic data from shot counts to attain AADT. These are:

1. Factoring Approach
2. Regression Based Approach

The methods are discussed below.

2.7.1 FACTORING APPROACH

The Factoring Approach is widely used in the United States primarily because it is recommended in the Federal Highway Administrator's (FHWA) Traffic Monitoring Guide (Office of Highway Policy, 2001), (Office of Highway Information Management, 1995), the American Association of State Highway and Transportation Official's Guidelines for Traffic Data Programs (AASHTO 1992), and the ASTM Standard Practice for Highway Traffic Monitoring (ASTM 1994). This approach uses data from permanent counters to develop group factors, which are applied to the short counts to estimate summary measures. Daily and monthly factors to expand short-term counts in an agency's jurisdiction are developed following the approach described in these guidelines. A day-of-the-week factor compensates for differences between the monthly average daily traffic volume and the average volume on a Monday, Tuesday, Wednesday, etc. In effect, it is used to estimate an MADT volume from a 24-hour count. There are, therefore, seven day-of-the-week factors for each month for a total of 84 factors for the year. If a short count is taken on a Monday in July, then the day-of-the-week factor for a Monday in July is used to expand the short count to an average daily traffic volume for the month. Similarly, there is one seasonal factor for each month for a total of 12 factors. Using the previous example, an AADT volume can be estimated from the short count by multiplying the MADT estimate by the seasonal factor for July. It is recommended in the most recent Traffic Monitoring Guide (Office of Highway Policy Information, 2001) that factors is calculated using the current year of data.

Developing seasonal factors for a jurisdiction involves two tasks:

- Grouping of permanent counters with similar variability; and
- Identifying unique characteristics for each group.

It is important for an agency to have a firm understanding of all the traffic characteristics within its jurisdiction to ensure an adequate number of groups are developed describing each seasonal pattern. Ideally, the variability within each group should be minimized while the variability between groups is maximized. In most jurisdictions, three to five groups tend to adequately reflect the variation exhibited by all counters (Office of Highway Information Management, 1995).

The factors applied to individual short counts are averages calculated for each group of permanent counters. Permanent counters are grouped based on a clustering analysis, which segments the permanent counter population based on seasonal or regional variability. The determination of seasonal and daily factors requires a minimum dataset to ensure statistical validity. It has been found by the FHWA that five to eight individual counters should be included in each group to determine average factors that are statistically significant. This results in a minimum of 25 permanent counters to determine expansion factors for a jurisdiction (Office of Highway Information Management, 1995).

Short-term counts are assigned to a group by reviewing characteristics such as functional classification, seasonal patterns, geography and levels of surrounding development. The assignment process requires a good knowledge of the agency's transportation system and professional judgment.

2.7.2 REGRESSION BASED APPROACH

The premise behind all short count expansion is the assumption that the seasonal variation of a short count can be estimated from a dataset of permanent counters with similar variation patterns. In the regression-based system, a short-term count is matched to a permanent counter using regression analysis. Once collected, the short count data is compared to data from the permanent counters during the same time period. The intent is to find a permanent counter whose volume variation pattern compares well with the short count's variation. (The comparison can be made on hourly or, more commonly, daily traffic volumes)

Least squares linear regression is the most common regression method of comparison. The coefficient of determination (R^2) is calculated for each permanent-short count regression. The permanent counter having the highest R^2 value is selected as the one with a variation in traffic volumes best matching the short count. Summary measures such as annual, monthly, summer and winter average daily traffic volumes (AADT, MADT, SADT and WADT) are then estimated using the equation developed from the regression analysis.

2.8 PREVIOUSLY PERFORMED STUDIES IN BANGLADESH

Not many studies on similar topic were performed in Bangladesh. This is probably due to lack of continuous reliable traffic and axle load data. The literature review has revealed that the following studies were made on partially similar topic. A brief discussion on those studies has been rendered in this article.

2.8.1 DEVELOPMENT OF GEOMETRIC DESIGN STANDARDS, RHD 1994

This study was performed by Joint venture of Howard Humphreys and Partners Ltd. (UK) and CEBTP (France) in collaboration with local consultant Development Design Consultants Ltd. The study was report was published in 1994. This was a project of Roads and Highways Department of Ministry of Communication of Government of Bangladesh, financed by European Economic Community, named "Road Materials and Standards Study Bangladesh". As a part of this study, Volume VIIA covered Development of Geometric Design Standards.

During this study, traffic survey was performed on four major corridors in Bangladesh namely Dhaka-Aricha Road, Dhaka-Sylhet Road, Dhaka-Mymensingh Road and Dhaka-Chittagong Road. Using these data and data collected from RHD, flow variation analyses were performed. In this study, hourly flow variations, 12-24 and 16-24 hourly factors, peak hour factor were determined. Daily and Seasonal variation of traffic flow were also analyzed and respective factors were determined.

The analyses could not be made and hence the factors could not be determined with high accuracy because of lack of long duration count data availability. The consultants performed year-long surveys at each location with varying time period, but no consistent data base was available at that time. In some cases, ferry record data was used, where deficiencies were noticed like not all the road traffic cross river by ferry. Moreover, during the survey period large number of non-motorized vehicle used to use highways as well. Due to these reasons, the factors evaluated in the project do not best represent the actual present scenario of traffic flow.

2.8.2 VEHICULAR FLOW PATTERN STUDY ON JAMUNA BRIDGE, 2001

Rahman, S.K. (2002) performed a study on Vehicular Flow Pattern on Jamuna Multipurpose Bridge Access Road in 2002 during his B.Sc. Engg. project work.

That study report has been extensively conferred with during this study. The project used 5 years of daily traffic data as well as 13 weeks of hourly data in the analyses.

The expansion factors determined in that study more or fewer matches with those determined here. But, the study lacked some important analyses such as Eid factor, Truck Percentage, etc.

2.8.3 RHD PAVEMENT DESIGN GUIDE 2005

Most recent highway design standards of Bangladesh are RHD Pavement Design Guide, published on April 2005, recommends the following ESAL for pavement design:

Light Truck	:	1.00
Medium Truck	:	4.62
Heavy Truck	:	4.80
Mini Bus	:	0.50
Standard Bus	:	1.00

The above vehicle equivalency factors (damaging factors) should be upgraded in urgent basis. The pavement should be designed at least for a higher load limit. This would ensure that the pavement would last longer. Although elastic theory predicts fatigue failure of bituminous pavement layers from load repetition, the effect of application of high intensity point load, even instantaneously, can be most damaging to the entire pavement structure. Standard design methods recommend more or less constant thickness of base and sub-base courses in flexible pavement. To account for excessive axle loads, thicker bituminous binder course (which is an expensive material) layers have to be provided.

The pavement design guide also suggest traffic growth rate 10% per annum for National Highways in Bangladesh, which should be upgraded corridor wise. Traffic flow analyses in different corridors will divulge the fact that the growth factor parameter vary from year to year and corridor to corridor.

2.8.4 AXLE LOAD SURVEY RESULTS, 1994

An investigation of the characteristics and variations of axle loading was performed for the development of representative traffic loading recommendations for Highways in Bangladesh in 1994. The analysis was done by Roads and Highways Department with the financial help of European Economic Community. The axle load survey was done by portable WIMP in most of the important corridors of Bangladesh. With the help of this exploration, pavement structures were designed that were suited to the spectrum of road traffic loads. Unfortunately, this type of study is not carried out in the last eighteen years in Bangladesh by Roads and Highways Department. In developed countries, traffic survey is mandatory in every year for major highways.

2.9 OVERVIEW

From the discussions made in this Chapter, brief ideas on the evaluation of pavemet design parameters have been found. This Chapter illustrated the important basic related terms and definitions used in this thesis. Several Guidelines including RHD pavement design guide 2005, Road materials and stradard study 1994, Road Note 29, AASHTO pavement design manual, Austroad pavement design guide, etc. have provided useful recommendations on types of counts and development of methodologies.

This Chapter also discussed about the previously performed studies in Bangladesh on partially related topics. It is revealed that, there are scopes to make further comprehensive analyses on the traffic and axle load characteristics on different corridors of Bangladesh, in view of the fact that, no such work has done solely before in Bangladesh. On the contrary, to be acquainted with recent traffic demand and to protect the expensive transport infrastructure, each country should perform similar type of study every year. The next Chapter will elaborately explain the methodology adopted for the evaluation of pavement design parameters.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

To evaluate the pavement design parameters for National Highways of Bangladesh, it is extremely necessary to adopt a sound, systematic approach for data collection, analysis and development of the framework. Pavement design parameters include both geometrical and structural design of pavements. Mainly traffic flow related parameters are emphasized to upgrade for the design of pavements in this research for different corridors of Bangladesh. Traffic data collection system is an important task in the developed countries and they use lots of money by procuring machines and manpower for data collection and preservation. Whereas, developing countries like Bangladesh have always shortage of money to maintain road infrastructure. Hence, traffic data collection and preservation has least importance in our country. But, without proper traffic data, road infrastructure design with some assumption may lead to fail the structure in immature time. For this reason, an organized methodology is required to fulfill the objectives of this research.

This chapter discusses about the methods adopted during corridor selection, data collection, sorting of raw data, identification and minimization or elimination of data errors, development of flow patterns, determination of expansion factors, regression analyses, study of other factors related to traffic flow, determination of frequency distribution of axle loads and damage factor. In order to achieve the objectives of this study, all the above tasks are to be compiled in one comprehensive framework, which can be used for evaluation of pavement design parameters in different National Highways of Bangladesh.

3.2 CORRIDOR SELECTION

Some of the major highway corridors in Bangladesh are –

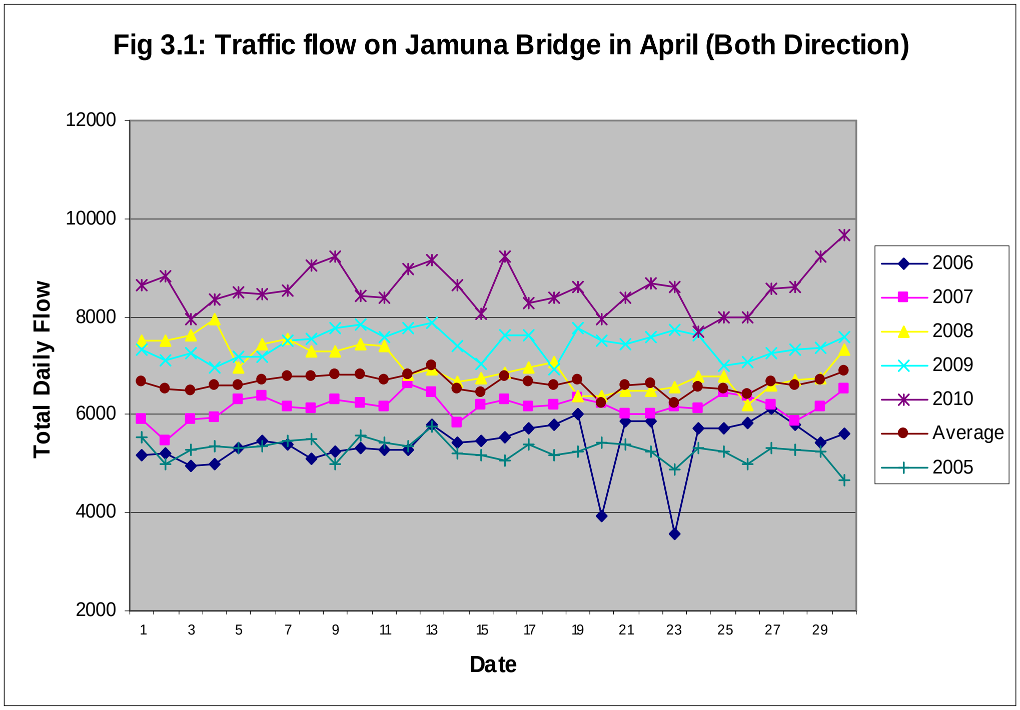
- Dhaka-Chittagong Highway (National Highway No. N1)
- Dhaka-Sylhet Highway (National Highway No. N2)
- Dhaka-North Bengal Corridor (National Highway No. N5 and N6)

- Dhaka-Aricha Highway (National Highway No. N5)
- Dhaka-Mawa Highway to South Bengal (National Highway No. N8)

Different corridors exhibit different characteristics because of the variation in their economic activities. For example, if a corridor is full of mineral resources, the flow pattern, directional distribution, traffic composition would be different from those of an agriculturally resourceful corridor. All these considerations are to play their roles in flow pattern analysis and the development of the framework model. However, in either case, for an efficient analysis of traffic flow characteristics on rural highways, large quantity of reliable data is required.

Long duration reliable traffic data was not available throughout the country before the commencement of Operation and Manintenance Program performed by Communication Ministry of Bangladesh. Manual toll collection program is now discouraged by RHD.The infrastructures are developing for Computerize toll collection systems by Operation and Manintenance Program. Toll collection systems in some major corridors like Dhaka-Chittagong, Dhaka-Sylhet, etc. are already accustomed to computerize toll collection technique. Lond term data is collected from the toll collecting operators of Jamuna bridge, Meghna-Gomoti bridge, Bhairab bridge and Dhaleshari bridge. The Roads and Highways Department of Bangladesh is not preserving any traffic data from computerize toll plaza and as a result, the data may lost when a new company is employed to collect toll. The new company installs their software to the machines of toll plaza by erasing previous company's software. Thus, the whole past traffic data become lost by the neglegence of RHD authority.

Nevertheless, most of the toll operators in selected corridors possess traffic data of their lease time, and the qualities of those data are found to be high. Although, traffic generation and flow is a random event, but research has shown that, traffic flow in a particular corridor maintains definite flow pattern and also the same is repetitive in nature. Figure 3.1 shows a typical daily traffic flow pattern on Jamuna Bridge in the month of April.



From the above figure, it can be seen that, all days of the month maintain similar flow variation pattern with growth of annual traffc flow. This undoubtedly proves the stability of that corridor from traffic flow point of view and also the quality of the data and only this type of quality data is worth to be used for evaluation of pavement design parameters.

3.3 DATA COLLECTION

There is no permanent counting station to measure traffic data in any corridors of Bangladesh. Insufficiency of long term traffic flow and axle load data has force engineers to assume parameters of pavement design from nearby countries like India. Long term traffic data is necessary for determining pavement desing parameters and the prediction of future traffic demand accurately. Road and Highways department of Bangladesh has no special program to collect corridor wise annual traffic and axle load data. Hence, during the research it was a challenge to collect fair amount of traffic flow and axle load data with which a reliable evaluation could be made. The following sources have been used for data collection:

- 4 years (January 2005 to May 2009) of both direction daily flow data on Jamuna Bridge toll plaza by Marga Net One Limited (MNOL), the then bridge operator and maintenance company.
- 1 year (June 2009 to August 2010) of daily flow data on Jamuna Bridge collected by Bangabandhu Bridge Special Organization (BBSO).
- 3 years (January 2007 to December 2009) of both direction daily flow data on Bhairab and Ashuganj Bridges toll plaza by Sigma-RCL JV Ltd., the then bridge operator and maintenance company.
- 4 years (January 2006 to December 2009) of both direction daily flow data on Meghna-Gomoti Bridges toll plaza by RCL and MBEL-ATT JV Ltd., the then bridge operator and maintenance company.
- 1 year (October 2009 to September 2010) of both directions daily flow data on First and Second Dhaleshari Bridges toll plaza by Keraniganj Road Sub-division, RHD.
- 1 year (January 2009 to April 2010) of both direction daily flow data on Nalka-Hatikamrul-Bonpara road collected by MBEL-ATT JV Ltd., the present toll operator.
- Axle load data (1st February to 29th February 2012) collected on Dhaka-Aricha highways by Regnum Resource Ltd., the present axle load control station operator.
- Axle load data (1st February to 29th February 2012) collected on Dhaka-Chittagong highways by Asian Traffic Technology (ATT) Ltd., the present axle load control station operator.

All the computerized toll operators use similar data collection and recording method. Data is entered into the computer at the toll collection booth at the time of toll collection and they are directly stored into the main database of the toll plaza. The vehicle classification is identified manually by the toll collector as per the registration of respective vehicle. From the main database, the toll operator prepares a monthly summary of daily traffic flow record along with toll amount and submits the same to the concerned authority.

Collecting necessary data for this research from the operators was not an easy task. Comprehensive effort has been given for this purpose. At the beginning of this research, data was collected from Bangladesh Bridge Authority (BBA) after official request from BUET to obtain electronic version of traffic flow data from the year 2006. In that year of 2010, the toll was collected on Jamuna bridge by Bangabandhu Bridge Special Organization (BBSO) and they initially gave only 1 year data from June 2009 to August 2010. The author came to know that they have no access to previous toll operator's (Marga Net One Limited) database. However, after inquiring staffs of BBSO, the author got an address of a person named Mr. Kiron Dev Nath, who was database in charge of MNOL. Then after finding that person, he gave the password of the system to BBSO, and it became possible to collect data of Jamuna bridge. Similar types of incidence happened at the time of data collection of Bhairab bridge and Meghna-Gomoti bridge. The author had to visit the above mentioned toll plaza several times for the purpose of data collection.

3.3.1 PROBLEM ENCOUNTERED DURING DATA COLLECTION

Here follows some of the problems encountered while collection of the traffic and axle load data:

- The concerned government authorities do not keep any systematic record of traffic data in electronic version, which is extremely needed for research purpose.
- RHD should instruct all the toll operators to maintain hourly traffic flow database, which is a basic form of traffic flow tools. Hourly flow pattern is the key structure for traffic monitoring system. But unfortunately, no such data is found from any toll operators rather they show unwillingness to preserve hourly data.
- The operators do not use specified software to maintain a unified data collection and recording system. As a result, the data were collected as hard copy and they had to be put into the input file of the framework manually.

- There does not exist any unified vehicle classification system. It was found that each corridor have its own vehicle classification system.
- Only tolled vehicles are counted and recorded by the operator. It is to be mentioned here that the government vehicles and maintenance vehicles are exempted from toll and thus considerable amount of government vehicles are not counted and hence leading to minor data errors.
- Large buses carry significant amount of axle load, but the axle load control stations measure axle load of trucks only.
- The axle load data recording system of Gomoti toll plaza is not satisfactory. No trained people were involved in this process. Also, axle load collecting system in this toll plaza is temporary.
- Meghna axle load control station measures vehicle axle load when it is moving. This type of data collection may produce faulty data in some cases.

3.4 DATA PROCESSING

Data processing task involves exclusion of data during unstabilized period, identification of external factors causing variations in regular patterns and elimination of those external factors. After the data processing has been completed, the summarized data is sorted in such a manner that the analyses works are best facilitated.

3.5 DEVELOPMENT OF FRAMEWORK

The objectives of this study are to develop a framework through which the following analyses can be made for different corridors.

- Summarizing daily, weekly, monthly & yearly traffic data
- Traffic composition
- Directional Distribution
- Render daily, monthly, yearly flow pattern charts
- Identifying data noises

- Flow pattern of predominant vehicle classes
- Calculation of Daily Expansion Factors
- Calculation of Monthly Expansion Factors
- Yearly Growth Pattern and determination of Growth Factors
- Regression analysis of daily and monthly data and preparation of correlation charts
- Corridorwise vehicle flow pattern analysis
- Calculation of absolute overloading and rear axle loading pattern
- Comparison of past and present axle load characteristics
- Frequency distribution of axle weight
- Calculation of damage factor and ESAL.

The framework should be such that, raw data from field surveys can be entered into the input spreadsheet and the formulae & equations are interlinked with the output charts and tables. In this study, Microsoft Excel compatible with MS Windows has been used for the purpose, although more comprehensive and user friendly model could have been established with a framework developed with MS Access Data Base hyper linked with Visual Basic. However, the latter method is recommended for future works.

3.5.1 FRAMEWORK TYPES

A number of analysis models have been developed during this thesis depending on the type of input data and analysis scope. For plotting daily, monthly, yearly flow variation patterns and determination of expansion factors, the following models have been developed.

1. The first model plots variation of flow pattern like daily flow variation, weekly flow variation, monthly/ seasonal flow variation, traffic composition, directional distribution charts, impact of Eid festival, traffic growth factor, comparison of traffic flow between two roads in same corridor and other types of traffic flow analysis for N-5 corridors. Corridor analyses between Hatikamrul road and

Jamuna bridge daily data can be useful for auditing purpose since it plots the traffic daily flow on the two mentioned locations in the same charts which compares the traffic movement and also determines the percentage of traffic volume on Hatikamrul road to that on Jamuna bridge. If the two flow patterns are similar, it is easily understood that the toll collections have been accurate.

2. From the summarized traffic flow sheet, the second model plots daily flow variation, weekly flow variation, monthly flow variation, traffic composition, daily and monthly directional distribution charts, impact of Eid festival, traffic growth pattern, comparison of traffic between N-2 and N-5 corridors, and other types of traffic flow analysis for N-2 corridor. Three years of traffic data are collected from SIGMA-RCL Joint Venture Company. The analyses would be more consistent if more years of data are available.

3. The third model illustrates daily flow variation, weekly flow variation, monthly flow variation, traffic composition, impact of Eid festival, traffic growth pattern, corridor analysis among N-1, N-2 and N-5 corridors, and other sorts of traffic flow analysis for N-1 corridor. Analyses such as directional distribution, etc. are not included in the model because only bi-directional total daily traffic flow data are available from the operator. Corridor model analyses can be a useful tool to understand traffic flow pattern among corridors and it also provides potential thought for structural design of concern highways.

4. The forth model demonstrates various traffic flow analyses on N-8 corridor like daily flow variation, weekly flow variation, monthly flow variation, traffic composition, daily and monthly directional distribution charts, and impact of Eid festival. Only one year of traffic data are found on N-8 corridor for analyses.

5. The fifth model illustrates axle load characteristics in two different corridors. It also includes comparison between past and present axle load data analyses, frequency distribution of axle load among corridors, and determination of damage factor. More than thirteen thousand axle load data is collected from Dhaka-Chittagong corridor and more than twelve thousand axle load data is collected from Dhaka-Aricha corridor.

6. The last model plots daily and monthly expansion factor, vehicle class wise growth factor, daily and monthly regression models for N-1, N-2, and N-5 corridors.

3.6 OVERVIEW

This chapter describes the total analysis procedure of the present study starting from selection of corridors, data collection to problem encountered during data collection, data processing, and the development of framework for analyses. The type of each framework and the components of the skeleton are illustrated briefly to recognize the research pattern correctly. However, the next Chapter will focus on the detail analyses of pavement design parameters in different National Highways of Bangladesh.

CHAPTER 4

EVALUATION OF TRAFFIC FLOW RELATED PARAMETERS IN DIFFERENT CORRIDORS

4.1 INTRODUCTION

Assessment of pavement design parameters especially traffic flow related parameters in different corridors of Bangladesh are taken into consideration for this thesis work. To analyze flow related parameters, long duration round the clock traffic flow data is mandatory. According to achieve this task, data have been collected in different forms from the toll operators of Jamuna Bridge, Bhairab Bridge, Meghna-Gomoti Bridge and Dhaleshari Bridge. All these data on different corridors have been sorted and summarized into a format to make them usable for the analysis and modeling purpose. This chapter discusses the traffic data analyses and various flow characteristics on different bridges that will finally evaluate various pavement design related parameters.

4.2 ANALYSIS OF FLOW CHARACTERISTICS IN N-5 CORRIDOR (JAMUNA BRIDGE)

Using the summarized database of traffic flow on Jamuna bridge, a range of analysis on traffic flow have been rendered during this study. This section contains the analysis of flow characteristics on Jamuna bridge. Primarily the flow patterns have been developed to see the nature of traffic flow fluctuation and then various flow characteristics have been established.

4.2.1 FLOW PATTERN

Traffic flow varies over time. The variation is observed in hours of day, days of week, months of year showing definite repetitive nature. These variations are important aspects of flow characteristics, which have been discussed in the following sections.

4.2.2 DAILY FLOW VARIATION

Daily flow fluctuation on highways is an important parameter of flow characteristics where the variation of flow in days-of-week is observed. From the analyses of 5 years data collected from Marga Net One Limited (MNOL) and Bangabandhu Bridge Special Organization (BBSO) (2005 to 2009), distinct daily flow fluctuation pattern can be achieved. In Figures 4.1a & b, the average daily flow, in either direction, in percentage of total weekly volume have been plotted against respective days of week. It is clearly observed that daily flow variation for inbound (West to East) and outbound (East to West) traffic does not exhibit similar pattern.

Figure 4.1a: Daily Flow Fluctuation on Jamuna Bridge (East to West Direction)

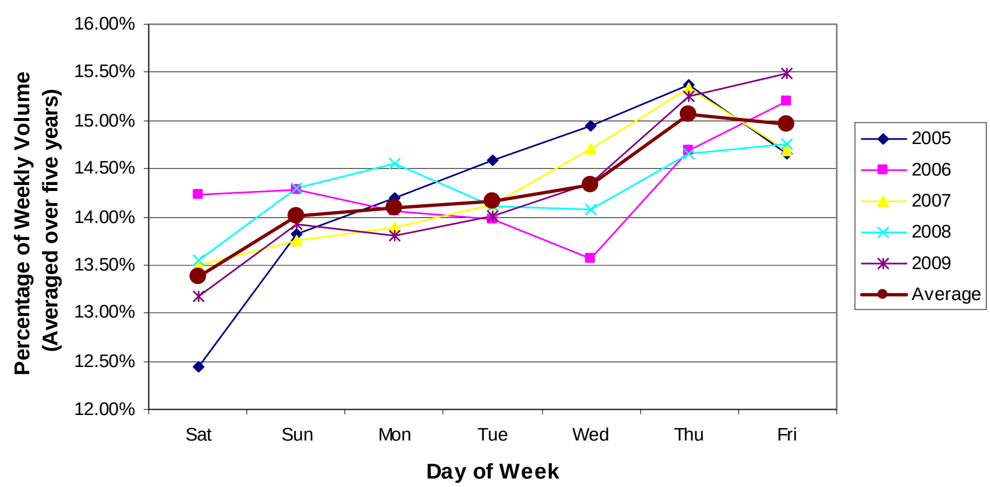


Figure 4.1b: Daily Flow Fluctuation on Jamuna Bridge (West to East Direction)

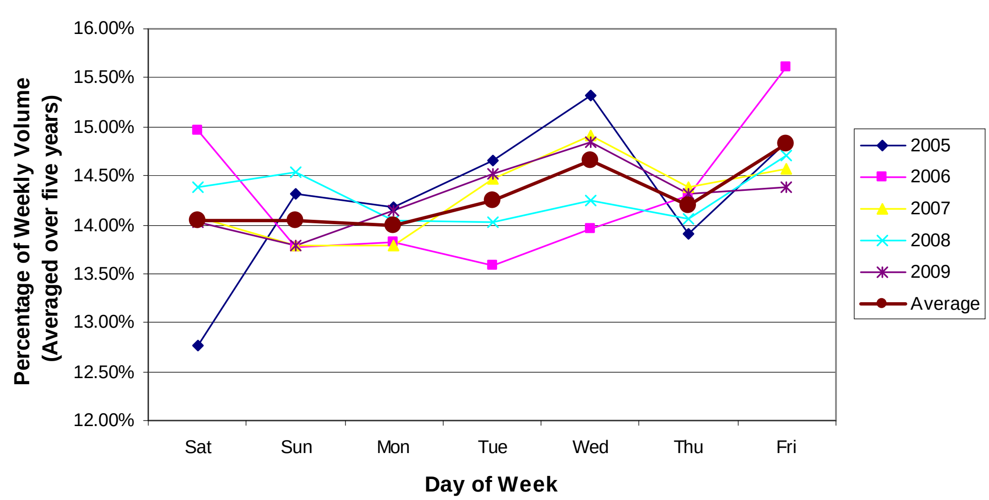
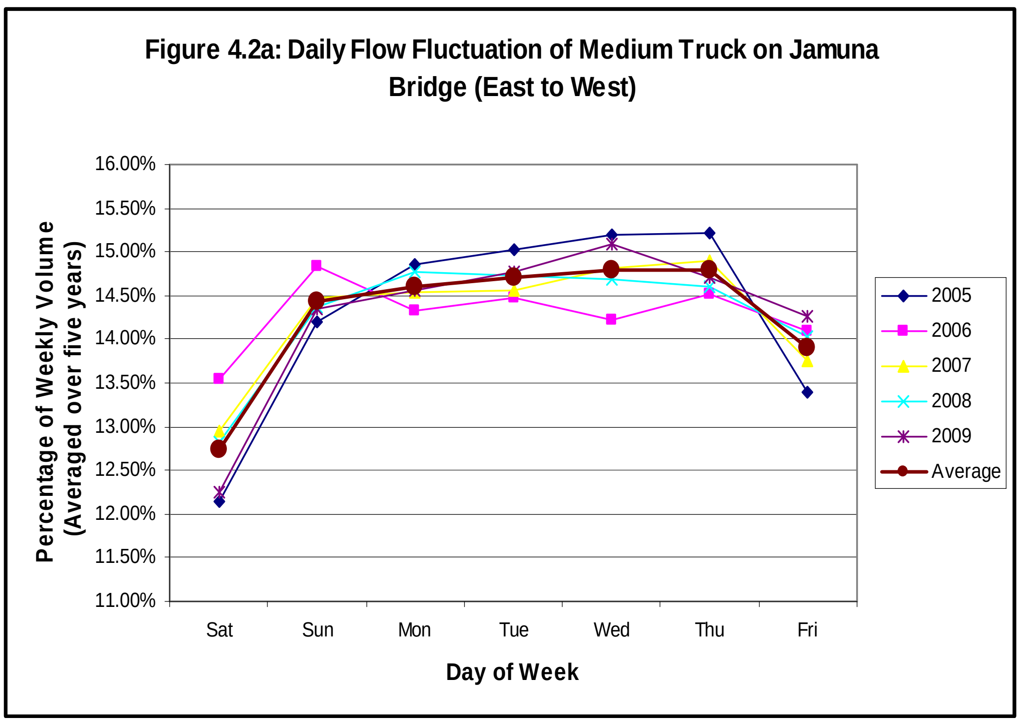
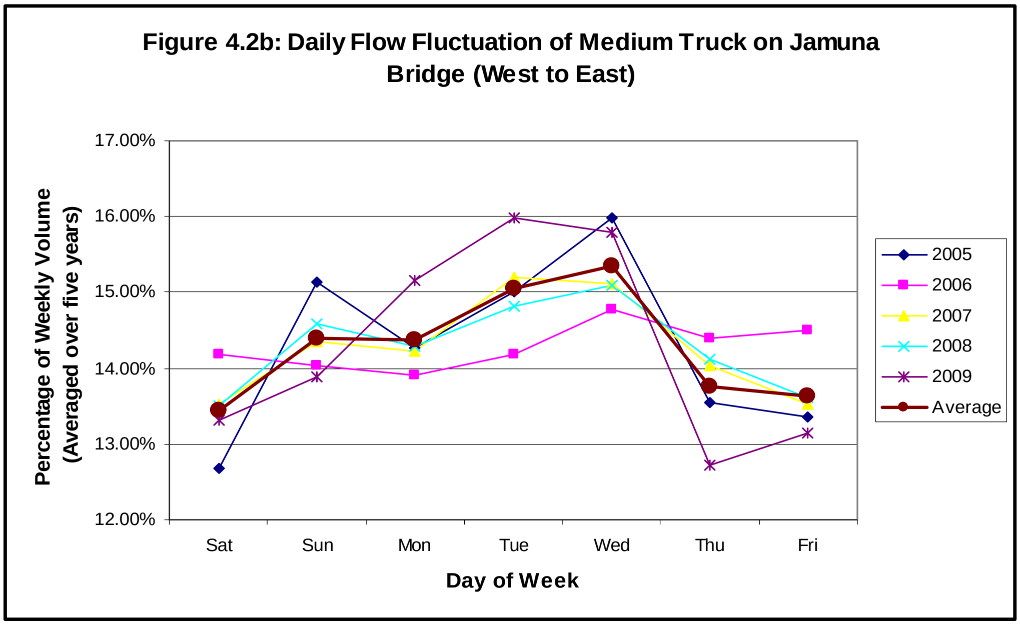


Figure 4.1a shows the flow variation for traffic from East to West. On this direction, it is found that the average maximum flow occurs on Thursday (15.06%) and Friday (14.96%). This may happen because of weekend factor, i.e. people from North Bengal tend to visit their native town/village during the weekend from their workplaces in Dhaka. On the other hand, for West to East flow direction (Figure 4.1b) average maximum flow takes place on Friday (14.82%) and Saturday (14.04%), because people return to workplaces in Dhaka at the beginning of week. In both the cases, the curves tend to sag on midweek (Monday & Tuesday) where traffic flow is relatively minimum.

It is apparent from the above patterns that freight vehicle movement has little impact on these variations, as weekend factor is more prominent on passenger movement. Therefore, the need for analyzing daily flow variation separately for vehicle classes is realized. Accordingly, curves have been plotted for three predominant vehicle classes on Jamuna bridge, which are given hereunder.





In Figure 4.2a and Figure 4.2b, daily flow variation of medium trucks are shown for outbound and inbound traffic respectively. It is observed from figure 4.2a that, the daily flow percentages for outbound medium trucks are relatively equal on all weekdays than those for inbound medium trucks. From figure 4.2a & b, distinct drop of outbound and inbound medium trucks are seen on Saturday and Friday due to weekend factor. Relatively maximum flow of medium trucks found on Tuesday and Wednesday on N-5 corridor.

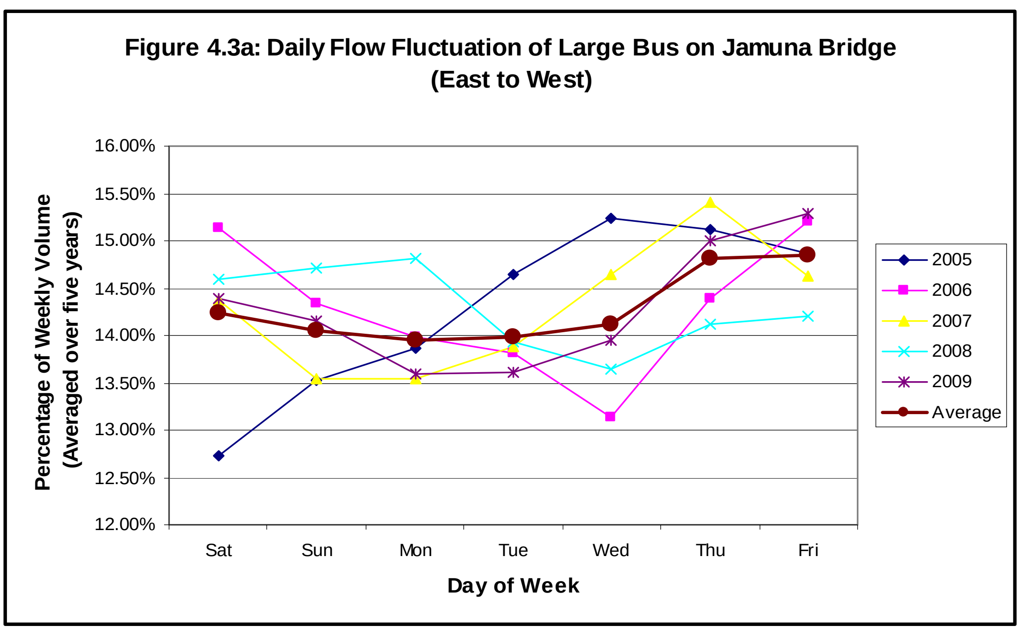
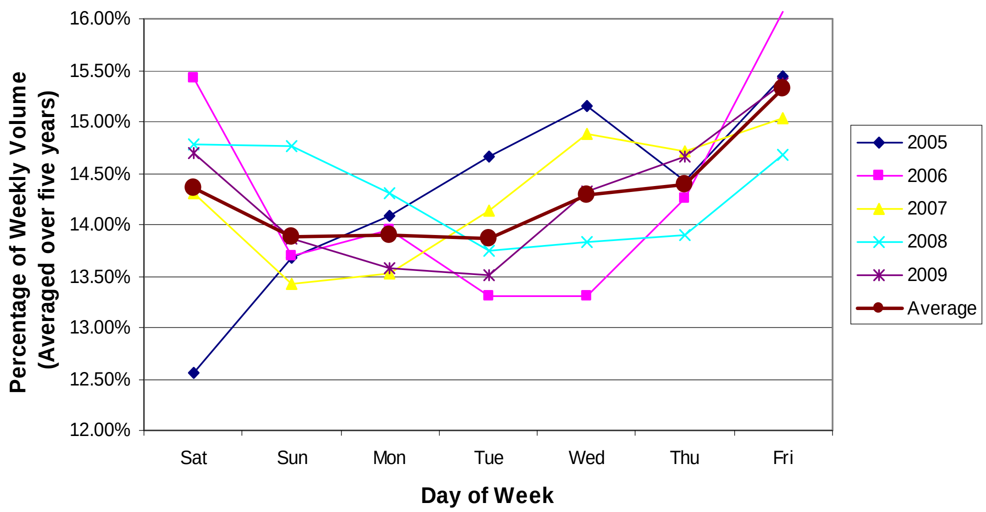


Figure 4.3b: Daily Flow Fluctuation of Large Bus on Jamuna Bridge (West to East)



In the case of Large Bus, as shown in Figures 4.3a and 4.3b, the daily flow variation is similar to that for total traffic, where daily percentage of flow rise on weekend with a moderate sag on midweek. For both direction of flow, the highest flow occurs on Friday, which is justified by the weekend factor. Relatively minimum flow of large bus is observed on Monday and Tuesday on N-5 corridor.

But from the patterns of daily flow fluctuation of Light Vehicles, as shown in Figures 4.4a and 4.4b, huge rise of flow on weekend are observed. For outbound traffic, the maximum flow occurs on Friday, carrying 17.73% of total weekly volume, which is quite high in comparison to the other major vehicle classes. For inbound traffic pattern, prominent sag on midweek is observed with most traffic traveling on Friday (17.16%) and Saturday (15.61%).

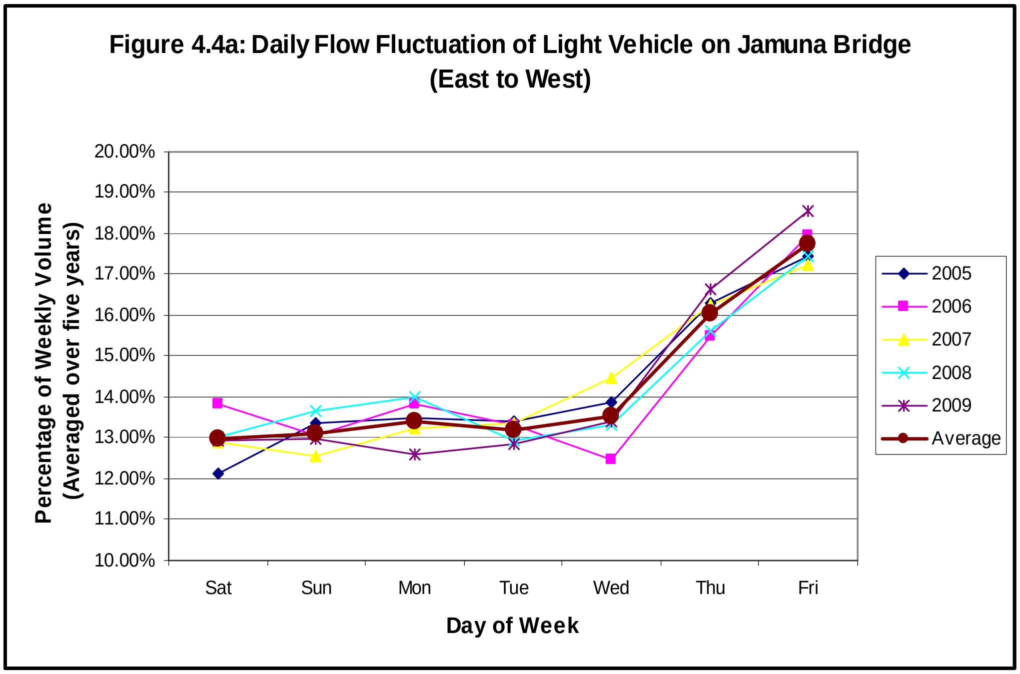


Figure 4.4a: Daily Flow Fluctuation of Light Vehicle on Jamuna Bridge
(East to West)
Percentage of Weekly Volume
(Averaged over five years)
20.00%
19.00%
18.00%
17.00%
16.00%
15.00%
14.00%
13.00%
12.00%
11.00%
10.00%
Sat
Sun
Mon
Tue
Wed
Thu
Fri
Day of Week
2005
2006
2007
2008
2009
Average

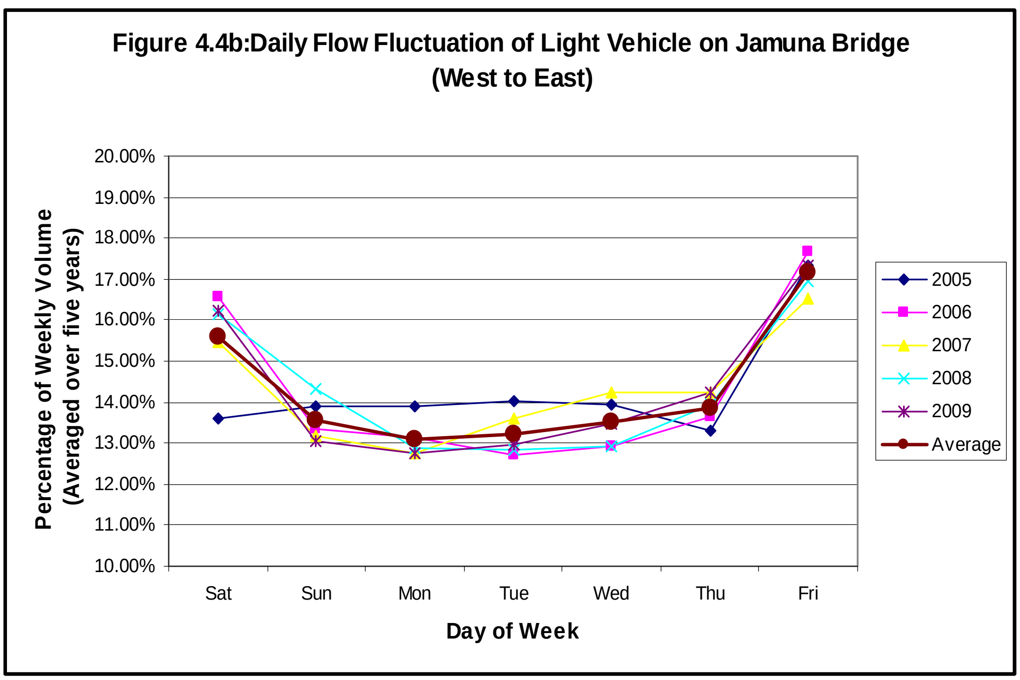
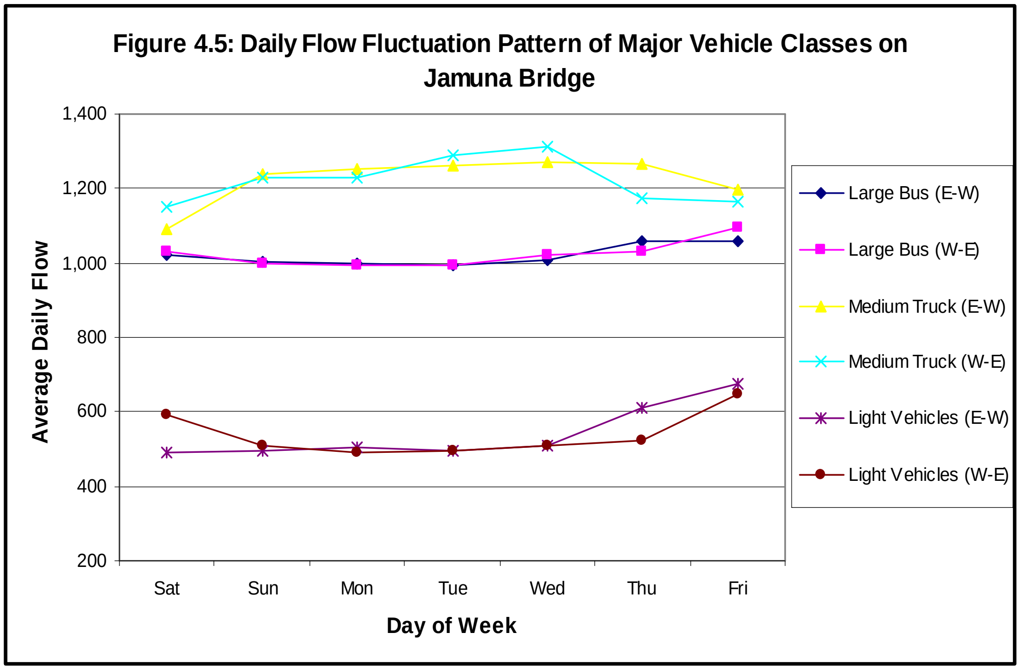


Figure 4.4b:Daily Flow Fluctuation of Light Vehicle on Jamuna Bridge
(West to East)
Percentage of Weekly Volume
(Averaged over five years)
20.00%
19.00%
18.00%
17.00%
16.00%
15.00%
14.00%
13.00%
12.00%
11.00%
10.00%
Sat
Sun
Mon
Tue
Wed
Thu
Fri
Day of Week
2005
2006
2007
2008
2009
Average

The following Figure summarizes the pattern of these three major vehicles classes.



Now, it is a matter of interest to see, how each month of year affects this daily flow fluctuation. To make this observation, curves have been plotted showing daily flow variation for all months of a year during this study. Two of such charts are given in Figure 4.6 and Figure 4.7, where the average daily flow variation pattern are found to conform to those obtained from the previous analyses, but no definite relation can be established in terms of influence of individual month on these daily variations. This implies that, individual month has no significant effect on daily variation of traffic flow on the N-5 corridor.

Figure 4.6:Month-wise Daily Traffic Flow Variation on Jamuna Bridge, 2005 (Both Direction)

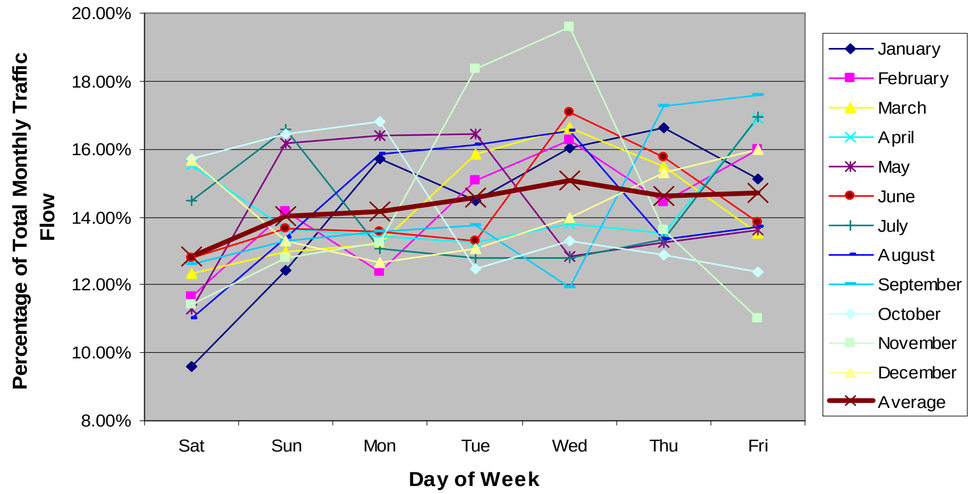
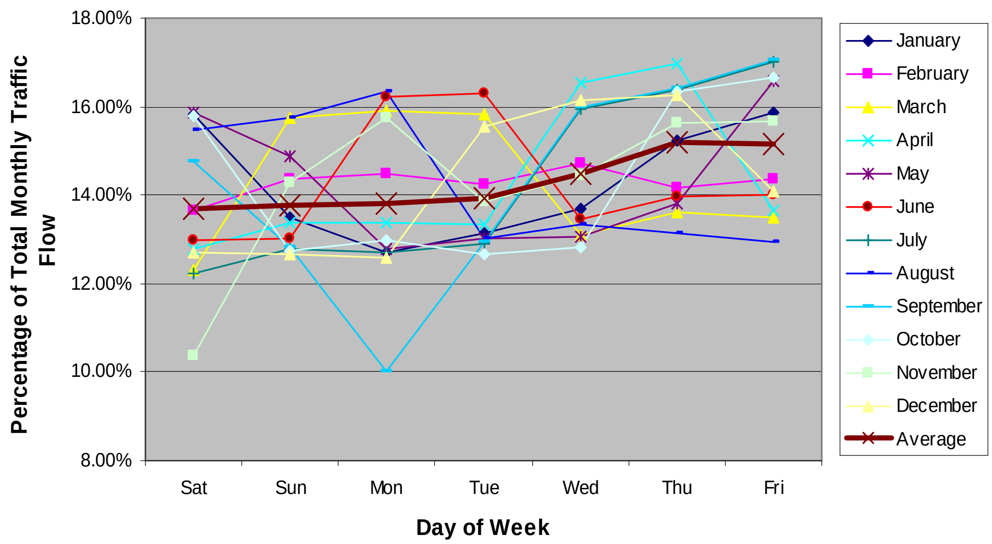


Figure 4.7:Month-wise Daily Traffic Flow Variation on Jamuna Bridge, 2009 (Both Direction)



It is to be noted here that, only two years (2005 and 2009) of month-wise daily flow variation pattern have been shown above. Similar analyses curves for 2006, 2007 & 2008 are given in the Appendix B (Figure B1 to B3).

Summary of Findings:

From the above analyses, the following important flow characteristics parameters have been obtained.

Table 4.1: Summary Table - Daily Flow Variation

Vehicle Class	Flow Direction	Maximum Flow		Minimum Flow	
		Day of Week	Percentage of Weekly Volume	Day of Week	Percentage of Weekly Volume
Total Traffic	East to West	Friday	15.06%	Saturday	13.38%
	West to East	Friday	14.82%	Tuesday	14.00%
Medium Truck	East to West	Sunday	14.80%	Saturday	12.74%
	West to East	Monday	15.36%	Friday	13.44%
Large Bus	East to West	Friday	14.84%	Wednesday	13.96%
	West to East	Friday	15.32%	Tuesday	13.87%
Light Vehicles	East to West	Friday	17.73%	Sunday	12.97%
	West to East	Friday	17.16%	Tuesday	13.08%

4.2.3 WEEKLY FLOW VARIATION

Depending on the economic activities of highway corridors, traffic flow may exhibit weekly flow variation, i.e. considering four weeks in a month; the flow may vary from week to week. To find out these characteristics on the N-5 corridor, weekly flow analyses have been done in this thesis.

Each month has been divided into four weeks. The first three weeks have seven days each and the fourth week, except February, has 9 to 10 days depending on the month. So, it is anticipated that the fourth week will naturally contain more traffic. To compensate this possible error, the model uses weekly ADT instead of weekly volume and then compares between the four weekly ADTs of each month from January 2005 to December 2009. A typical table of weekly flow variation analyses is shown in Table 4.2, 4.2a, 4.2b.

Curves have been plotted in Figure 4.8a and 4.8b showing variation in weekly flow on Jamuna bridge in the year 2009. From the chart, it is seen that, the weekly flow percentages of most of the month maintain significant pattern in a year. Individual two or three month shows different characteristics due to Eid day, hartal, etc.

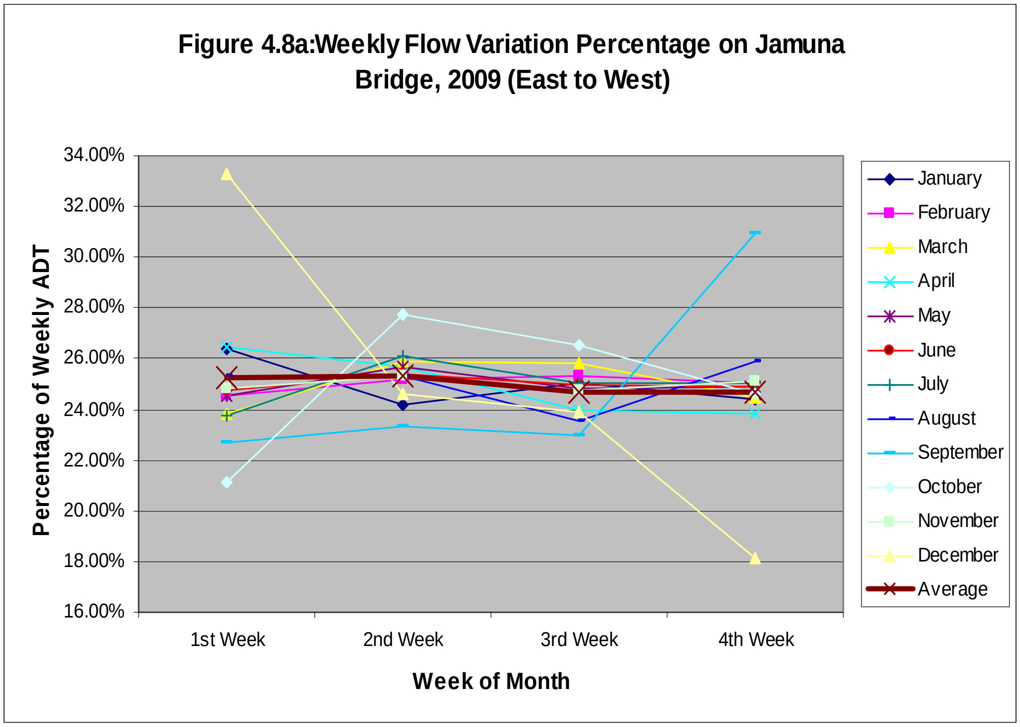


Figure 4.8a:Weekly Flow Variation Percentage on Jamuna Bridge, 2009 (East to West)
Percentage of Weekly ADT
34.00%
32.00%
30.00%
28.00%
26.00%
24.00%
22.00%
20.00%
18.00%
16.00%
1st Week
2nd Week
3rd Week
4th Week
Week of Month
January
February
March
April
May
June
July
August
September
October
November
December
Average

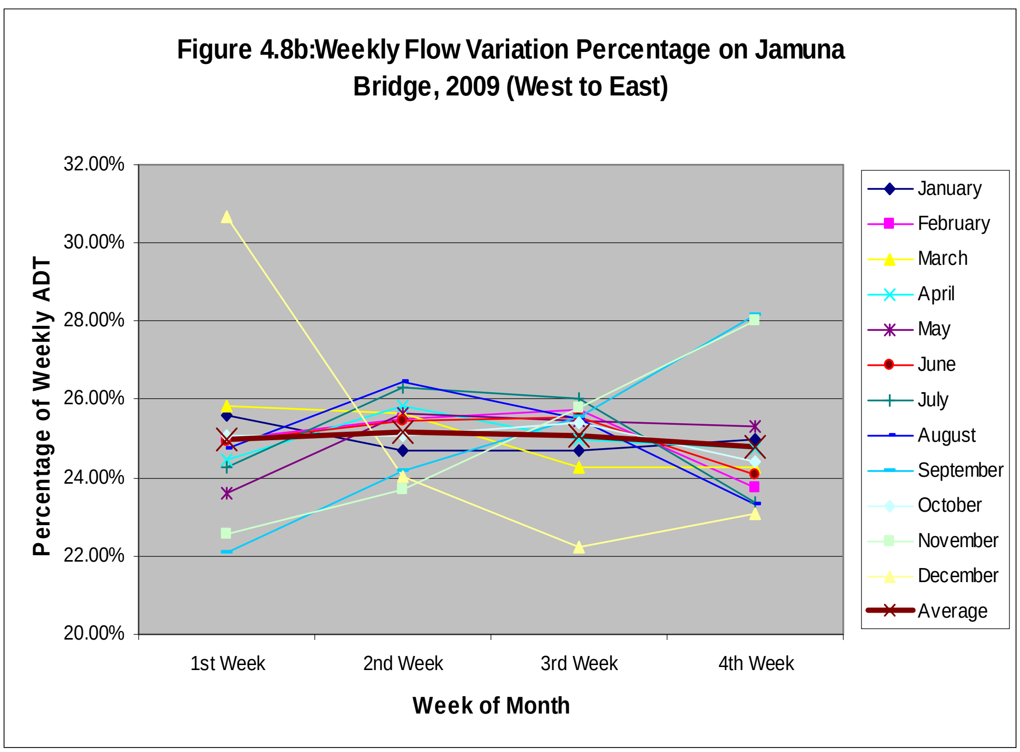


Figure 4.8b:Weekly Flow Variation Percentage on Jamuna Bridge, 2009 (West to East)
Percentage of Weekly ADT
32.00%
30.00%
28.00%
26.00%
24.00%
22.00%
20.00%
1st Week
2nd Week
3rd Week
4th Week
Week of Month
January
February
March
April
May
June
July
August
September
October
November
December
Average

From figure 4.9, it implies that, in the North Bengal corridor, there exists specific weekly flow variation pattern. The average curve (for the year 2005-2009) shows that, the first three week of a month, there is a trend of increasing traffic slightly and the last week of the month traffic decrease same way.

However, Table 4.2 summarizes the weekly flow variation on Jamuna bridge for five years. The graphical representation is shown in Figure 4.9, 4.9a and 4.9b. Year wise weekly flow fluctuation charts for the other four years are given in Appendix B (Figure B4 to B11).

Table 4.2: Summary of Weekly Flow Variation (Both Direction)

Year	Weekly Flow Percentage			
	1st Week	2nd Week	3rd Week	4th Week
2005	24.80%	25.47%	25.28%	24.45%
2006	24.90%	24.38%	25.51%	25.21%
2007	24.40%	25.17%	25.70%	24.73%
2008	25.47%	25.28%	24.74%	24.51%
2009	24.57%	25.11%	25.45%	24.86%
Average	24.83%	25.08%	25.34%	24.75%

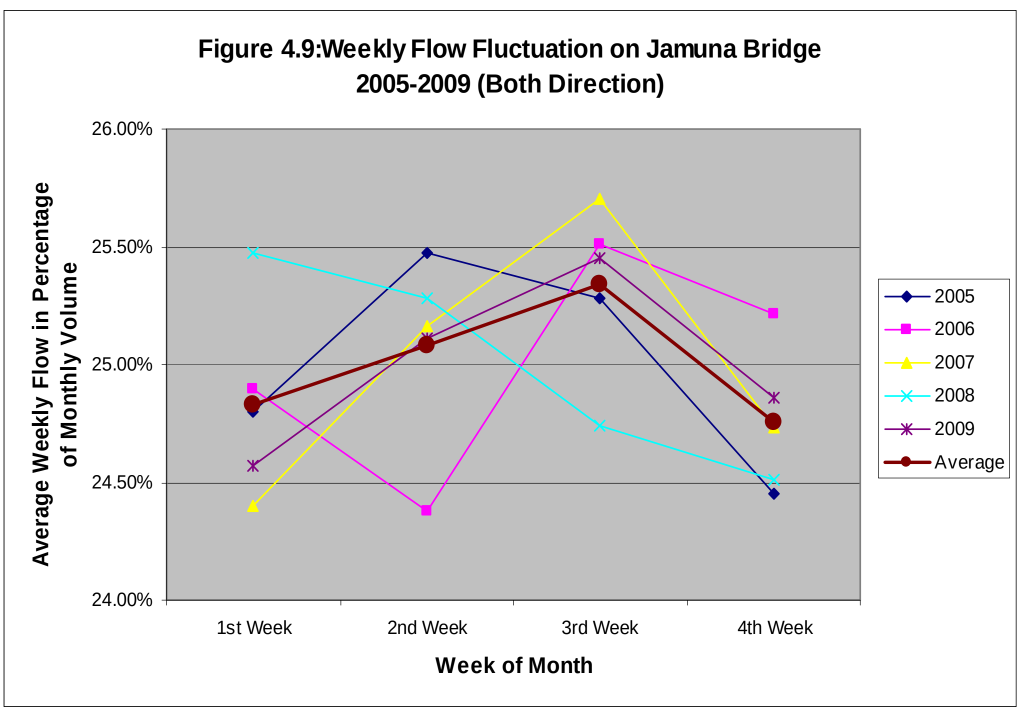


Table 4.2a: Summary of Weekly Flow Variation (East to West)

Year	Weekly Flow Percentage			
	1st Week	2nd Week	3rd Week	4th Week
2005	24.86%	25.40%	25.48%	24.25%
2006	24.74%	24.63%	25.31%	25.32%
2007	24.20%	25.29%	25.95%	24.57%
2008	25.27%	25.35%	24.71%	24.67%
2009	24.18%	25.05%	25.84%	24.93%
Average	24.65%	25.14%	25.46%	24.75%

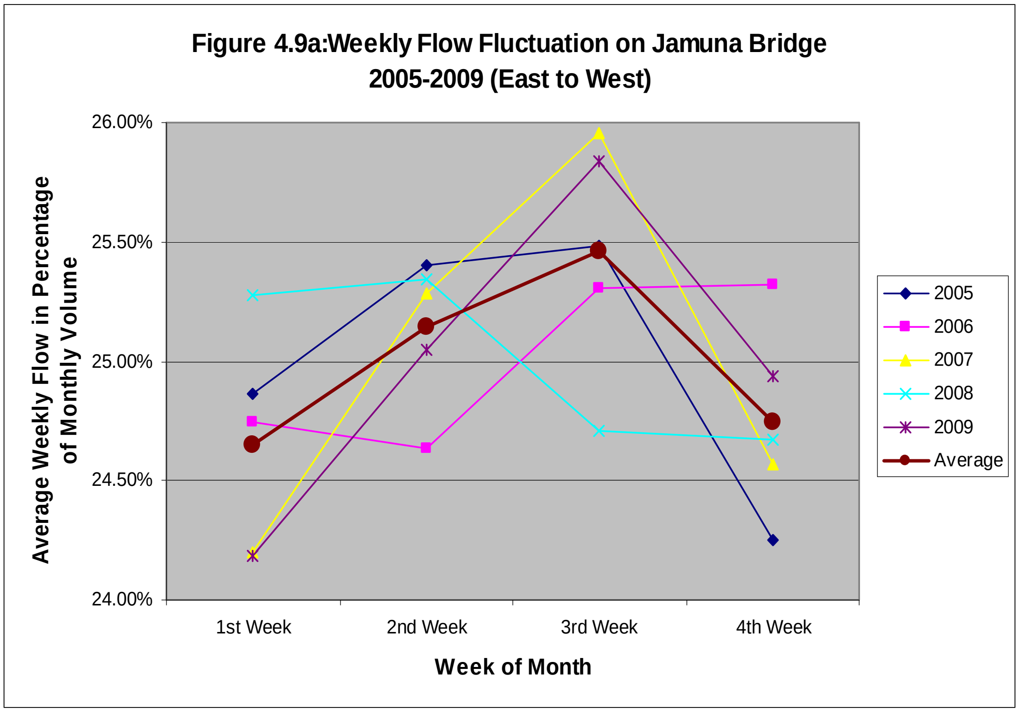
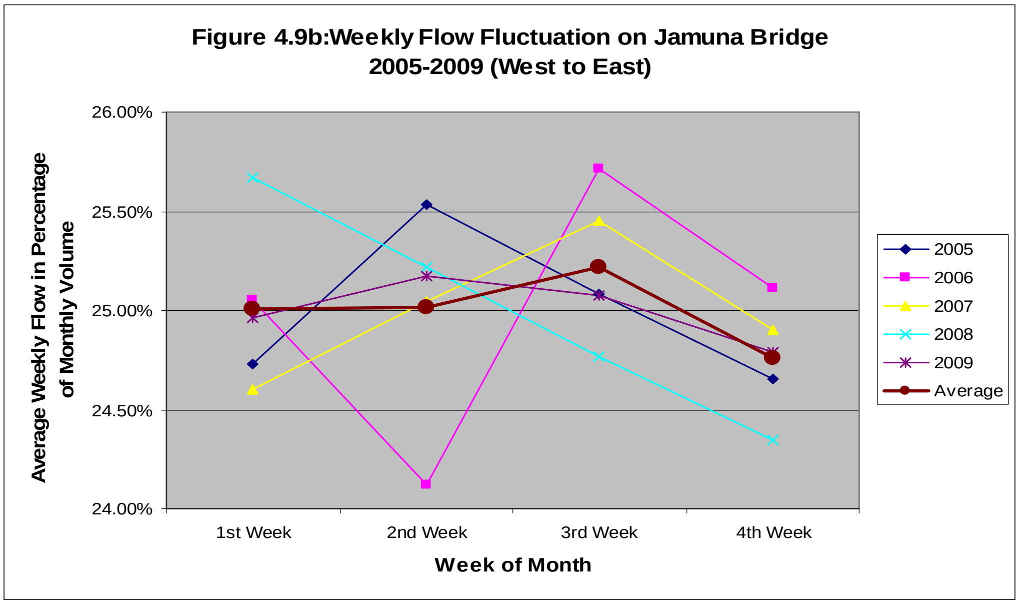


Table 4.2b: Summary of Weekly Flow Variation (West to East)

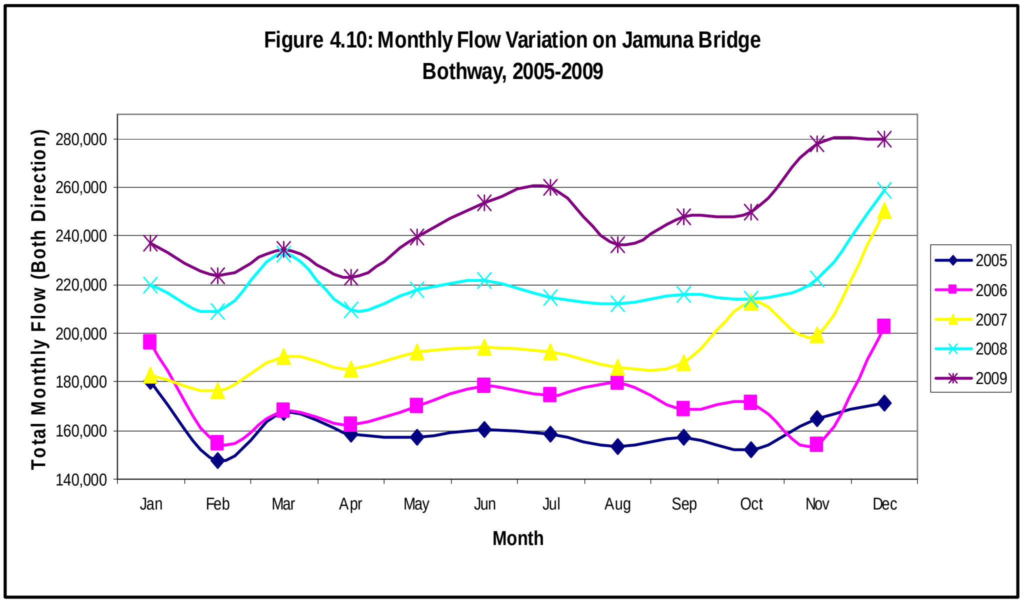
Year	Weekly Flow Percentage			
	1st Week	2nd Week	3rd Week	4th Week
2005	24.73%	25.54%	25.08%	24.65%
2006	25.06%	24.12%	25.71%	25.11%
2007	24.60%	25.05%	25.45%	24.90%
2008	25.67%	25.21%	24.77%	24.35%
2009	24.96%	25.17%	25.07%	24.79%
Average	25.00%	25.02%	25.22%	24.76%



4.2.4 MONTHLY FLOW VARIATION

Monthly flow variation is an important parameter in traffic flow characteristics. It is also named as Seasonal variation of flow. In this study, five years of traffic flow data on Jamuna bridge collected from Marga Net One Limited (MNOL) and Bangabandhu Bridge Special Organization (BBSO) have been used for monthly flow variation analyses, which have given a thorough understanding of nature of traffic flow variation in different months of a year.

Characteristics curves showing monthly flow variation is shown in Figure 4.10. It can be seen that, monthly flow variation in every year shows very similar repetitive nature of flow fluctuation. The magnitude of flow has risen every year but the flow pattern remains same, which implies that month has influences over traffic flow along this corridor.



The following table (Table 4.3) shows the monthly flow variation on Jamuna bridge, in percentage of total yearly volume, from the years 2005 to 2009. The graphical representation is shown on Figure 4.11.

Table 4.4 shows the maximum and minimum monthly flow percentage, by sorting the above table. Maximum and minimum flow is marked in red and blue respectively.

Table 4.3: Monthly Bi-directional Flow Variation on Jamuna Bridge, (2005-2009).

Month\Year	2005	2006	2007	2008	2009
Jan	180,426	196,278	182,787	219,713	237,308
Feb	147,964	154,703	176,282	208,812	223,575
Mar	167,355	168,354	190,420	232,404	234,368
Apr	158,215	162,053	185,136	209,366	222,787
May	157,247	170,153	192,508	217,671	239,455
Jun	160,719	178,056	194,433	221,612	253,497
Jul	158,730	174,472	192,399	214,606	259,745
Aug	153,591	179,494	186,088	212,331	236,128
Sep	157,462	168,778	188,161	216,116	247,680
Oct	152,113	171,521	212,973	214,256	249,826
Nov	165,180	154,014	199,045	222,333	277,905
Dec	171,311	202,618	250,577	258,719	279,918
Yearly Volume	**1,930,313**	**2,080,494**	**2,350,809**	**2,647,939**	**2,962,192**

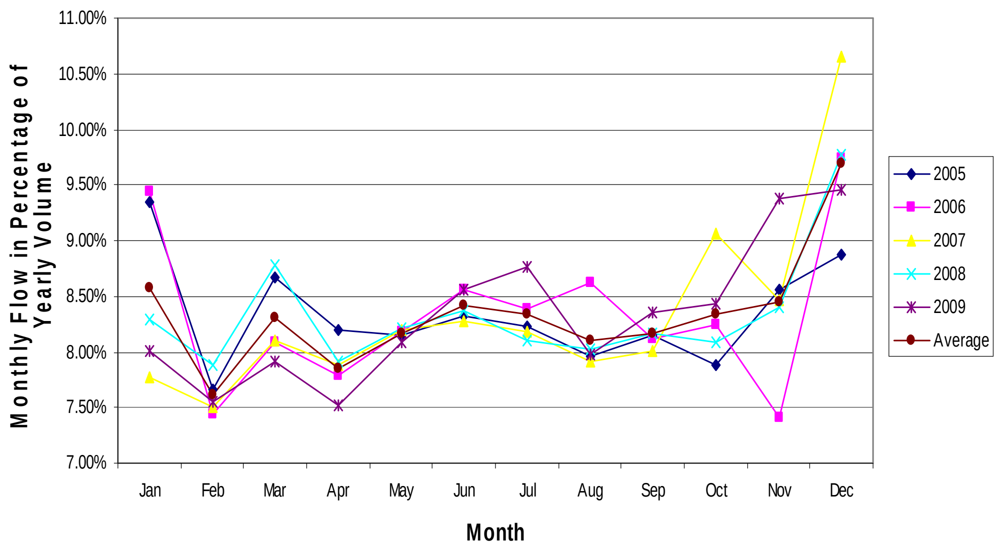
Source Data: MargaNet, BBSO.

Table 4.4: Maximum & Minimum Monthly Flow Table

Month\Year	2005	2006	2007	2008	2009	Average
Jan	9.35%	9.43%	7.78%	8.30%	8.01%	**8.57%**
Feb	7.67%	7.44%	7.50%	7.89%	7.55%	**7.61%**
Mar	8.67%	8.09%	8.10%	8.78%	7.91%	**8.31%**
Apr	8.20%	7.79%	7.88%	7.91%	7.52%	**7.86%**
May	8.15%	8.18%	8.19%	8.22%	8.08%	**8.16%**
Jun	8.33%	8.56%	8.27%	8.37%	8.56%	**8.42%**
Jul	8.22%	8.39%	8.18%	8.10%	8.77%	**8.33%**
Aug	7.96%	8.63%	7.92%	8.02%	7.97%	**8.10%**
Sep	8.16%	8.11%	8.00%	8.16%	8.36%	**8.16%**
Oct	7.88%	8.24%	9.06%	8.09%	8.43%	**8.34%**
Nov	8.56%	7.40%	8.47%	8.40%	9.38%	**8.44%**
Dec	8.87%	9.74%	10.66%	9.77%	9.45%	**9.70%**
Total	100.00%	100.00%	100.00%	100.00%	100.00%	**100.00%**
Max.	**9.35%**	**9.74%**	**10.66%**	**9.77%**	**9.45%**	**9.70%**
Min.	**7.67%**	**7.40%**	**7.50%**	**7.89%**	**7.52%**	**7.61%**

Source Data: MargaNet, BBSO.

Figure 4.11: Monthly Flow Variation
(In percentage of Yearly Volume for Bi-Directional Traffic)



It is found from above tables that, the average maximum monthly flow percentage occurs more frequently on November, December and January while the average maximum flow occurs on December. On the other hand, February carries minimum flow more frequently. Broadly, it is observed, as shown in Table 4.5, (graphically represented in Figure 4.13) that more flow occurs on dry season (50.49%) than on the rainy season (49.51%). Following are the possible reasons behind such distribution of monthly flow.

- In Bangladesh dry season is considered from November to April, and rainy season stays from May to October. Because of more freight movement on waterways during the rainy season, the traffic flow percentage on roadway is less. The seasonal distribution chart is as follows:

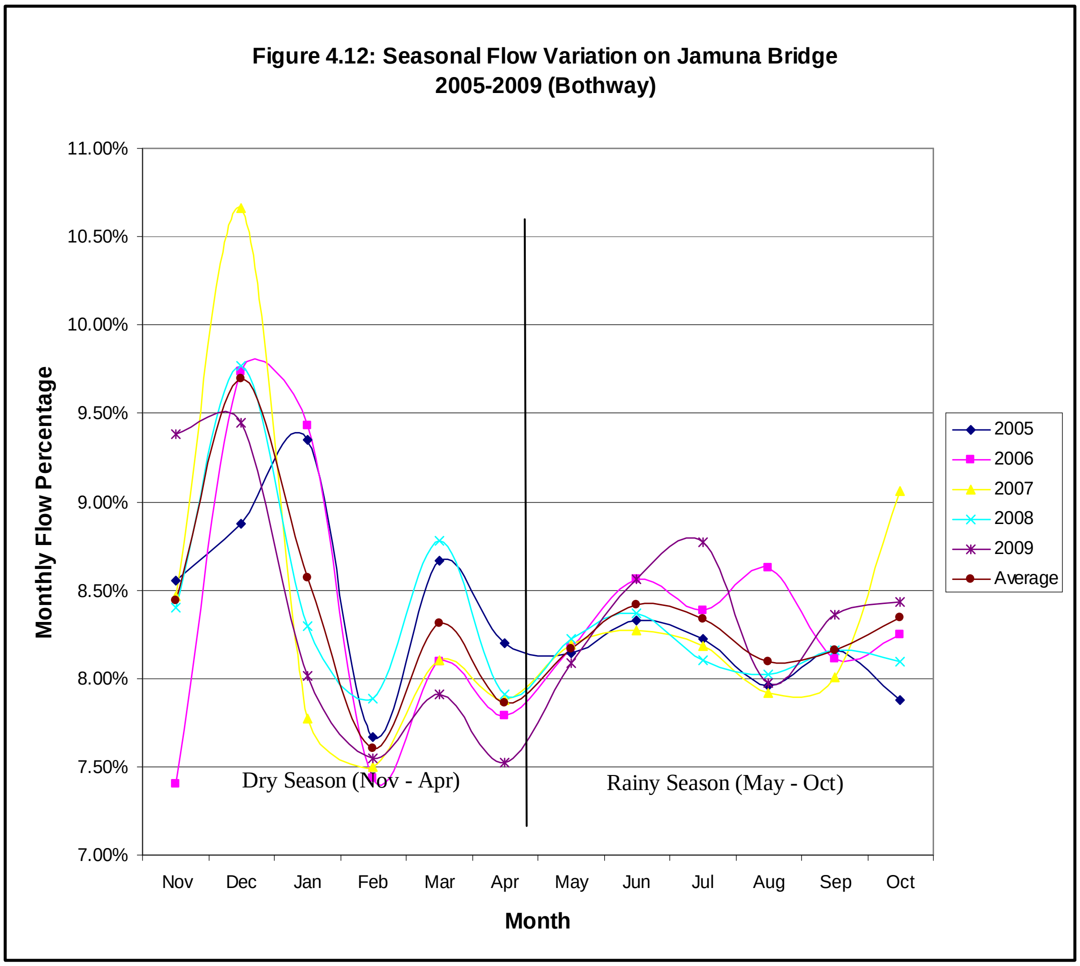
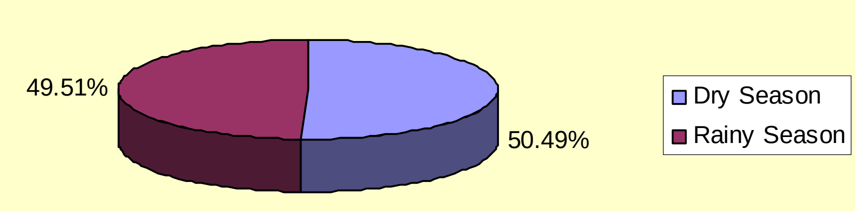


Table 4.5: Summarized Seasonal Flow Variation Table

Dry Season		Rainy Season	
Month	**Flow % in Season**	**Month**	**Flow % in Season**
Nov	8.44%	May	8.16%
Dec	9.70%	Jun	8.42%
Jan	8.57%	Jul	8.33%
Feb	7.61%	Aug	8.10%
Mar	8.31%	Sep	8.16%
Apr	7.86%	Oct	8.34%
Total	50.49%	Total	49.51%

Data Source: MargaNet, BBSO.

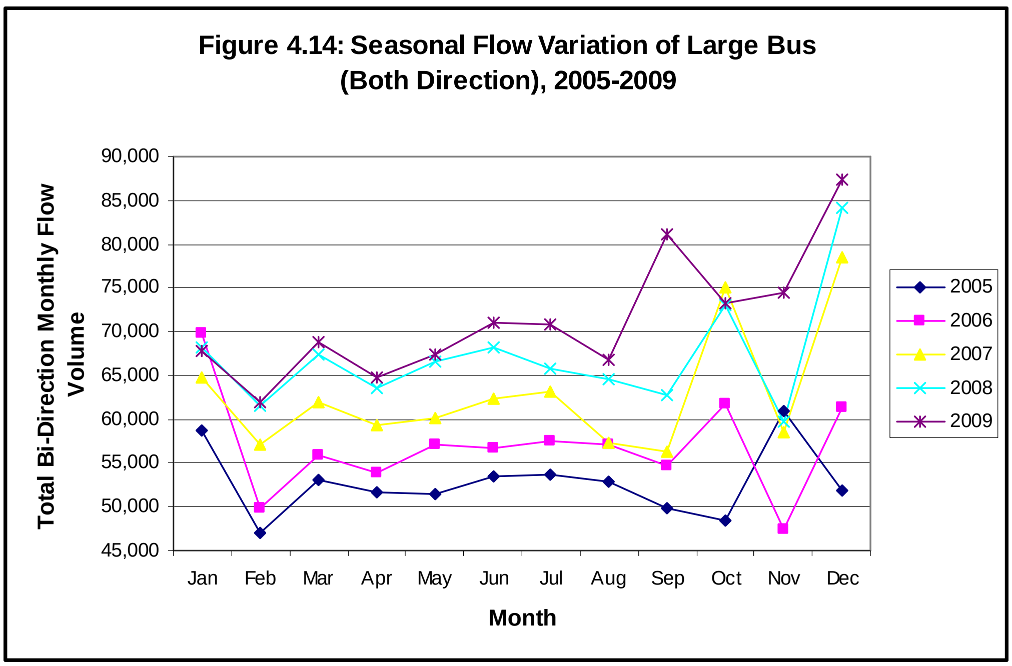
Figure 4.13: Seasonal Distribution of Traffic on Jamuna Bridge (Bothway), 2005-2009



- Recreational trips are more pronounced during the winter, which is a part of dry season.
- Presence of Eid festivals in Dry season during the years under consideration in this study has its significant effect on increased traffic flow, which is evident from the vehicle classwise seasonal flow variations on Figures 4.14, 4.15 and 4.16. The effect of Eid festivals is more pronounced on flow of light vehicles, which might be a contributing factor for higher traffic flow during the Eid seasons.

It is to be mentioned here that, although dry season carries higher percentage of yearly traffic, among the months in dry season, February carries significantly lower volume of traffic. This may be because of lesser number of days in the month. Besides, in some years February has fallen between two Eids and thus carrying lower volume of traffic in comparison to adjacent months.

Table 4.6, 4.7 and 4.8 shows the monthly flow variation in years from 2005 to 2009 for Large Bus, Medium Truck and Light Vehicles at a glance, with maximum and minimum monthly flow marked as red and blue respectively. Year-wise separate tables showing seasonal flow variations are given in the Appendix B (Table B6 to B10).



analyses. From the investigation of 1 year data collected from Roads & Highways Department (October 2009 to September 2010), distinct daily flow fluctuation patterns are achieved. In Figure 4.91, the average daily flow in percentage of total weekly volume has been plotted against respective days of week. It is observed that daily flow variation for inbound (North to South) and outbound (South to North) traffic exhibit similar pattern like other corridors.

Figure 4.91: Daily Flow Fluctuation on Dhaka-Mawa National Highway

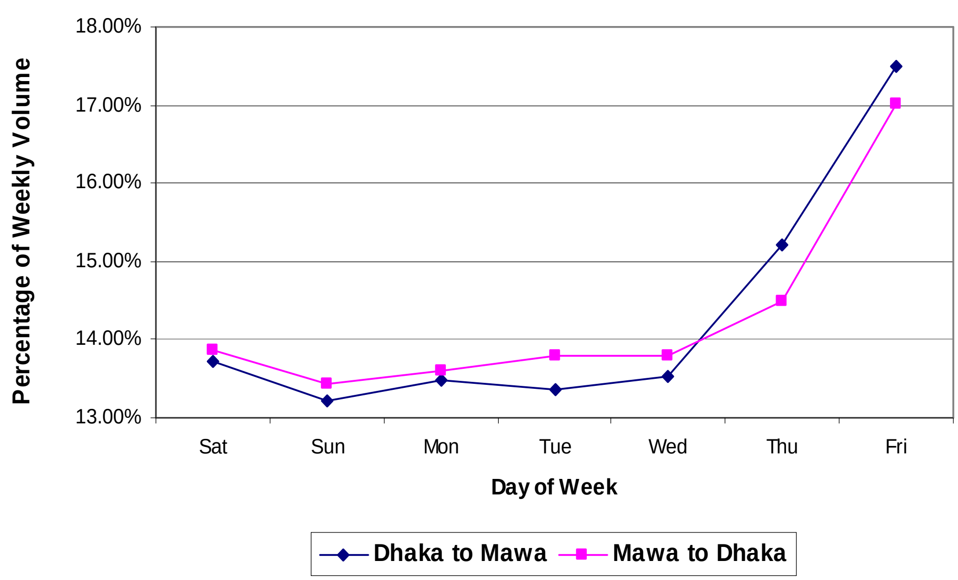
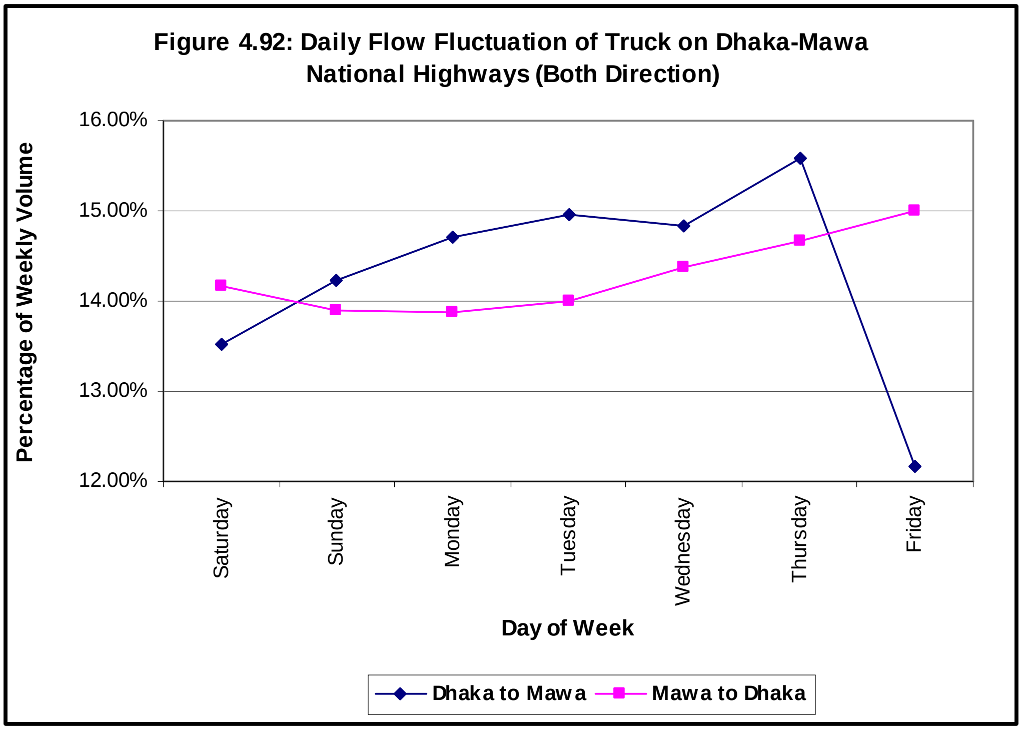
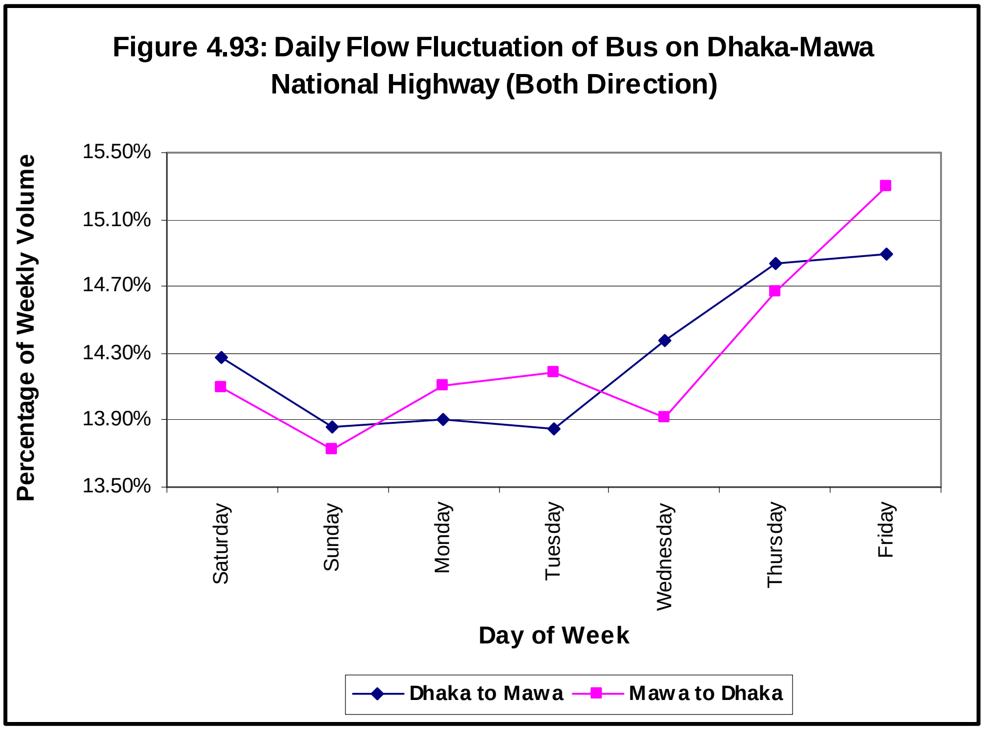


Figure 4.91 shows the flow variation for traffic on N-8 corridor. It is found that the average maximum flow occurs on Thursday (15.00%) and Friday (17.25%). This may happen because of weekend factor. On the other hand, weekly volume remains steady from Saturday to Wednesday at a range 13.00% to 14.00%.

It is evident from the above patterns, that freight vehicle movement has little impact on these variations, as weekend factor is more prominent on passenger movement. Therefore, the need for analyzing daily flow variation separately for vehicle classes is realized. Accordingly, curves have been plotted for five predominant vehicle classes on First & Second Dhaleshari bridge, which are given hereunder.

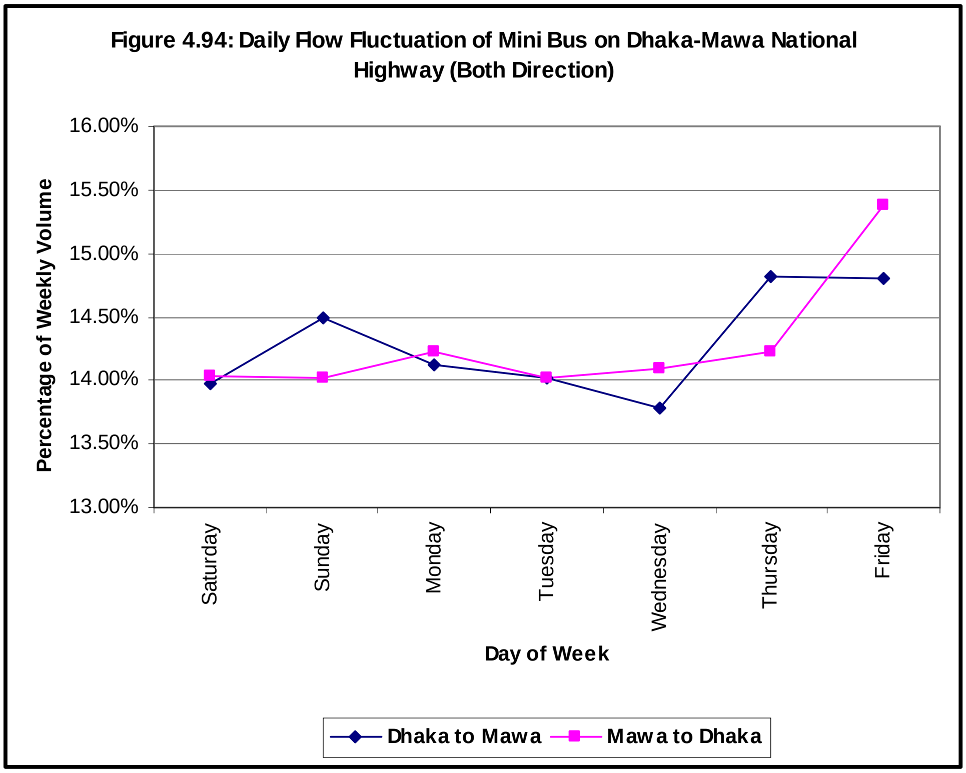


In Figure 4.92, daily flow variation of trucks is shown for outbound and inbound traffic. It is observed from figure 4.92 that, the daily flow percentages of trucks are following an upward trend from Sunday to Thursday for outbound and inbound traffic. But inbound trucks are higher than outbound. As trucks moving towards southern part of the country from Dhaka are not coming back through the same corridor. It is also observed that, distinct drop of inbound trucks are seen on Saturday and Friday due to weekend factor. Relatively maximum flow of trucks found on Wednesday and Thursday on N-8 corridor.

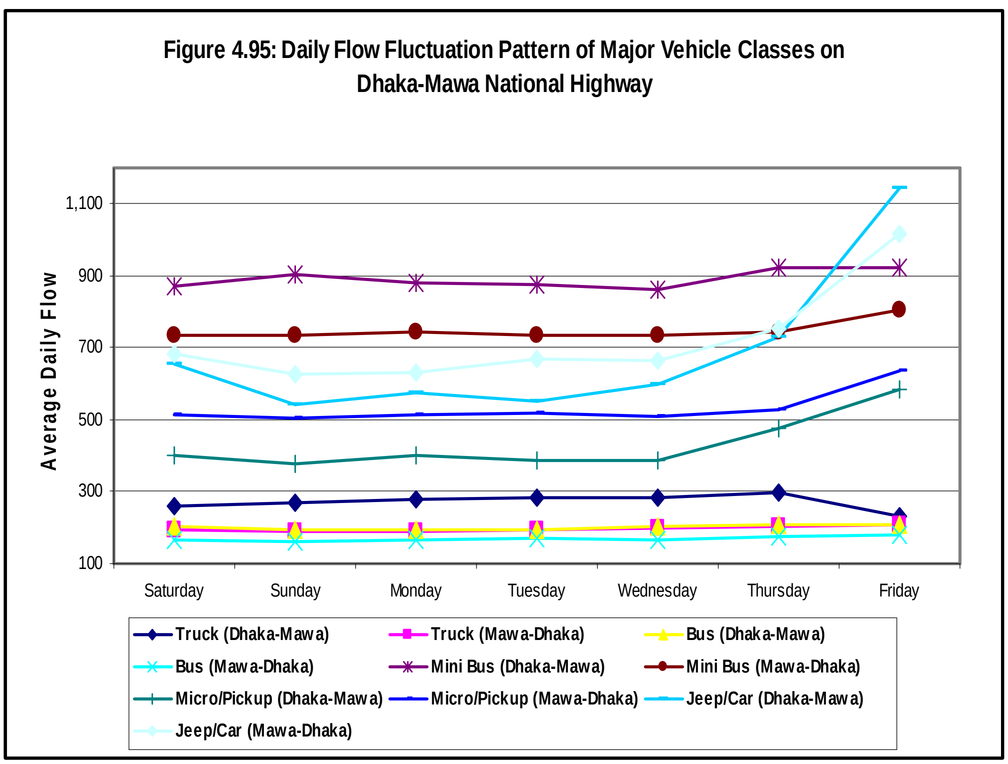


In the case of Bus, as shown in Figures 4.93, the daily flow variation is similar to that for total traffic, where daily percentage of flow rises on weekend. For both direction of flow, the highest flow occurs on Friday, which is justified by the weekend factor. Relatively minimum flow of bus is observed on Sunday and Tuesday on N-8 corridor.

From the patterns of daily flow fluctuation of Mini Bus, as shown in Figures 4.94, moderate rise of flow on weekend are observed. From Saturday to Thursday, the percentage of weekly volume varies from 13.80% to 14.60% for both inbound and outbound traffic.



The following Figure summarizes the pattern of these three major vehicles classes.

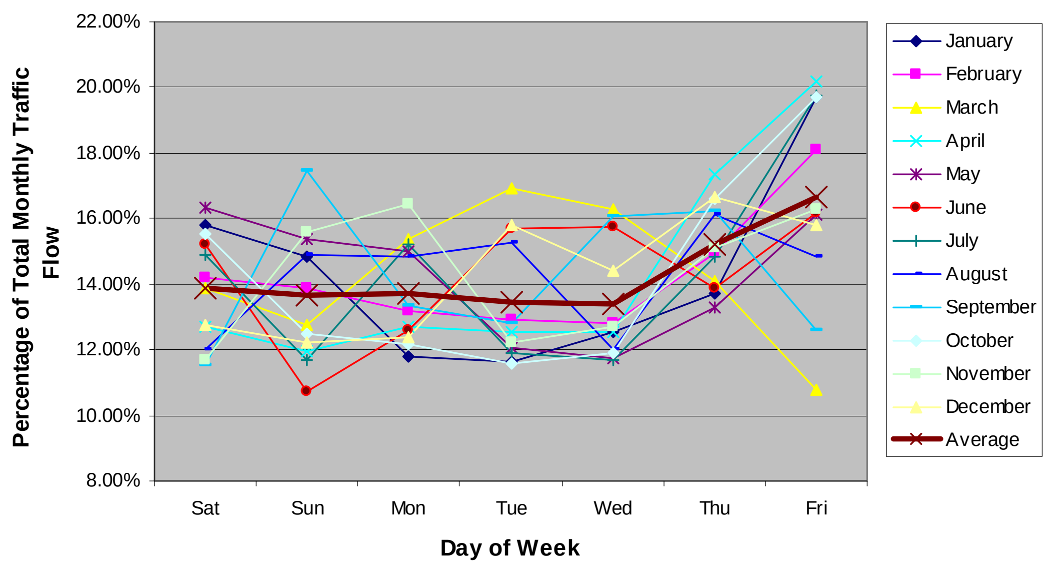


From the detail analysis of data, it is seen in graph how each month of year affects this daily flow fluctuation. To make this observation, curves have been plotted showing daily flow variation for all months of a year during this study. Only one chart is given in Figure 4.96, where the average daily flow variation pattern are found to conform to those obtained from the previous analyses. It is seen from the graph that, Wednesday, Thursday and Friday has a tendency of traffic increase. Friday shows the maximum amount of traffic on the corridor.

As Munshiganj district is near to capital Dhaka, people frequently comes to visit here in holidays and people of southern portions of Bangladesh goes to their home districts and come back within weekends. These are the reasons of increasing traffic from Wednesday to Friday.

Due to shortage of data, only one graph is plotted which implies that, individual month has no significant effect on daily variation of traffic flow on the N-8 corridor.

Figure 4.96: Month-wise Daily Traffic Flow Variation on First & Second Dhaleshari Bridge,Oct'09-Sep'10 (Both Direction)



Summary of Findings:

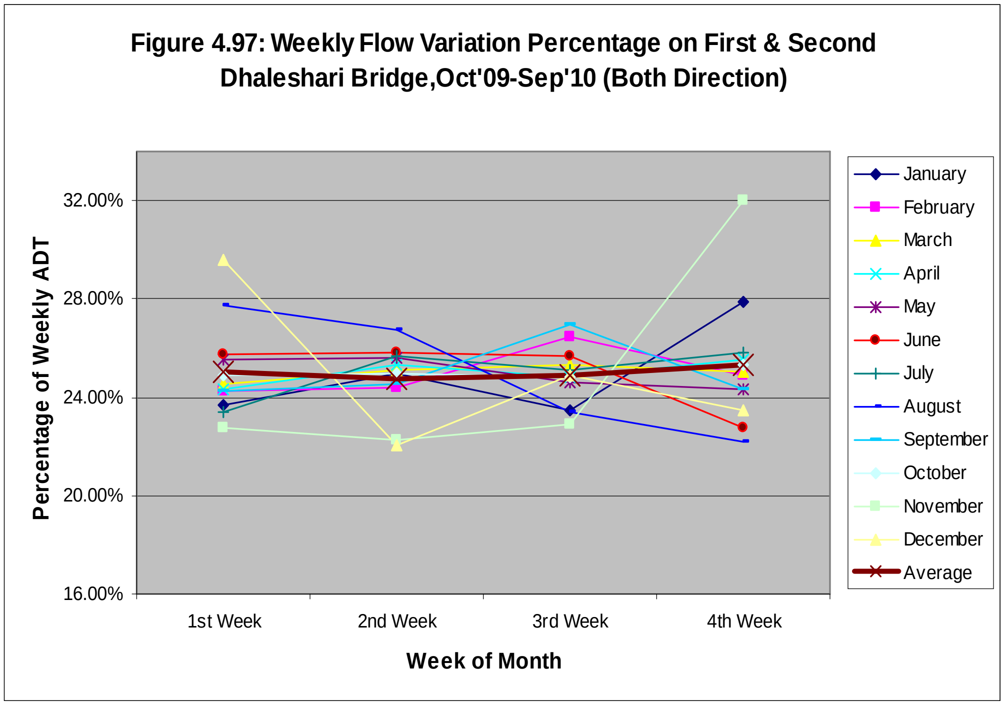
From the above analyses, the following important flow characteristics parameters have been obtained.

Table 4.46: Summary Table - Daily Flow Variation

Vechicle Class	Flow Direction	Maximum Flow		Minimum Flow	
		Day of Week	Percentage of Weekly Volume	Day of Week	Percentage of Weekly Volume
Total Traffic	Dhaka to Mawa	Friday	17.49%	Sunday	13.22%
	Mawa to Dhaka	Friday	17.02%	Sunday	13.44%
Truck	Dhaka to Mawa	Thursday	15.60%	Friday	12.18%
	Mawa to Dhaka	Friday	14.99%	Sunday	13.90%
Bus	Dhaka to Mawa	Friday	14.90%	Sunday	13.84%
	Mawa to Dhaka	Friday	15.29%	Sunday	13.70%
Mini Bus	Dhaka to Mawa	Thursday	14.82%	Wednesday	13.79%
	Mawa to Dhaka	Friday	15.37%	Tuesday	14.01%
Micro/Pickup	Dhaka to Mawa	Friday	19.40%	Sunday	12.54%
	Mawa to Dhaka	Friday	17.10%	Sunday	13.55%
Jeep/Car	Dhaka to Mawa	Friday	23.86%	Sunday	11.27%
	Mawa to Dhaka	Friday	20.14%	Sunday	12.45%

4.5.2 WEEKLY FLOW VARIATION

Depending on the economic activities of highway corridors, traffic flow may exhibit weekly flow variation, i.e. considering four weeks in a month; the flow may vary from week to week. To find out these characteristics on the N-8 corridor, weekly flow analysis has been done in this study. This model uses weekly ADT instead of weekly volume and then compares between the four weekly ADTs of each month from October 2009 to September 2010. It implies from figure 4.13a that, in the N-8 corridor, a steady shape weekly flow variation pattern is observed. It indicates that individual week has no influence upon traffic flow.



4.5.3 MONTHLY FLOW VARIATION

Monthly flow variation is an important parameter in traffic flow characteristics. One year of traffic flow data on First and Second Dhaleshari Bridge collected from Roads and Highways Department has been used for monthly flow variation analyses, which have given a thorough understanding of nature of traffic flow variation in different months of a year.

In the N-8 corridor, flow in every month has unique characteristics. Flow rise in every Thursday and Friday of weeks. This characteristic is predominant in the Dhaka to Mawa highway portion only. There may be reasons of weekend factor and mawa ferry ghat is a famous tourist spot for the Padma River. The graph below is showing traffic flow in the month of October 2009 and May 2010 in figure 4.98 and 4.99.

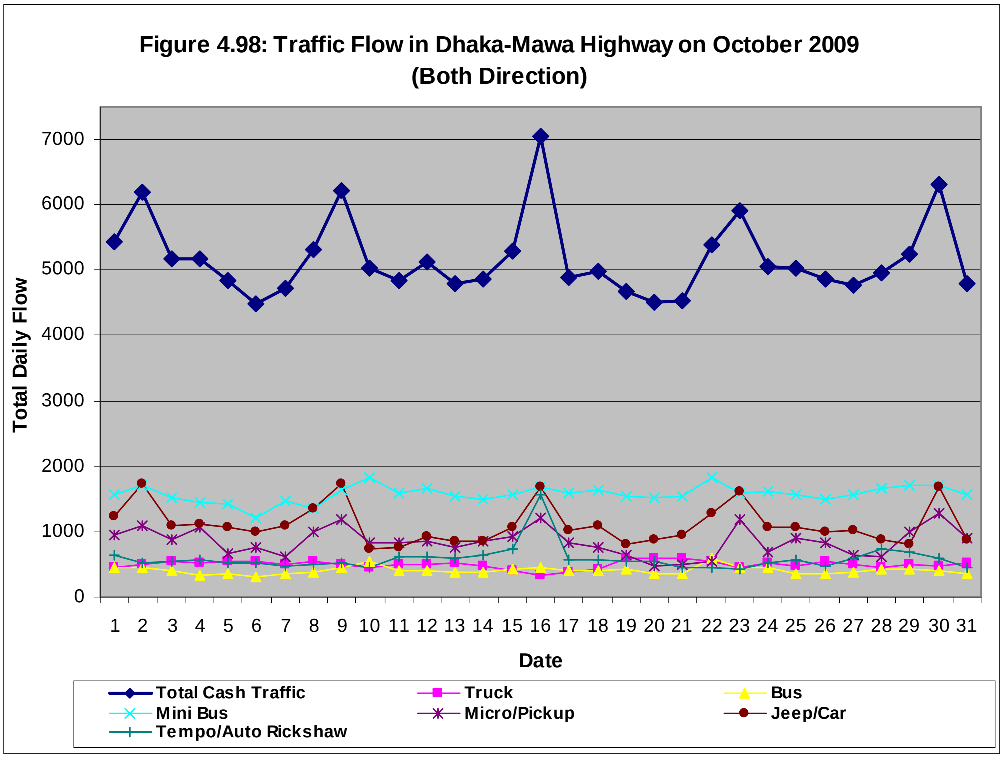


Figure 4.98: Traffic Flow in Dhaka-Mawa Highway on October 2009
(Both Direction)
Total Daily Flow
0
1000
2000
3000
4000
5000
6000
7000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Date
Total Cash Traffic
Truck
Bus
Mini Bus
Micro/Pickup
Jeep/Car
Tempo/Auto Rickshaw

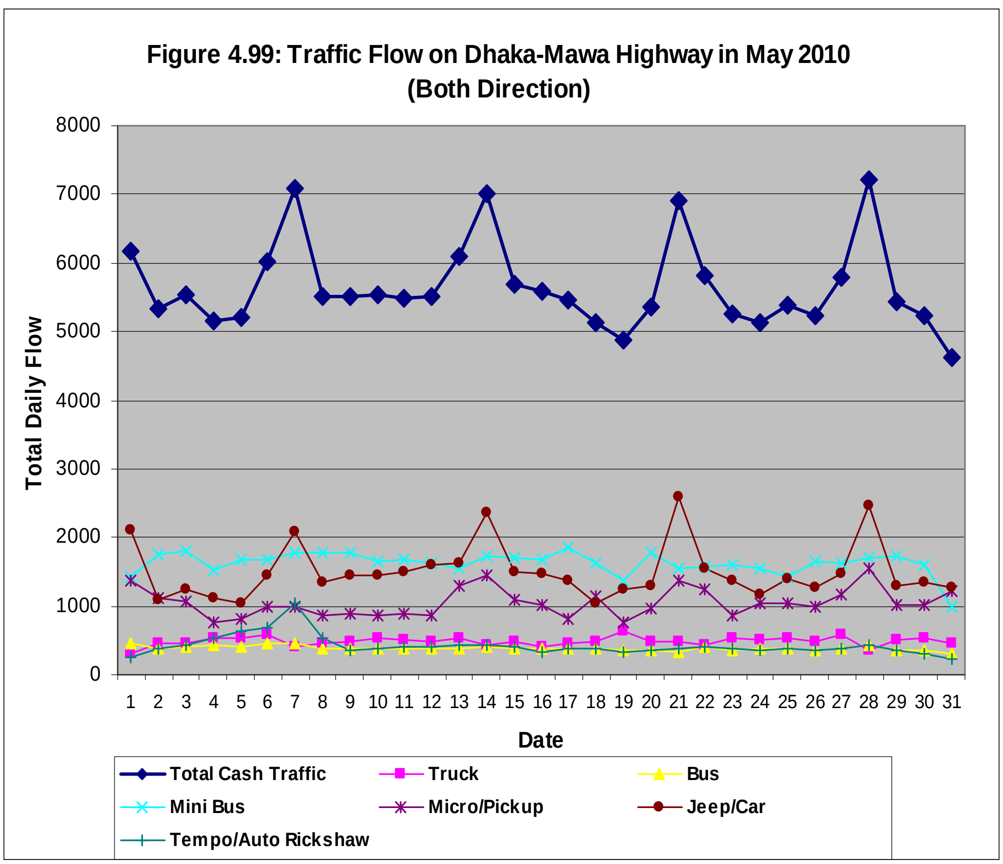


Figure 4.99: Traffic Flow on Dhaka-Mawa Highway in May 2010
(Both Direction)
Total Daily Flow
0
1000
2000
3000
4000
5000
6000
7000
8000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Date
Total Cash Traffic
Truck
Bus
Mini Bus
Micro/Pickup
Jeep/Car
Tempo/Auto Rickshaw

Characteristics curves showing monthly flow variation is shown in Figure 4.100. It can be seen that, monthly flow variation curve has its own characteristics. Flow is maximum in December, March and May. On the otherhand, from June to October it has downward characteristics. In the month of August, flow is minimum on that corridor. Flow in N-8 corridor heavily depends upon rainy seasons. The southern part of Bangladesh has network of rivers, so traffic movement depends on ferry where bridge is not present. In the mawa ghat, when weather is stormy the traffic movement become less. Herce, August is the less traffic movement month.

Figure 4.100: Monthly Flow Variation on First & Second Dhaleshari Bridge from October 2009 to September 2010 (Bothway)

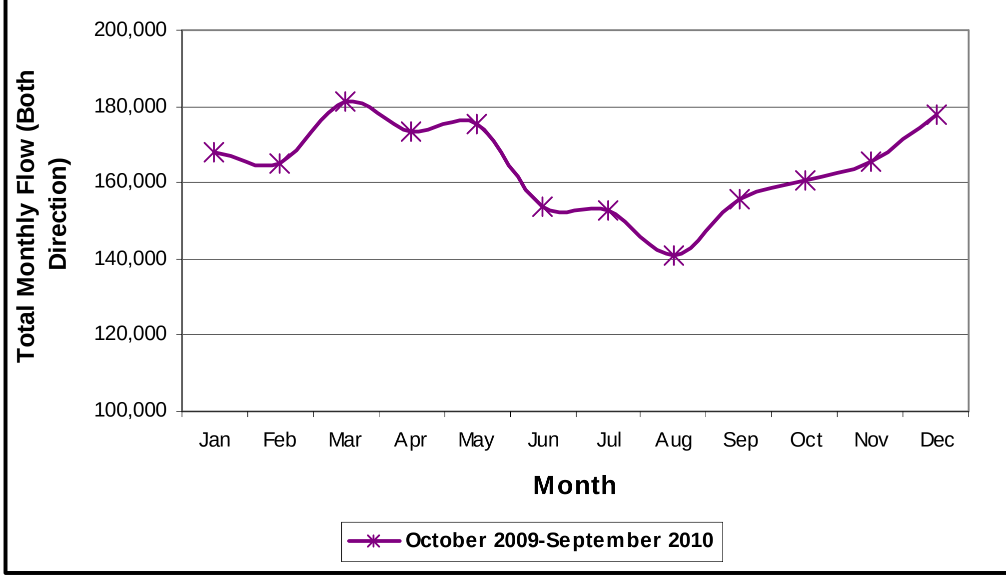


Table 4.47 shows the maximum and minimum monthly flow percentage, by sorting the above table. Maximum and minimum flow is marked in red and blue respectively.

Table 4.47: Maximum & Minimum Monthly Flow Table

Month\Year	Oct'09-Sep'10
January	8.53%
February	8.37%
March	9.21%
April	8.80%
May	8.90%
Jun	7.81%
July	7.75%
August	7.16%
September	7.91%
October	8.15%
November	8.40%
December	9.03%
Total	100.00%
Maximum Minimum	9.21% 7.16%

Source Data: Munshiganj Road Division,RHD.

Figure 4.101: Monthly Flow Variation First & Second Dhaleshari Bridge from October 2009 to September 2010 (In percentage of Yearly Volume for Bi-Directional Traffic)

It is found from above tables that, the average maximum monthly flow percentage occurs on March, May and December. On the other hand, June to October carry less amount of flow. Minimum flow occurs in August (7.16%), which is reasonably surprising. Broadly, it is observed, as shown in Table 4.48, (graphically represented in Figure 4.103) that less flow occurs on rainy season (47.67%) than on the dry season (52.33%). Following are the possible reasons behind such distribution of monthly flow:

- In Bangladesh dry season is considered from November to April, and rainy season stays from May to October. Due to Mongla port, more freight movement on waterways during the rainy season making the traffic flow percentage on roadway is lower. The seasonal distribution chart is as follows in figure 4.102:

Figure 4.102: Seasonal Flow Variation on First & Second Dhaleshari Bridge October'09-September'10 (Bothway)

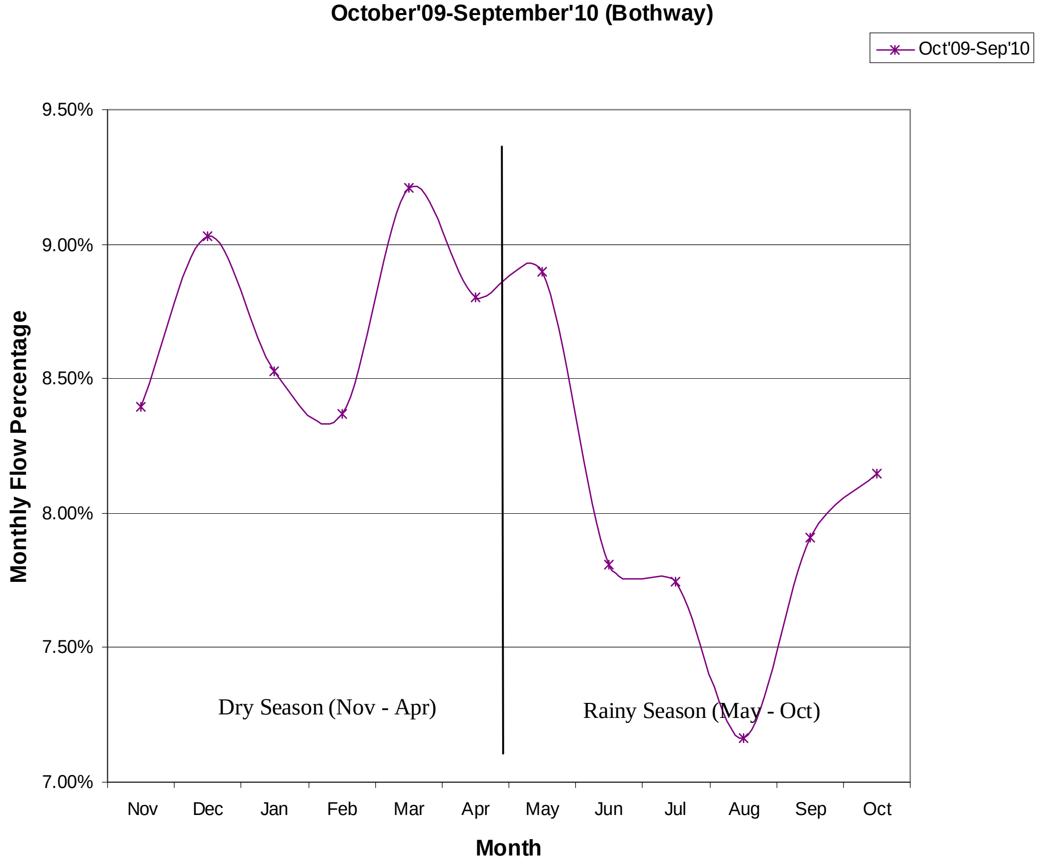
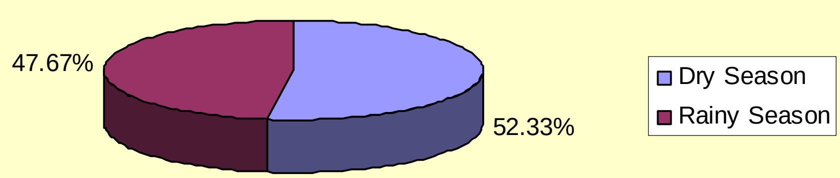


Table 4.48: Summarized Seasonal Flow Variation Table

Dry Season		Rainy Season	
Month	**Flow % in Season**	**Month**	**Flow % in Season**
Nov	8.40%	May	8.90%
Dec	9.03%	Jun	7.81%
Jan	8.53%	Jul	7.75%
Feb	8.37%	Aug	7.16%
Mar	9.21%	Sep	7.91%
Apr	8.80%	Oct	8.15%
Total	52.33%	Total	47.67%

Data Source: RHD.

Figure 4.103: Seasonal Distribution of Traffic on First & Second Dhaleshari Bridge (Bothway), Oct'09-Sep'10



- Recreational trips are more pronounced during the weekends.
- In the dry season, freight movement is higher on N-8 corridor. As the southern part of Bangladesh has several rivers that are peaceful in winter causes no interruption of traffic flow, like mawa ferry ghat.

Figure 4.104, 4.105 and 4.106 is illustrating seasonal flow variation of minibus, truck, jeep/car accordingly below in N-8 corridor. Table 4.49 is summarizing seasonal flow variation in N-8 corridor.

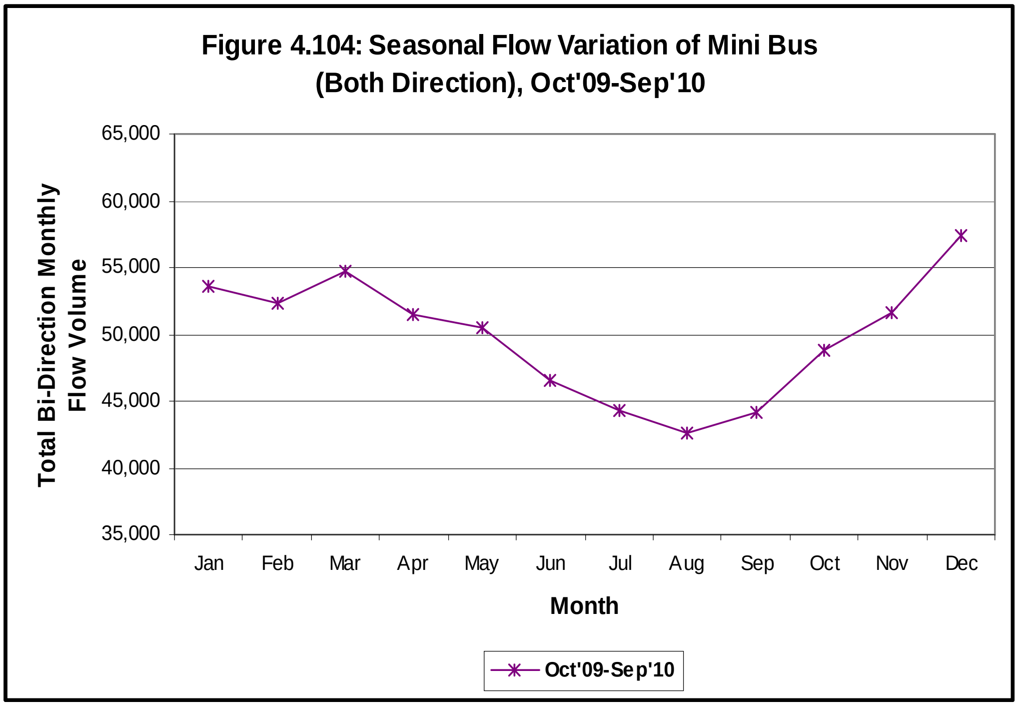


Figure 4.104: Seasonal Flow Variation of Mini Bus
(Both Direction), Oct'09-Sep'10
Total Bi-Direction Monthly
Flow Volume
65,000
60,000
55,000
50,000
45,000
40,000
35,000
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
Oct'09-Sep'10

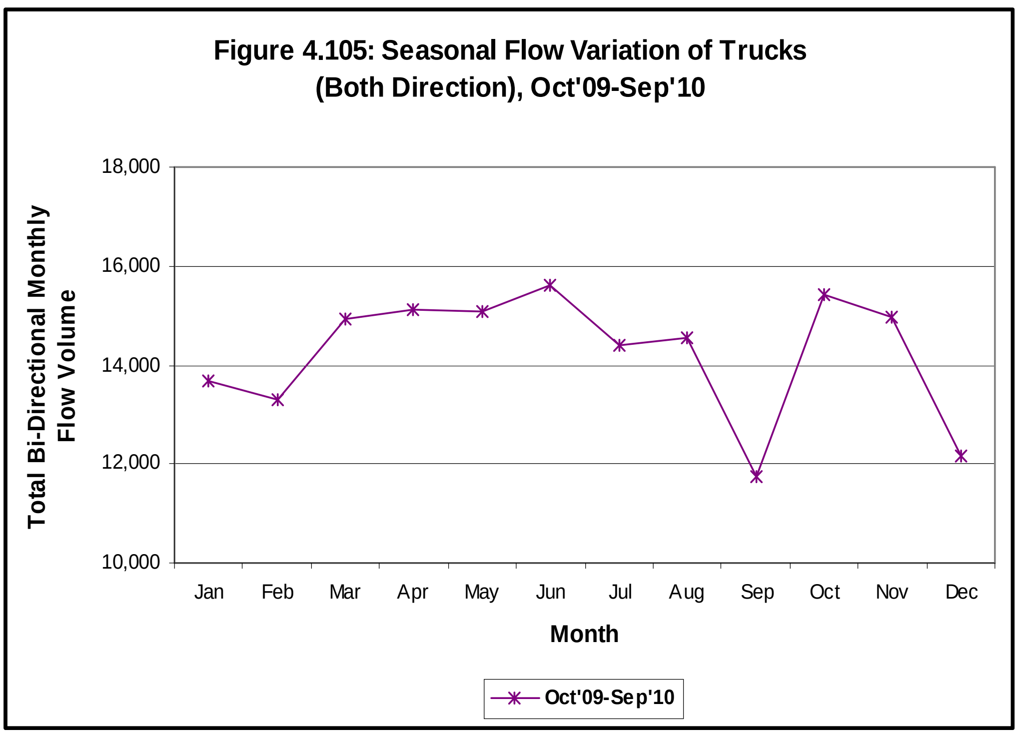
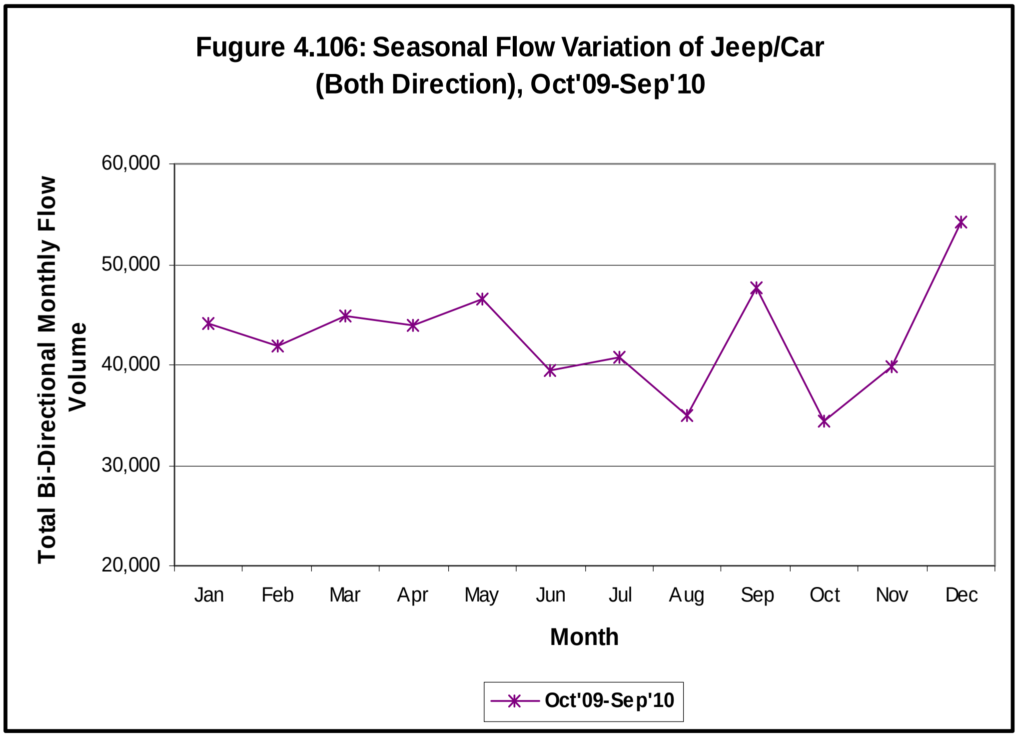


Figure 4.105: Seasonal Flow Variation of Trucks
(Both Direction), Oct'09-Sep'10
Total Bi-Directional Monthly
Flow Volume
18,000
16,000
14,000
12,000
10,000
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
Oct'09-Sep'10



Summary of Findings:

Following are the summarized findings from the seasonal flow analyses on First and Second Dhaleshari Bridge:

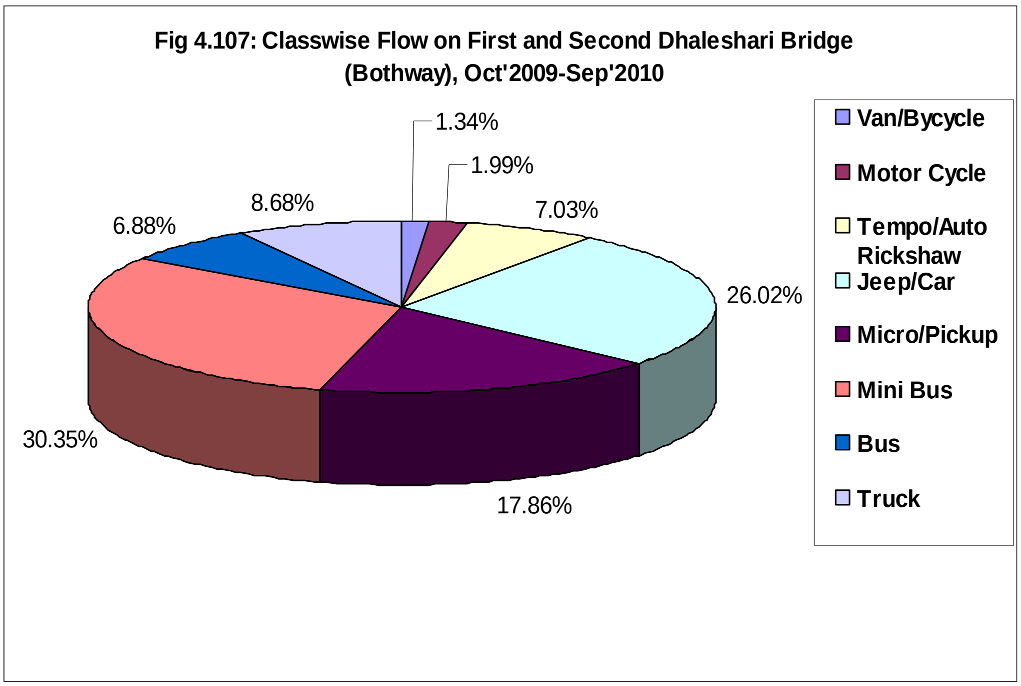
Table 4.49: Summary Table - Seasonal Flow Variation on N-8

Vehicle Class	Maximum Flow		Minimum Flow	
	Month	Percentage of Yearly Volume	Month	Percentage of Yearly Volume
Total Traffic	March	9.21%	August	7.16%
Truck	June	9.14%	September	6.86%
Mini Bus	December	9.61%	August	7.13%
Car/Jeep	December	10.58%	October	6.70%
Bus	October	9.34%	September	7.00%

4.5.4 TRAFFIC COMPOSITION

In First and Second Dhaleshari bridges, total traffic is divided into eight classes considering vehicle size and capacity as follows.

1. Class 1: Van/Bicycle
2. Class 2: Motor Cycle
3. Class 3: Tempo/ Auto Rickshaw
4. Class 4: Jeep/ Car
5. Class 5: Micro/ Pickup
6. Class 6: Mini Bus
7. Class 7: Bus
8. Class 8: Truck



In Figure 4.107 vehicle class percentages on First and Second Dhaleshari bridges are shown. It is found that, minibus has the highest percentage (30.35%) in the traffic stream. In the Dhaka-Mawa route, people frequently visit the capital and recently people who cannot afford living the capital Dhaka, they stay in the suburb. Hence, minibus is the popular mode of choice for passengers. People, who can afford car, frequently visit the city and goes to Southern part of the country and causing Jeep/car the second highest percentage of vehicle class, the proportion of which was

26.02%. The third highest contributing class to the total traffic flow is micro/pickup which is 17.86% of the total traffic stream. The fourth highest vehicle class is Truck, which has 8.68% and the next vehicle class is bus (6.88%). Due to shortage of several years' data, comparisons cannot be calculated. But this data will be used for future research of this corridor. Weighing scale was installed at the 11th kilometer of N-8 which is close to toll plaza, but unfortunately it is not under operation from the date of its setup on the year 1998.

Toll free vehicle have not been taken into consideration in this analyses. The government vehicles, operator's vehicles and some other VVIP vehicles are not counted by the operator as they are toll exempted.

4.5.5 DIRECTIONAL DISTRIBUTION

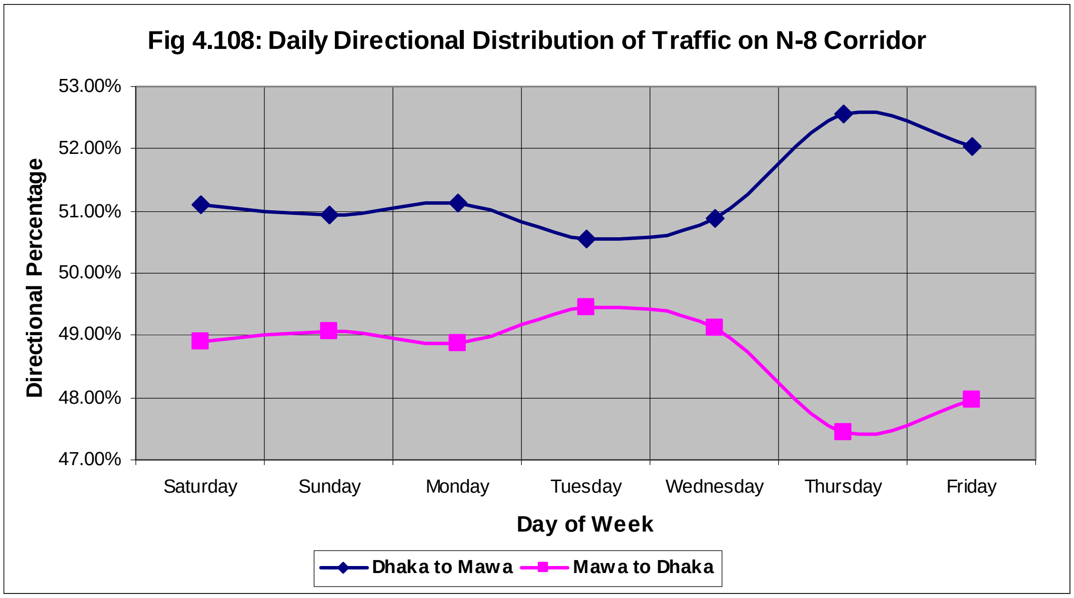
Directional distribution of traffic in N-8 corridor may vary with type and utility of road user. Following discussion will disclose more detail about this corridor.

4.5.5.1 DAILY DIRECTIONAL DISTRIBUTION

Analyses of daily directional distribution of traffic on First and Second Dhaleshari bridge has been done using 1 year (October 2009 to September 2010) of traffic data collected from RHD. In Table 4.50, the summarized daily directional distribution data are shown. Here average daily ADT on each day of week have been determined from 1 years' data.

Table 4.50: Daily Directional Distribution of Traffic on N-8 Corridor

Weekday	Daily ADT			Directional Split	
	Dhaka to Mawa	Mawa to Dhaka	Total	Dhaka to Mawa	Mawa to Dhaka
Saturday	2,663	2,550	5,213	51.09%	48.91%
Sunday	2,568	2,472	5,040	50.95%	49.05%
Monday	2,618	2,503	5,120	51.12%	48.88%
Tuesday	2,592	2,535	5,128	50.56%	49.44%
Wednesday	2,629	2,539	5,168	50.87%	49.13%
Thursday	2,952	2,666	5,617	52.55%	47.45%
Friday	3,397	3,130	6,528	52.04%	47.96%



It can seen in Figure 4.108 that, daily directional distribution varies from around 47.45% to 52.55%. People working in and around capital Dhaka tend to visit their native town/village on the weekend and thus causing maximum flow towards southern part of country on Thursday, which is 52.55%. Surprisingly, Monday shows maximum traffic flow towards Dhaka, which is 49.44%.

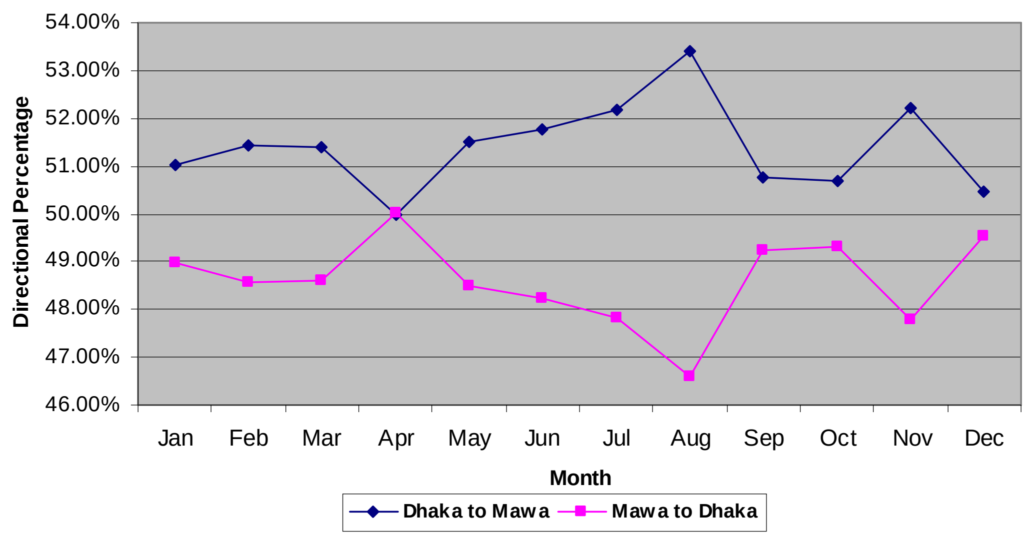
4.5.5.2 MONTHLY DIRECTIONAL DISTRIBUTION

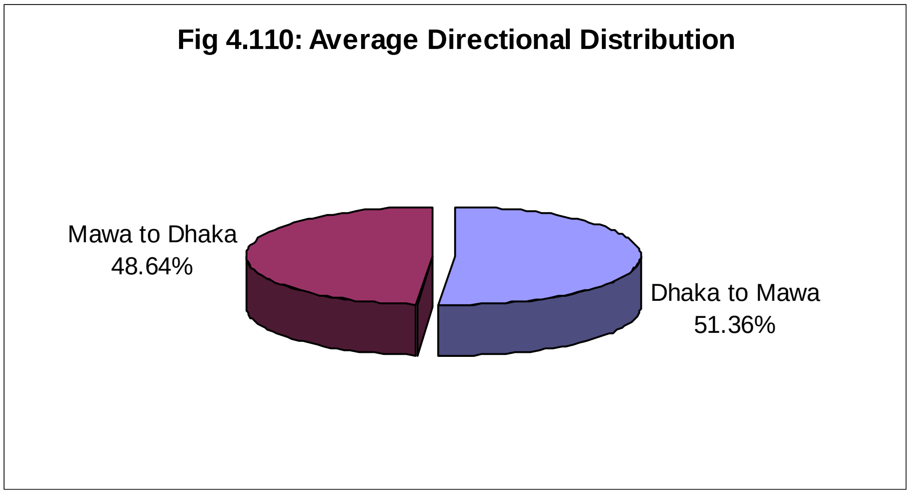
Month-wise directional distribution of traffic on First & Second Dhaleshari bridge is shown in Table 4.51. Figure 4.109 shows the graphical representation. From the table and figure, it can be seen that, the directional split is very close to 50%. This implies that there is no alternate route available for the users of this bridge. The overall monthly directional distribution is found to 51.36% in the Dhaka to Mawa direction and 48.64% in the Mawa to Dhaka Direction. Figure 4.110 shows the overall directional distribution of traffic on N-8 corridor.

Table 4.51: Monthly Directional Distribution of Traffic on First & Second Dhaleshari Bridge

Month	Monthly Volume			Directional Split	
	Dhaka to Mawa	Mawa to Dhaka	Total	Dhaka to Mawa	Mawa to Dhaka
Jan	85,741	82,294	168,035	51.03%	48.97%
Feb	84,853	80,156	165,009	51.42%	48.58%
Mar	93,209	88,181	181,390	51.39%	48.61%
Apr	86,277	86,330	172,607	49.98%	50.02%
May	90,302	85,047	175,349	51.50%	48.50%
Jun	79,703	74,303	154,006	51.75%	48.25%
Jul	79,136	72,565	151,701	52.17%	47.83%
Aug	75,402	65,779	141,181	53.41%	46.59%
Sep	79,106	76,741	155,847	50.76%	49.24%
Oct	81,359	79,122	160,481	50.70%	49.30%
Nov	86,352	79,061	165,413	52.20%	47.80%
Dec	91,290	89,629	180,919	50.46%	49.54%
Average	**84,394**	**79,934**	**164,328**	**51.36%**	**48.64%**

Fig 4.109: Monthly Directional Distribution in N-8 Corridor

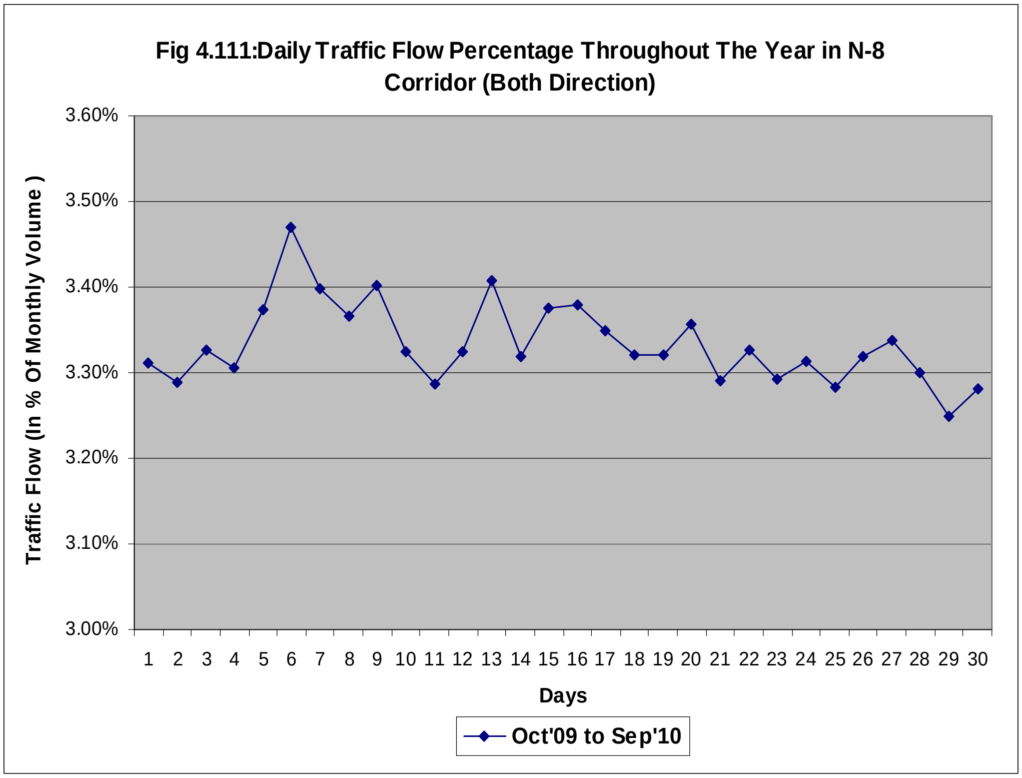




4.5.6 IMPACT OF EID FESTIVALS ON TRAFFIC FLOW

Eid festivals leave significant impact on traffic flow on First and Second Dhaleshari Bridges. Due to this, different traffic flow parameters are greatly affected and thus the need for analyzing the extent of Eid Festivals' impact is deeply realized. Since, the traffic flow around an Eid is higher than usual traffic flow, it is easily understood that, a factor representing the impact of Eid festival should be determined by which the traffic flow around an Eid can be more precisely estimated, which is expected to be the critical flow value.

For these analyses, one year of continuous daily traffic flow data obtained from RHD has been used. To identify the variation caused by Eid festivals, traffic flow in month containing Eid shall be compared with average yearly traffic flow or even traffic flow in other years for that particular month not containing Eid. By summarizing one year continuous daily flow data, it is found that, taking the average daily flow on all months in successive four years, the average daily flow percentage is around 3.29% to 3.47% of corresponding monthly flow volume (Figure. 4.111).

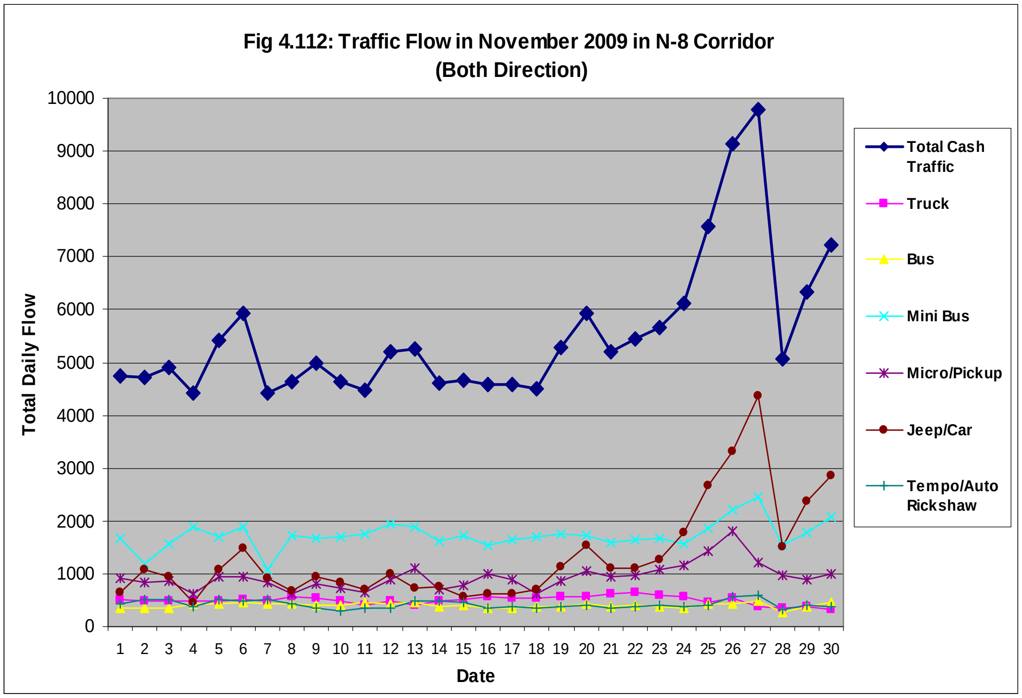


In Table 4.52, daily both directional flows, in percentage of total monthly volume, averaged over 12 months, are shown. Here it is to be noted that, flow percentage in 31st day of month is excluded because of presence of 31st day in only seven months in a year. However, the average daily flow percentage comes to be 3.33% with an astonishing standard deviation of only 0.05%. This leads to a fact that, even with the effects of all external factors causing deviations in normal traffic flow, the average daily flow is quite predictable.

Table 4.52: Summarized Daily Flow Percentage Table (Both Direction)

Date	**Daily Flow Percentage (Averaged Over 12 Months)**	
	(Oct'09 to Sep'10)	
1	3.31%	
2	3.29%	
3	3.33%	
4	3.31%	
5	3.37%	
6	3.47%	
7	3.40%	
8	3.37%	
9	3.40%	
10	3.33%	
11	3.29%	
12	3.32%	
13	3.41%	
14	3.32%	
15	3.38%	
16	3.38%	
17	3.35%	
18	3.32%	
19	3.32%	
20	3.36%	
21	3.29%	
22	3.33%	
23	3.29%	
24	3.31%	
25	3.28%	
26	3.32%	
27	3.34%	
28	3.30%	
29	3.25%	
30	3.28%	
	100.00%	
Average Daily Flow Percentage		**3.33%**
Standard Deviation		**0.05%**

Months from October 2009 to September 2010 have contained one Eid festival only. If that eid month, say November 2009 is taken into account, the flow variation exhibits some remarkable facts, as shown in Figure 4.112.



The traffic flow increase in Eid ul Azha occurs of 28th November 2009, which is distinctly visible on the above graph. Proper data preservation in that corridor can help to persue more research in future.

It is found that, from October 2009 to September 2010 AADT is 5398 in N-8 corridor. But the highest daily flow in a year caused by Eid event carries as much as 81.4% higher volume than AADT of that particular year. From this analysis, one can easily understand that, the highest daily flow in a particular year occurs at the time of Eid and the transportation planners should consider this fact while designing highways in Bangladesh.

4.6 OVERVIEW OF DIFFERENT CORRIDORS ANALYSES

The detail evaluation of pavement design parameters in different National Highways are made in this chapter and it is found that traffic movement in all corridors are more than anticipated. Traffic analyses exhibit prominent daily, monthly variations in all corridors, which are repetitive in nature. Therefore, future traffic flow prediction and modeling can be performed through the outcome of this study. Traffic flow related pavement design parameters should be upgraded in yearly basis for different corridors in Bangladesh. Not only number of vehicles but also overloading of axle in vehicles is vulnerable for road infrastructure. The next chapter will focus on the axle load characteristics in different National Highways of Bangladesh.

Table 4.6: Monthly Flow Variation of Large Bus on Jamuna Bridge

Year / Month	Total Monthly Flow of Large Bus (Both Direction)					Monthly Flow Percentage					
	2005	2006	2007	2008	2009	2005	2006	2007	2008	2009	**Average**
Jan	58,693	69,809	64,737	68,250	67,859	9.27%	10.22%	8.58%	8.47%	7.93%	**8.90%**
Feb	47,000	49,761	57,010	61,639	61,864	7.43%	7.28%	7.56%	7.65%	7.23%	**7.43%**
Mar	53,009	55,982	62,024	67,340	68,716	8.38%	8.20%	8.22%	8.35%	8.03%	**8.24%**
Apr	51,747	53,899	59,259	63,628	64,767	8.18%	7.89%	7.86%	7.89%	7.57%	**7.88%**
May	51,454	57,170	60,142	66,657	67,393	8.13%	8.37%	7.97%	8.27%	7.88%	**8.12%**
Jun	53,388	56,733	62,258	68,157	70,951	8.43%	8.31%	8.26%	8.46%	8.29%	**8.35%**
Jul	53,625	57,497	63,152	65,839	70,842	8.47%	8.42%	8.37%	8.17%	8.28%	**8.34%**
Aug	52,960	57,020	57,255	64,628	66,829	8.37%	8.35%	7.59%	8.02%	7.81%	**8.03%**
Sep	49,850	54,605	56,227	62,777	81,164	7.88%	7.99%	7.46%	7.79%	9.49%	**8.12%**
Oct	48,520	61,748	75,122	73,119	73,293	7.67%	9.04%	9.96%	9.07%	8.57%	**8.86%**
Nov	60,903	47,407	58,447	59,754	74,423	9.62%	6.94%	7.75%	7.41%	8.70%	**8.09%**
Dec	51,789	61,439	78,503	84,203	87,289	8.18%	8.99%	10.41%	10.45%	10.20%	**9.65%**
Total	**632,938**	**683,070**	**754,136**	**805,991**	**855,390**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**
Max. Flow	60,903	69,809	78,503	84,203	87,289	9.62%	10.22%	10.41%	10.45%	10.20%	9.65%
Min. Flow	47,000	47,407	56,227	59,754	61,864	7.43%	6.94%	7.46%	7.41%	7.23%	7.43%

Source Data: Marganet, BBSO.

Table 4.7: Monthly Flow Variation of Medium Truck on Jamuna Bridge

Month \ Year	Total Monthly Flow of Medium Truck (Both Direction)					Monthly Flow Percentage					
	2005	2006	2007	2008	2009	2005	2006	2007	2008	2009	**Average**
Jan	73,007	70,980	64,936	88,225	87,858	9.46%	8.83%	7.17%	9.17%	8.43%	**8.61%**
Feb	63,779	61,431	71,823	83,243	83,067	8.27%	7.64%	7.93%	8.66%	7.97%	**8.09%**
Mar	72,459	65,466	76,216	94,025	83,080	9.39%	8.14%	8.42%	9.78%	7.97%	**8.74%**
Apr	64,638	64,191	75,904	79,160	79,273	8.38%	7.98%	8.39%	8.23%	7.60%	**8.12%**
May	62,426	64,234	75,405	78,268	82,928	8.09%	7.99%	8.33%	8.14%	7.95%	**8.10%**
Jun	63,337	71,102	74,093	79,475	93,222	8.21%	8.84%	8.19%	8.26%	8.94%	**8.49%**
Jul	60,865	67,439	71,462	77,881	98,332	7.89%	8.39%	7.89%	8.10%	9.43%	**8.34%**
Aug	58,781	70,859	72,591	75,059	86,573	7.62%	8.81%	8.02%	7.80%	8.30%	**8.11%**
Sep	62,374	65,274	77,067	79,828	72,723	8.08%	8.12%	8.51%	8.30%	6.97%	**8.00%**
Oct	61,408	56,248	71,436	62,805	85,832	7.96%	7.00%	7.89%	6.53%	8.23%	**7.52%**
Nov	55,254	63,296	80,860	83,547	99,339	7.16%	7.87%	8.93%	8.69%	9.53%	**8.44%**
Dec	73,172	83,551	93,420	80,227	90,521	9.48%	10.39%	10.32%	8.34%	8.68%	**9.44%**
Total	**771,500**	**804,071**	**905,213**	**961,743**	**1,042,748**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**
Max. Flow	73,172	83,551	93,420	94,025	99,339	9.48%	10.39%	10.32%	9.78%	9.53%	9.44%
Min. Flow	55,254	56,248	64,936	62,805	72,723	7.16%	7.00%	7.17%	6.53%	6.97%	7.52%

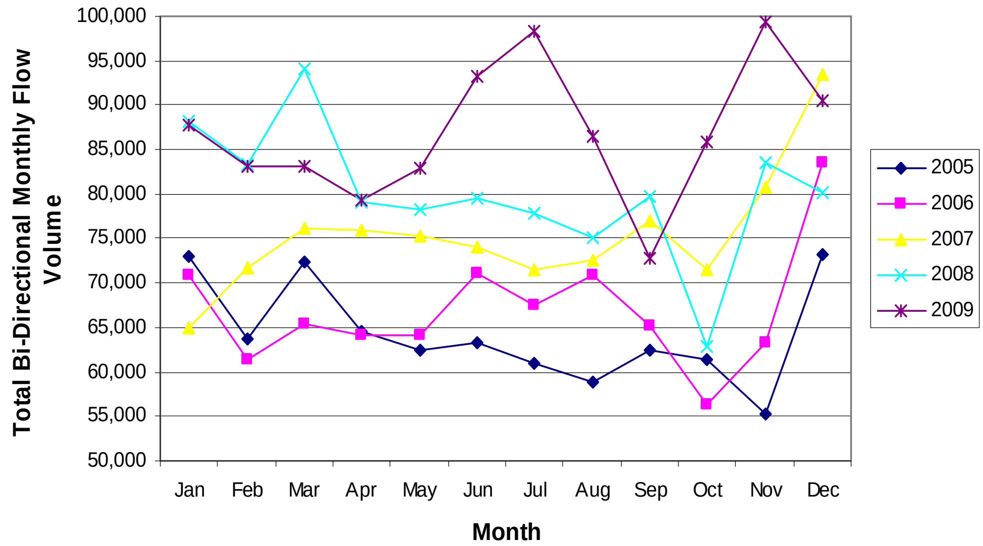
Source Data: Marganet, BBSO.

Table 4.8: Monthly Flow Variation of Light Vehicles on Jamuna Bridge

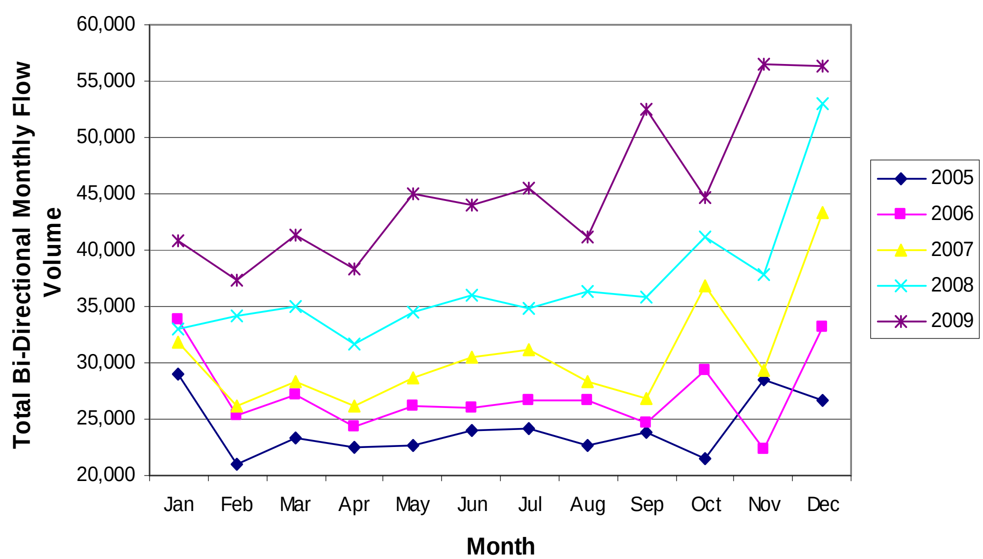
Year / Month	Total Monthly Flow of Light Vehicles (Both Direction)					Monthly Flow Percentage					
	2005	2006	2007	2008	2009	2005	2006	2007	2008	2009	Average
Jan	28,939	33,825	31,816	32,978	40,850	9.98%	10.39%	8.66%	7.44%	7.51%	**8.80%**
Feb	21,080	25,315	26,225	34,094	37,328	7.27%	7.78%	7.14%	7.69%	6.86%	**7.35%**
Mar	23,373	27,098	28,352	35,068	41,312	8.06%	8.32%	7.71%	7.91%	7.60%	**7.92%**
Apr	22,442	24,409	26,193	31,720	38,414	7.74%	7.50%	7.13%	7.15%	7.06%	**7.32%**
May	22,650	26,137	28,647	34,526	45,022	7.81%	8.03%	7.79%	7.78%	8.28%	**7.94%**
Jun	24,080	25,969	30,467	36,018	44,046	8.31%	7.98%	8.29%	8.12%	8.10%	**8.16%**
Jul	24,141	26,695	31,207	34,822	45,516	8.33%	8.20%	8.49%	7.85%	8.37%	**8.25%**
Aug	22,633	26,643	28,259	36,400	41,214	7.81%	8.18%	7.69%	8.21%	7.58%	**7.89%**
Sep	23,899	24,685	26,825	35,916	52,581	8.24%	7.58%	7.30%	8.10%	9.67%	**8.18%**
Oct	21,558	29,266	36,792	41,123	44,743	7.44%	8.99%	10.01%	9.27%	8.23%	**8.79%**
Nov	28,429	22,398	29,342	37,915	56,468	9.81%	6.88%	7.98%	8.55%	10.38%	**8.72%**
Dec	26,686	33,130	43,415	52,927	56,338	9.20%	10.18%	11.81%	11.93%	10.36%	**10.70%**
Total	**289,910**	**325,570**	**367,540**	**443,507**	**543,832**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**
Max. Flow	28,939	33,825	43,415	52,927	56,468	9.98%	10.39%	11.81%	11.93%	10.38%	10.70%
Min. Flow	21,080	22,398	26,193	31,720	37,328	7.27%	6.88%	7.13%	7.15%	6.86%	7.32%

Source Data: MargaNet,BBSO.

Figure 4.15: Seasonal Flow Variation of Medium Trucks (Both Direction), 2005-2009



Fugure 4.16: Seasonal Flow Variation of Light Vehicles on Jamuna Bridge (Both Direction), 2005-2009



Summary of Findings:

Following are the summarized findings from the seasonal flow analyses on Jamuna Bridge.

Table 4.6: Summary Table - Seasonal Flow Variation (average of five years)

Vehicle Class	Maximum Flow		Minimum Flow	
	Month	Percentage of Yearly Volume	Month	Percentage of Yearly Volume
Total Traffic	December	9.70%	February	7.61%
Medium Truck	December	9.44%	October	7.52%
Large Bus	December	9.65%	February	7.43%
Light Vehicles	December	10.70%	April	7.32%

4.2.5 TRAFFIC COMPOSITION

Traffic composition, particularly the proportion of heavy vehicles in a traffic stream, is a very important parameter of traffic flow. Geometric and structural design of any road facility greatly depends on traffic composition. Therefore, it is essential to know about the traffic composition of a highway for comprehensive flow pattern analyses.

In Bangladesh there is no unified vehicle classification system until now. Hence, different road operators are using different vehicle classification system and thus making traffic composition analyses more complex. In Jamuna bridge, since it is a tolled bridge, it was necessary to define a vehicle classification for setting toll amount for different classes of vehicles passing through the bridge.

In Jamuna bridge, total traffic is divided into seven classes considering vehicle size and capacity as follows.

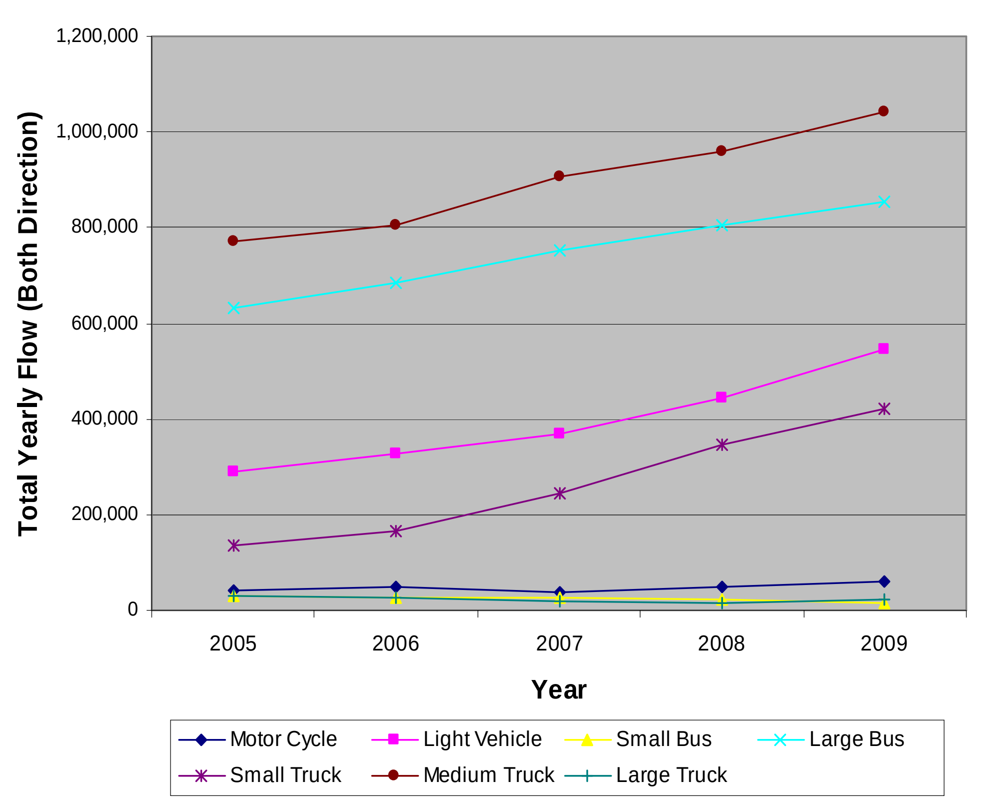
1. Motor Cycle: Motor cycles, two wheelers
2. Light Vehicle: Car, Jeep, Pickup, Microbus
3. Small Bus: Buses containing upto 29 seats
4. Large Bus: Buses containing equal to or more than 30 seats

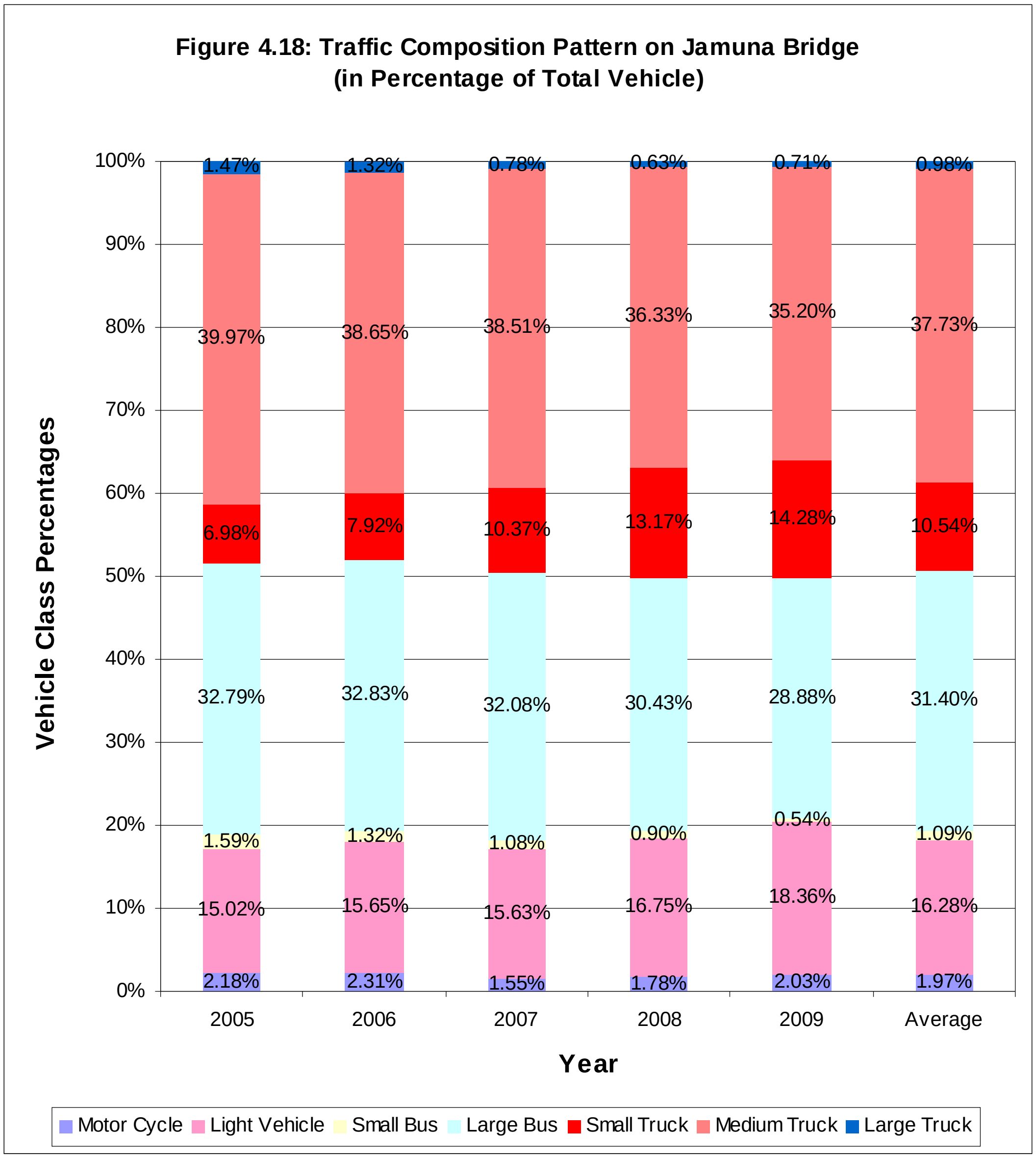
5. Small Truck: Truck having less than 5 ton carrying capacity
6. Medium Truck: Trucks having 5 to 8 ton carrying capacity
7. Large Truck: Multi-axle trucks, semi-trailers having more than 8 ton carrying capacity.

From the analyses of traffic composition on the Jamuna bridge, some important findings have been obtained which have been discussed in this section.

Figure 4.17 shows the classification wise yearly volume of traffic on Jamuna bridge, while Figure 4.18 shows the traffic composition pattern from 2005 to 2009 on Jamuna Bridge. It can be seen from the Figure that most predominant vehicle classes are medium truck, large bus and light vehicles. The proportion of small bus has decreasing trend and currently its volume is very low. It is also found that, the proportion of small truck has considerably increased. The percentage of large truck on N-5 corridor is very low.

Figure 4.17: Vehicle Class-wise Yearly Flow on Jamuna Bridge





In Figure 4.18, vehicle class percentages on Jamuna bridge are shown. It is found that, medium truck has the highest percentage in the traffic stream. In 2005, the percentage was 39.97% and during the next years the proportion is almost same. The average percentage of medium truck from 2005 to 2009 is 37.73%. The second highest percentage of vehicle class is Large Bus, the proportion of which was 32.79% in 2005 and 28.88% in 2009. The average percentage of Large Bus from 2005 to 2009 is 31.40%. The third highest contributing class to the total traffic flow is Light Vehicles, which includes cars, pickups, Jeeps, microbuses etc. In 2005, its percentage was 15.02% and after gradual increase in proportion, it became 18.36% in the year of 2009, the average is found to be 16.28%. Taking the traffic flow data on Jamuna Bridge from 2005 to 2009, it is found that these three pre-dominant vehicle classes comprise of total 85.41% of total traffic flow. Rest 14.59% is shared between motorcycle (1.97%), small bus (1.09%), small truck (10.54%) and large truck (0.98%). From the highway's structural and geometric point of view, it is a matter of concern that, the percentage of heavier vehicles is increasing every year and lighter vehicles are decreasing. From 1999 to 2005, the percentage of motorcycle has reduced from 2.18% to 2.03%, light vehicles slightly increased from 15.02% to 18.36%, the percentage of small trucks has risen from 6.98% to 14.28%, medium trucks slightly decreased from 39.97% to 35.20%, large bus decreased from 32.79% to 28.88% and Large truck from 1.47% to 0.71%. Introduction of luxury buses for passenger travels in all major routes of Bangladesh is a contributing factor behind small bus being replaced by large bus. But, the reason behind increase in percentage of small truck might be the tendency to save toll. Since the classification system used by BBA is based on the capacity of the trucks, but toll is not collected in weight basis. Although, a weighing scale was installed at the toll plaza initially, but currently it is not under operation. So, truck owners show the carrying capacity of their vehicles much less than the actual to escape higher toll amount, although they are carrying as much as three times of their permitted capacity, as has been observed physically.

It is also to be noted here that, only tolled vehicle have been taken into consideration in this analyses. The military vehicles, operator's vehicles and some other VVIP vehicles are not counted by the operator since they are toll exempted, although fair quantity (about 2.5% of tolled vehicles) of such vehicles pass the bridge every day.

4.2.6 HEAVY VEHICLE PERCENTAGE

Percentage of heavy vehicles refers to the percentage of truck and bus in a traffic stream. Heavier vehicles cause more damage to the roadway. For this reason, this is an important parameter for structural design of highway. Moreover, higher proportion of larger sized vehicles is important in the aspect of geometric design of highways as large vehicles are critical for the design of grade, turnings, road width, warrant for curve widening and auxiliary lane at vertical curve etc. The following section discusses the proportion of heavier vehicles on Jamuna bridge flow and their travel pattern.

4.2.6.1 TRUCK PERCENTAGE

In Jamuna bridge, according to the vehicle classification system used by the operators, truck as a class is sub-divided into three groups namely small trucks, medium trucks and large trucks. Small trucks are of capacity less than 5 tons. In Bangladesh commonly used 3-ton capacity trucks, mainly small utility covered trucks are contained within this class. Trucks having capacity of 5 ton to 8 ton are classed as Medium trucks. This class is most common in Bangladesh and hence contributor of the highest percentage of traffic. Large trucks' capacity is more than 8 ton and usually possesses more than two rear axles. It is observed from field survey that the toll collectors are often confused about the classification between the trucks falling near to boundary conditions.

However, from the analyses of traffic flow data from 2005 to 2009 on Jamuna bridge, taking the average of these years, it is found that the percentage of all classes of trucks 49.26% of total vehicle. Among this, the percentages of small truck, medium truck and large trucks are 10.54%, 37.73% and 0.98% respectively (Figure 4.19). Table 4.7 shows the year-wise truck percentages. Figure 4.20 shows the growth pattern of trucks on North Bengal Corridor.

Table 4.7: Truck Percentages on Jamuna Bridge (Both Direction)

Year	Small Truck	Medium Truck	Large Truck	Total Trucks
2005	6.98%	39.97%	1.47%	**48.42%**
2006	7.92%	38.65%	1.32%	**47.89%**
2007	10.37%	38.51%	0.78%	**49.66%**
2008	13.17%	36.33%	0.63%	**50.13%**
2009	14.28%	35.20%	0.71%	**50.20%**
Average	**10.54%**	**37.73%**	**0.98%**	**49.26%**

Date Source: MargaNet, BBSO.

Figure 4.19: Annual Truck Percentages on Jamuna Bridge (Average from 2005 to 2009)

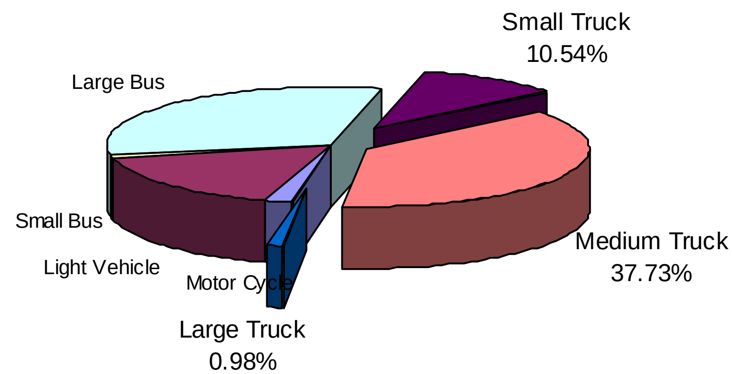
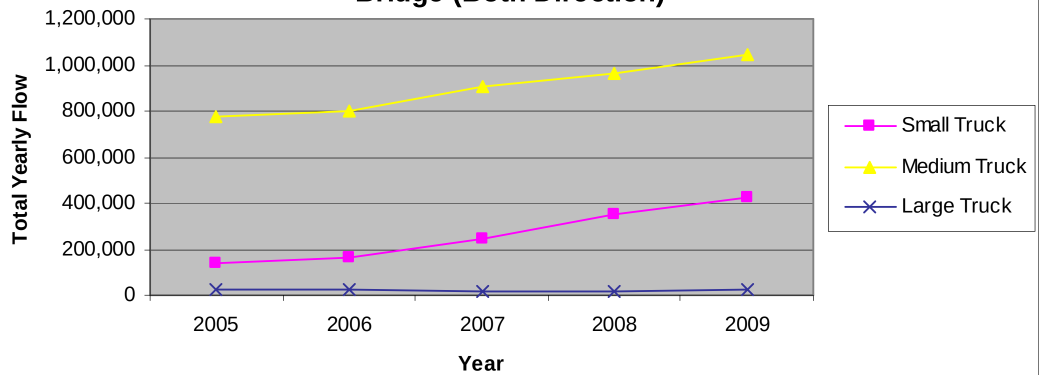


Figure 4.20: Yearly Flow of Trucks on Jamuna Bridge (Both Direction)



4.2.6.2 BUS PERCENTAGE

Buses passing through Jamuna bridge are classified into two groups namely Small Bus and Large Bus. Buses having capacity of 30 seats of less are classed as small bus and buses having more than 30 seats capacity are classed as Large Bus.

Table 4.8: Yearly Flow of Bus on Jamuna Bridge (Both Direction)

Year	Small Bus	Large Bus	Total Buses
2005	30,720	632,938	663,658
2006	27,376	683,070	710,446
2007	25,362	754,136	779,498
2008	23,892	803,648	827,540
2009	16,025	855,390	871,415
Average	**24,675**	**745,836**	**770,511**

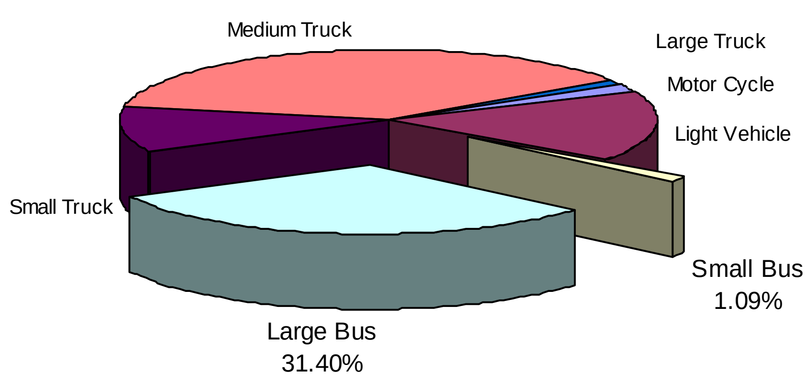
Date Source: MargaNet, BBSO.

Table 4.9: Bus Percentages on Jamuna Bridge (Both Direction)

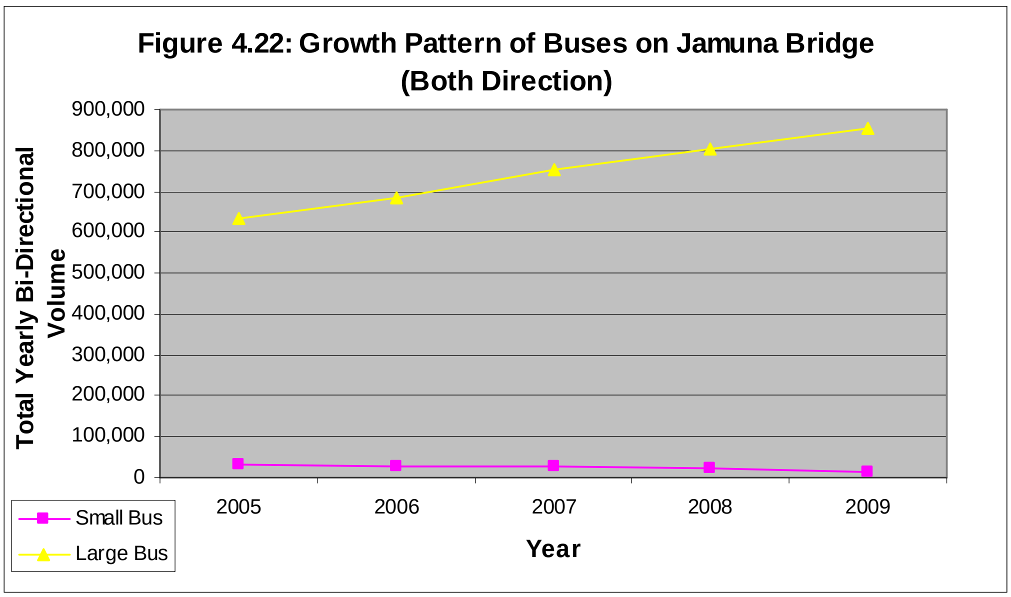
Year	Small Bus	Large Bus	Total Buses
2005	1.59%	32.79%	**34.38%**
2006	1.32%	32.83%	**34.15%**
2007	1.08%	32.08%	**33.16%**
2008	0.90%	30.43%	**31.34%**
2009	0.54%	28.88%	**29.42%**
Average	**1.09%**	**31.40%**	**32.49%**

Date Source: MargaNet, BBSO.

Figure 4.21: Annual Bus Percentages on Jamuna Bridge (Averaged over 5 years)



From Figure 4.21, it is seen that total 32.49% of total annual flow (taking average from 2005 to 2009) comprises of buses. Among this, 31.40% is large bus and 1.09% is small bus. Annual increase pattern of total number buses is shown in Figure 4.22. Although the total number is increasing at a fairly high rate, but from Table 4.9, it can be seen that the percentage of bus has slightly decreasing with respect to total traffic (34.38% in 2005 and 29.42% in 2009). This has happened because the percentage of large bus has increased every year at an average rate of 7.83% per annum but at the same time, small bus percentage has fallen equally.



4.2.7 DIRECTIONAL DISTRIBUTION

Directional distribution of a two-way road varies within a wide range depending on the type and utility of a road facility. In some cases, as in urban commuter road, the directional flow can reach even over 80% during the peak hours [Pignataro 1973]. Again, some rural highways may show unequal directional split of traffic based on its economic activities, availability of alternate route and many other reasons. Hence, the importance of directional distribution of a two-way road system for complete analyses of traffic flow characteristics can be understood.

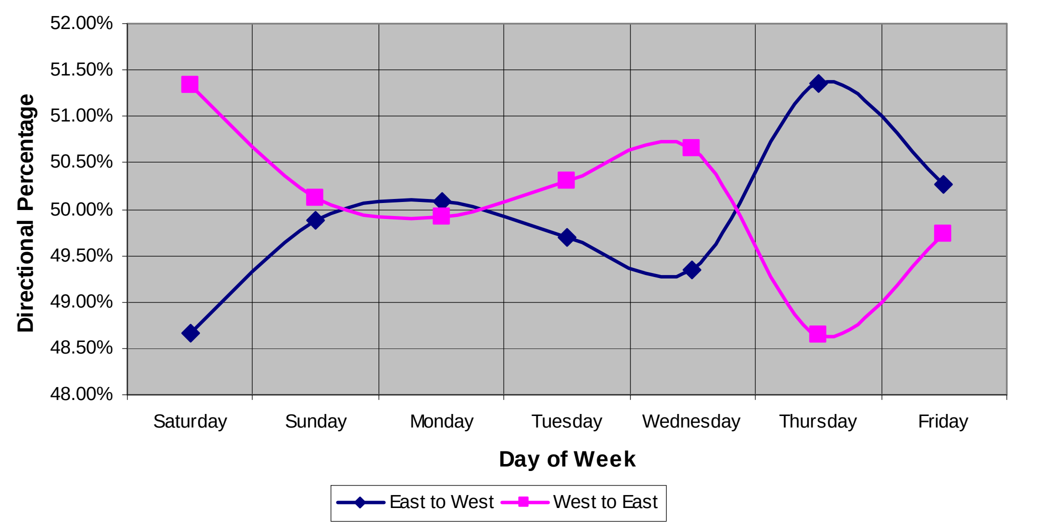
4.2.7.1 DAILY DIRECTIONAL DISTRIBUTION

Analyses of daily directional distribution of traffic on Jamuna bridge has been done using 5 years (2005 to 2009) of traffic data collected by Marganet and BBSO. In Table 4.10, the summarized daily directional distribution data are shown. Here average daily ADT on each day of week have been determined from 5 years' data.

Table 4.10: Daily Directional Distribution of Traffic on Jamuna Bridge

Weekday	Avg. Daily ADT			Directional Split	
	East to West	West to East	Total	East to West	West to East
Saturday	3,066	3,236	6,302	48.66%	51.34%
Sunday	3,210	3,225	6,436	49.89%	50.11%
Monday	3,229	3,219	6,448	50.08%	49.92%
Tuesday	3,240	3,278	6,518	49.70%	50.30%
Wednesday	3,280	3,367	6,647	49.35%	50.65%
Thursday	3,448	3,265	6,714	51.36%	48.64%
Friday	3,433	3,397	6,830	50.27%	49.73%

Figure 4.23: Daily Directional Distribution of Traffic in N-5 Corridor



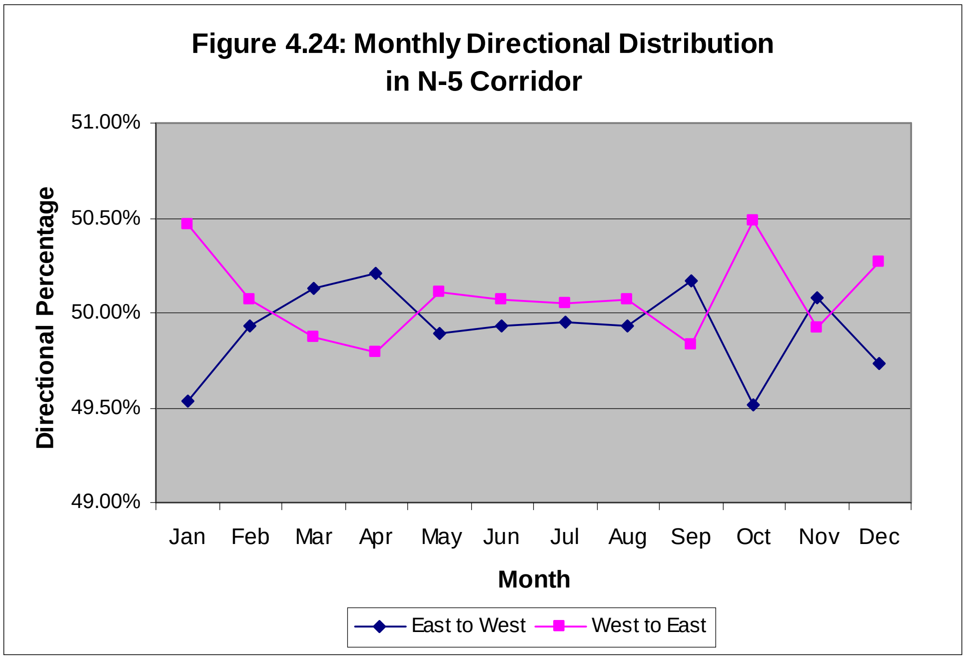
It can seen in Figure 4.23 that, daily directional distribution varies from around 48% to 51.50%. People working in and around capital Dhaka tend to visit their native town/village on the weekend and thus causing maximum outbound (East to West) flow on Thursday, which is 51.36%. Again, they return to their workplaces in and around Dhaka on Saturday creating maximum inbound (West to East) traffic (51.34%) on Saturdays.

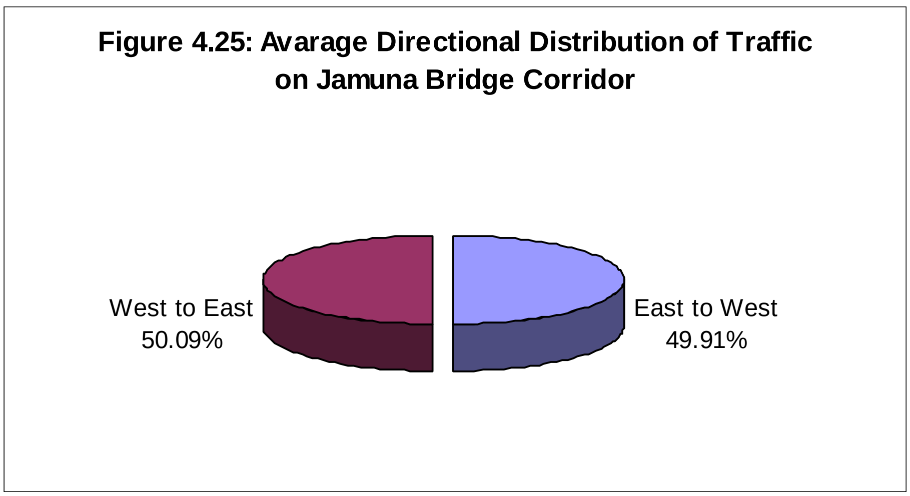
4.2.7.2 MONTHLY DIRECTIONAL DISTRIBUTION

Month-wise directional distribution of traffic on Jamuna bridge is shown in Table 4.11. Figure 4.24 shows the graphical representation. From the table and Figure, it can be seen that, the directional split is very close to 50%. This implies that there is no alternate route available for the users of this bridge. The overall directional distribution, averaged over 5 years monthly traffic flow data, is found to 50.09% in the West to East direction and 49.91% in the East to West Direction. Figure 4.25 shows the overall directional distribution of traffic on Jamuna bridge.

Table 4.11: Monthly Directional Distribution of Traffic on Jamuna Bridge

Month	Average Monthly Volume (2005 to 2009)			Directional Split	
	East to West	West to East	Total	East to West	West to East
Jan	100,704	102,599	203,302	49.53%	50.47%
Feb	91,016	91,252	182,267	49.94%	50.06%
Mar	99,538	99,042	198,580	50.12%	49.88%
Apr	94,147	93,364	187,511	50.21%	49.79%
May	97,500	97,907	195,407	49.90%	50.10%
Jun	100,700	100,964	201,663	49.93%	50.07%
Jul	99,893	100,097	199,990	49.95%	50.05%
Aug	96,635	96,892	193,526	49.93%	50.07%
Sep	98,141	97,499	195,639	50.16%	49.84%
Oct	99,108	101,030	200,138	49.52%	50.48%
Nov	102,014	101,682	203,695	50.08%	49.92%
Dec	115,691	116,938	232,629	49.73%	50.27%
Average	99,590	99,939	199,529	**49.91%**	**50.09%**





4.2.8 IMPACT OF EID FESTIVALS ON TRAFFIC FLOW

Eid festivals leave significant impact on traffic flow on Jamuna Bridge, which is anticipated in other corridors in Bangladesh as well. Due to this, different traffic flow parameters are greatly affected and thus the need for analyzing the extent of Eid Festivals' impact is deeply realized. Since, the traffic flow around an Eid is higher than usual traffic flow, it is easily understood that, a factor representing the impact of Eid festival should be determined by which the traffic flow around an Eid can be more precisely estimated, which is expected to be the critical flow value.

For these analyses, five years of continuous daily traffic flow data obtained from MargaNet and BBSO have been used. To identify the variation caused by Eid festivals, traffic flow in month containing Eid shall be compared with average yearly traffic flow or even traffic flow in other years for that particular month not containing Eid. By summarizing five years' continuous daily flow data, it is found that, taking the average daily flow on all months in successive five years, the average daily flow percentage is around 3.00% to 3.50% of corresponding monthly flow volume (Figure. 4.26).

Figure 4.26: Average Continuous Daily Flow Percentage

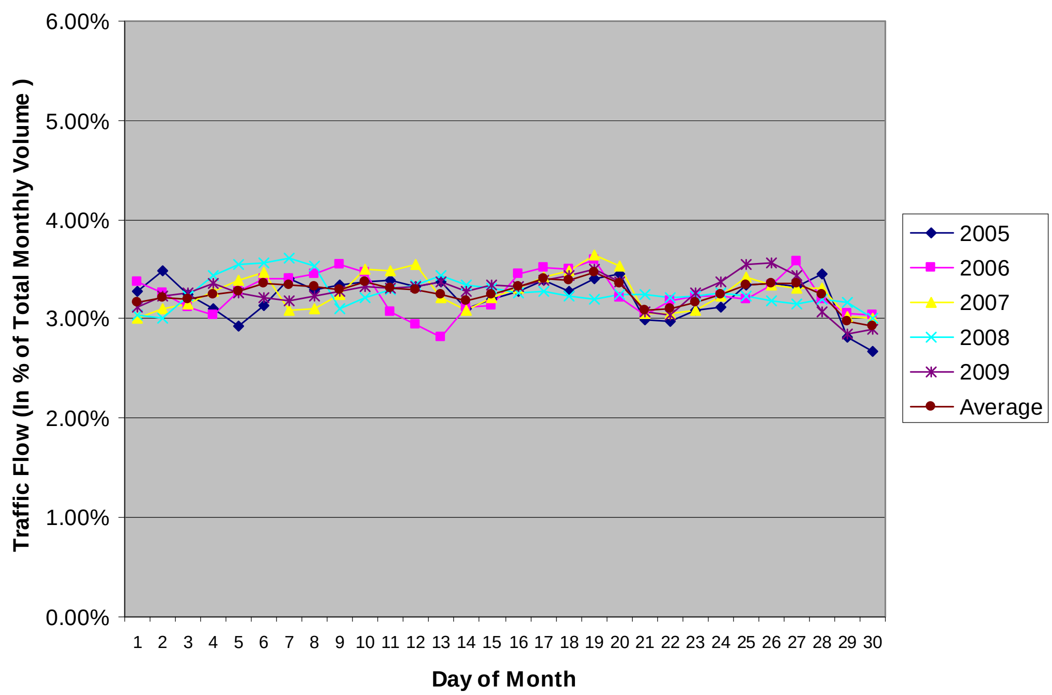


Table 4.12: Summarized Daily Flow Percentage Table (Both Direction)

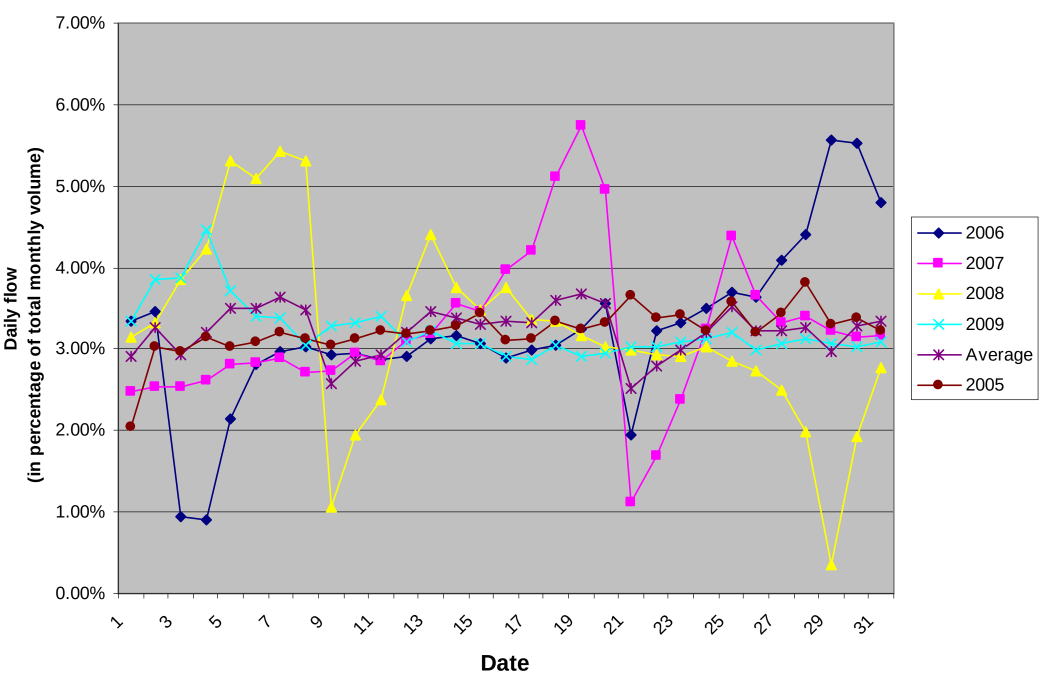
Date	Daily Flow Percentage (Averaged Over 12 Months)					
	2005	**2006**	**2007**	**2008**	**2009**	**Average**
1	3.28%	3.37%	3.01%	3.03%	3.13%	3.16%
2	3.49%	3.27%	3.11%	3.00%	3.23%	3.22%
3	3.25%	3.12%	3.14%	3.24%	3.27%	3.20%
4	3.10%	3.05%	3.28%	3.43%	3.35%	3.24%
5	2.93%	3.27%	3.38%	3.55%	3.26%	3.28%
6	3.13%	3.40%	3.47%	3.57%	3.22%	3.36%
7	3.41%	3.41%	3.09%	3.61%	3.19%	3.34%
8	3.29%	3.45%	3.10%	3.53%	3.23%	3.32%
9	3.34%	3.54%	3.25%	3.10%	3.27%	3.30%
10	3.37%	3.46%	3.50%	3.21%	3.33%	3.37%
11	3.39%	3.08%	3.49%	3.29%	3.31%	3.31%
12	3.33%	2.94%	3.56%	3.35%	3.33%	3.30%
13	3.37%	2.81%	3.21%	3.44%	3.38%	3.24%
14	3.10%	3.12%	3.08%	3.34%	3.28%	3.18%
15	3.20%	3.13%	3.22%	3.31%	3.34%	3.24%
16	3.28%	3.46%	3.30%	3.26%	3.33%	3.32%
17	3.39%	3.51%	3.43%	3.28%	3.40%	3.40%
18	3.28%	3.50%	3.49%	3.23%	3.45%	3.39%
19	3.41%	3.60%	3.65%	3.19%	3.50%	3.47%
20	3.45%	3.21%	3.54%	3.25%	3.37%	3.36%
21	3.00%	3.04%	3.06%	3.24%	3.07%	3.08%
22	2.98%	3.19%	3.06%	3.21%	3.04%	3.10%
23	3.08%	3.22%	3.08%	3.23%	3.26%	3.17%
24	3.12%	3.23%	3.22%	3.27%	3.37%	3.24%
25	3.34%	3.20%	3.42%	3.23%	3.54%	3.34%
26	3.36%	3.33%	3.34%	3.18%	3.57%	3.36%
27	3.33%	3.57%	3.31%	3.16%	3.43%	3.36%
28	3.45%	3.21%	3.30%	3.20%	3.08%	3.25%
29	2.82%	3.05%	3.02%	3.17%	2.85%	2.98%
30	2.67%	3.04%	3.01%	3.01%	2.90%	2.93%
31	3.06%	2.20%	1.90%	1.89%	1.74%	2.16%
	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Average Daily Flow Percentage (Averaged Over 5 Years)						**3.23%**
Standard Deviation						**0.23%**

Data Source: MargaNet, BBSO.

In Table 4.12, daily both directional flow, in percentage of total monthly volume, averaged over 12 months, from 2005 to 2009, is shown. Here it is to be noted that, flow percentage in 31st day of month came to be low because of presence of 31st day in only seven months in a year. This has been compensated by taking proportionate 12 months' flow value for the 31st day. However, the average daily flow percentage comes to be 3.23% with an astonishing standard deviation of only 0.23%. This leads to a fact that, even with the effects of all external factors causing deviations in normal traffic flow, the average daily flow is quite predictable.

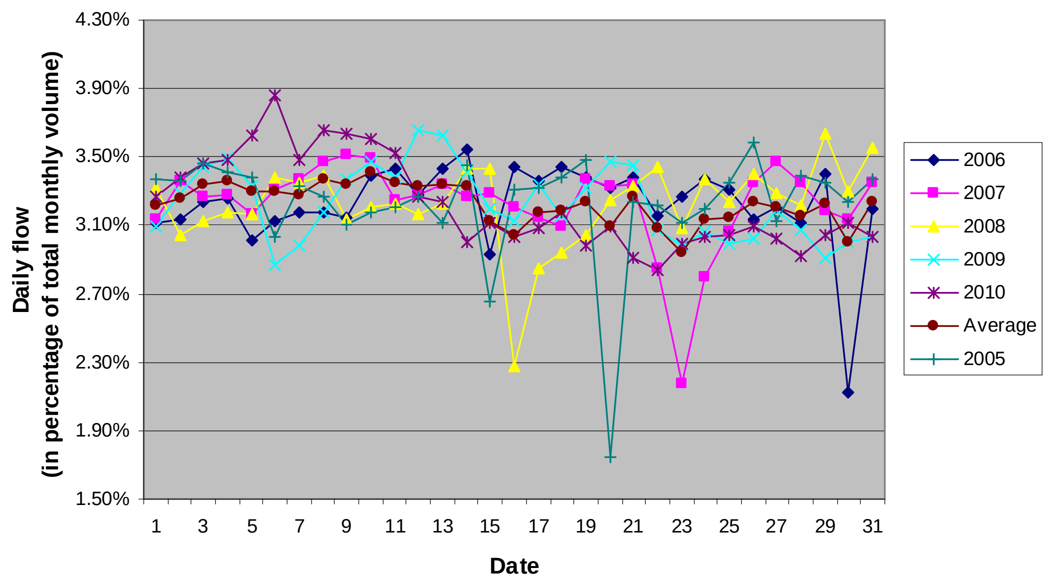
Now, for the years under consideration in this study, months from September to January have contained two Eid festivals. If an Eid month, say December is taken into account, the flow variation exhibits some remarkable facts, as shown in Figure 4.27.

Figure 4.27:Daily Flow Pecentage on December in Jamuna Bridge



It can be clearly seen that, 2005, 2006 and 2009 year maintain near about 3.00% to 3.50% of daily flow percentage, since December did not contain any Eid during these years. On the contrary, for the years 2007 and 2008, two distinct peaks followed by abrupt fall in traffic flow are observed. In all cases, the lowest traffic occurred on Eid day and the peak flow has taken place two days prior to Eid. Naturally one can understand that, this has happened because of increased passenger movement during Eid, as most city people usually spend Eid at their native town or village and the Eid vacation starts from the previous day of Eid day. So, the peak flow occurs two days prior to Eid. Flow chart for August also exhibits similar characteristics, as shown in Figure 4.28.

Figure 4.28: Daily Flow Pecentage on August in Jamuna Bridge



In this case, the Eid festivals have taken place on August in the years 2006, 2007 and 2008. In every case, the flow rises to the peak before Eid and immediately falls on Eid day. Some other falls are also observed which might have occurred for strikes or Hartals. But, since these are potentially creating critical flow value, the issue is not important in this study.

From the above analyses for all individual Eid months, it has been found that, the peak flow percentage raises upto 5.90% in December 2007. But in most of the cases the peak value stays within a range of 5.00% to 6.00%, which is approximately 70% higher than normal traffic flow.

Another approach can be made to see the impact of Eid festivals on daily traffic flow. If all the daily bi-directional flow in a particular year is sorted in the descending order, it is found that, most of the peak daily volume occurs within one week of Eid. In Table 4.13, the daily both directional traffic volumes in the year 2005 to 2009 has been sorted in descending order and highest 15 daily volumes are listed. It is observed that, most of the days carrying highest daily traffic in a year are within a week of an Eid.

It is also found that, the highest daily flow in a year caused by Eid event carries as much as 120% higher volume than AADT of that particular year. From these analyses, one can easily understand that, the highest daily flow in a particular year occurs at the time of Eid and the transportation planners should consider this fact while designing highways in Bangladesh.

Table 4.13: Highest Daily Traffic Flow within a Year

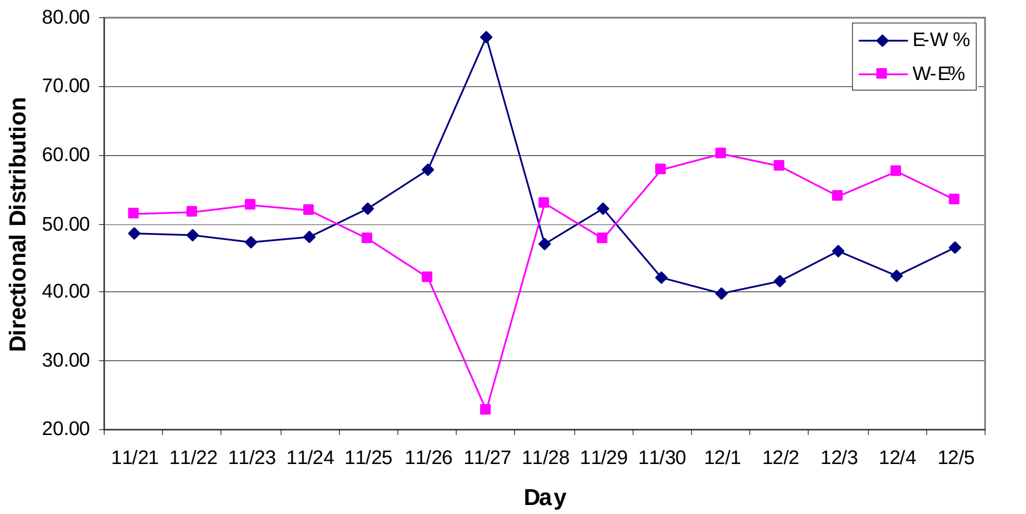
Sl. No. (In Descending Order of Daily Flow Volume)	2005 (AADT = 5289)			2006 (AADT = 5700)			2007 (AADT = 6441)			2008 (AADT = 7235)			2009 (AADT = 8116)		
	Date	Total Bi-Directional Daily Flow	Percentage higher than AADT	Date	Total Bi-Directional Daily Flow	Percentage higher than AADT	Date	Total Bi-Directional Daily Flow	Percentage higher than AADT	Date	Total Bi-Directional Daily Flow	Percentage higher than AADT	Date	Total Bi-Directional Daily Flow	Percentage higher than AADT
1	01/20/05	11216	112.06%	01/10/06	10893	91.11%	12/19/07	14409	123.71%	12/07/08	14049	94.18%	11/26/09	17438	114.86%
2	01/19/05	9676	82.95%	01/09/06	10217	79.25%	12/18/07	12806	98.82%	12/08/08	13758	90.16%	11/27/09	15985	96.96%
3	11/02/05	9325	76.31%	10/22/06	9410	65.09%	12/20/07	12410	92.67%	12/05/08	13740	89.91%	11/25/09	14412	77.58%
4	01/28/05	7938	50.09%	01/08/06	9340	63.86%	12/25/07	10977	70.42%	12/06/08	13179	82.16%	09/18/09	13590	67.45%
5	01/18/05	7843	48.29%	10/27/06	9216	61.68%	10/12/07	10722	66.46%	09/23/08	11640	60.88%	11/24/09	13445	65.66%
6	01/17/05	7544	42.64%	10/31/06	8187	43.63%	01/06/07	10771	67.23%	12/13/08	11412	57.73%	09/19/09	13017	60.39%
7	11/01/05	7427	40.42%	01/06/06	8105	42.19%	12/17/07	10557	63.90%	09/30/08	11056	52.81%	12/04/09	12475	53.71%
8	11/03/05	7390	39.72%	10/23/06	7979	39.98%	10/11/07	10397	61.42%	12/04/08	10926	51.02%	09/23/09	11764	44.95%
9	11/08/05	6975	31.88%	01/07/06	7910	38.77%	12/16/07	9970	54.79%	12/03/08	9980	37.94%	09/25/09	11649	43.53%
10	01/16/05	6928	30.99%	10/20/06	7731	35.63%	01/05/07	9590	48.89%	12/14/08	9730	34.49%	09/17/09	11334	39.65%
11	01/26/05	6895	30.36%	10/21/06	7606	33.44%	12/26/07	9158	42.18%	12/16/08	9707	34.17%	12/03/09	10819	33.30%
12	11/07/05	6842	29.36%	11/01/06	7584	33.05%	10/10/07	9106	41.38%	12/12/08	9444	30.53%	12/02/09	10789	32.93%
13	01/21/05	6721	27.08%	01/15/06	7535	32.19%	12/14/07	8895	38.10%	10/05/08	9247	27.81%	09/26/09	10621	30.86%
14	01/27/05	6394	20.89%	01/16/06	7107	24.68%	01/10/07	8841	37.26%	09/28/08	9189	27.01%	12/05/09	10404	28.19%
15	01/15/05	6060	14.58%	10/19/06	7020	23.16%	12/15/07	8674	34.67%	10/06/08	9014	24.59%	11/20/09	10294	26.84%

Data Source: MNOL, BBSO.

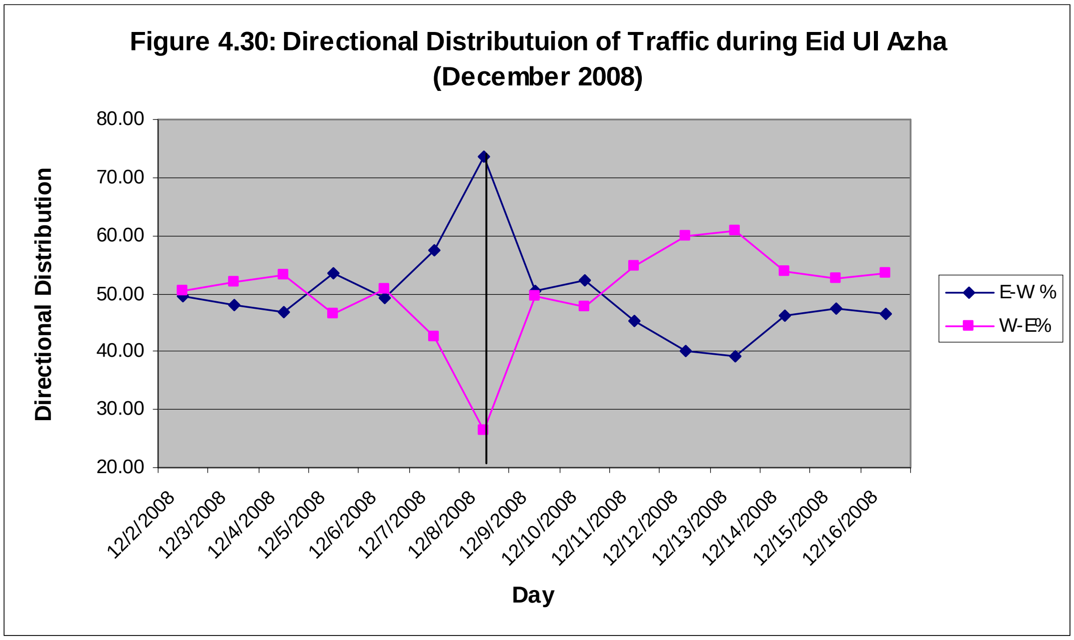
Now, this is of interest to see whether this causes any significant directional split. The both directional flow percentage itself has come to be 70% higher than average daily flow. If that is coupled with higher percentage of flow in a particular direction, that will certainly pertain the highest flow value, which is critical for geometric design.

In Article 4.2.8, the directional distribution analyses has been shown where it has been found that the maximum directional split come to be 51.34% and mostly it is a 50-50 directional distribution corridor. But from the directional distribution curve plotted in Figure 4.29, it is found that, in November, 2009 the East to West flow on the previous day of Eid day has reached up to 77.26%. On the day where highest flow percentage had taken place, i.e. on 26th November, the outbound traffic flow was 57.86%, which is significantly higher than normal directional distribution. Moreover, it is observed that, before Eid festival, the outbound increases from around six days and reaches the peak and then starts falling while the inbound traffic starts increasing after Eid. From similar analyses for other Eid months, it has been found that the impact of Eid start from five days prior to the Eid day and stays until 5/6 after Eid.

Figure 4.29: Directional Distribution of Traffic along Jamuna Bridge During Eid Ul Azha Event in November 2009



A similar analysis of Eid impact on directional distribution of traffic flow is shown in Figure 4.30, where the maximum directional split from East to West is 73.60%.



Summary of Findings:

From the above analyses, it is clearly understood that, Eid festivals have crucial impact on traffic flow in N-5 Corridor. Therefore, for accurate estimation of AADT from short counts, not only expansion factors are sufficient for precise estimation, but also an Eid factor is to be determined and introduced, so that the peak hour flow can be correctly estimated.

- Duration of Eid Impact: 5 days before and 6 days after Eid day; total 11 days.
- Maximum Daily Flow Percentage: 5.90% (bothway) before Eid in December 2007.
- Average Daily Flow Percentage: 3.23%, Standard Deviation: 0.23%
- All highest Daily Volume in a year are within Eid effect range, carrying upto 120% more traffic than AADT.
- Maximum Directional Distribution: 77.26%, East to West, November 2009

- Average maximum Directional Distribution before Eid day: 71.71% (Averaged over 7 Eid occasions)

4.2.9 TRAFFIC GROWTH PATTERN

Traffic growth is a natural phenomenon in any country. It can be found from previous flow pattern analyses that, although the daily, monthly flow variation exhibit similar fluctuation pattern, but the magnitude of flow increases every successive year (Figure 4.10). This indicates that since the stabilization of the corridor, total yearly traffic is gradually increasing. An analysis of traffic growth pattern is important for reliable prediction of future traffic flow by extrapolation method. Moreover, for estimating future traffic for geometric and structural design or prediction of future traffic flow in terms of PCU and total ESAL, the pattern of growth rate of traffic is necessary. This article analyzes the five years of traffic flow data from 2005 to 2009 to understand the true pattern of traffic growth.

Figure 4.31: Yearly Traffic Growth on Jamuna Bridge

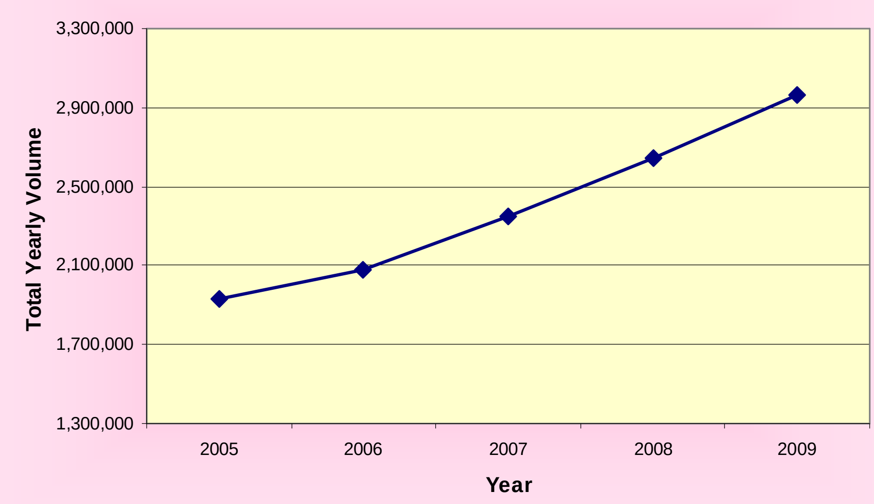


Figure 4.31 plots the total bi-directional yearly traffic volume on Jamuna bridge against respective years from 2005 to 2009. From the graph, it is clearly seen that the yearly traffic growth is almost linear. In 2005, the total yearly traffic volume was 1,930,313. During the next five years it has gradually increased and has become near about three million (exact Figure is 2,962,192) in 2009. The average growth rate has been found to be 11.17% per annum, which is higher than average national

growth rate (8-10%) used in the Roads and Highways design manual [Pavement Design Guide, Roads & Highways Department, April 2005].

Now, during the analyses of traffic composition described in Article 4.2.6, it was found that, percentage of various vehicle classes with respect to total yearly is not constant throughout the study period (Figure 4.18). Rather, they are changing from year to year at a significant rate. Some vehicle classes are increasing every year while some are decreasing. Therefore, it can be easily understood that, flat growth rate for total traffic is not representative of the actual scenario. This invokes the need for traffic growth pattern analyzed individually for all vehicle classes.

Figure 4.32: Classwise Yearly Growth Pattern of Traffic on Jamuna Bridge

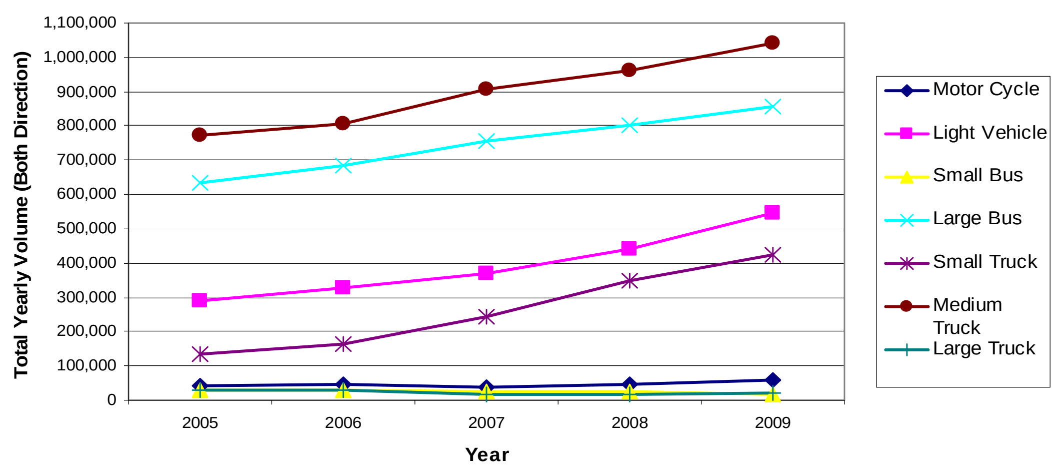
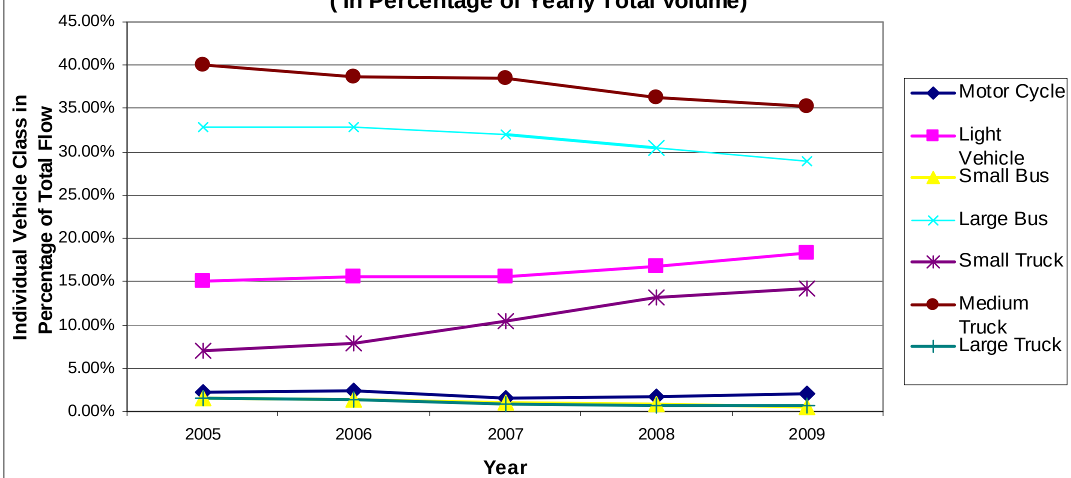


Figure 4.33: Growth Pattern of Individual Vehicle Classes (In Percentage of Yearly Total Volume)



In Figure 4.32, total yearly flow of all seven vehicle classes used in Jamuna bridge is plotted against respective years from 2005 to 2009, while Figure 4.33 shows the yearly variation in percentage of individual vehicle classes with respect to total yearly volume. The observations made from the above graphs, separately for each vehicle class, are described hereunder.

4.2.9.1 Motor Cycle:

In 2005, total yearly volume of this class was 42,155 and in 2009 it became 60,012. During the intermediate years total volume was within a range from 36 to 48 thousand per year. The average yearly volume derived from five years is 46,748. The total yearly volume of Motor Cycle and the percentage of motorcycle with respect to total volume has not changed to great extent during the study period. In 2005, the percentage was 2.18% and gradually decreased every year and became 2.03% in 2009. This has happened because of increase in total traffic. Taking the average value during the study period, percentage of motorcycle is only 1.97% within the traffic stream.

4.2.9.2 Light Vehicles:

Light vehicles include cars, pickups, microbus, jeep etc. within this class. From Figure 4.32, it can be seen that total yearly volume of Light Vehicles has slightly increased from 2,89,910 in 2005 to 5,43,832 in 2009. The percentage of light vehicle has increased from 15.02% in 2005 to 18.36% in 2009. Average annual rise is 0.67% of total yearly volume. The change is quite noticeable in Figure 4.33. Taking the average value during the study period, percentage of light vehicle is 16.28% within the traffic stream.

4.2.9.3 Small Bus:

Small bus, which is classed as buses having sitting capacity up to 30, shows prominent slump in volume, as well as in yearly percentage. In 2005 total volume of Small Bus was 30,720, while in 2009 it became only 16,025. Annual percentage dropped from 1.59% to only 0.54%. Average percentage of small bus is only 1.09% within the traffic stream from the year 2005 to 2009. Toll rate of small bus is 550 taka, where as large bus rate is 800 taka. This may be the reason of decreasing small buses as owner of these buses are more interested to business with large buses.

4.2.9.4 Large Bus:

Due to construction of Jamuna Bridge, traffic movement towards north corridor has improved rapidly. Small bus replaces with large speedy luxury bus at a high rate. Figure 4.32 and 4.33 clearly shows this change. Large bus is the second highest traffic class in N-5 corridor. Total volume has increased from 6,32,938 to 8,55,390 during the five years under consideration. In average, 7,45,836 number of large bus trip generated each year from 2005 to 2009 on Jamuna bridge. But the annual percentage has dropped from 32.79% to 28.88%, which indicates that number of large bus has not increased proportionately with respect to total traffic from the year 2005 to 2009.

4.2.9.5 Small Trucks:

Volume of small trucks is increasing significantly on the N-5 corridor. The number of small truck rises 3.14 times in our study period. From 2005 to 2009, small truck increases from 1,34,709 to 4,23,137 respectively and the percentage of this class has risen from 6.98% in 2005 to 14.28% in 2009. Currently the axle load control station is not active at all, which instigate the truck owner to carry weights more than 5 tons in these small truck but they are giving toll at a rate of small truck.

4.2.9.6 Medium Trucks:

As discussed in article covering traffic composition, the class Medium Truck contains the highest percentage of traffic on Jamuna Bridge. In Figure 4.32 and 4.33, annual growth of this class is also found to be quite significant. In the year 2005, total volume was 7,71,500 and it increased to more than 1.5 times during the next five years. Although due to consequent increase in total traffic, the growth in annual percentage is not that steep. From 2005 to 2009, the percentage has risen from 39.97% to 35.20%. Ineffectiveness of axle load control station has promoted excess load carried by these truck frequently. Hence, the Jamuna bridge and highways are suffering heavy loads then their design load.

4.2.9.7 Large Trucks:

Large Truck contains the minimum percentage of annual traffic. From the year 2005 to 2009, number of large trucks varies from 28,381 to 21,048. Average yearly number of large truck trip is 22,400. The percentage of this class was 1.47% in 2005.

After gradual decrease, the same has become 0.71% in 2009. Considering the impact of Large Truck on the pavement, this apparent insignificant class is also to be taken into account.

Summary of Findings:

From the above analyses, it was firmly established that, consideration of flat growth rate for total vehicle is not correct. Rather, growth rate is to be determined for each individual class, which can be used more precisely for traffic flow prediction.

4.2.10 COMPARISON BETWEEN FLOW ON JAMUNA BRIDGE AND HATIKAMRUL ROAD

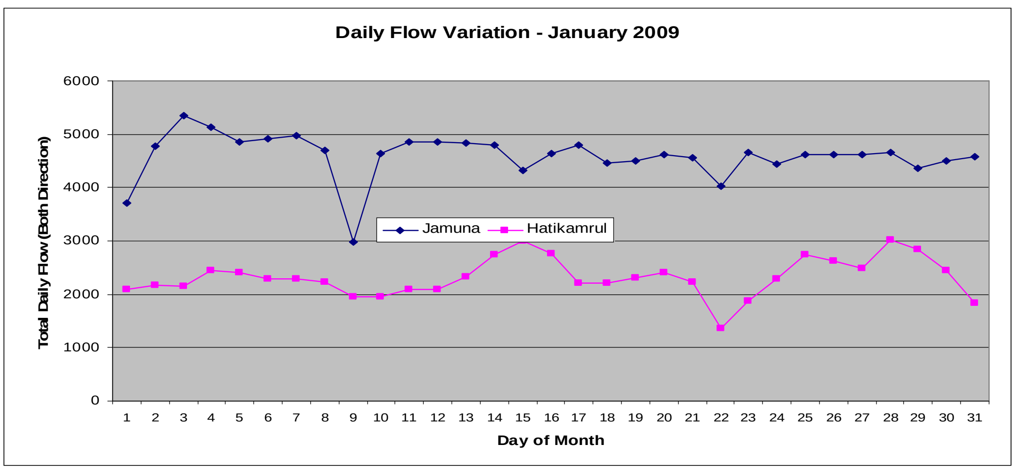
It has been previously established that, the flow data used in this thesis is of high quality. This was initially predicted by seeing the repetitive nature of the curve, which is a usual phenomenon in all traffic flow. Yet, some manipulation in data may be possible by the toll collectors to maintain the rhythmic nature. In order to reveal the fact if any such thing has happened or not, a framework has been developed in this study to check the consistency of data in a selected corridor by comparing the daily flow data recorded at two different stations in one corridor. For example, if daily flow data is recorded at Meghna Bridge and at a station at Noakhali on the Dhaka-Chittagong highway, the flow rate at the latter station would certainly be some percentage of the former, provided the internal flow between Comilla and Noakhali is not significantly high in comparison to the corridor flow.

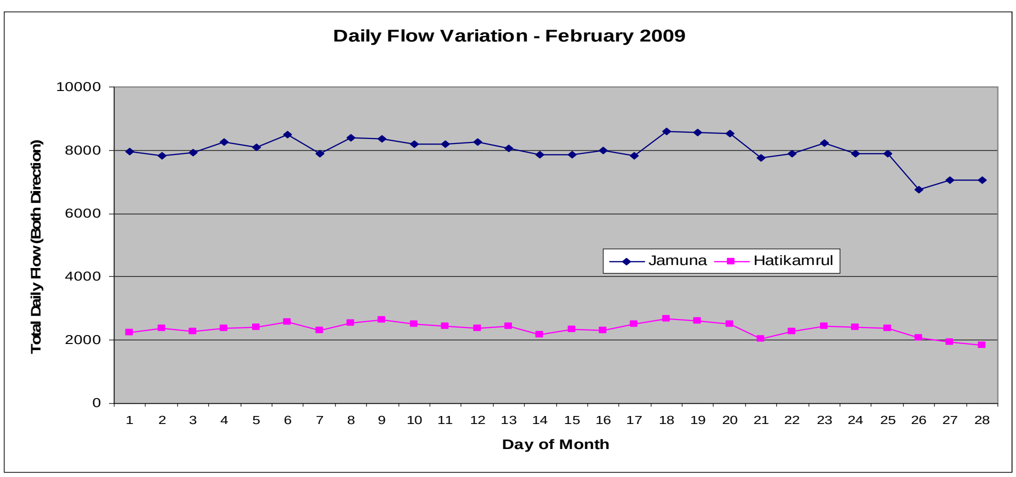
During this study one year daily traffic flow data on North Bengal Corridor at Hatikamrul station has been collected. Nalka-Hatikamrul-Bonpara road carries the inter-district vehicles towards mainly Rajshahi and Noagaon. The road is owned by the Roads and Highways department and is the first tolled road in Bangladesh. The data has been recorded by the toll operator of the road – MBEL Ltd. Since, the road carries a portion of traffic that pass through the Jamuna bridge, it is expected that the daily traffic flow variation pattern at both the stations will remain same, only the magnitude would differ. To check this, the data collected from both the stations were put in the framework and the following curves were obtained.

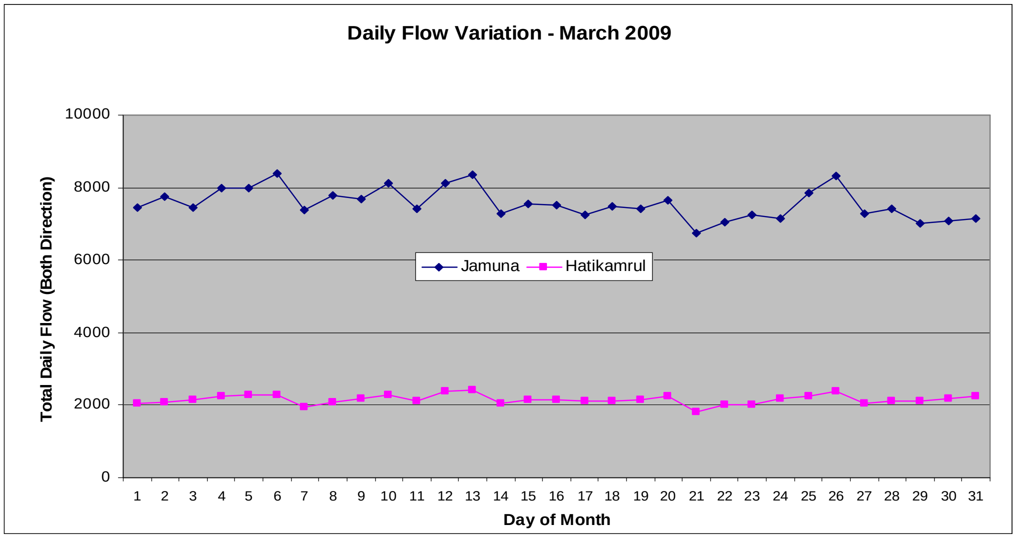
Table 4.14: Flow comparison between Jamuna Bridge and Hatikamrul Road

Month	Jamuna Bridge		Hatikamrul Station		Hatikamrul / Jamuna - Percentage	Avg.	Standard Deviation
	Monthly Total Volume	Monthly Percentage	Monthly Total Volume	Monthly Percentage			
Jan-09	237,308	8.01	71,882	7.78	**30.29%**	**31.11%**	**2.05**
Feb-09	223,575	7.55	66,088	7.15	**29.56%**		
Mar-09	234,368	7.91	66,877	7.24	**28.54%**		
Apr-09	222,787	7.52	63,064	6.82	**28.31%**		
May-09	239,455	8.08	74,405	8.05	**31.07%**		
Jun-09	253,497	8.56	87,040	9.42	**34.34%**		
Jul-09	259,745	8.77	89,631	9.70	**34.51%**		
Aug-09	236,128	7.97	75,861	8.21	**32.13%**		
Sep-09	247,680	8.36	73,536	7.96	**29.69%**		
Oct-09	249,826	8.43	75,536	8.17	**30.24%**		
Nov-09	277,905	9.38	90,593	9.80	**32.60%**		
Dec-09	279,918	9.45	89,686	9.70	**32.04%**		

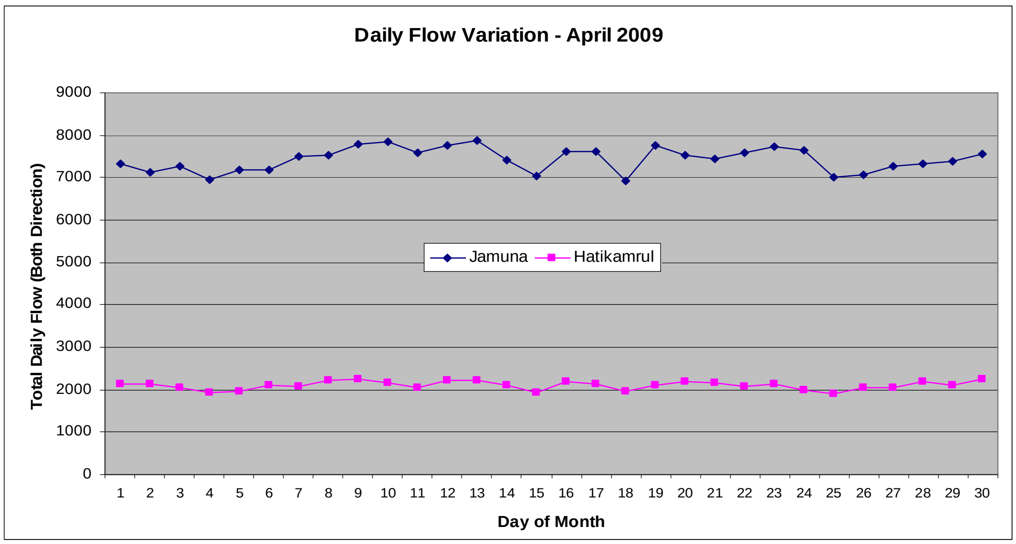
Data Source: MargaNet and MBEL.



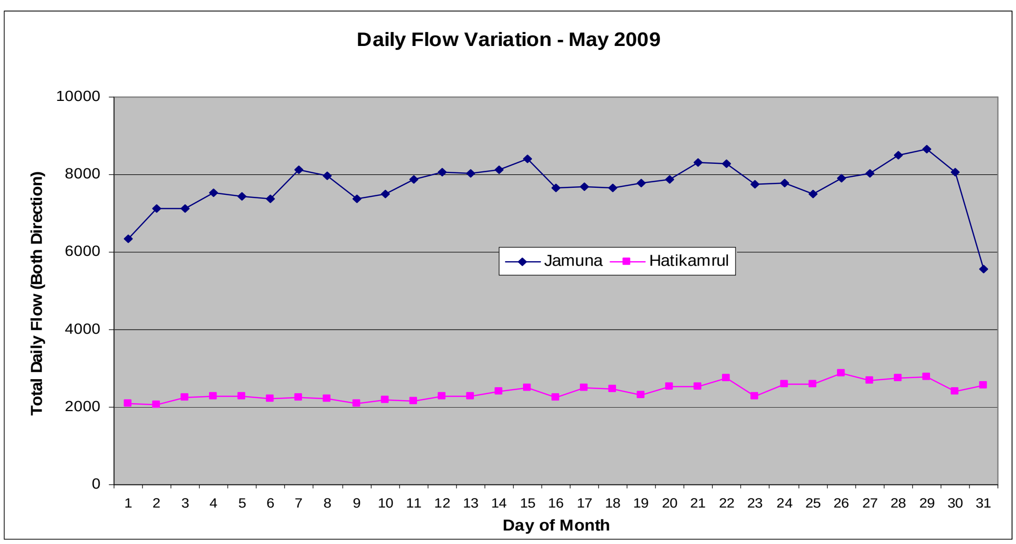




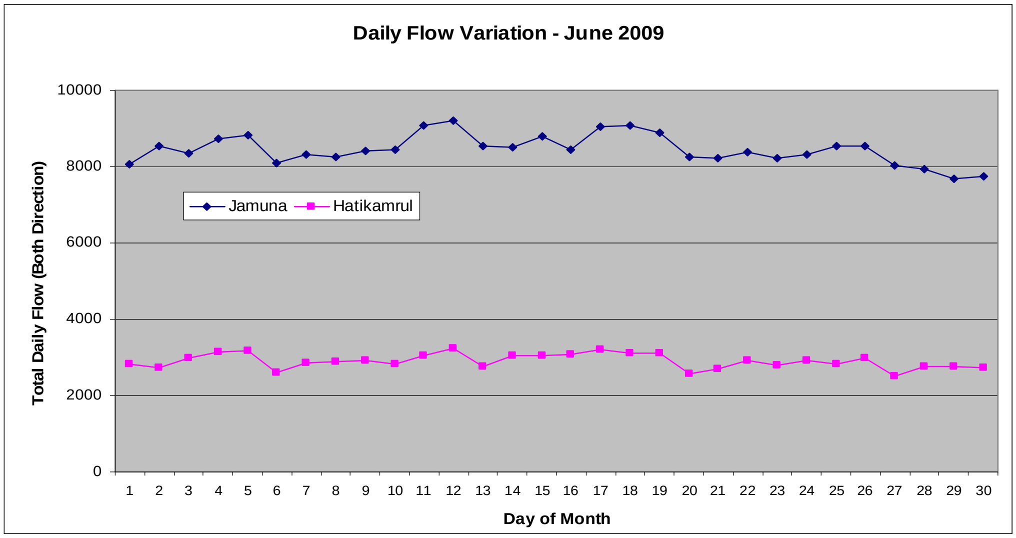
Daily Flow Variation - March 2009
Total Daily Flow (Both Direction)
Day of Month
Jamuna
Hatikamrul

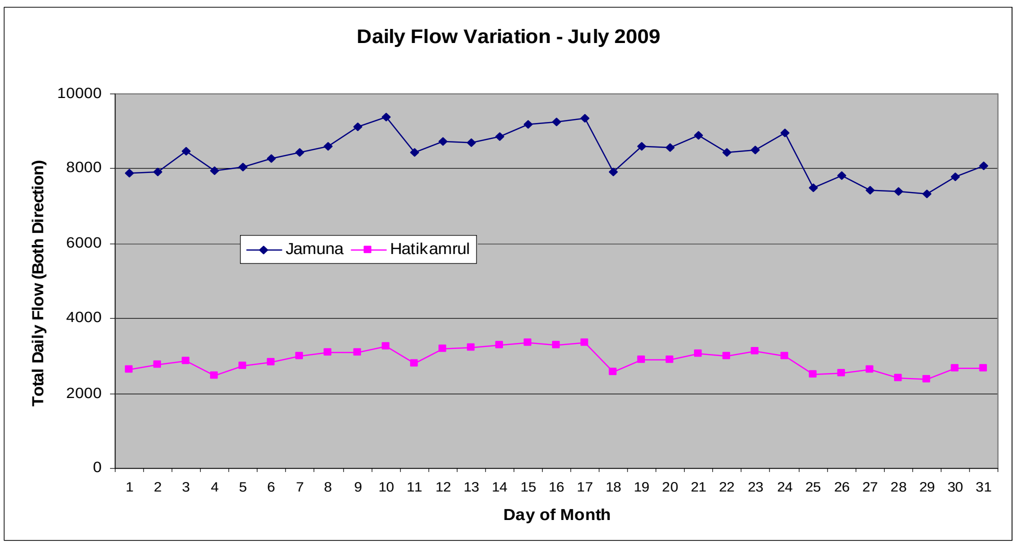


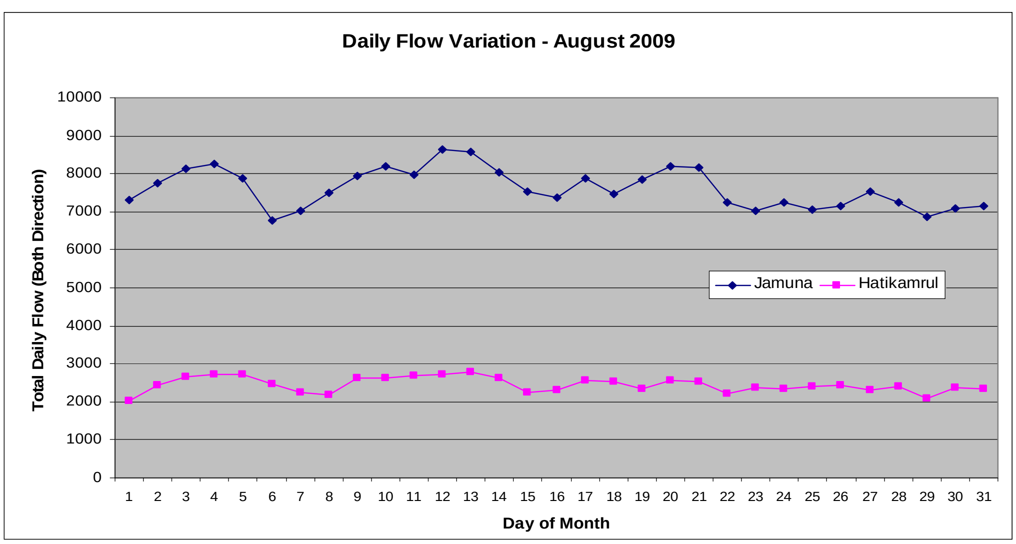
Daily Flow Variation - April 2009
Total Daily Flow (Both Direction)
Day of Month
Jamuna
Hatikamrul

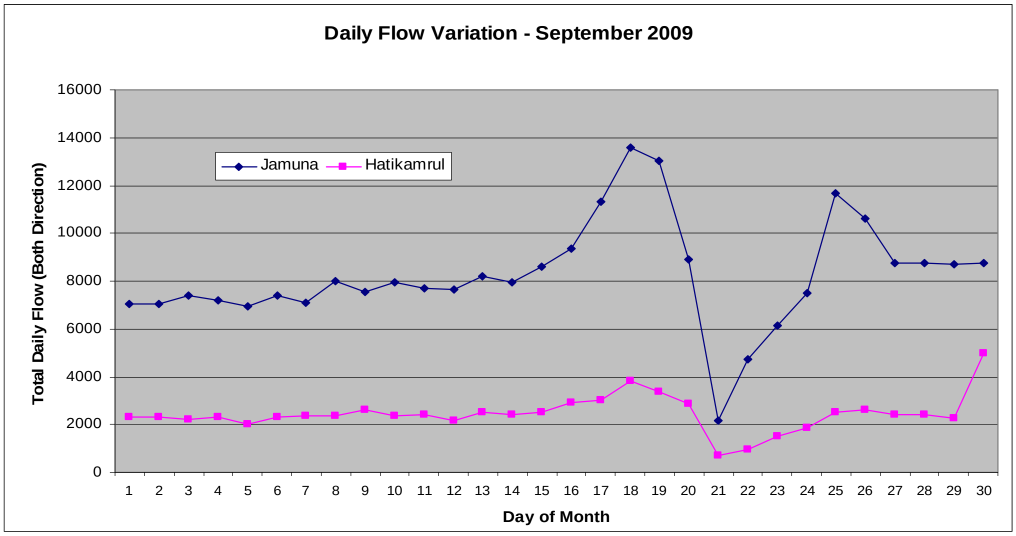


Daily Flow Variation - May 2009
Total Daily Flow (Both Direction)
Day of Month
Jamuna
Hatikamrul

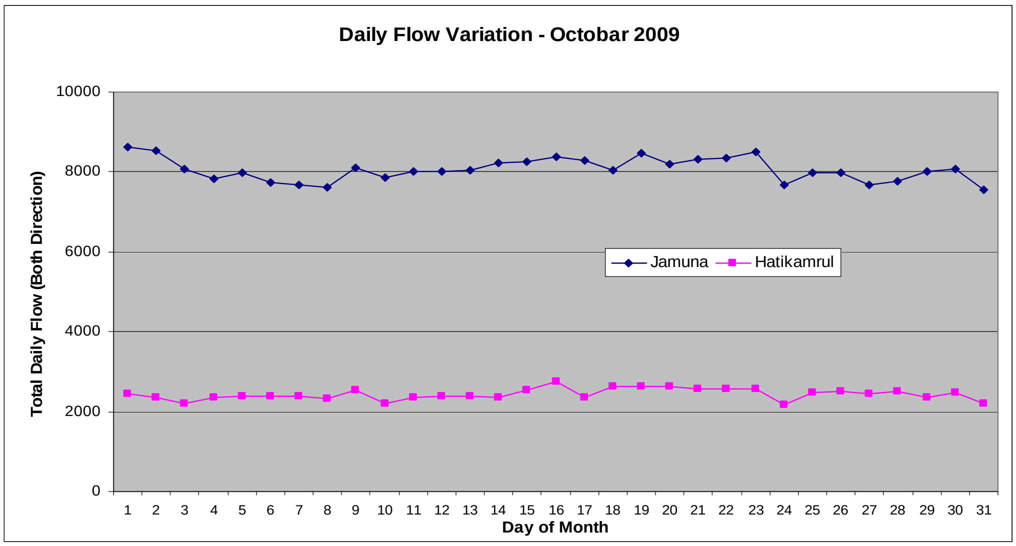

Daily Flow Variation - June 2009
Total Daily Flow (Both Direction)
Day of Month
Jamuna
Hatikamrul
10000
8000
6000
4000
2000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30


Daily Flow Variation - July 2009
Total Daily Flow (Both Direction)
Day of Month
Jamuna
Hatikamrul
10000
8000
6000
4000
2000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

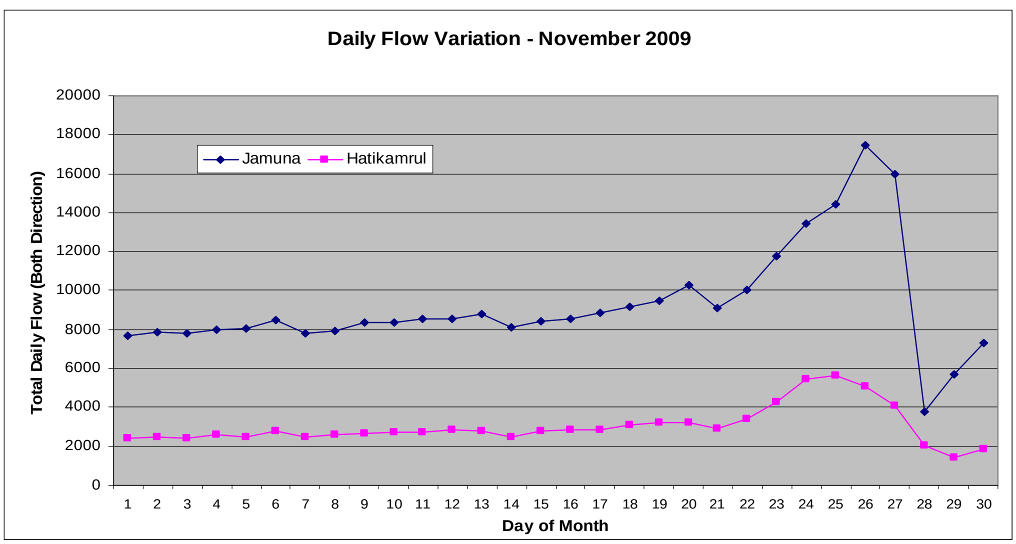

Daily Flow Variation - August 2009
Total Daily Flow (Both Direction)
Day of Month
Jamuna
Hatikamrul
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31



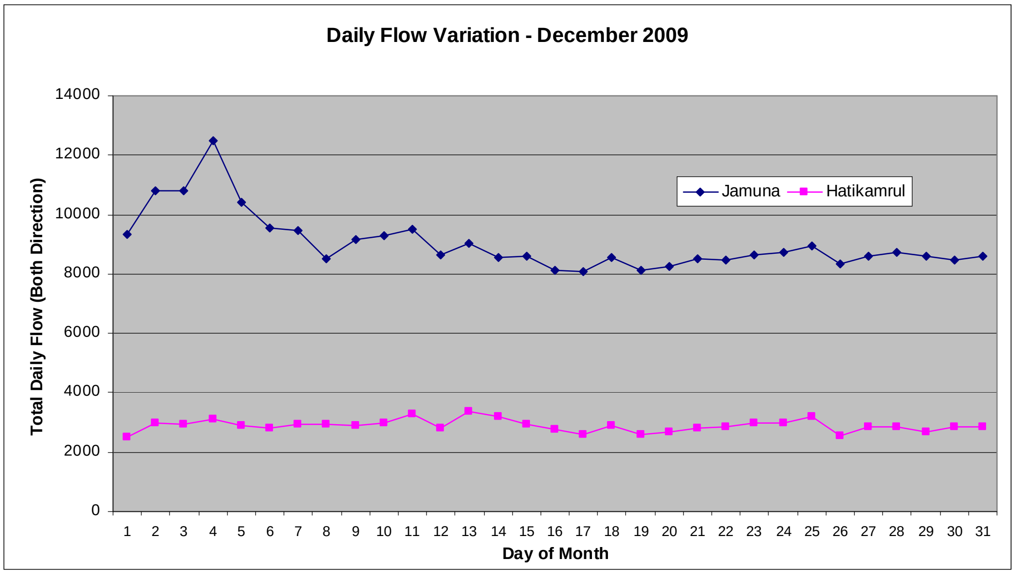
Daily Flow Variation - September 2009
Jamuna
Hatikamrul
Total Daily Flow (Both Direction)
Day of Month



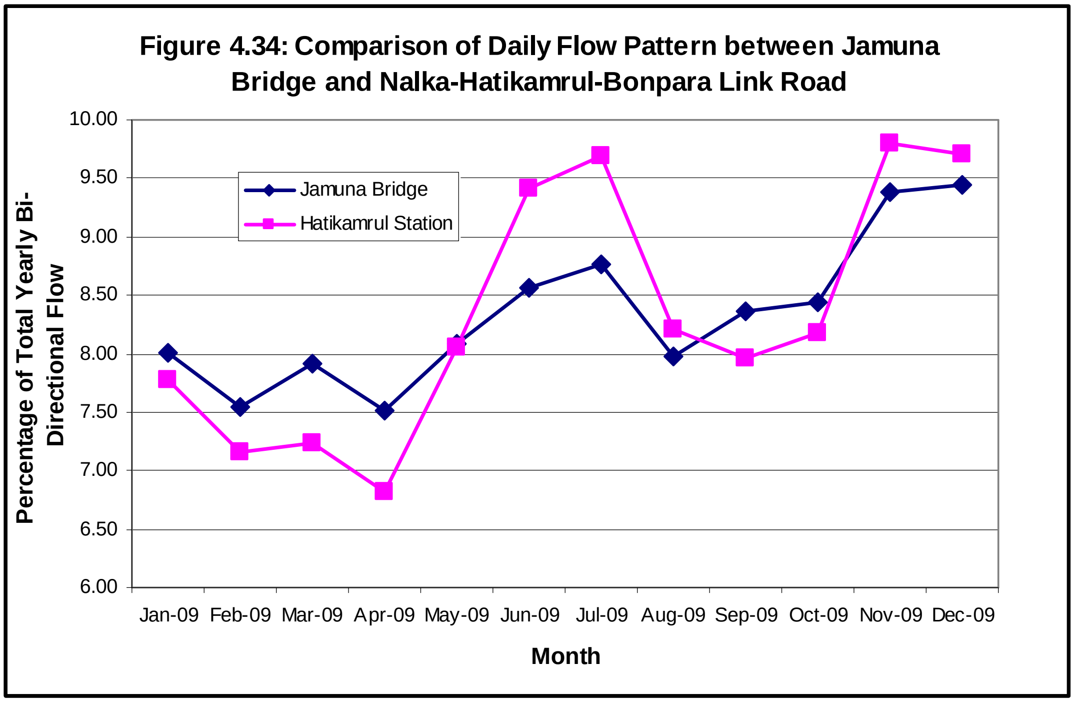
Daily Flow Variation - Octobar 2009
Jamuna
Hatikamrul
Total Daily Flow (Both Direction)
Day of Month



Daily Flow Variation - November 2009
Jamuna
Hatikamrul
Total Daily Flow (Both Direction)
Day of Month



From the above continuous daily flow patterns, one can easily understand that, Hatikamrul road carries a distinct portion of Jamuna bridge traffic. Despite different toll operator and authorities, the patterns are seen to have significant similarity, which implies that, both the toll operators have been performing well in collecting and recording data. It is also found from the analyses that, Hatikamrul road carries 31.11% of total traffic crossing the Jamuna bridge (as shown in Table 4.14). Further analyses on this might reveal important facts that may be useful for the transport planners for designing a new road facility. The framework can also be used for independent auditing purpose.



The above Figure (Figure 4.34) shows the comparison between daily traffic flow patterns recorded in Jamuna Bridge and Nalka-Hatikamrul-Bonpara Link road from January 2009 to December 2009. It is found from the Figure that, the two roads maintain very similar daily flow variation pattern, which certainly proves the consistency of data collection and preservation.

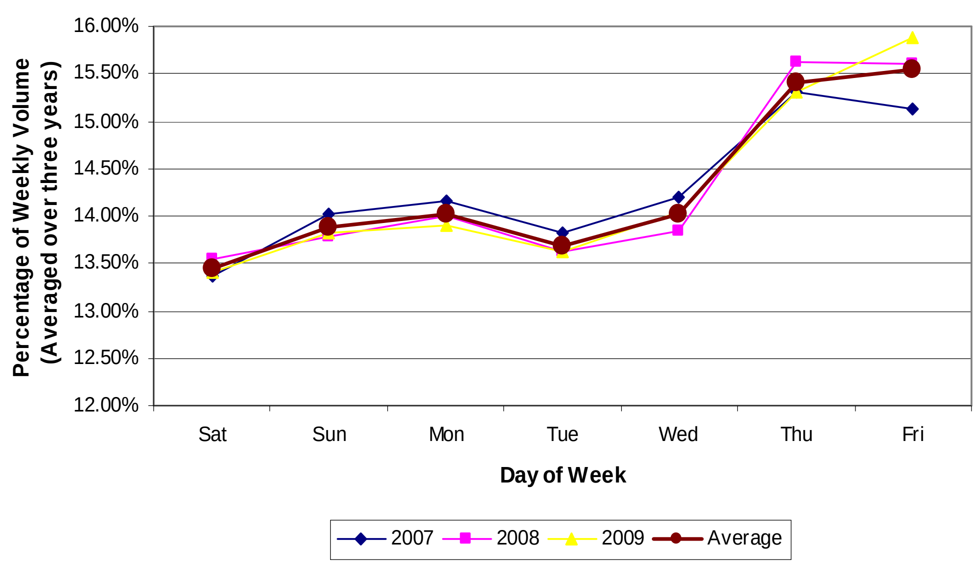
4.3 ANALYSIS OF FLOW CHARACTERISTICS IN N-2 CORRIDOR (BHAIRAB BRIDGE)

A range of analyses on traffic flow have been completed in Bhairab bridge corridor in order to evaluate pavement design parameters in N-2 corridor. This section includes the analysis of flow characteristics on Bhairab bridge. Primarily the flow patterns have been developed to see the nature of traffic flow fluctuation and then various flow characteristics have been established for evaluation.

4.3.1 DAILY FLOW VARIATION

From the analyses of 3 years data collected from SIGMA-RCL Joint Venture (2007 to 2009), distinct daily flow fluctuation pattern can be achieved. Daily flow variation is a basic form of analyses to indicate pavement design parameters correctly. In Figures 4.35a & b, the average daily flow, in either direction, in percentage of total weekly volume have been plotted against respective days of week. It is clearly observed that daily flow variation for inbound (West to East direction) and outbound (East to West direction) traffic does not exhibit similar pattern.

Figure 4.35a: Daily Flow Fluctuation on Bhairab Bridge (West to East)



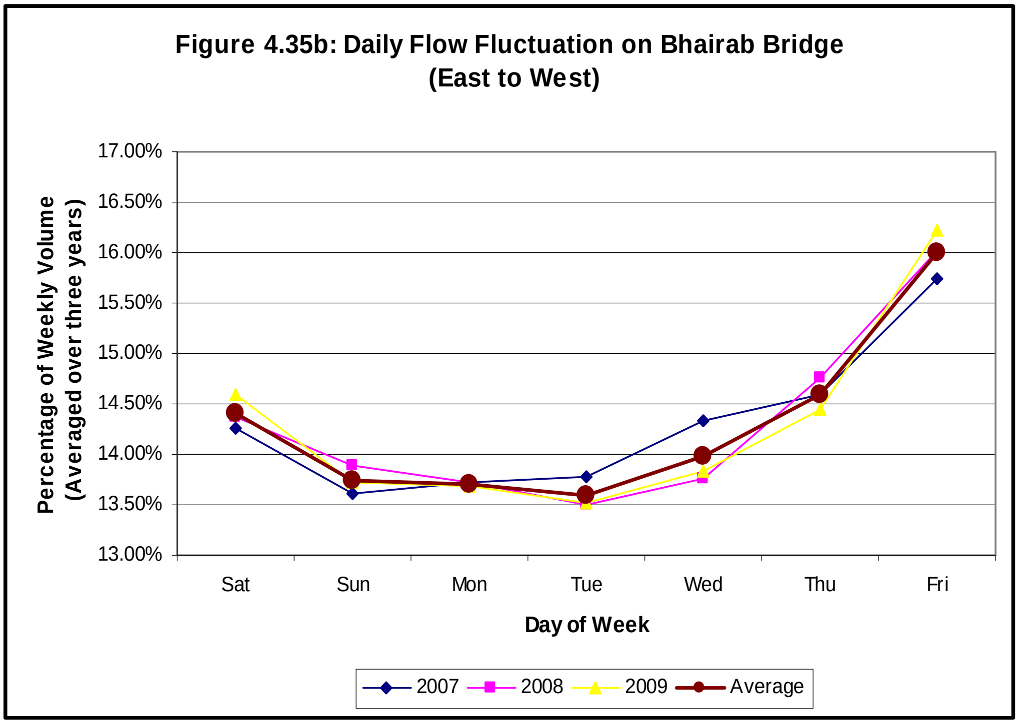


Figure 4.35a shows the flow variation for traffic from West to East. On this direction, it is found that the average maximum flow occurs on Thursday (15.41%) and Friday (15.54%). This may happen because of weekend factor, i.e. people of North East side of Bangladesh tend to visit their native town/village during the weekend from their workplaces in Dhaka. On the other hand, for East to West flow direction (Figure 4.35b) average maximum flow takes place on Friday (15.99%), because people return to workplaces in Dhaka. In both the cases, the curves tend to sag on midweek (Monday, Tuesday and Wednesday) where traffic flow is relatively minimum.

It is observed from the above traffic flow that, the weekend factor is dominating on passenger movement. Hence, vehicle class wise individual daily flow variation analyses are needed. As a result, curves have been plotted for the predominant vehicle classes on Bhairab bridge, which are given below.

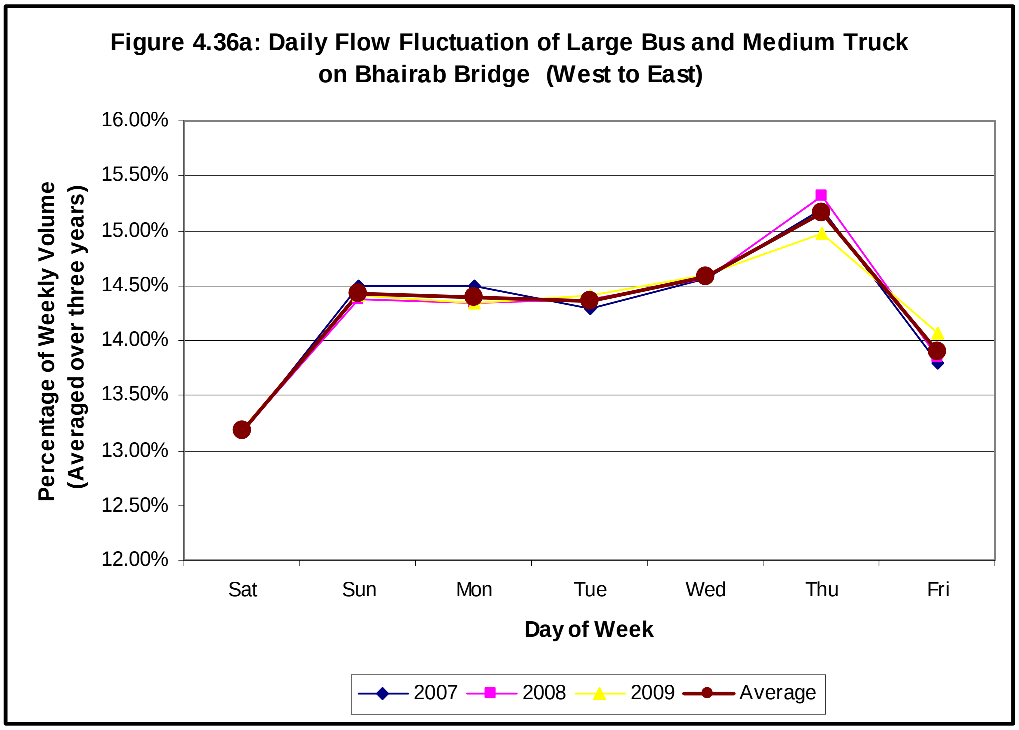


Figure 4.36a: Daily Flow Fluctuation of Large Bus and Medium Truck on Bhairab Bridge (West to East)
Percentage of Weekly Volume (Averaged over three years)
16.00%
15.50%
15.00%
14.50%
14.00%
13.50%
13.00%
12.50%
12.00%
Sat
Sun
Mon
Tue
Wed
Thu
Fri
Day of Week
2007
2008
2009
Average

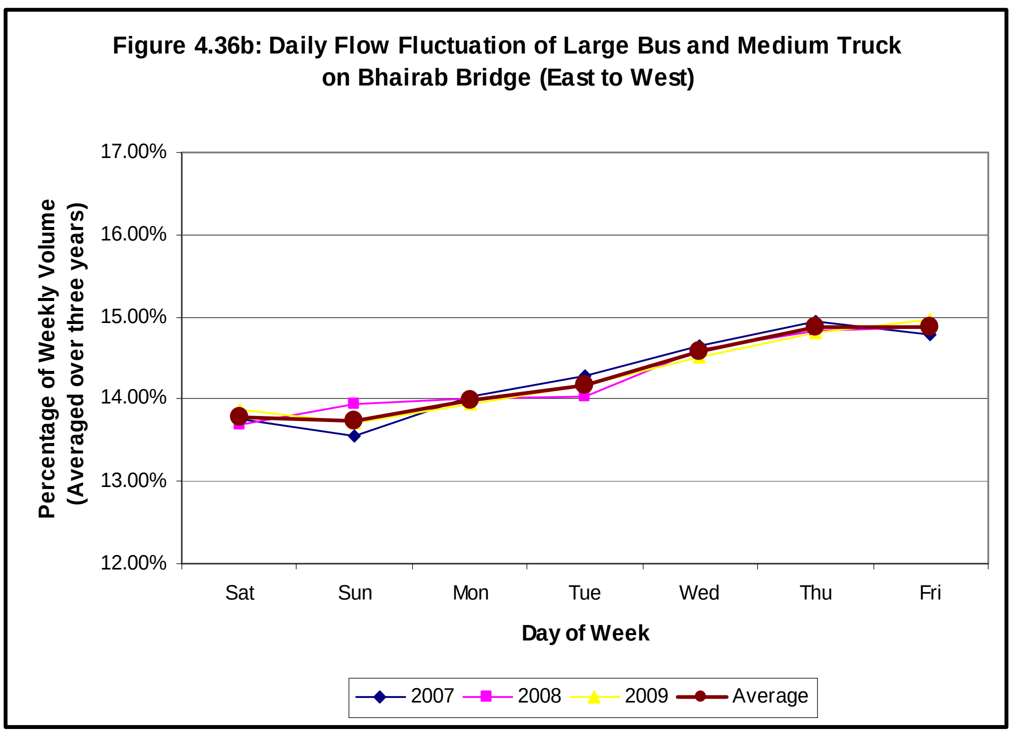


Figure 4.36b: Daily Flow Fluctuation of Large Bus and Medium Truck on Bhairab Bridge (East to West)
Percentage of Weekly Volume (Averaged over three years)
17.00%
16.00%
15.00%
14.00%
13.00%
12.00%
Sat
Sun
Mon
Tue
Wed
Thu
Fri
Day of Week
2007
2008
2009
Average

In Figure 4.36a and Figure 4.36b, daily flow variation of large bus and medium trucks are shown for inbound and outbound traffic respectively. It is observed from Figure 4.36a that, the daily flow percentages for inbound and outbound large bus and medium trucks are relatively equal on all weekdays. From Figure 4.36a & b, distinct rise of outbound and inbound large bus and medium trucks are seen on Thursday and Friday due to weekend factor. Relatively minimum flow of large bus and medium trucks are found on Saturday on N-2 corridor.

There is a significant error observed in vehicle classification system on Bhairab bridge toll plaza. It is seen that large bus and medium truck have been included in the same classification and their toll rate is same. Large bus carries passenger and medium truck carries fright. The Figure 4.36a & b don't differentiate passenger carrying status and fright carrying status of N-2 corridor clearly due to faulty classification system. Medium truck is the most dominant fright carrying mode in N-2 corridor. In recent years, overloading is common to all medium trucks and most of it carries significant over loading then its capacity which causes severe damages to the pavement structures.

But from the patterns of daily flow fluctuation of Light Vehicles, as shown in Figures 4.37a and 4.37b, huge rise of flow on weekend are observed. For inbound traffic, the maximum flow occurs on Thursday and Friday, carrying 16.26% and 17.76% of total weekly volume, which is quite high in comparison to the other major vehicle classes. For outbound traffic pattern, prominent sag on midweek is observed with most traffic traveling on Friday (17.53%).

Figure 4.37a: Daily Flow Fluctuation of Light Vehicle on Bhairab Bridge (West to East)

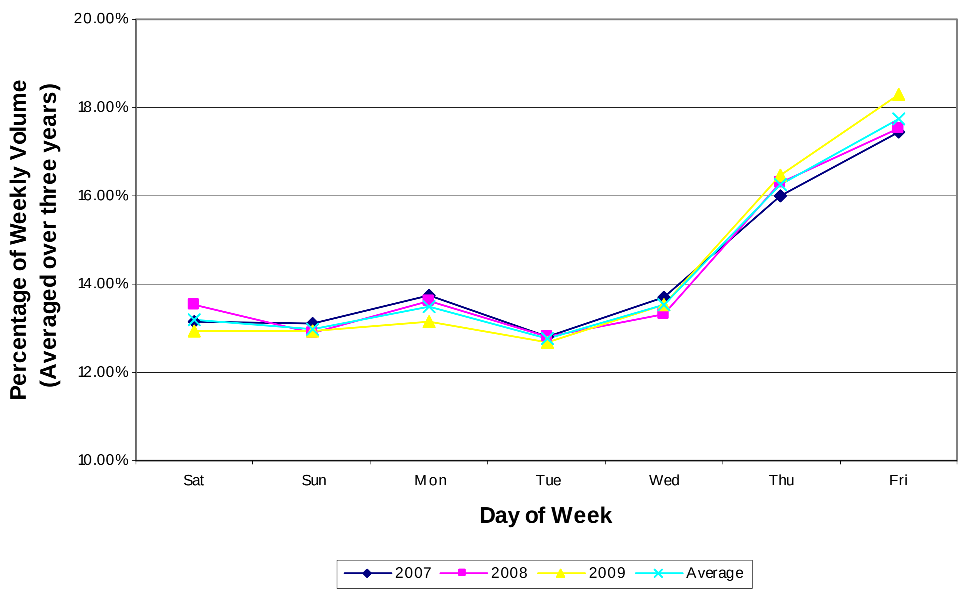
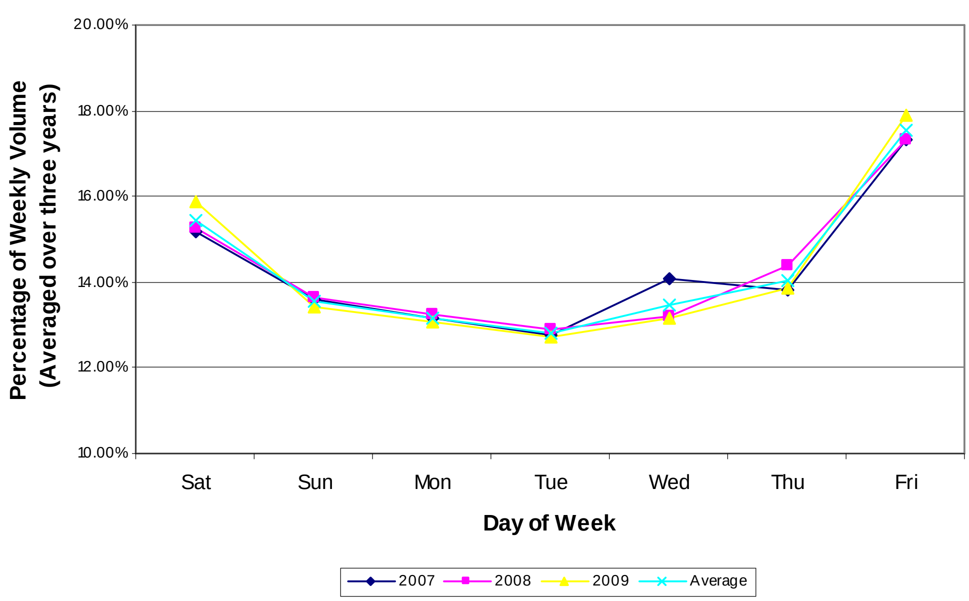
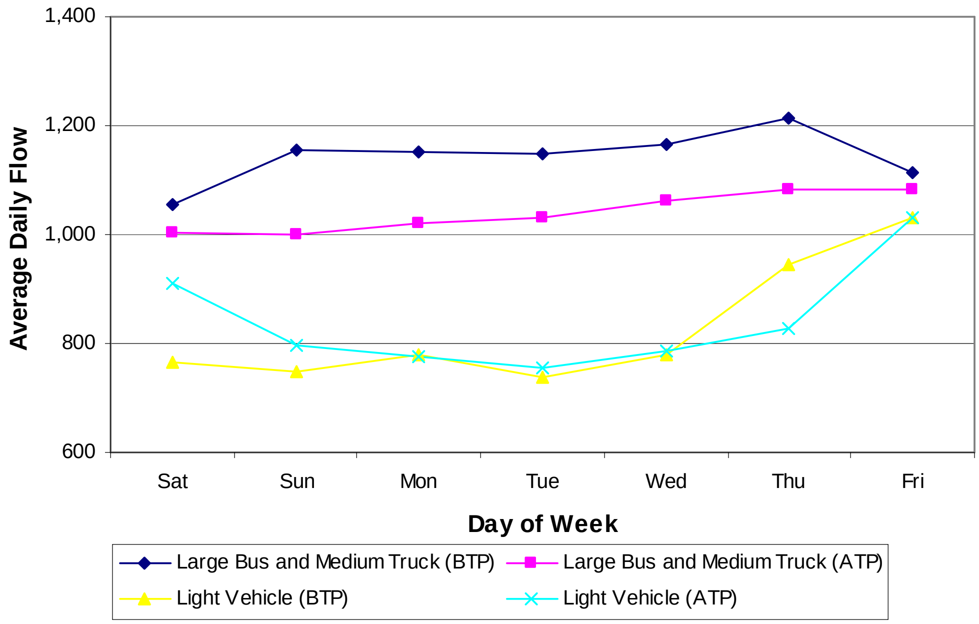


Figure 4.37b: Daily Flow Fluctuation of Light Vehicle on Bhairab Bridge (East to West)



The following Figure summarizes the pattern of these two major vehicles classes.

Figure 4.38: Daily Flow Fluctuation Pattern of Major Vehicle Classes on Bhairab Bridge



In the N-2 corridor, monthly traffic flow variation shows different characteristics then daily flow variations. To examine these, curves have been plotted showing daily flow variation for all months of a year during this study. Two of such charts are given in Figure 4.39 and Figure 4.40, where the average daily flow variation pattern are found to conform to those obtained from the previous analyses, but no definite relation can be established in terms of influence of individual month on these daily variations. This indicates that, individual month has no significant effect on daily variation of traffic flow in the N-2 corridor.

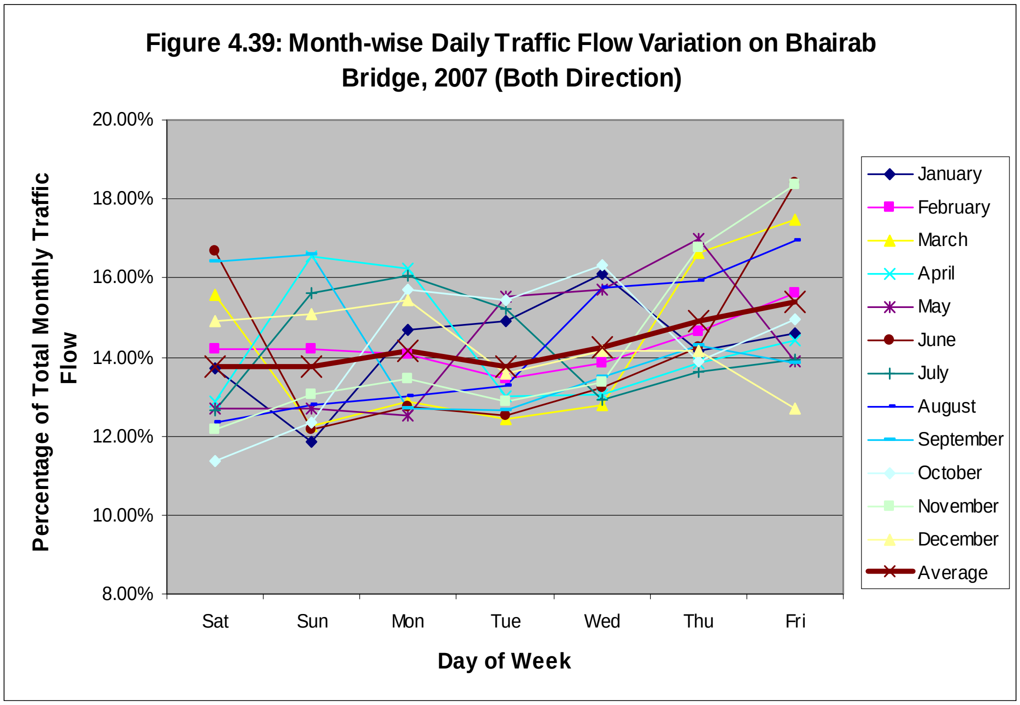


Figure 4.39: Month-wise Daily Traffic Flow Variation on Bhairab Bridge, 2007 (Both Direction)
Percentage of Total Monthly Traffic Flow
20.00%
18.00%
16.00%
14.00%
12.00%
10.00%
8.00%
Sat
Sun
Mon
Tue
Wed
Thu
Fri
Day of Week
January
February
March
April
May
June
July
August
September
October
November
December
Average

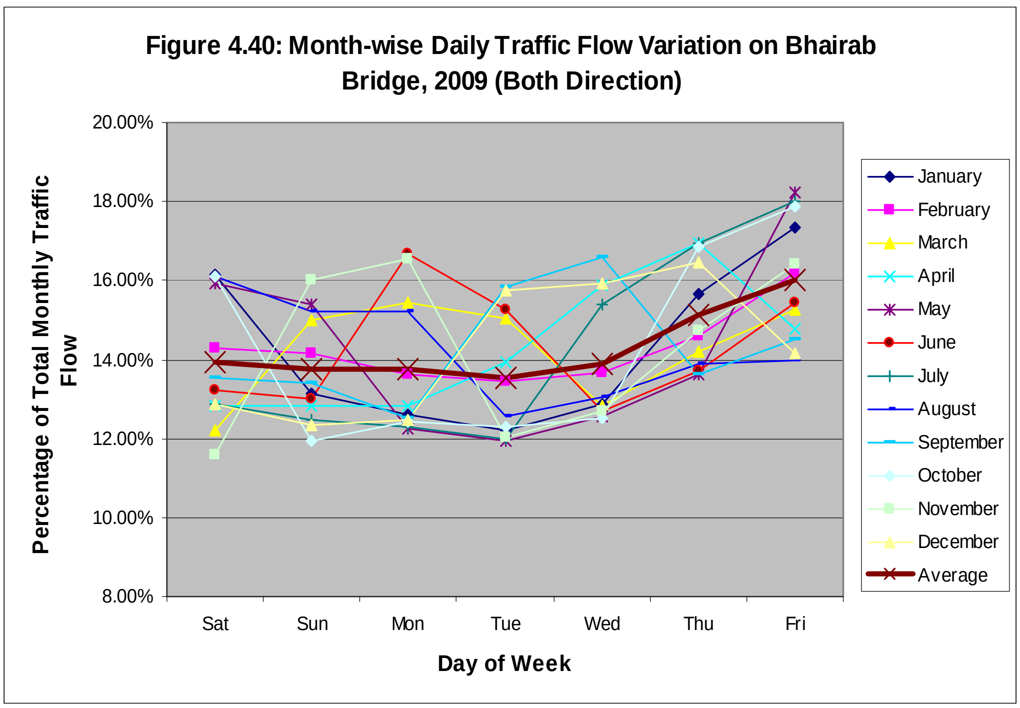


Figure 4.40: Month-wise Daily Traffic Flow Variation on Bhairab Bridge, 2009 (Both Direction)
Percentage of Total Monthly Traffic Flow
20.00%
18.00%
16.00%
14.00%
12.00%
10.00%
8.00%
Sat
Sun
Mon
Tue
Wed
Thu
Fri
Day of Week
January
February
March
April
May
June
July
August
September
October
November
December
Average

It is to be noted here that, two years (2007 and 2009) of month-wise daily flow variation pattern have been shown above. Similar analysis curves for the year 2008 are given in the Appendix B (Figure B12).

Summary of Findings:

From the above analyses, the following important flow characteristics parameters have been obtained.

Table 4.15: Summary Table - Daily Flow Variation

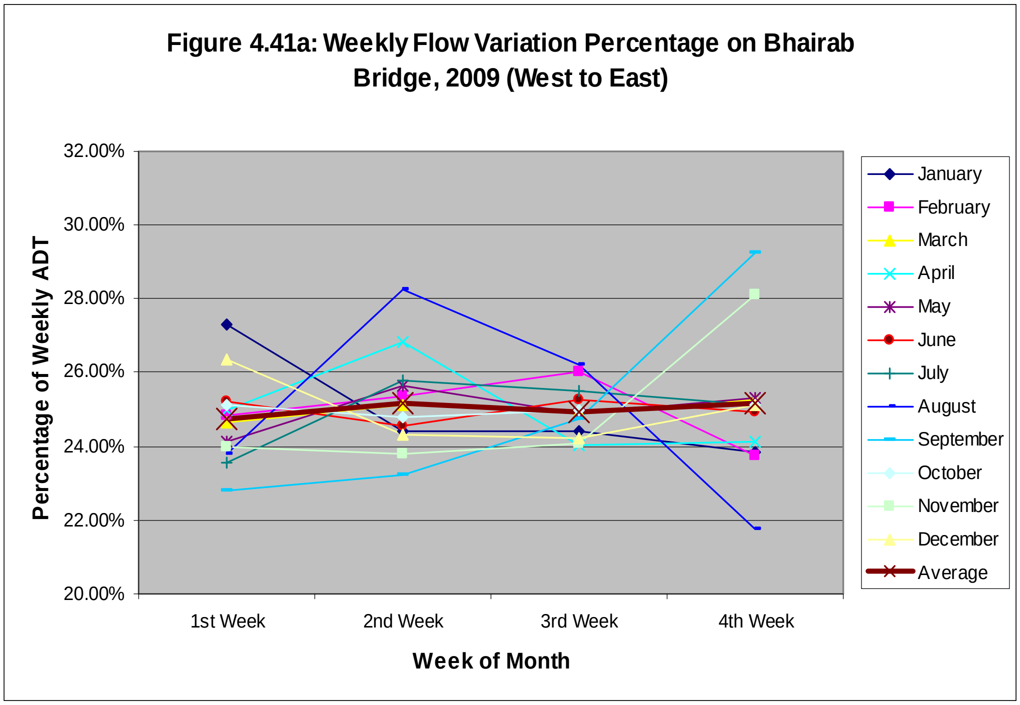
Vehicle Class	Flow Direction	Maximum Flow		Minimum Flow	
		Day of Week	Percentage of Weekly Volume	Day of Week	Percentage of Weekly Volume
Total Traffic	West to East	Friday	15.54%	Saturday	13.44%
	East to West	Friday	15.99%	Tuesday	13.60%
Large Bus & Medium Truck	West to East	Thursday	15.16%	Saturday	13.18%
	East to West	Friday	14.88%	Sunday	13.74%
Light Vehicles	West to East	Friday	17.76%	Tuesday	12.76%
	East to West	Friday	17.53%	Tuesday	12.80%

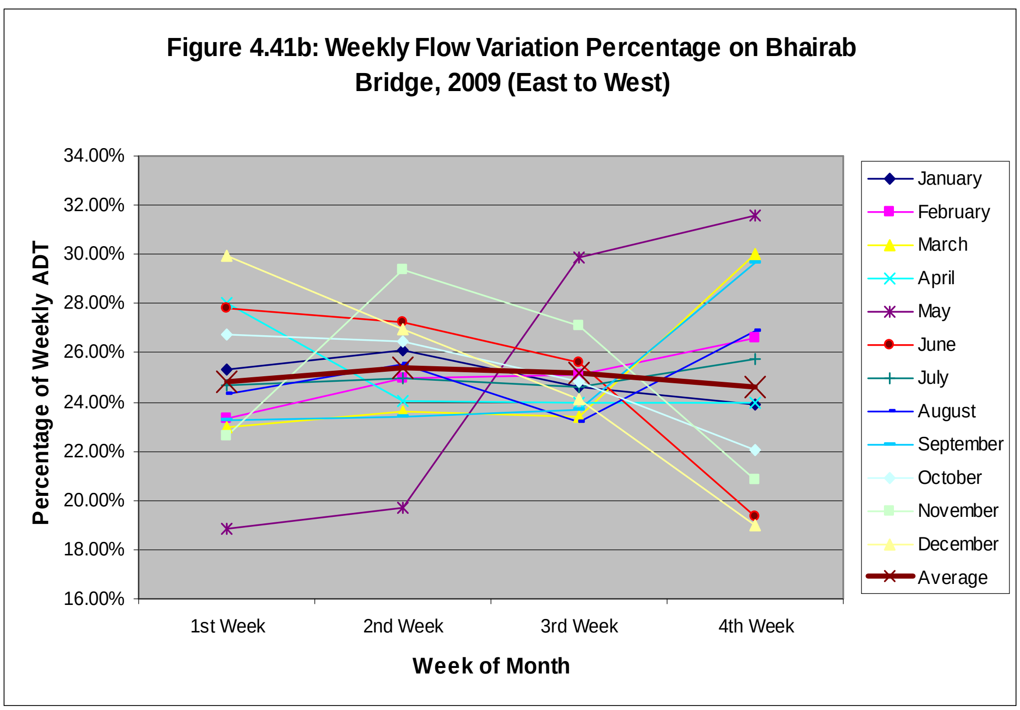
4.3.2 WEEKLY FLOW VARIATION

To find out weekly flow variation in N-2 corridor, a detail analyses have been done. Each month of a year has been divided into four weeks. The first three weeks have seven days each and the fourth week, except February, has 9 to 10 days depending on the month. So, it is anticipated that the fourth week will naturally contain more traffic. To compensate this possible error, the model uses weekly ADT and then compares between the four weekly ADTs of each month from January 2007 to December 2009. A typical table of weekly flow variation analysis is shown in Table 4.16, 4.16a and 4.16b.

Curves have been plotted in Figure 4.41a and 4.41b showing variation in weekly flow on Bhairab bridge in the year 2009. From the chart, it is seen that, the weekly flow percentages of most of the month maintain significant pattern in a year.

Individual two or three month shows different characteristics due to Eid day, hartal, etc.





From Figure 4.42, it implies that, in the North East side of our country, there exists specific weekly flow variation pattern. The average curve (for the year 2007, 2008, 2009) shows that, the second and third week of a month, there is a trend of increasing traffic slightly and the first and fourth week of the month traffic decrease same way.

However, Table 4.16 summarizes the weekly flow variation on Bhairab Bridge for three years. The graphical representation is shown in Figure 4.42, 4.42a and 4.42b. Year wise weekly flow fluctuation charts for the other two years are given in Appendix B (Figure B13 to B16).

Table 4.16: Summary of Weekly Flow Variation (Both Direction)

Year	Weekly Flow Percentage			
	1st Week	2nd Week	3rd Week	4th Week
2007	24.63%	25.08%	25.31%	24.97%
2008	24.87%	25.35%	25.07%	24.71%
2009	24.65%	25.04%	24.99%	25.31%
Average	24.72%	25.16%	25.12%	25.00%

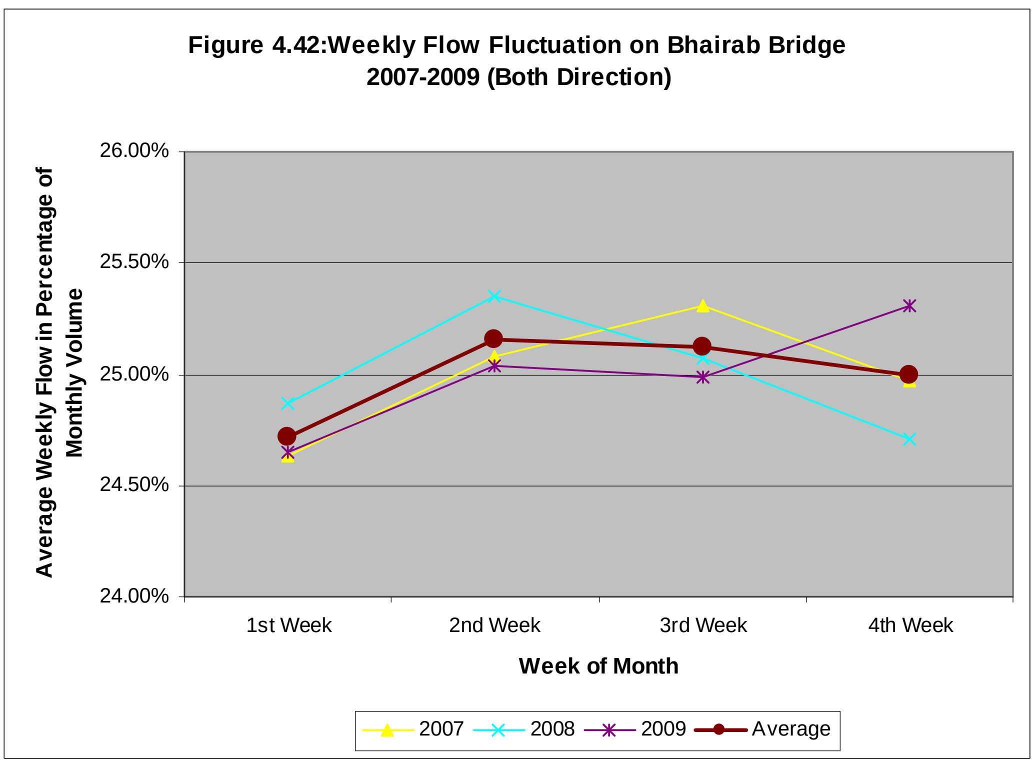


Table 4.16a: Summary of Weekly Flow Variation (West to East)

Year	Weekly Flow Percentage			
	1st Week	2nd Week	3rd Week	4th Week
2007	24.58%	25.10%	25.23%	25.09%
2008	24.90%	25.29%	24.98%	24.83%
2009	24.73%	25.15%	24.93%	25.19%
Average	24.74%	25.18%	25.05%	25.04%

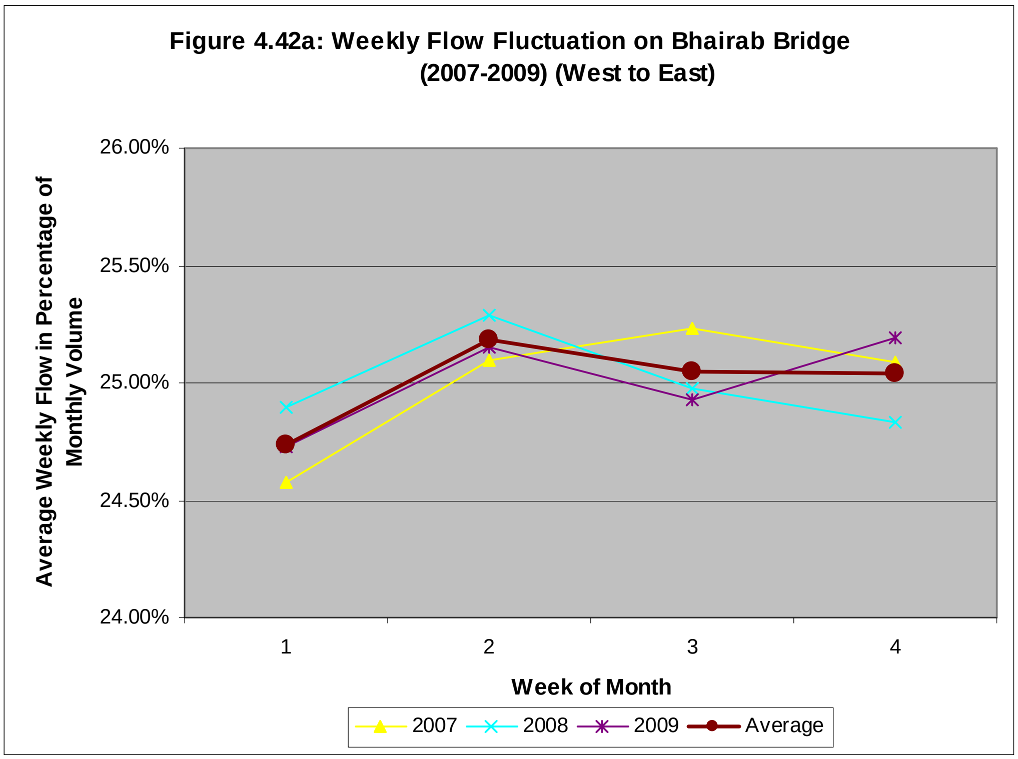
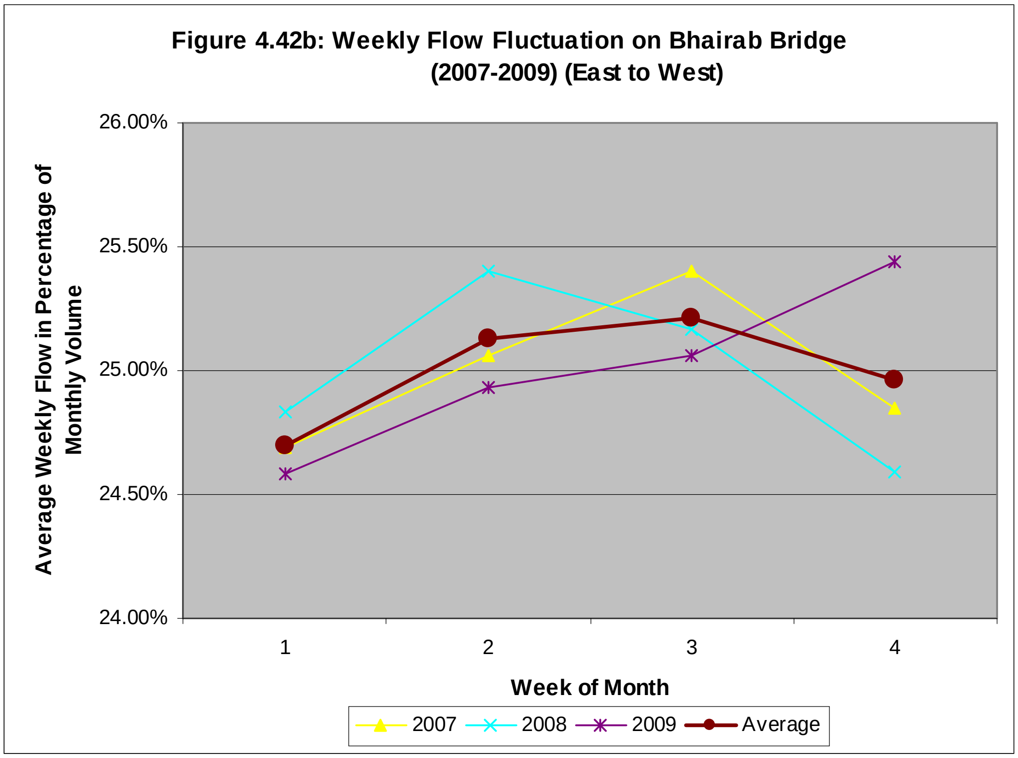


Table 4.16b: Summary of Weekly Flow Variation (East to West)

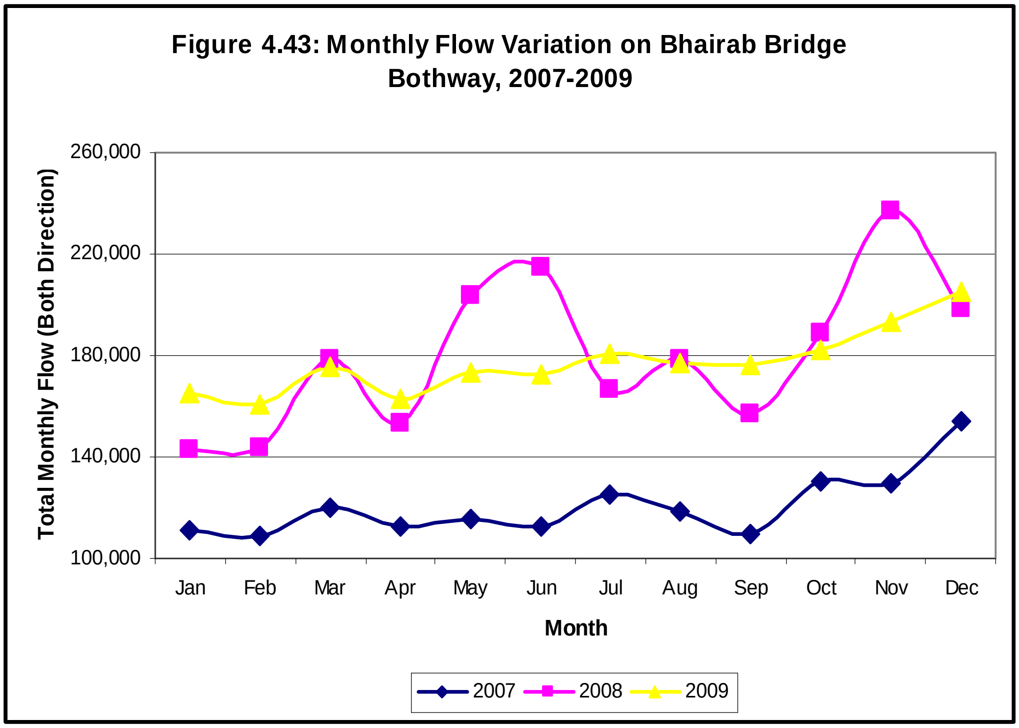
Year	Weekly Flow Percentage			
	1st Week	2nd Week	3rd Week	4th Week
2007	24.69%	25.06%	25.40%	24.85%
2008	24.83%	25.40%	25.17%	24.59%
2009	24.58%	24.93%	25.06%	25.44%
Average	24.70%	25.13%	25.21%	24.96%



4.3.3 MONTHLY FLOW VARIATION

In this part of thesis, three years of traffic flow data on Bhairab bridge collected from Sigma-RCL Joint Venture ltd. have been used for monthly flow variation analysis, which have given a thorough understanding of nature of traffic flow variation in different months of a year.

Characteristics curves showing monthly flow variation is shown in Figure 4.43. It can be seen that, monthly flow variation in every year shows very similar repetitive nature of flow fluctuation. The magnitude of flow has risen every year but the flow pattern remains same, which implies that month has influences over traffic flow along this corridor.



The following table (Table 4.17) shows the monthly flow variation on Bhairab bridge, in percentage of total yearly volume, for the years 2007 to 2009. The graphical representation is shown on Figure 4.44.

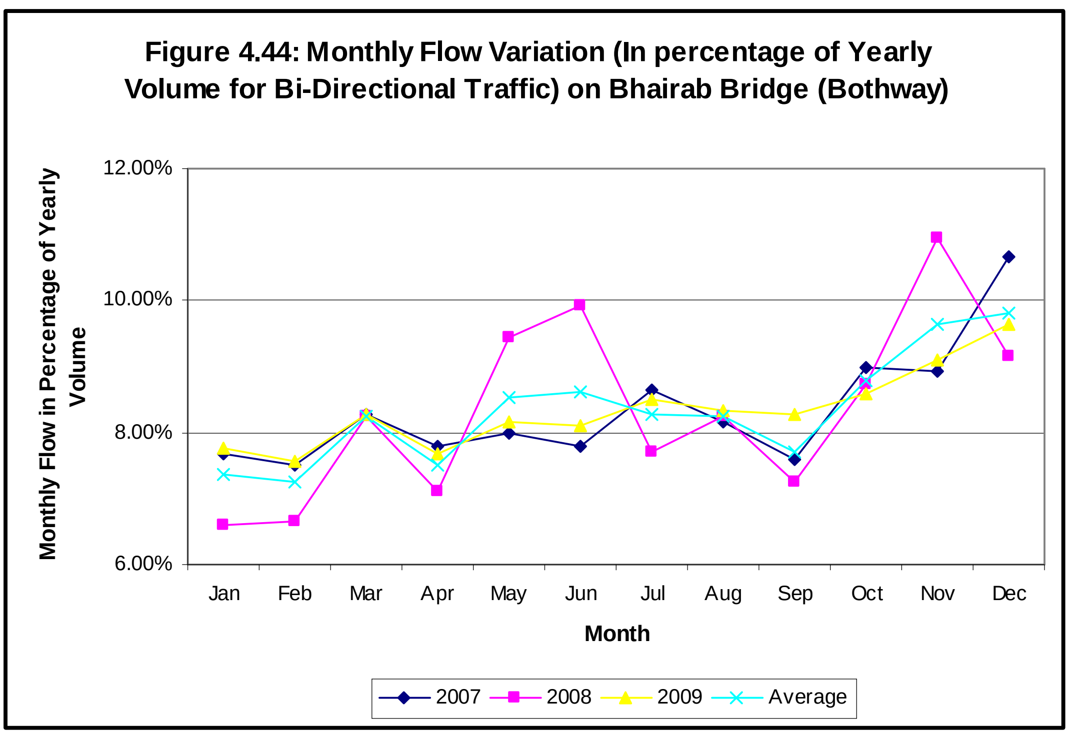


Table 4.17: Monthly Bi-directional Flow Variation on Bhairab Bridge, (2007-2009).

Month\Year	2007	2008	2009
Jan	111,264	142,849	165,147
Feb	108,794	143,810	160,869
Mar	119,673	178,453	175,773
Apr	112,696	153,613	162,958
May	115,816	204,053	173,608
Jun	112,770	214,629	172,284
Jul	125,261	166,635	180,520
Aug	118,221	178,741	176,987
Sep	109,984	157,233	175,972
Oct	130,364	189,231	182,337
Nov	129,286	236,827	193,099
Dec	154,420	198,370	204,986
Yearly Volume	**1,448,549**	**2,164,444**	**2,124,540**

Source Data: Sigma-RCL joint venture ltd.

Table 4.18 shows the maximum and minimum monthly flow percentage, by sorting the above table. Maximum and minimum flow is marked in red and blue respectively.

Table 4.18: Maximum & Minimum Monthly Flow Table

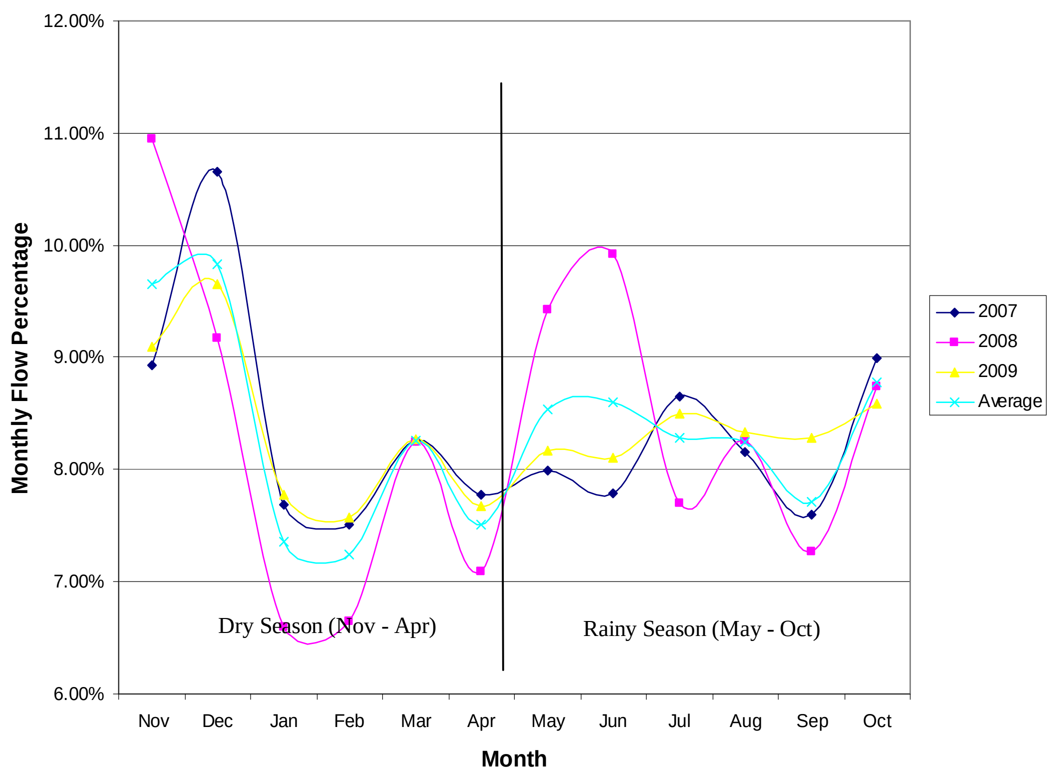
Month\Year	2007	2008	2009	Average
Jan	7.68%	6.60%	7.77%	**7.35%**
Feb	7.51%	6.64%	7.57%	**7.24%**
Mar	8.26%	8.24%	8.27%	**8.26%**
Apr	7.78%	7.10%	7.67%	**7.52%**
May	8.00%	9.43%	8.17%	**8.53%**
Jun	7.79%	9.92%	8.11%	**8.60%**
Jul	8.65%	7.70%	8.50%	**8.28%**
Aug	8.16%	8.26%	8.33%	**8.25%**
Sep	7.59%	7.26%	8.28%	**7.71%**
Oct	9.00%	8.74%	8.58%	**8.77%**
Nov	8.93%	10.94%	9.09%	**9.65%**
Dec	10.66%	9.16%	9.65%	**9.82%**
Total	100.00%	100.00%	100.00%	**100.00%**
Max.	10.66%	10.94%	9.65%	9.82%
Min.	7.51%	6.60%	7.57%	7.24%

Source Data: Sigma-RCL joint venture ltd.

It is seen from above tables that, the average maximum monthly flow percentage occurs more frequently on November and December while the average maximum flow occurs on December. On the other hand, February carries minimum flow more frequently. Broadly, it is observed, as shown in Table 4.19, (graphically represented in Figure 4.45) that more flow occurs on rainy season (50.15%) than on the dry season (49.85%). Following are the possible reasons behind such distribution of monthly flow.

- In Bangladesh dry season is considered from November to April, and rainy season stays from May to October. Because of less freight movement on waterways during the rainy season due to inconvenience of transport facilities, the traffic flow percentage on roadway is more. The seasonal distribution chart is as follows:

Figure 4.45: Seasonal Flow Variation on Bhairab Bridge 2007-2009 (Bothway)



- Recreational trips are more pronounced during the rainy season on Dhaka-Sylhet corridor.

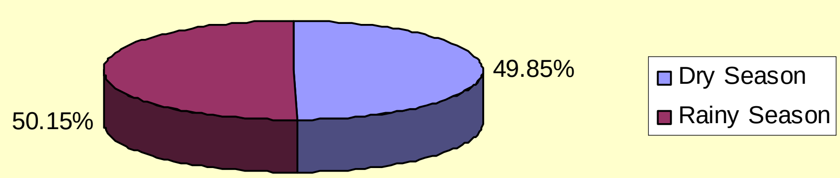
- Dhaka-Sylhet corridor is one of the largest national highway of Bangladesh. Fright mostly construction materials transported to the whole country from Sylhet and roadway is the best suitable mode of transport with respect of other modes as transport through road is speedy and time consuming. In this corridor, traffic intensity is more or less same throughout the year.

Table 4.19: Summarized Seasonal Flow Variation Table

Dry Season		Rainy Season	
Month	**Flow % in Season**	**Month**	**Flow % in Season**
Nov	9.65%	May	8.53%
Dec	9.82%	Jun	8.60%
Jan	7.35%	Jul	8.28%
Feb	7.24%	Aug	8.25%
Mar	8.26%	Sep	7.71%
Apr	7.52%	Oct	8.77%
Total	49.85%	Total	50.15%

Data Source: Sigma-RCL joint venture ltd.

Figure 4.46: Seasonal Distribution of Traffic on Bhairab Bridge (Bothway), 2007-2009



It is to be noted here that, February carries significantly lower volume of traffic. This may be because of lesser number of days in the month. Besides, in some years

February has fallen between two Eids and thus carrying lower volume of traffic in comparison to adjacent months.

Table 4.20 and 4.21 shows the monthly flow variation in years from 2007 to 2009 for Large Bus, Medium Truck and Light Vehicles at a glance, with maximum and minimum monthly flow marked as red and blue respectively. Year-wise separate tables showing seasonal flow variations are given in the Appendix B (Table B16 to B18).

Table 4.20: Monthly Flow Variation of Large Bus and Medium Truck on Bhairab Bridge

Year / Month	Total Monthly Flow of Large Bus and Medium Truck (Both Direction)			Monthly Flow Percentage of Large Bus and Medium Truck (Both Direction)			
	2007	2008	2009	2007	2008	2009	**Average**
Jan	55,810	64,822	68,119	7.88%	7.64%	8.62%	**8.05%**
Feb	57,520	63,600	68,617	8.12%	7.50%	8.69%	**8.10%**
Mar	63,631	70,617	74,848	8.98%	8.33%	9.47%	**8.93%**
Apr	60,228	63,878	67,281	8.50%	7.53%	8.52%	**8.18%**
May	59,436	78,671	60,142	8.39%	9.27%	7.61%	**8.43%**
Jun	55,202	92,079	62,258	7.79%	10.86%	7.88%	**8.84%**
Jul	60,302	64,395	63,152	8.51%	7.59%	7.99%	**8.03%**
Aug	57,616	66,040	57,255	8.13%	7.79%	7.25%	**7.72%**
Sep	54,841	63,303	56,227	7.74%	7.46%	7.12%	**7.44%**
Oct	56,494	60,468	75,122	7.97%	7.13%	9.51%	**8.20%**
Nov	61,687	95,520	58,447	8.71%	11.26%	7.40%	**9.12%**
Dec	65,764	64,837	78,503	9.28%	7.64%	9.94%	**8.95%**
Total	**708,531**	**848,230**	**789,971**	**100.00%**	**100.00%**	**100.00%**	**100.00%**
Max. Flow	65,764	95,520	78,503	9.28%	11.26%	9.94%	9.12%
Min. Flow	54,841	60,468	56,227	7.74%	7.13%	7.12%	7.44%

Source Data: Sigma-RCL Joint Venture ltd.

Table 4.21: Monthly Flow Variation of Light Vehicles on Bhairab Bridge

Year / Month	Total Monthly Flow of Light Vehicles (Both Direction)			Monthly Flow Percentage of Light Vehicles (Both Direction)			
	2007	**2008**	**2009**	**2007**	**2008**	**2009**	**Average**
Jan	27,793	45,913	53,202	7.17%	5.83%	8.15%	7.05%
Feb	26,031	47,555	47,905	6.71%	6.04%	7.34%	6.70%
Mar	27,798	69,684	52,390	7.17%	8.86%	8.02%	8.01%
Apr	25,296	51,560	47,146	6.52%	6.55%	7.22%	6.76%
May	27,865	81,755	54,311	7.18%	10.39%	8.32%	8.63%
Jun	30,278	79,406	54,689	7.81%	10.09%	8.37%	8.76%
Jul	36,004	61,985	60,007	9.28%	7.88%	9.19%	8.78%
Aug	31,213	67,129	55,384	8.05%	8.53%	8.48%	8.35%
Sep	28,024	48,789	52,416	7.22%	6.20%	8.03%	7.15%
Oct	38,543	73,096	52,216	9.94%	9.29%	8.00%	9.07%
Nov	36,629	83,890	59,362	9.44%	10.66%	9.09%	9.73%
Dec	52,424	76,119	64,069	13.51%	9.67%	9.81%	11.00%
Total	**387,898**	**786,881**	**653,097**	**100.00%**	**100.00%**	100.00%	100.00%
Max. Flow	52,424	83,890	64,069	13.51%	10.66%	9.81%	11.00%
Min. Flow	25,296	45,913	47,146	6.52%	5.83%	7.22%	6.70%

Source Data: Sigma-RCL Joint Venture ltd.

Figure 4.47: Seasonal Flow Variation of Large Bus and Medium Truck (Both Direction), 2007-2009

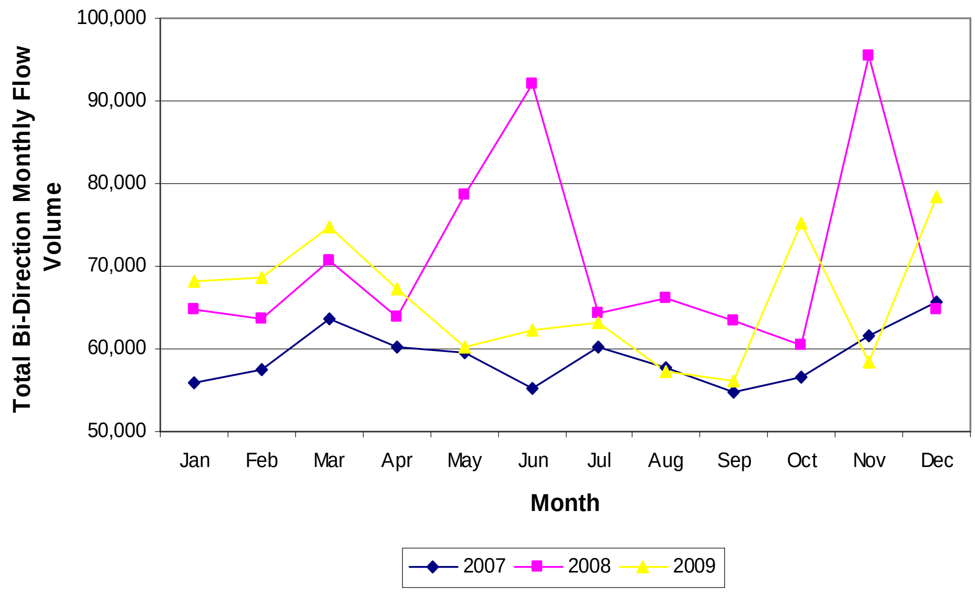
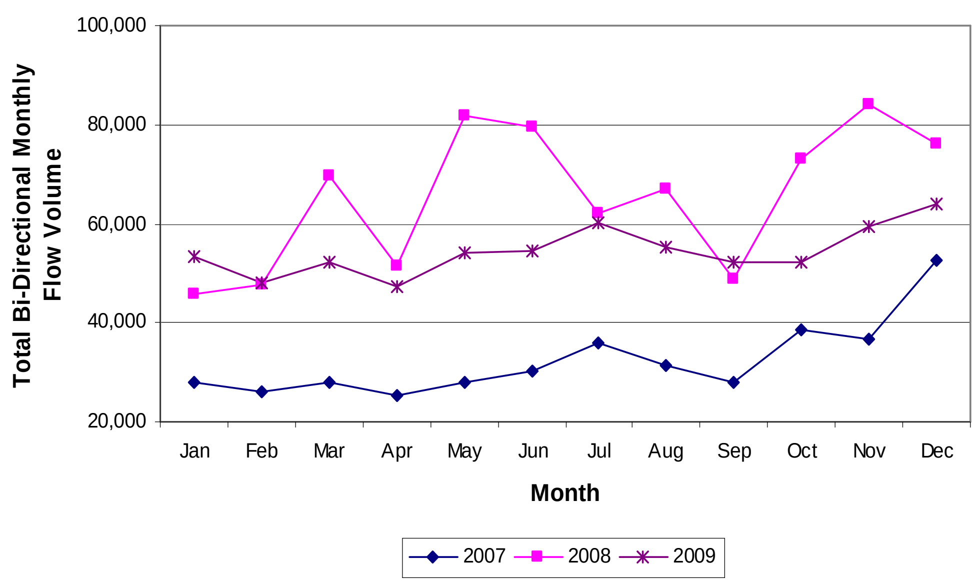


Figure 4.48: Seasonal Flow Variation of Light Vehicle (Both Direction), 2007-2009



Summary of Findings:

Following are the summarized findings from the seasonal flow analysis on Bhairab Bridge.

Table 4.20: Summary Table - Seasonal Flow Variation (average of three years)

Vehicle Class	Maximum Flow		Minimum Flow	
	Month	Percentage of Yearly Volume	Month	Percentage of Yearly Volume
Total Traffic	December	9.82%	February	7.24%
Large Bus and Medium Truck	November	9.12%	September	7.44%
Light Vehicles	December	11.00%	February	6.70%

4.3.4 TRAFFIC COMPOSITION

The proportion of heavy vehicles in a traffic stream is very important parameter for geometric and structural design of any pavement. Analysis of traffic composition gives the idea of proportion of heavy vehicles. So, it is crucial to know the traffic composition of N-2 corridor in order to evaluate it's pavement design parameters.

Vehicles moving all over the country in Bangladesh are the same nature. But different toll operators are using different vehicle classification system in the highways and making traffic composition analysis more complex. In Bhairab bridge, since it is a tolled bridge, it was necessary to define a vehicle classification for setting toll amount for different classes of vehicles passing through the bridge. The classification system has some serious laggings which have been discussed in the latter part of this thesis.

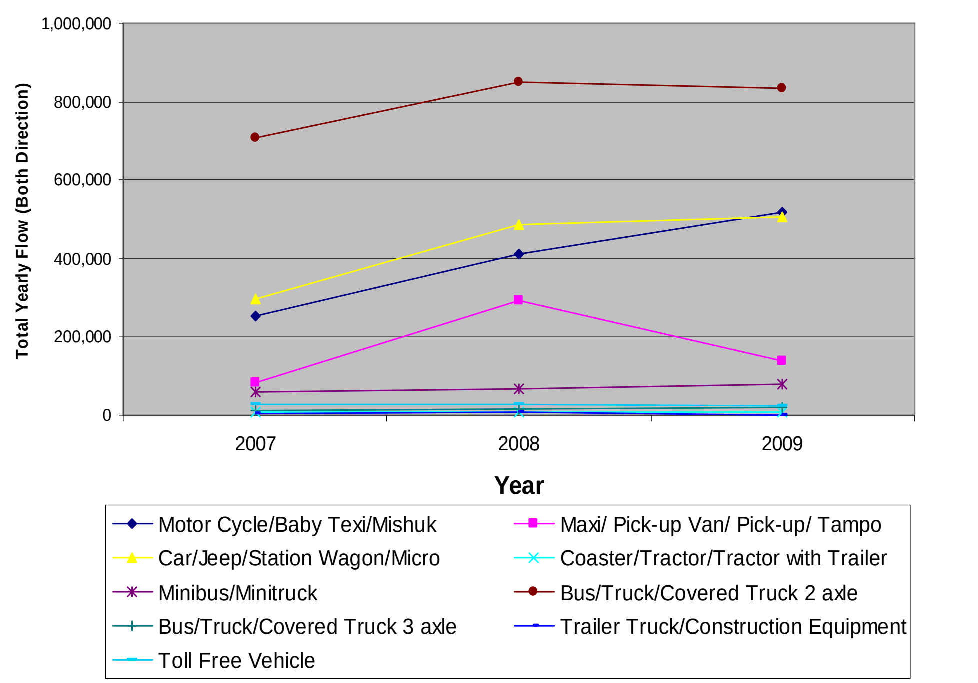
In Bhairab bridge, total traffic is divided into eight classes considering vehicle size and capacity as follows.

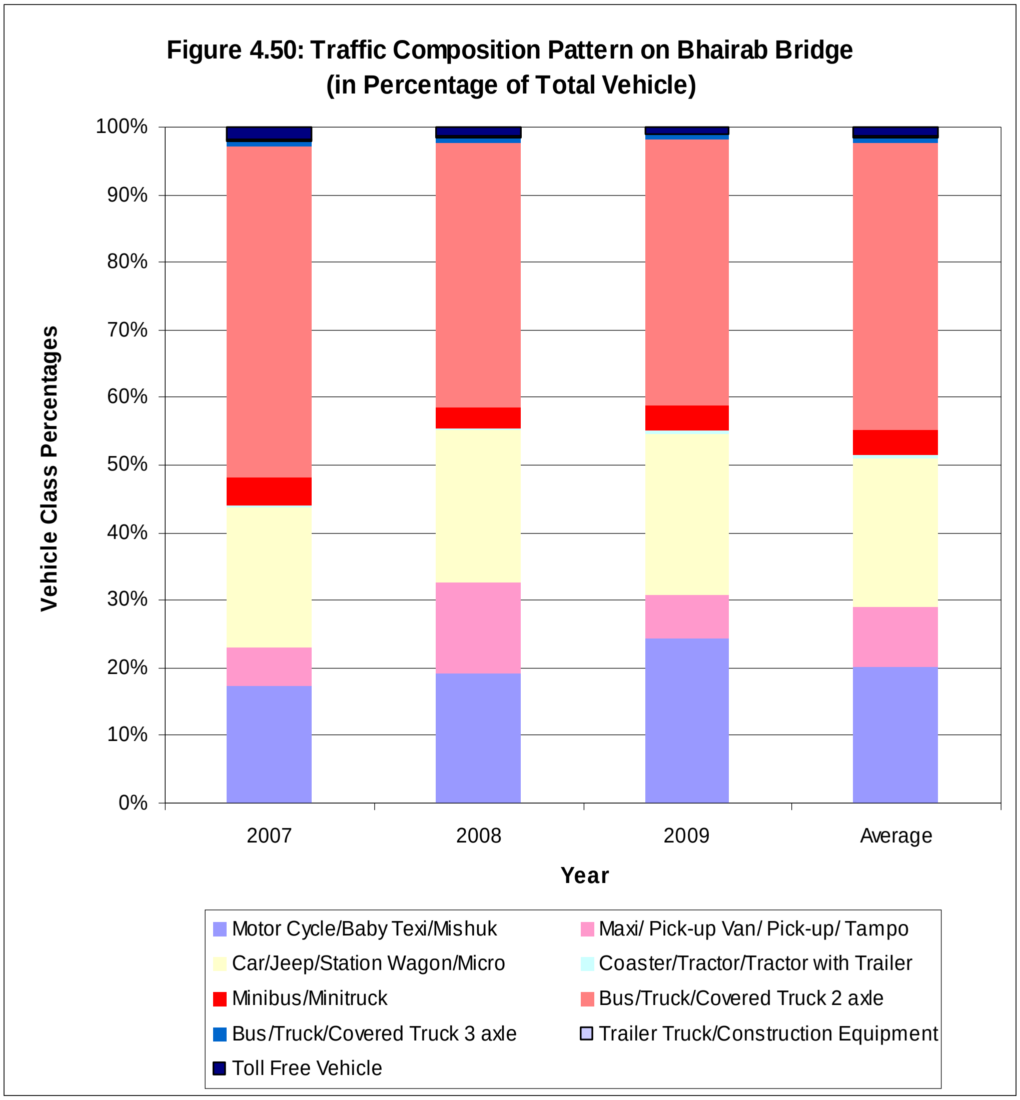
1. Class I: Motor cycle/Baby Taxi/Mishuk
2. Class II: Maxi/Pick-up Van/ Pick-up/Tampo
3. Class III: Car/Jeep/Station Wagon/Micro

4. Class IV: Coaster/Tractor/Tractor with Trailer
5. Class V: Mini bus/Mini truck
6. Class VI: Bus/Truck/Covered Truck 2 axle
7. Class VII: Bus/Truck/Covered Truck 3 axle
8. Class VIII: Trailer Truck/Construction Equipment.

Figure 4.49 shows the classification wise yearly volume of traffic on N-2 corridor, while Figure 4.50 shows the traffic composition pattern from 2007 to 2009 on Bhairab Bridge. It is seen from the graph that most predominant vehicle classes are medium truck, large bus and light vehicles. The proportion of Bus/Truck/Covered Truck 2 axle is the highest quantity of the existing traffic. Car/Jeep/Station wagon/Micro is the second prevailing vehicle class. The number of Motor cycle/Baby Taxi/Mishuk has considerably increased from 2007 to 2009. On the other hand, quantity of Maxi/Pick-up/Tampo has decreased considerably from 2008 to 2009. The percentage of trailer truck/construction equipment on N-2 corridor is very low.

Figure 4.49: Vehicle Class-wise Yearly Flow on Bhairab Bridge





In Figure 4.50, vehicle class percentages on Bhairab bridge are shown. It is found that, Bus/Truck/Covered Truck 2 axle has the highest percentage in the traffic stream. The percentage of Bus/Truck/Covered Truck 2 axle from 2007 to 2009 is 48.91%, 39.19% and 39.28% respectedly. The average percentage of Bus/Truck/Covered Truck 2 axle from 2007 to 2009 is 42.46%. The second highest percentage of vehicle class is Motor Cycle/Baby Taxi/Mishuk, the proportion of which was 17.36% in 2007 and 24.35% in 2009. The average percentage of this vehicle class from 2007 to 2009 is 22.26%. The third highest contributing class to the total traffic flow is Light Vehicles, which includes Car/Jeep/Station Wagon/Micro. In 2007, its percentage was 20.50% and after gradual increase in proportion, it became 23.74% in the year of 2009, the average is found to be 22.24%. Taking the traffic flow data on Bhairab Bridge from 2007 to 2009, it is found that these three pre-dominant vehicle classes comprise of total 84.97% of total traffic flow. Rest 15.03% is shared between Maxi/Pick-up/Tampo (8.63%), Mini bus/Mini Truck (3.59%), Bus/Truck/Covered Truck 3 axle (0.81%) and Coaster/Tractor/Tractor with Trailer (0.41%). The traffic percentage is increasing every year in N-2 corridor that is stressful for the pavement. From 2007 to 2009, the percentage of Motor Cycle/Baby Texi/Mishuk has increased from 17.36% to 24.35%, Car/Jeep/Station Wagon/Micro slightly increased from 20.50% to 23.74%, the percentage of Maxi/ Pick-up/ Pick-up/ Tampo has risen from 5.82% to 6.56%, Minibus/Minitruck slightly decreased from 3.98% to 3.68% and Bus/Truck/Covered Truck 2 axle decreased considerably from 48.91% to 39.28%. It is a matter of surprise that, 2 axle truck and bus has the same toll class and same rate. The amount and percentage of truck on N-2 corridor cannot be determined due to this faulty classification system.

It is also to be noted here that, the government and army vehicles, operator’s vehicles and some other VVIP vehicles are counted by the operator since they are toll exempted and this toll free vehicles are 1.42% of total traffic.

4.3.5 HEAVY VEHICLE PERCENTAGE

Percentage of heavy vehicles refers to the percentage of truck and bus in a traffic stream. Heavier vehicles cause more damage to the roadway. For this reason, this is an important parameter for structural design of highway. Moreover, higher proportion of larger sized vehicles is important in the aspect of geometric design of highways as large vehicles are critical for the design of grade, turnings, road width, warrant for curve widening and auxiliary lane at vertical curve etc. The following section discusses the proportion of heavier vehicles on N-2 corridor and their travel pattern.

4.3.5.1 TRUCK AND BUS PERCENTAGE

In Bhairab toll plaza, according to the vehicle classification system used by the operators, truck as a class is sub-divided into three groups namely small trucks, medium trucks and large trucks. Small trucks are of capacity less than 5 tons. In

Bangladesh commonly used 3-ton capacity trucks, mainly small utility covered trucks are contained within this class. Trucks having capacity of 5 ton to 8 ton are classed as Medium trucks. This class is most common in Bangladesh and hence contributor of the highest percentage of traffic. Large trucks' capacity is more than 8 ton and usually possesses more than two rear axles. It is observed from field survey that the toll collectors are often confused about the classification between the trucks falling near to boundary conditions.

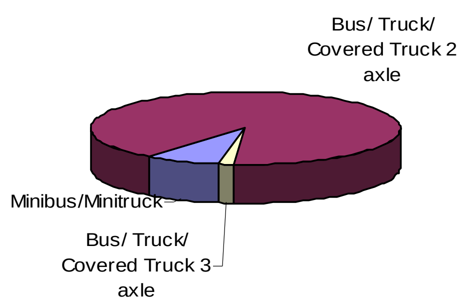
However, from the analysis of traffic flow data from 2007 to 2009 on Bhairab toll plaza, taking the average of these years, it is found that the average percentages of minibus/mini truck, bus/truck/covered truck 2 axle, bus/truck/covered truck 3 axle are 7.67%, 90.59% and 1.74% respectively (Figure 4.51). Table 4.21 shows the year-wise bus and truck percentages.

Table 4.21: Bus and Truck Percentages on Bhairab-Ashuganj Toll Plaza (Both Direction)

Year	MiniBus/Mini Truck	Bus/Truck/Covered Truck 2 Axle	Bus/Truck/Covered Truck 3 Axle	Total Bus and Truck
2007	7.39%	90.98%	1.63%	**100.00%**
2008	7.20%	91.15%	1.65%	**100.00%**
2009	8.41%	89.65%	1.94%	**100.00%**
Average	**7.67%**	**90.59%**	**1.74%**	**100.00%**

Date Source: RCL-Sigma JV.

Figure 4.51: Annual Bus & Truck Percentages on Bhairab Bridge (Average from 2007 to 2009)



4.3.6 DIRECTIONAL DISTRIBUTION

Directional distribution is a vital parameter for evaluation of pavement. The ratio of mixed traffic is high in Bangladesh and hence, directional distribution plays a significant role. The detail analyses of directional distribution in N-2 corridor are explained below.

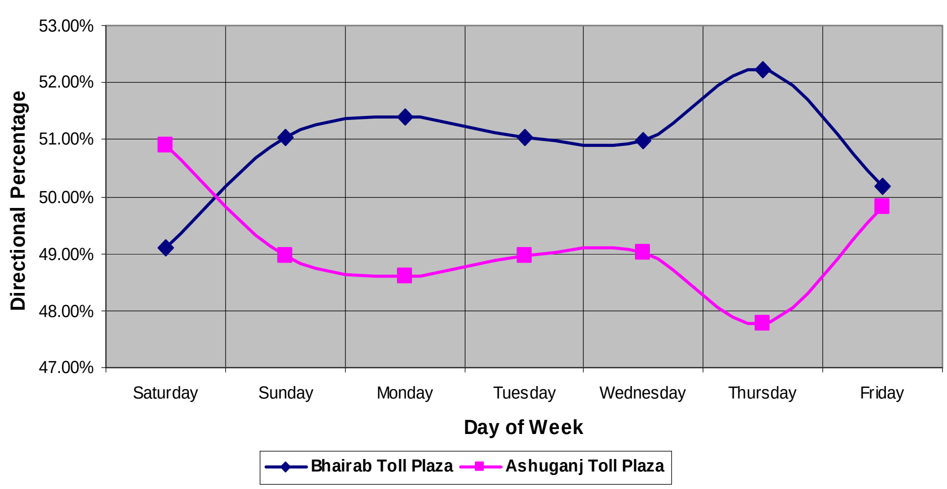
4.3.6.1 DAILY DIRECTIONAL DISTRIBUTION

Analysis of daily directional distribution of traffic on Bhairab bridge has been done using 3 years (2007 to 2009) of traffic data collected by Sigma-RCL JV ltd. In Table 4.22, the summarized daily directional distribution data are shown. Here average daily ADT on each day of week have been determined from 3 years' data.

Table 4.22: Daily Directional Distribution of Traffic on Bhairab Bridge

Weekday	Avg. Daily ADT			Directional Split	
	West to East	East to West	Total	West to East	East to West
Saturday	2,506	2,596	5,102	49.11%	50.89%
Sunday	2,582	2,477	5,059	51.04%	48.96%
Monday	2,609	2,467	5,076	51.39%	48.61%
Tuesday	2,548	2,445	4,993	51.03%	48.97%
Wednesday	2,610	2,509	5,119	50.98%	49.02%
Thursday	2,874	2,629	5,503	52.22%	47.78%
Friday	2,906	2,885	5,791	50.17%	49.83%

Figure 4.52: Daily Directional Distribution of Traffic in N-2 Corridor



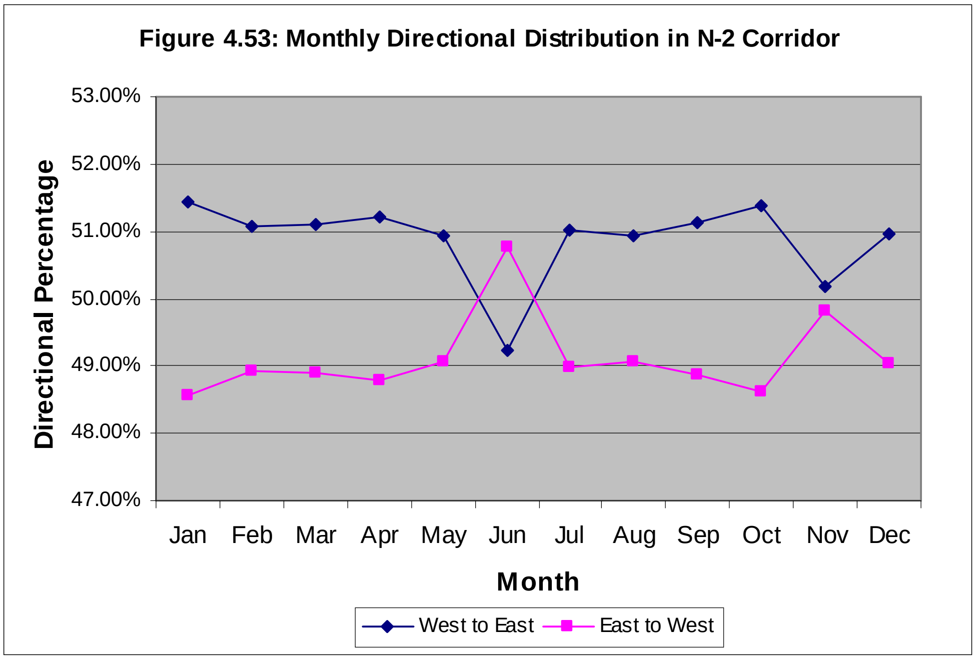
It can seen in Figure 4.52 that, daily directional distribution varies from around 47% to 53%. People working in and around capital Dhaka tend to visit their native town/village on the weekend and thus causing maximum flow on Thursday, which is 52.22%. Again, they return to their workplaces in and around Dhaka on Saturday creating maximum flow on Saturday, which is 50.89%.

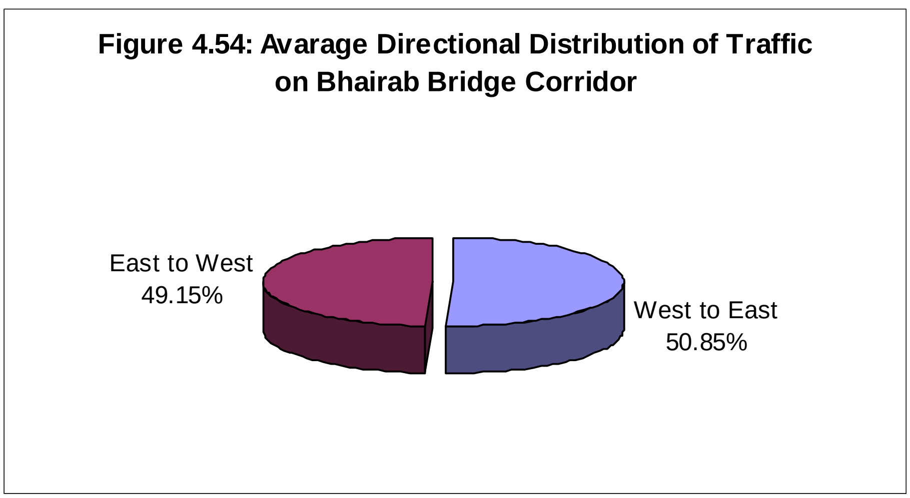
4.3.6.2 MONTHLY DIRECTIONAL DISTRIBUTION

Month-wise directional distribution of traffic on Bhairab bridge is shown in Table 4.23. Figure 4.53 shows the graphical representation. From the table and Figure, it can be seen that, the directional split is very close to 50%. This implies that there is no alternate route available for the users of this bridge. The overall directional distribution, averaged over 3 years monthly traffic flow data, is found to 50.85% in the West to East direction and 49.15% in the East to West Direction. Figure 4.54 shows the overall directional distribution of traffic on Bhairab bridge.

Table 4.23: Monthly Directional Distribution of Traffic on Bhairab Bridge

Month	Average Monthly Volume (2007 to 2009)			Directional Split	
	West to East	East to West	Total	West to East	East to West
Jan	71,874	67,879	139,753	51.43%	48.57%
Feb	70,396	67,428	137,824	51.08%	48.92%
Mar	80,735	77,231	157,966	51.11%	48.89%
Apr	73,289	69,800	143,089	51.22%	48.78%
May	83,762	80,731	164,492	50.92%	49.08%
Jun	81,983	84,578	166,561	49.22%	50.78%
Jul	80,338	77,134	157,472	51.02%	48.98%
Aug	80,449	77,534	157,983	50.92%	49.08%
Sep	75,549	72,181	147,730	51.14%	48.86%
Oct	85,951	81,360	167,311	51.37%	48.63%
Nov	93,521	92,883	186,404	50.17%	49.83%
Dec	94,745	91,180	185,925	50.96%	49.04%
Average	81,049	78,327	159,376	**50.85%**	**49.15%**





4.3.7 IMPACT OF EID FESTIVALS ON TRAFFIC FLOW

Eid festivals leave significant impact on traffic flow on Bhairab Bridge, which is anticipated in other corridors in Bangladesh as well. Due to this, different traffic flow parameters are greatly affected and thus the need for analyzing the extent of Eid Festivals' impact is deeply realized. Since, the traffic flow around an Eid is higher than usual traffic flow, it is easily understood that, a factor representing the impact of Eid festival should be determined by which the traffic flow around an Eid can be more precisely estimated, which is expected to be the critical flow value.

For this analysis, three years of continuous daily traffic flow data obtained from SIGMA-RCL JV have been used. To identify the variation caused by Eid festivals, traffic flow in month containing Eid shall be compared with average yearly traffic flow or even traffic flow in other years for that particular month not containing Eid. By summarizing five years' continuous daily flow data, it is found that, taking the average daily flow on all months in successive five years, the average daily flow percentage is around 3.10% to 3.70% of corresponding monthly flow volume (Figure. 4.55).

Figure 4.55: Average Continuous Daily Flow Percentage in N-2 Corridor

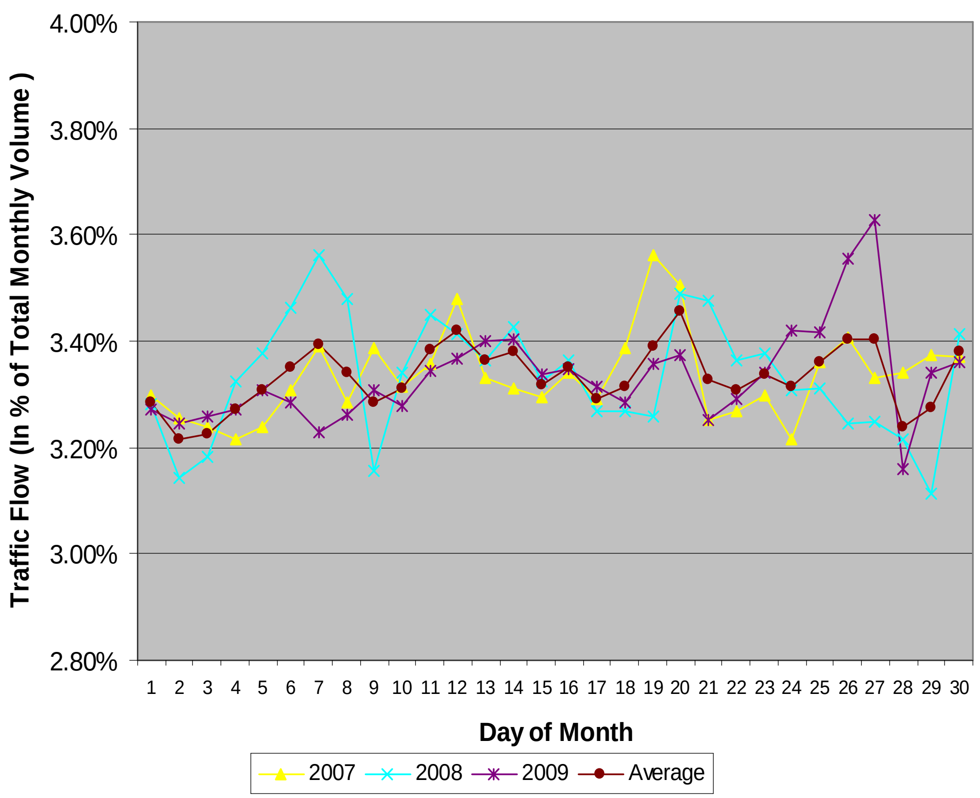


Table 4.24: Summarized Daily Flow Percentage Table (Both Direction)

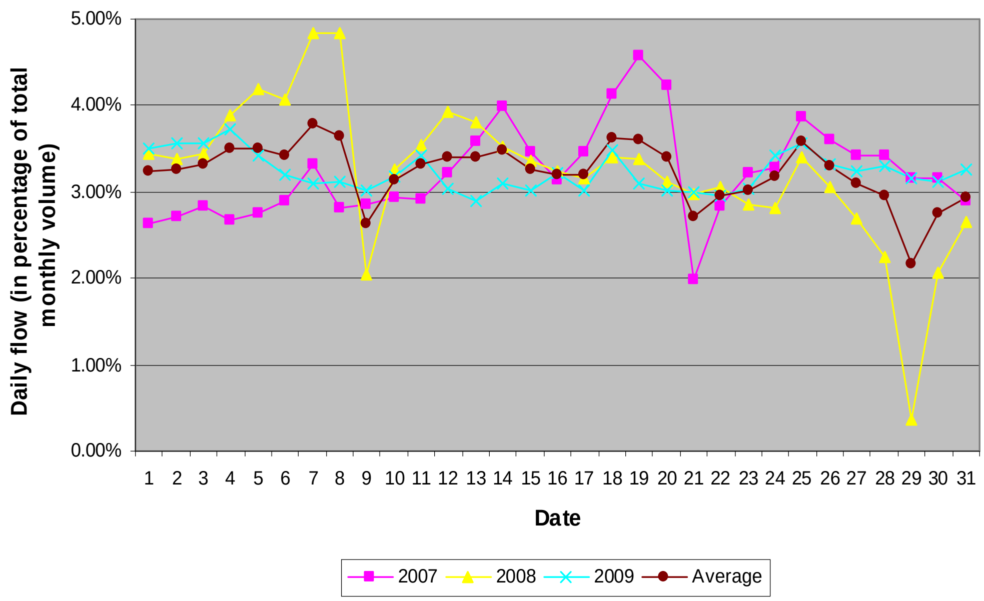
Date	Daily Flow Percentage (Averaged Over 12 Months)			
	2007	2008	2009	Average
1	3.30%	3.28%	3.27%	3.28%
2	3.25%	3.14%	3.25%	3.21%
3	3.24%	3.18%	3.26%	3.23%
4	3.22%	3.33%	3.27%	3.27%
5	3.24%	3.38%	3.31%	3.31%
6	3.31%	3.46%	3.28%	3.35%
7	3.39%	3.56%	3.23%	3.39%
8	3.29%	3.48%	3.26%	3.34%
9	3.39%	3.16%	3.31%	3.28%
10	3.31%	3.34%	3.28%	3.31%
11	3.36%	3.45%	3.34%	3.38%
12	3.48%	3.41%	3.37%	3.42%
13	3.33%	3.36%	3.40%	3.37%
14	3.31%	3.43%	3.40%	3.38%
15	3.29%	3.32%	3.34%	3.32%
16	3.34%	3.36%	3.35%	3.35%
17	3.29%	3.27%	3.31%	3.29%
18	3.39%	3.27%	3.28%	3.31%
19	3.56%	3.26%	3.36%	3.39%
20	3.50%	3.49%	3.37%	3.46%
21	3.25%	3.48%	3.25%	3.33%
22	3.27%	3.37%	3.29%	3.31%
23	3.30%	3.38%	3.34%	3.34%
24	3.21%	3.31%	3.42%	3.31%
25	3.36%	3.31%	3.42%	3.36%
26	3.41%	3.25%	3.55%	3.40%
27	3.33%	3.25%	3.63%	3.40%
28	3.34%	3.21%	3.16%	3.24%
29	3.37%	3.11%	3.34%	3.28%
30	3.37%	3.41%	3.36%	3.38%
	100.00%	100.00%	100.00%	100.00%
Average Daily Flow Percentage (Averaged Over 3 Years)				3.33%
Standard Deviation				0.06%

Data Source: SIGMA-RCL JV.

In Table 4.24, daily both directional flows, in percentage of total monthly volume, averaged over 12 months, from 2007 to 2009, is shown. The average daily flow percentage comes to be 3.33% with an astonishing standard deviation of only 0.06%. This leads to a fact that, even with the effects of all external factors causing deviations in normal traffic flow, the average daily flow is quite predictable.

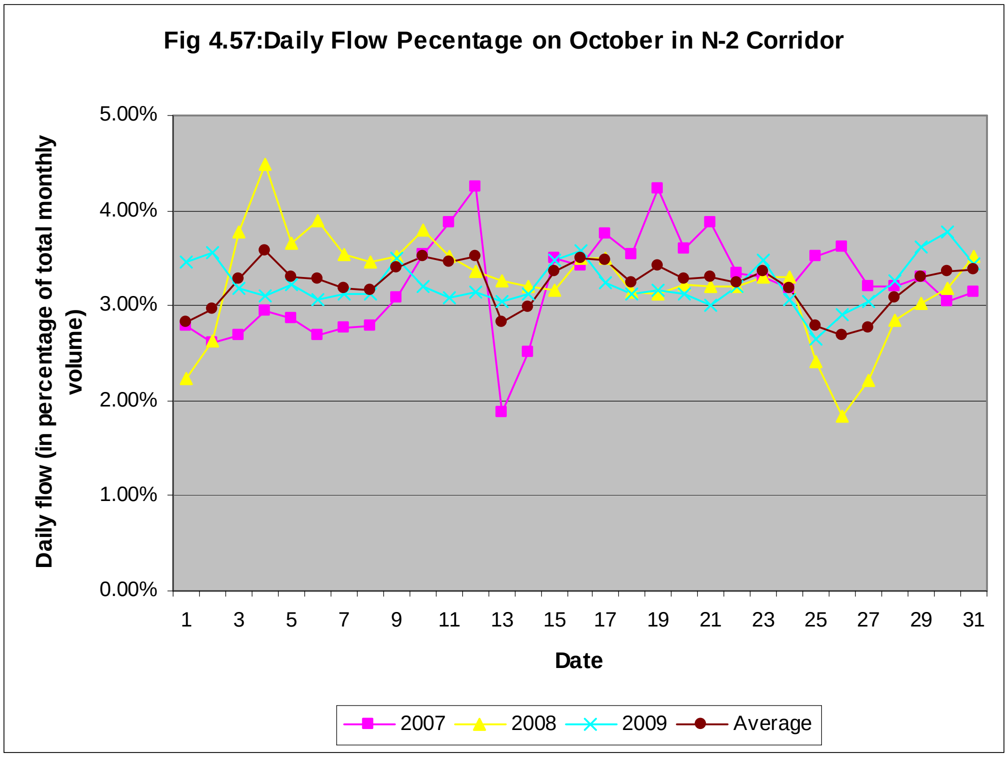
Now, for the years under consideration in this study, months from September to January have contained two Eid festivals. If an Eid month, say December is taken into account, the flow variation exhibits some remarkable facts, as shown in Figure 4.56.

Fig 4.56: Daily Flow Pecentage on December



It can be clearly seen that 2009 year maintain near about 2.90% to 3.80% of daily flow percentage, since December did not contain any Eid during this years. On the contrary, for the years 2007 and 2008, two distinct peaks followed by abrupt fall in traffic flow are observed. In all cases, the lowest traffic occurred on Eid day and the peak flow has taken place two days prior to Eid. Naturally one can understand that, this has happened because of increased passenger movement during Eid, as most city people usually spend Eid at their native town or village and the Eid vacation starts from the previous day of Eid day. So, the peak flow occurs two days prior to

Eid. Flow chart for October also exhibits similar characteristics, as shown in Figure 4.57.



In this case, the Eid festivals have taken place on October in the years 2007 and 2008. In every case, the flow rises to the peak before Eid and immediately falls on Eid day. Some other falls are also observed which might have occurred for strikes or Hartals. But, since these are potentially creating critical flow value, the issue is not important in this study.

From the above analysis for all individual Eid months, it has been found that, the peak flow percentage raises upto 4.90% in December 2008. But in most of the cases the peak value stays within a range of 4.00% to 5.00%, which is approximately 60% higher than normal traffic flow.

Another approach can be made to see the impact of Eid festivals on daily traffic flow. If all the daily bi-directional flow in a particular year is sorted in the descending order, it is found that, most of the peak daily volume occurs within one week of Eid. In Table 4.25, the daily both directional traffic volumes in the year 2007 to 2009 has been sorted in descending order and highest 15 daily volumes are listed. It is observed that, most of the days carrying highest daily traffic in a year are within a week of an Eid.

It is also found that, the highest daily flow in a year caused by Eid event carries as much as 171.51% higher volume than AADT of that particular year. From this analysis, one can easily understand that, the highest daily flow in a particular year occurs at the time of Eid and the transportation planners should consider this fact while designing highways in Bangladesh.

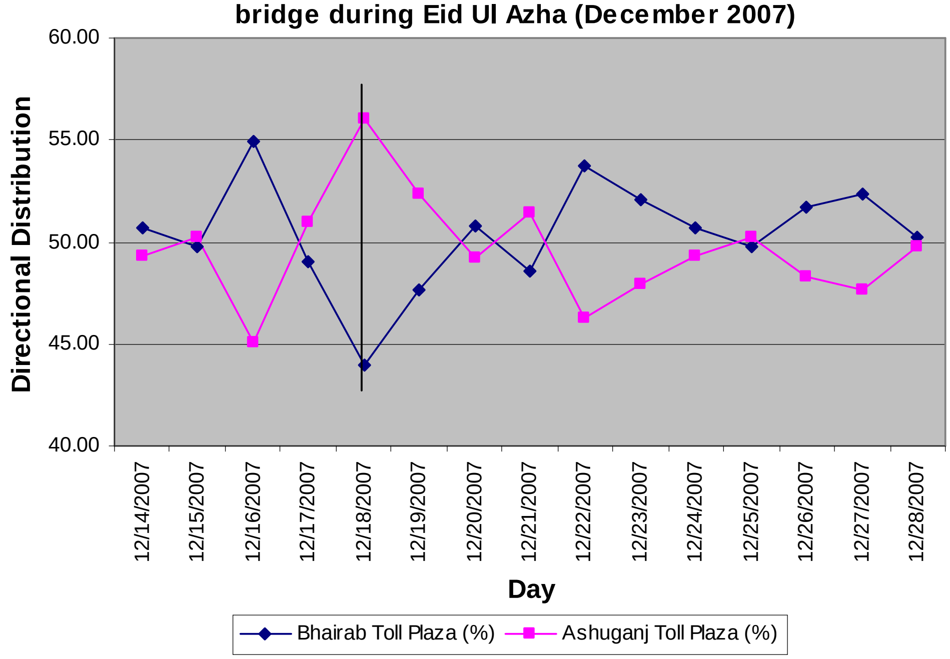
Table 4.25: Highest Daily Traffic Flow within a Year

Sl. No. (In Descending Order of Daily Flow Volume)	2007 (AADT = 3967)			2008 (AADT = 5928)			2009 (AADT = 5821)		
	Date	Total Bi-Directional Daily Flow	Percentage higher than AADT	Date	Total Bi-Directional Daily Flow	Percentage higher than AADT	Date	Total Bi-Directional Daily Flow	Percentage higher than AADT
1	01/06/07	10771	171.51%	12/07/08	9605	62.03%	11/27/09	11375	95.41%
2	01/05/07	9590	141.74%	12/08/08	9597	61.89%	11/26/09	9416	61.76%
3	12/19/07	7065	78.09%	10/04/08	8501	43.40%	09/25/09	7963	36.80%
4	12/20/07	6546	65.01%	12/05/08	8302	40.05%	12/04/09	7631	31.09%
5	01/04/07	6441	62.36%	12/06/08	8071	36.15%	11/25/09	7418	27.44%
6	12/18/07	6389	61.05%	09/30/08	7812	31.78%	12/03/09	7312	25.61%
7	12/14/07	6145	54.90%	12/12/08	7790	31.41%	12/02/09	7285	25.15%
8	12/25/07	5962	50.29%	12/04/08	7711	30.08%	12/01/09	7181	23.36%
9	12/26/07	5574	40.51%	12/13/08	7530	27.02%	09/24/09	7158	22.97%
10	10/12/07	5543	39.73%	10/06/08	7384	24.56%	09/26/09	7133	22.54%
11	10/19/07	5512	38.95%	10/03/08	7133	20.33%	12/03/09	7130	22.49%
12	12/15/07	5350	34.86%	09/29/08	7046	18.86%	09/30/09	7130	22.49%
13	12/17/07	5337	34.53%	12/11/08	7015	18.34%	12/05/09	7019	20.58%
14	12/28/07	5297	33.53%	12/14/08	6992	17.95%	11/24/09	6967	19.69%
15	12/27/07	5270	32.85%	10/05/08	6933	16.95%	11/23/09	6614	13.62%

Now, this is of interest to see whether this causes any significant directional split. The both directional flow percentage itself has come to be 171.50% higher than average daily flow. If that is coupled with higher percentage of flow in a particular direction, that will certainly pertain the highest flow value, which is critical for geometric design.

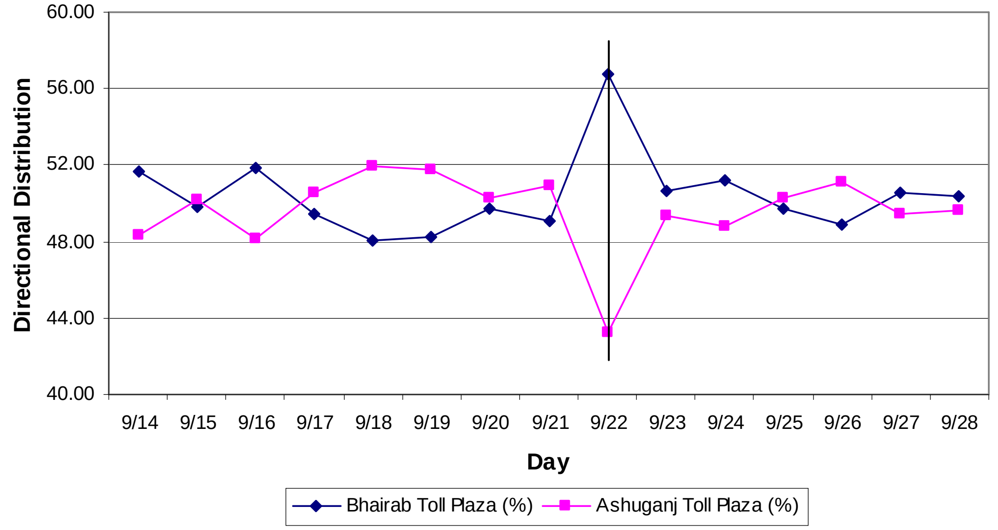
In the directional distribution analysis it has been found that the maximum directional split come to be 51.43% and mostly it is a 50-50 directional distribution corridor. But from the directional distribution curve plotted in Figure 4.58, it is found that, in December, 2007 the West to East to flow before 5 days of Eid has reached up to 55.00%, which is significantly higher than normal directional distribution. Also, two days before Eid, there is significant rise of directional distribution of traffic from East to West, which is 55.10%. Moreover, it is observed that, before Eid festival, the variation of directional distribution increases from around five days and reaches the maximum and then starts falling slowly and become normal after Eid. From similar analysis for other Eid months, it has been found that the impact of Eid start from five days prior to the Eid day and stays until 5/6 after Eid.

Figure 4.58: Directional Distribution of traffic along Bhairab bridge during Eid Ul Azha (December 2007)



Similar analysis of Eid impact on directional distribution of traffic flow is shown in Figure 4.59, where the maximum directional split from West to East is 56.50%.

Figure 4.59: Directional Distribution of Traffic along Bhairab Bridge During Eid-Ul-Fitr (Sepetember 2009)



Summary of Findings:

It is clearly observed form the analysis that, Eid festivals have vital impact on traffic flow in N-2 Corridor. Therefore, for accurate estimation of AADT from short counts, not only expansion factors are sufficient for precise estimation, but also an Eid factor is to be determined and introduced, so that the peak hour flow can be correctly estimated.

- Duration of Eid Impact: 5 days before and 5 days after Eid day; total 10 days.
- Maximum Daily Flow Percentage: 4.90% (bothway) before Eid in December 2008.
- Average Daily Flow Percentage: 3.33%, Standard Deviation: 0.06%
- All highest Daily Volume in a year are within Eid effect range, carrying upto 171.51% more traffic than AADT.
- Maximum Directional Distribution: 56.79%, West to East, September 2009
- Average maximum Directional Distribution before Eid day: 50.64% (Averaged over 6 Eid occasions)

4.3.8 TRAFFIC GROWTH PATTERN

The magnitude of traffic flow is increasing every year in all highways of Bangladesh. Therefore, correct analysis of traffic growth pattern is essential for the evaluation of pavement design parameters. For the prediction of future traffic flow, traffic growth factor parameter plays an important role. This article analyzes the three years of traffic flow data from 2007 to 2009 to understand the true pattern of traffic growth in Dhaka-Sylhet corridor.

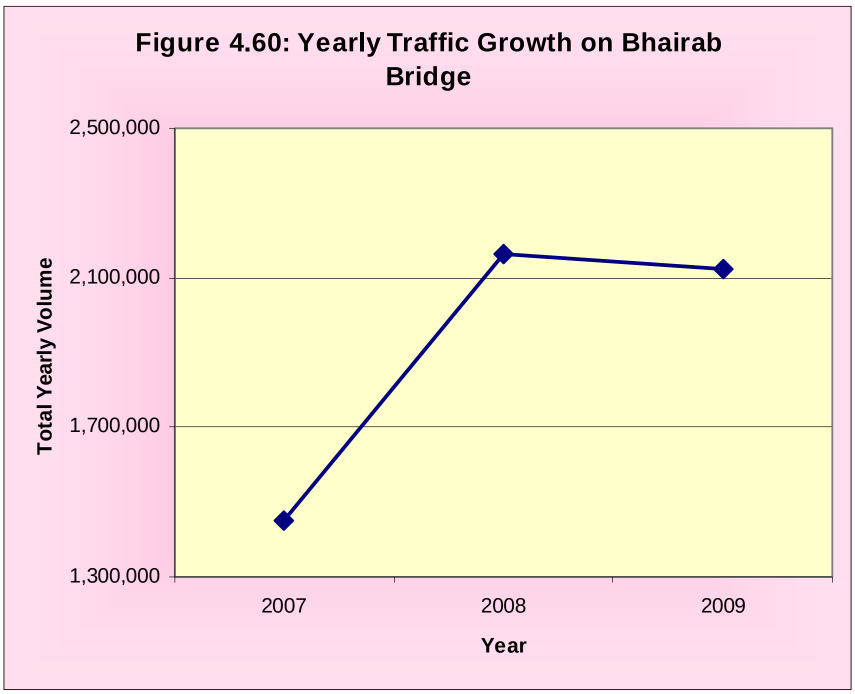
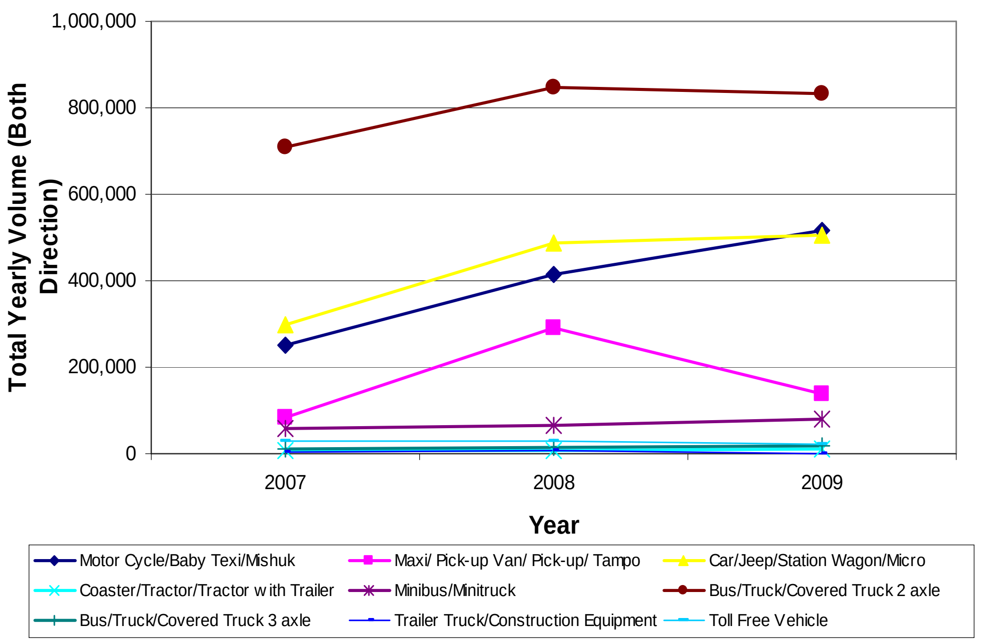


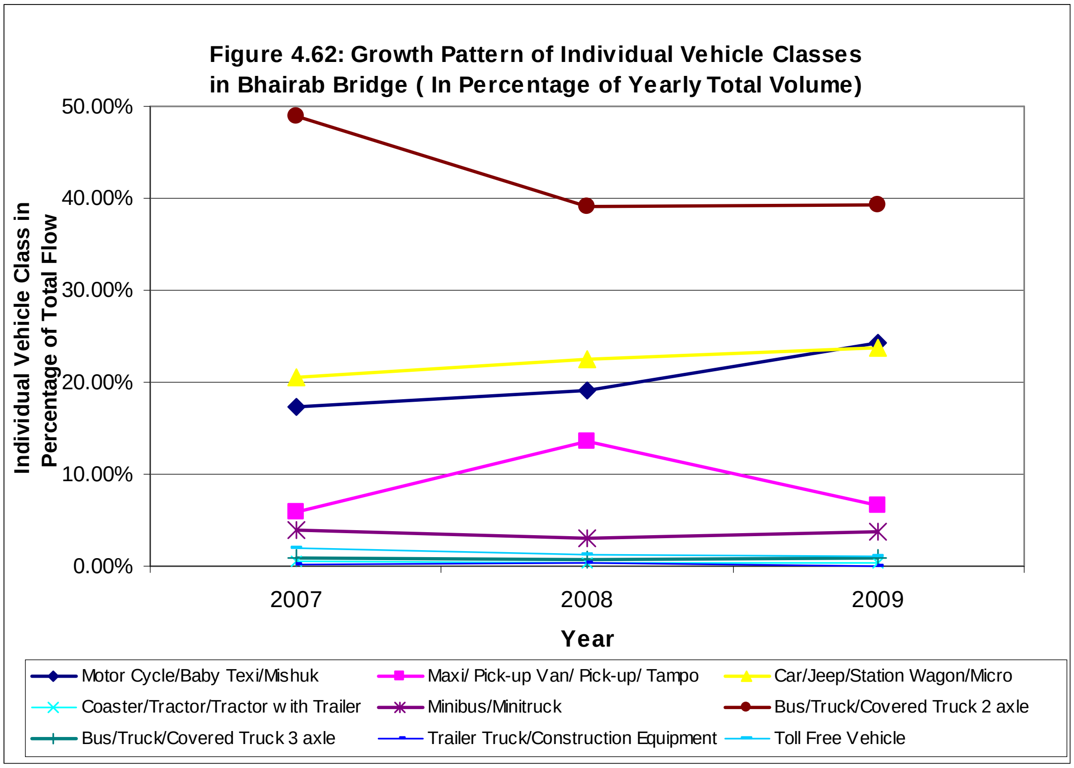
Figure 4.60 plots the total bi-directional yearly traffic volume on N-2 corridor against respective years from 2007 to 2009. In 2007, the total yearly traffic volume was 1,448,549. During the next year it has drastracally increased and has become 2,164,444 in 2008. The growth rate has been found to be 49.42%, which is much higher than average national growth rate (8-10%) used in the Roads and Highways design manual. But in 2009, the traffic volume decreased to 2,124,540 and so does the growth factor become -1.84%, which is very surprising with respect to Bangladesh condition. The average growth rate has been found to be 23.79% per annum in N-2 corridor.

It is noted that, like other corridors the percentage of various vehicle classes with respect to total yearly flow is not constant throughout the study period. Rather, they are changing from year to year at a significant rate. Some vehicle classes are increasing every year while some are decreasing. Therefore, it can be easily understood that, flat growth rate for total traffic is not representative of the actual scenario. This invokes the need for traffic growth pattern analyzed individually for all vehicle classes.

Figure 4.61: Classwise Yearly Growth Pattern of Traffic on Bhairab Bridge



In Figure 4.61, total yearly flow of all seven vehicle classes used in Bhairab bridge is plotted against respective years from 2007 to 2009, while Figure 4.62 shows the yearly variation in percentage of individual vehicle classes with respect to total yearly volume. The observations made from the above graphs, separately for each vehicle class, are described hereunder.



4.3.8.1 Motor Cycle/ Baby Taxi/ Mishuk:

In 2007, total yearly volume of this class was 251,433, in 2008 it rises to 412,924 and finally in 2009 it became 517,380. The average yearly volume derived from three years is 393,912. The total yearly volume of Motor Cycle/ Baby Taxi/ Mishuk and the percentage of this class with respect to total volume has increased a little every year during the study period. In 2007, the percentage was 17.36%, in 2008, the percentage increasd to 19.08% and became 24.35% in 2009. This has happened because of increase in total traffic. Taking the average value during the study period, percentage of motorcycle/ Baby Taxi/ Mishuk is 20.26% within the traffic stream.

4.3.8.2 Maxi/Pick-up Van/ Pick-up/Tampo:

From Figure 4.61, it can be seen that total yearly volume of Maxi/Pick-up Van/ Pick-up/Tampo has increased surprisingly from 84,337 in 2007 to 292,489 in 2008. But the volume decreased to 139,455 in 2009. The percentage of this class has increased from 5.82% in 2007 to 13.51% in 2008 but again decreased to 6.56% in 2009. The change is quite noticeable in Figure 4.44. Taking the average value during the study period, percentage of Maxi/Pick-up Van/ Pick-up/Tampo is 8.63% within the traffic stream.

4.3.8.3 Car/Jeep/Station Wagon/Micro:

Car/Jeep/Station Wagon/Micro shows moderate in volume in the traffic stream in N-2 corridor. In 2007 total volume of this class was 296,928, which gradually increased to 486,878 in 2008 and in 2009 it became 504,380. Annual percentage increased from 20.50% to 22.49% and then 23.74%. Average volume of this class is 429,395 and the average percentage of this class is 22.24% within the traffic stream from the year 2007 to 2009.

4.3.8.4 Coaster/Tractor/Tractor with Trailer:

Volume of traffic of this class is the second lowest among N-2 corridor. In 2007, the volume was 6,633, which gradually rise to 7,514 in 2008 and then tends to 9,262 in the year 2009. In average, 7,803 number of trip generated each year from 2007 to 2009 on Bhairab bridge. The percentage of this class with respect to total traffic was 0.46%, 0.35% and 0.44% respectedly from the year 2007 to 2009.

4.3.8.5 Minibus/Minitruck:

Volume of Minibus/Minitruck is very low on the N-2 corridor. From 2007 to 2009, percentage of Minibus/Minitruck decreases from 3.98% to 3.68% respectively but the total number of trip increase from 57,584 to 78,266 that are because of the increase of total number of traffic. The average number of trip is 67,621 and this is 3.59% of total traffic.

4.3.8.6 Bus/Truck/Covered Truck 2 axle:

The class Bus/Truck/Covered Truck 2 axle contains the highest percentage of traffic on Bhairab Bridge. In Figure 4.61 and 4.62, annual growth of this class is also found to be quite significant. In the year 2007, total volume was 708,531 and it increased to 848,230 in 2008 and then slightly decreased to 834,520. From 2007 to 2009, the percentage has fallen from 48.91% to 39.28%. Also, uselessness of axle load control station has promoted excess load carried by truck/covered truck 2 axle frequently. Hence, the Bhairab bridge and highways are suffering heavy loads then their design load.

4.3.8.7 Bus/Truck/Covered Truck 3 axle:

Bus/Truck/Covered Truck 3 axle contains the minimum percentage of annual traffic. From the year 2007 to 2009, number of large trucks varies from 12,665 to 18,031. Average yearly number of Bus/Truck/Covered Truck 3 axle trip is 15,347. The percentage of this class was 0.87% in 2007. After slow decrease, the same has become 0.71% in 2008, then increase to 0.85% in 2009. Considering the impact of Large Truck on the pavement, this apparent insignificant class is also to be taken into account.

Summary of Findings:

Growth rate needs to be determined for each individual vehicle class that can be used more precisely for future traffic flow prediction. Consideration of flat growth rate for total vehicle is not a correct technique to evaluate this parameter.

4.3.9 COMPARISON OF TRAFFIC FLOW BETWEEN N-5 CORRIDOR AND N-2 CORRIDOR

Due to natural, political and geographical similarity, most of the important corridor of Bangladesh should follow same repetitive nature of curve and traffic flow. Both the national highways like N-2 and N-5 are vital corridor in Bangladesh. Also, manipulation of data may be possible by the toll collectors to maintain the rhythmic nature. A framework has been developed in this study to check the consistency of data in two different corridors by comparing the daily flow data recorded at two different stations. Magnitude and nature of traffic flow curve may give the possible pavement design criteria and standard for corridors of Bangladesh.

During this study three year daily traffic flow data on North Bengal Corridor and North East Corridor of Bangladesh have been collected. The data has been originally recorded by the toll operator of the Jamuna and Bhairab Bridge like MNOL, BBSO, and SIGMA-RCL JV. The collected data from both the stations were put in the framework and the following curves were obtained.

Table 4.26: Flow comparison between Jamuna Bridge and Bhairab Bridge in the year 2007

Month	Jamuna Bridge		Bhairab Bridge		Bhairab / Jamuna - Percentage	Avg.	Standard Deviation
	Monthly Total Volume	Monthly Percentage	Monthly Total Volume	Monthly Percentage			
Jan-07	182,787	7.78	111,264	7.68	**60.87%**	**61.61%**	**2.24**
Feb-07	176,282	7.50	108,794	7.51	**61.72%**		
Mar-07	190,420	8.10	119,673	8.26	**62.85%**		
Apr-07	185,136	7.88	112,696	7.78	**60.87%**		
May-07	192,508	8.19	115,816	8.00	**60.16%**		
Jun-07	194,433	8.27	112,770	7.79	**58.00%**		
Jul-07	192,399	8.18	125,261	8.65	**65.10%**		
Aug-07	186,088	7.92	118,221	8.16	**63.53%**		
Sep-07	188,161	8.00	109,984	7.59	**58.45%**		
Oct-07	212,973	9.06	130,364	9.00	**61.21%**		
Nov-07	199,045	8.47	129,286	8.93	**64.95%**		
Dec-07	250,577	10.66	154,420	10.66	**61.63%**		

Data Source: MNOL, BBSO, SIGMA-RCL JV.

Table 4.27: Flow comparison between Jamuna Bridge and Bhairab Bridge in the year 2008

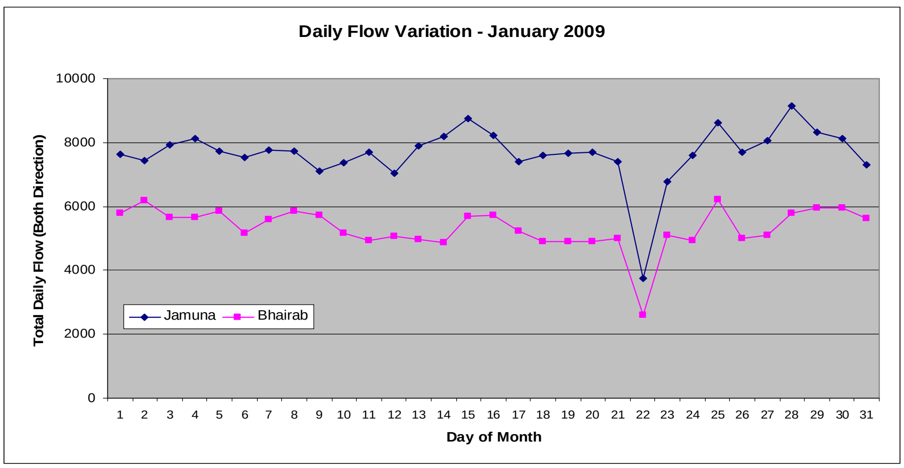
Month	Jamuna Bridge		Bhairab Bridge		Bhairab / Jamuna - Percentage	Avg.	Standard Deviation
	Monthly Total Volume	Monthly Percentage	Monthly Total Volume	Monthly Percentage			
Jan-08	219,713	8.30	142,849	6.60	**65.02%**	**81.73%**	**12.43**
Feb-08	208,812	7.89	143,810	6.64	**68.87%**		
Mar-08	232,404	8.78	178,453	8.24	**76.79%**		
Apr-08	209,366	7.91	153,613	7.10	**73.37%**		
May-08	217,671	8.22	204,053	9.43	**93.74%**		
Jun-08	221,612	8.37	214,629	9.92	**96.85%**		
Jul-08	214,606	8.10	166,635	7.70	**77.65%**		
Aug-08	212,331	8.02	178,741	8.26	**84.18%**		
Sep-08	216,116	8.16	157,233	7.26	**72.75%**		
Oct-08	214,256	8.09	189,231	8.74	**88.32%**		
Nov-08	222,333	8.40	236,827	10.94	**106.52%**		
Dec-08	258,719	9.77	198,370	9.16	**76.67%**		

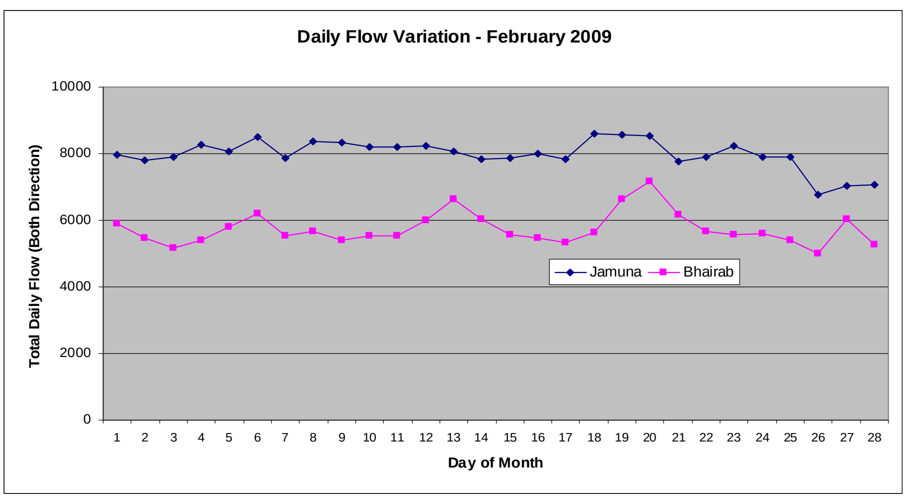
Data Source: MNOL, BBSO, SIGMA-RCL JV.

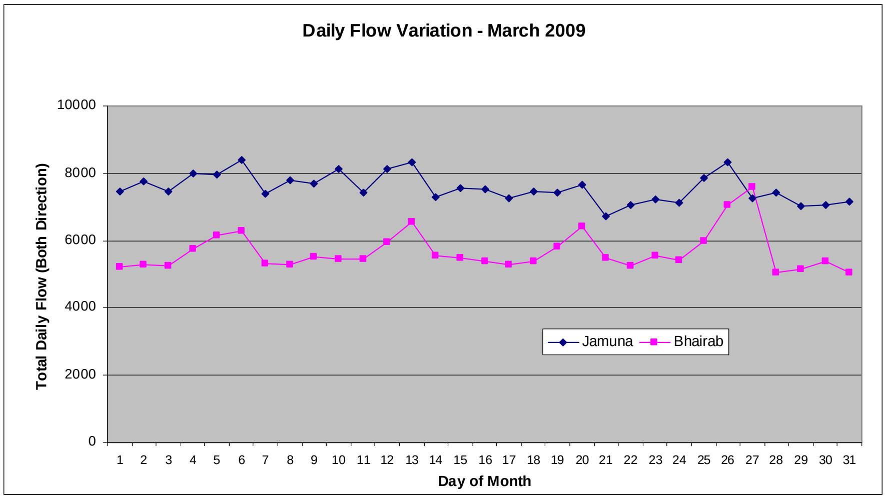
Table 4.28: Flow comparison between Jamuna Bridge and Bhairab Bridge in 2009

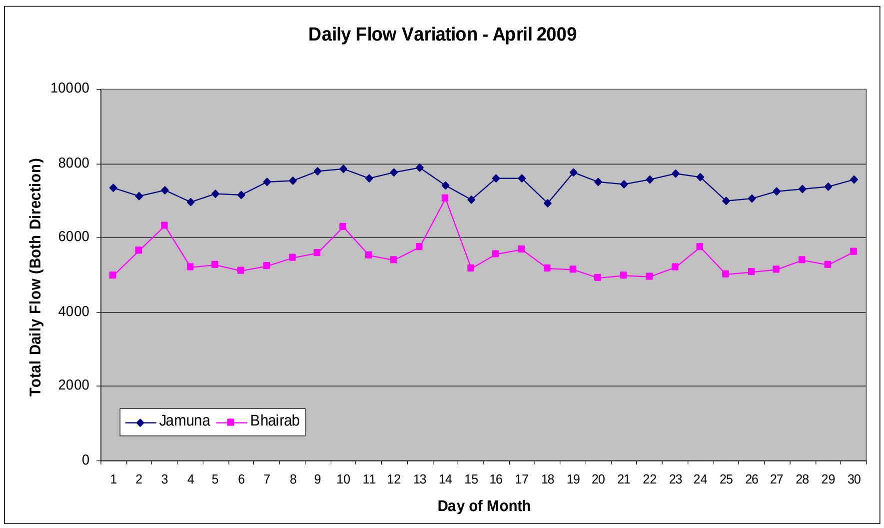
Month	Jamuna Bridge		Bhairab Bridge		Bhairab / Jamuna - Percentage	Avg.	Standard Deviation
	Monthly Total Volume	Monthly Percentage	Monthly Total Volume	Monthly Percentage			
Jan-09	237,308	8.01	165,147	7.77	**69.59%**	**71.78%**	**2.27**
Feb-09	223,575	7.55	160,869	7.57	**71.95%**		
Mar-09	234,368	7.91	175,773	8.27	**75.00%**		
Apr-09	222,787	7.52	162,958	7.67	**73.15%**		
May-09	239,455	8.08	173,608	8.17	**72.50%**		
Jun-09	253,497	8.56	172,284	8.11	**67.96%**		
Jul-09	259,745	8.77	180,520	8.50	**69.50%**		
Aug-09	236,128	7.97	176,987	8.33	**74.95%**		
Sep-09	247,680	8.36	175,972	8.28	**71.05%**		
Oct-09	249,826	8.43	182,337	8.58	**72.99%**		
Nov-09	277,905	9.38	193,099	9.09	**69.48%**		
Dec-09	279,918	9.45	204,986	9.65	**73.23%**		

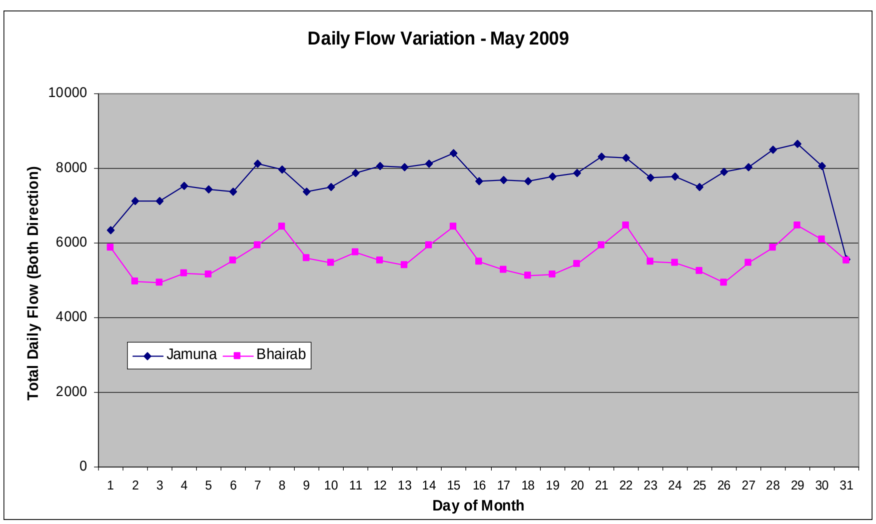
Data Source: MNOL, BBSO, SIGMA-RCL JV.

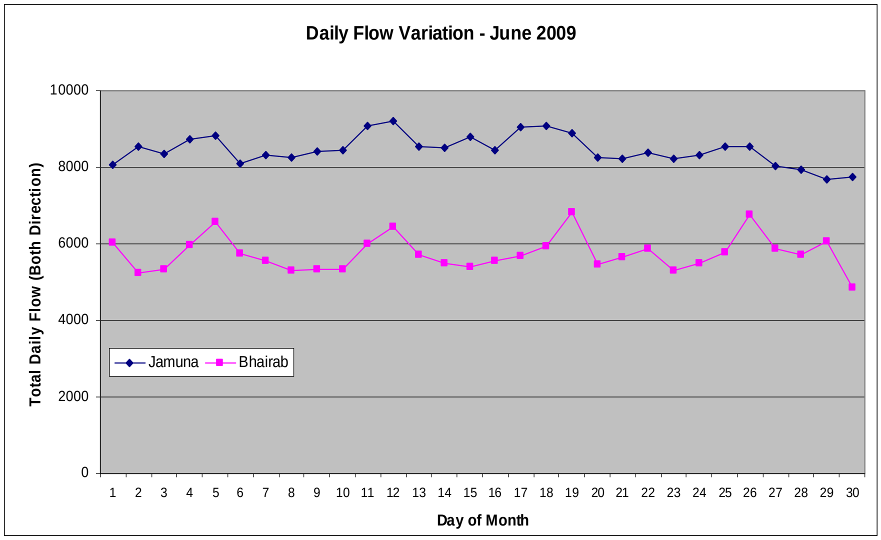


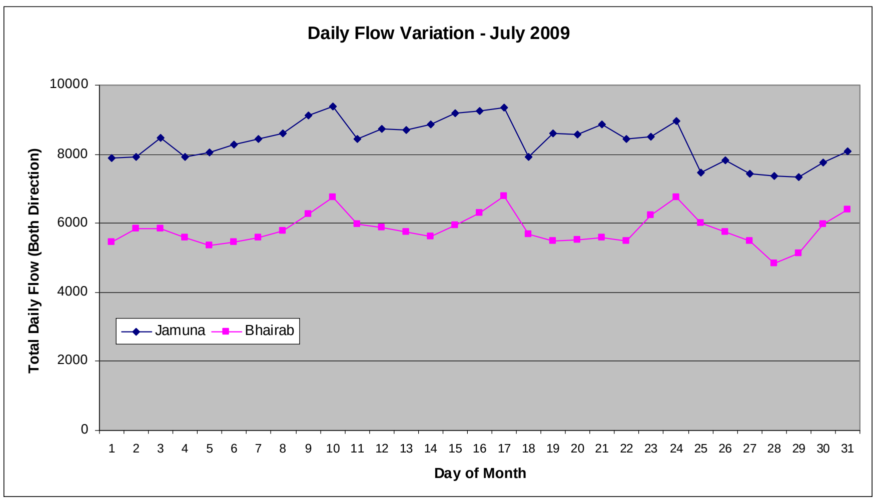


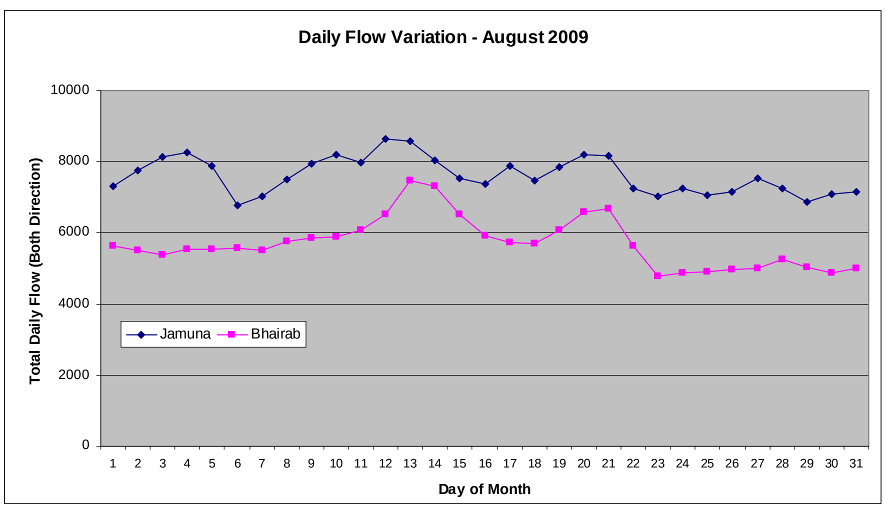

Daily Flow Variation - March 2009
Total Daily Flow (Both Direction)
0
2000
4000
6000
8000
10000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Day of Month
Jamuna
Bhairab

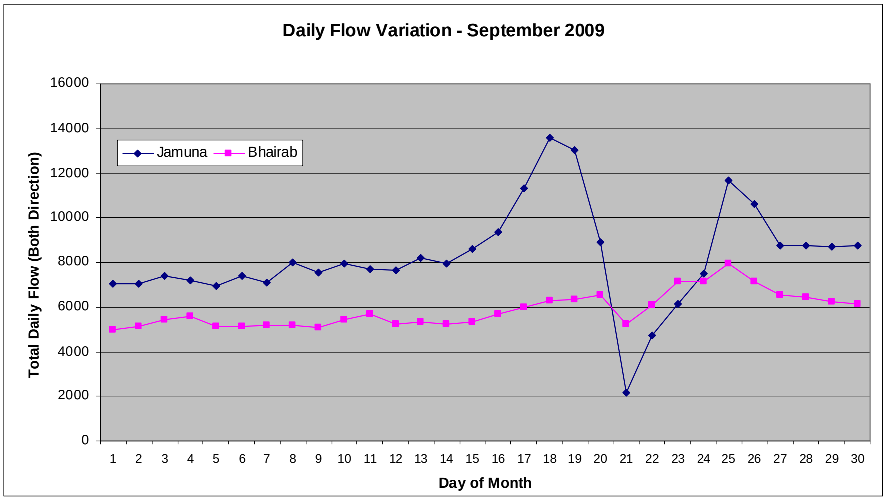

Daily Flow Variation - April 2009
Total Daily Flow (Both Direction)
0
2000
4000
6000
8000
10000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Day of Month
Jamuna
Bhairab

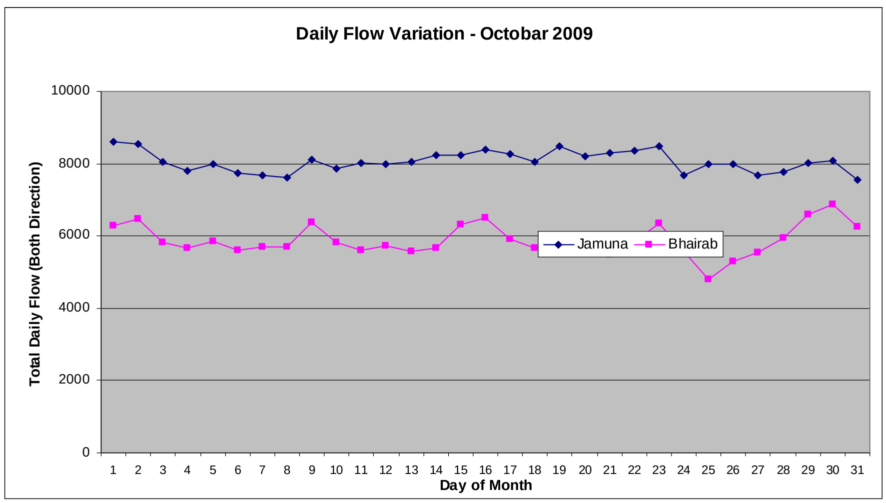

Daily Flow Variation - May 2009
Total Daily Flow (Both Direction)
0
2000
4000
6000
8000
10000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Day of Month
Jamuna
Bhairab

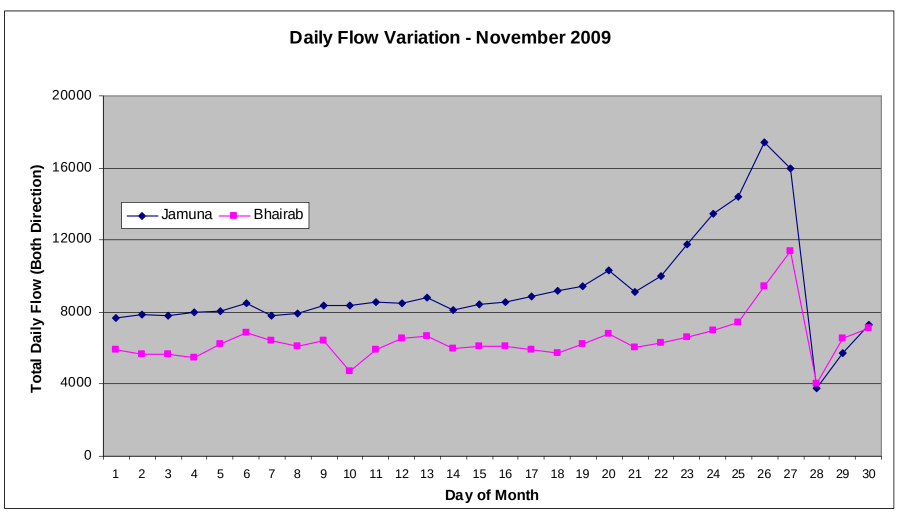

Daily Flow Variation - June 2009
Total Daily Flow (Both Direction)
10000
8000
6000
4000
2000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Day of Month
Jamuna
Bhairab

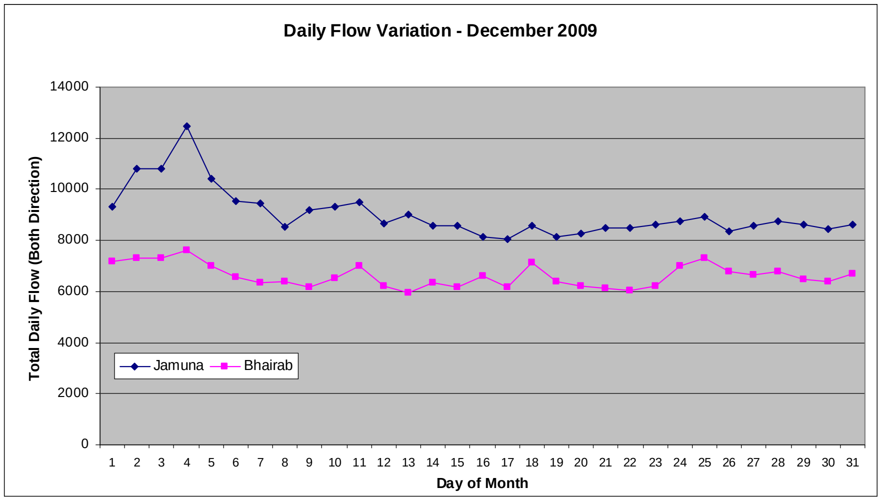

Daily Flow Variation - July 2009
Total Daily Flow (Both Direction)
10000
8000
6000
4000
2000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Day of Month
Jamuna
Bhairab


Daily Flow Variation - August 2009
Total Daily Flow (Both Direction)
10000
8000
6000
4000
2000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Day of Month
Jamuna
Bhairab


Daily Flow Variation - September 2009
Jamuna
Bhairab
Total Daily Flow (Both Direction)
Day of Month


Daily Flow Variation - Octobar 2009
Jamuna
Bhairab
Total Daily Flow (Both Direction)
Day of Month


Daily Flow Variation - November 2009
Jamuna
Bhairab
Total Daily Flow (Both Direction)
Day of Month



From the above continuous daily flow patterns, one can easily understand that, N-5 corridor carries more traffic then N-2 corridor. Despite different toll operator and authorities, the patterns are seen to have significant similarity, which implies that, both the toll operators have been performing well in collecting and recording data. It is also found from the analysis that, N-2 corridor carries 61.61%, 81.73% and 71.78% of total traffic respectedly from the year 2007 to 2009 with respect to N-5 corridor (as shown in Table 4.26, 4.27, 4.28). Further analysis on this might reveal important facts that may be useful for the transport planners for designing a new road facility. The framework can also be used for independent auditing purpose.

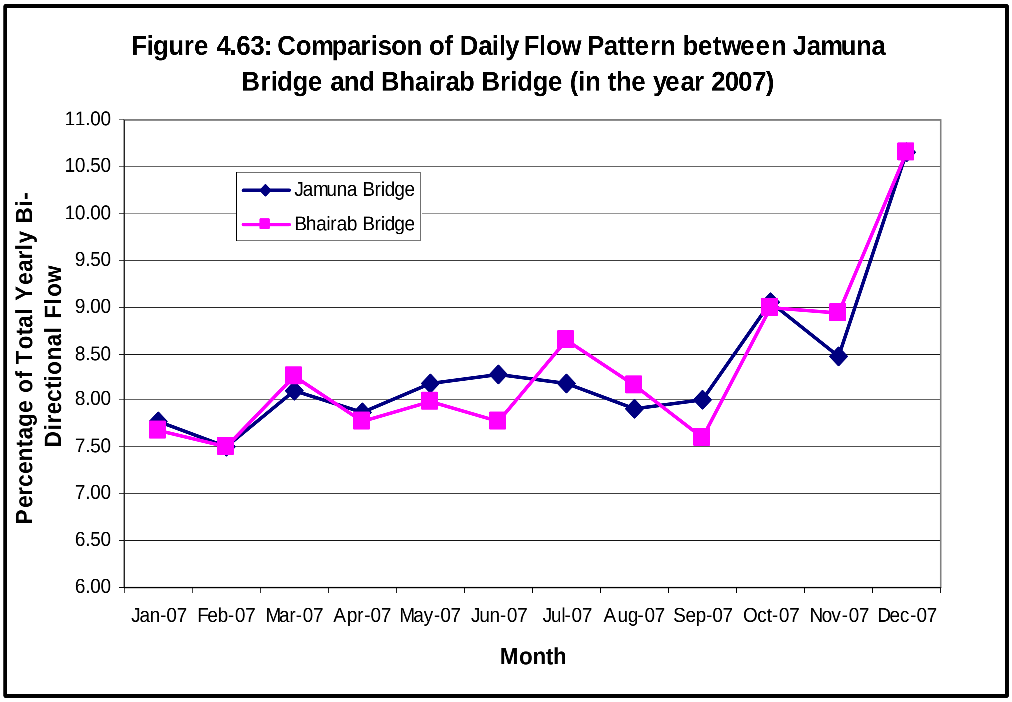


Figure 4.63: Comparison of Daily Flow Pattern between Jamuna Bridge and Bhairab Bridge (in the year 2007)
Percentage of Total Yearly Bi-Directional Flow
11.00
10.50
10.00
9.50
9.00
8.50
8.00
7.50
7.00
6.50
6.00
Jamuna Bridge
Bhairab Bridge
Jan-07 Feb-07 Mar-07 Apr-07 May-07 Jun-07 Jul-07 Aug-07 Sep-07 Oct-07 Nov-07 Dec-07
Month

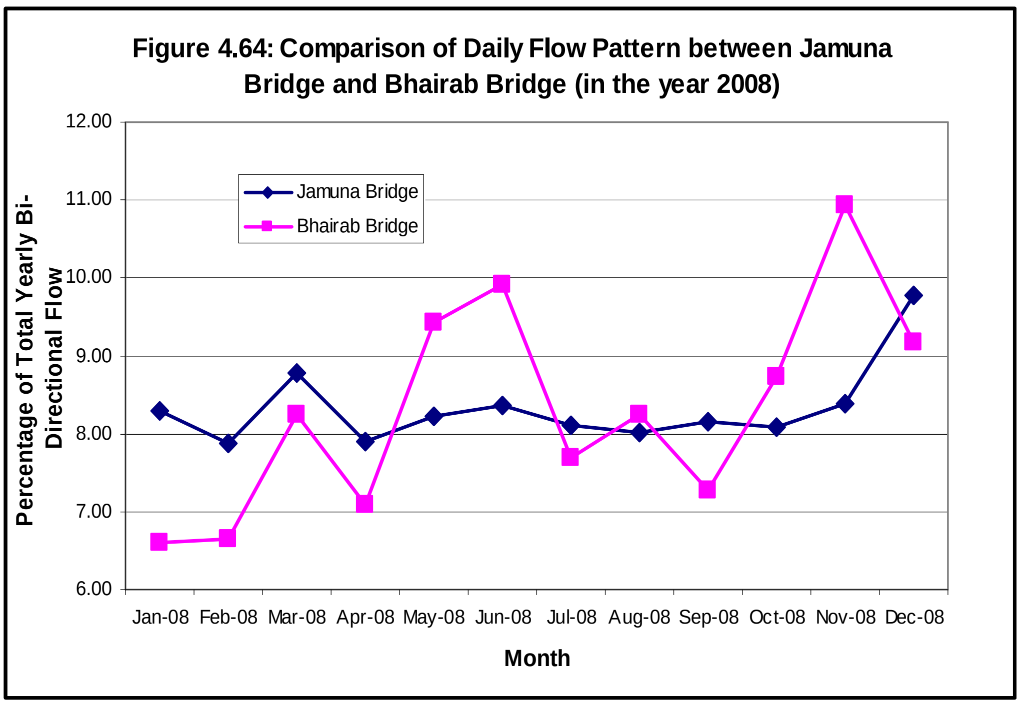
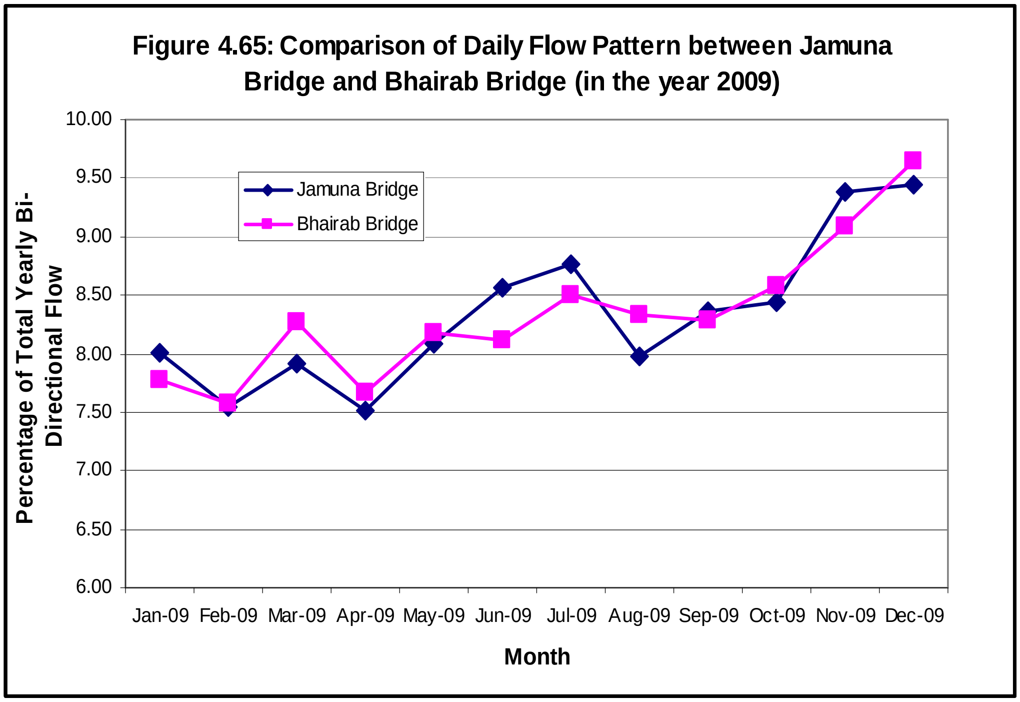


Figure 4.64: Comparison of Daily Flow Pattern between Jamuna Bridge and Bhairab Bridge (in the year 2008)
Percentage of Total Yearly Bi-Directional Flow
12.00
11.00
10.00
9.00
8.00
7.00
6.00
Jamuna Bridge
Bhairab Bridge
Jan-08 Feb-08 Mar-08 Apr-08 May-08 Jun-08 Jul-08 Aug-08 Sep-08 Oct-08 Nov-08 Dec-08
Month



The above Figure (Figure 4.63, 4.64, 4.65) shows the comparison between daily traffic flow patterns recorded in Jamuna Bridge and Bairab Bridge from January 2007 to December 2009. It is found from the Figure that, the two roads maintain very similar daily flow variation pattern, which certainly proves the consistency of data collection and preservation.

4.4 ANALYSIS OF FLOW CHARACTERISTICS IN N-1 CORRIDOR (MEGHNA-GOMOTI BRIDGE)

Dhaka-Chittagong (N-1) corridor is the most vital highway of Bangladesh. Economic activity of Bangladesh largely depends upon this road. But it is a matter of sorrow that the Government has no plan to collect and preserve traffic data for this corridor. However, an attempt has been taken to collect data from Meghna and Gomoti toll plaza sites for traffic flow analysis. This section includes the analysis of flow characteristics on Meghna-Gomoti bridges. Primarily the flow patterns have been developed to see the nature of traffic flow fluctuation and then various flow characteristics have been established for evaluation.

4.4.1 DAILY FLOW VARIATION

Daily flow fluctuation on highways is an important parameter of flow characteristics where the variation of flow in days-of-week is observed. From the analyses of 4 years data collected from RCL and MBEL-ATT JV (2006 to 2009), distinct daily flow fluctuation pattern can be achieved. It is a matter of regret that neither Roads and Highways Department nor the concern company of the contractor's are concern about the research value of the data. Hence, they don't preserve it properly and it was not possible to collect data for inbound and outbound traffic separetely.

From the data analyses, it is seen in graph how each month of year affects this daily flow fluctuation. To make this observation, curves have been plotted showing daily flow variation for all months of a year during this study. Two of such charts are given in Figure 4.66 and Figure 4.67, where the average daily flow variation pattern are found to conform to those obtained from the previous analyses, but no definite relation can be established in terms of influence of individual month on these daily variations. This implies that, individual month has no significant effect on daily variation of traffic flow on the N-1 corridor.

Figure 4.66: Month-wise Daily Traffic Flow Variation on Meghna-Gomoti Bridge, 2006 (Both Direction)

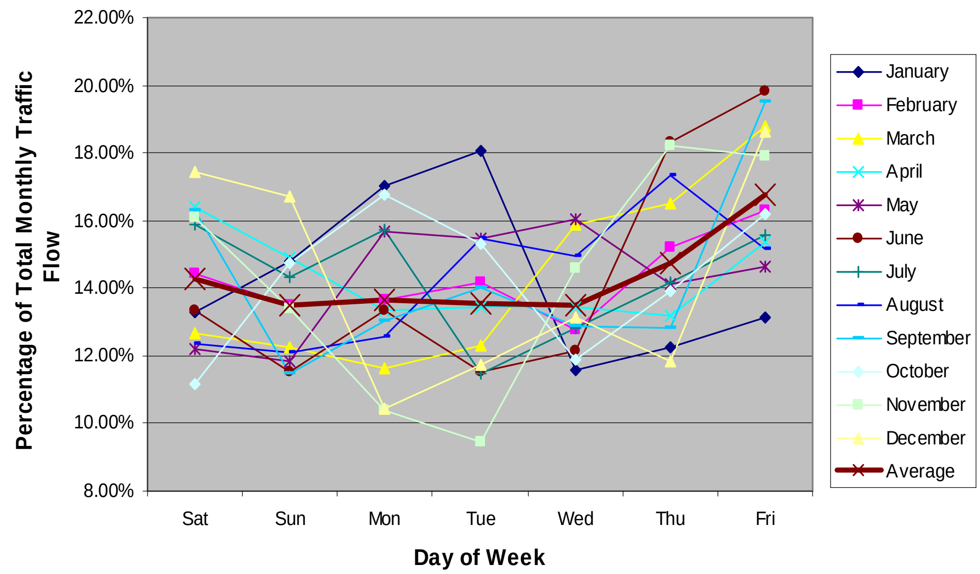
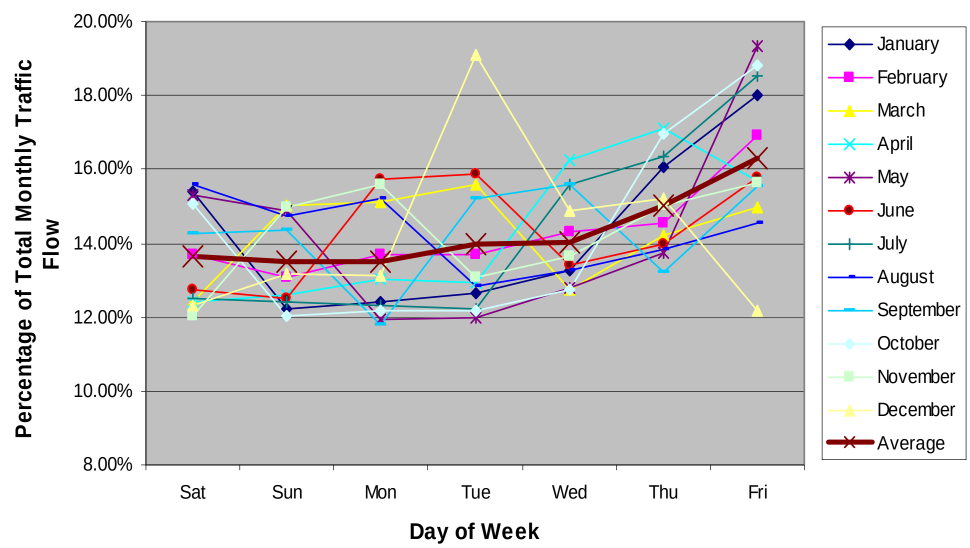


Figure 4.67: Month-wise Daily Traffic Flow Variation on Meghna-Gomoti Bridge, 2009 (Both Direction)



It is to be noted here that, only two years (2006, 2009) of month-wise daily flow variation pattern have been shown above. Similar analyses curves for 2007 & 2008 are given in the Appendix B (Figure B17 to B18).

Summary of Findings:

From the above analyses, the following important flow characteristics parameters have been obtained, where it is obvious that Friday possess maximum traffic flow of 16.37% of weekly volume in N-1 corridor. On the other hand, from Saturday to Tuesday the daily traffic flow varies from 13.50% to 13.79% of weekly volume and Sunday has the minimum traffic flow of 13.50% of the weekly volume. In addition, Thursday has second highest traffic volume of 14.86% of weekly volume in N-1 corridor. This analysis indicates that the flow pattern sags on midweek.

Table 4.29: Summary Table - Daily Flow Variation

	2006	2007	2008	2009	Average Flow
Saturday	13.59%	14.29%	13.61%	13.62%	13.78%
Sunday	13.34%	13.51%	13.64%	13.51%	13.50%
Monday	13.80%	13.64%	13.51%	13.51%	13.62%
Tuesday	13.71%	13.52%	13.95%	13.96%	13.79%
Wednesday	14.48%	13.50%	14.33%	14.03%	14.09%
Thursday	14.92%	14.77%	14.71%	15.03%	14.86%
Friday	16.15%	16.78%	16.24%	16.32%	16.37%

4.4.2 WEEKLY FLOW VARIATION

Depending on the economic activities of highway corridors, traffic flow may exhibit weekly flow variation, i.e. considering four weeks in a month; the flow may vary from week to week. To find out these characteristics on the N-1 corridor, weekly flow analyses have been done in this section.

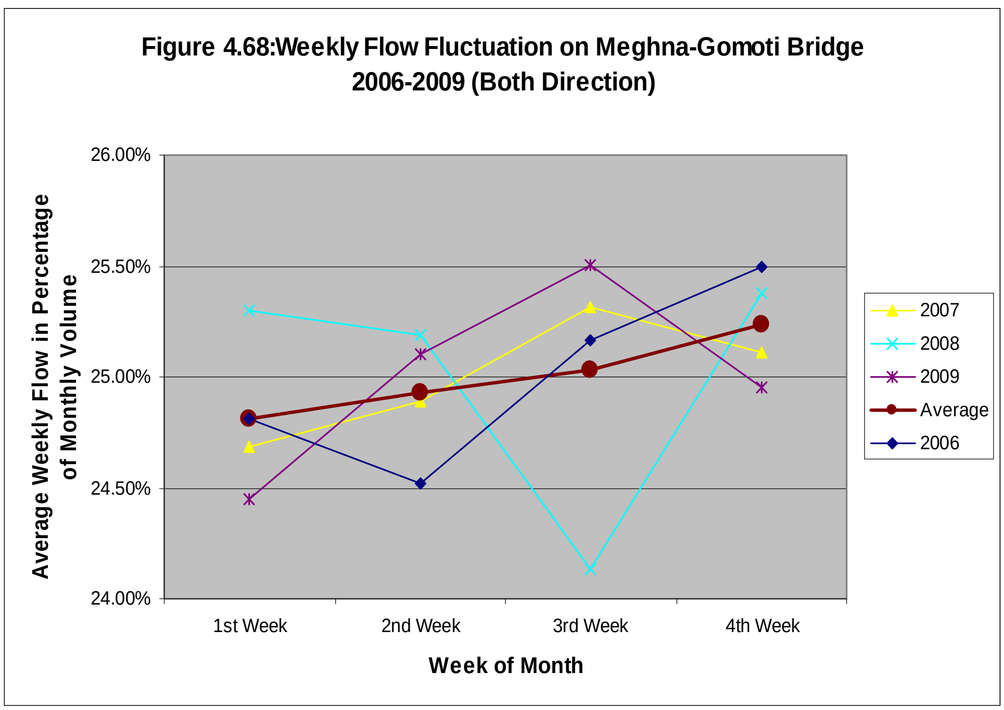
Each month has been divided into four weeks. The first three weeks have seven days each and the fourth week, except February, has 9 to 10 days depending on the month. So, it is anticipated that the fourth week will naturally contain more traffic. To compensate this possible error, the model uses weekly ADT instead of weekly volume and then compares between the four weekly ADTs of each month from January 2006 to December 2009. A typical table of weekly flow variation analyses is shown in Table 4.30.

From Figure 4.68, it implies that, in the N-1 corridor, there exists specific weekly flow variation pattern. The average curve (for the year 2006 to 2009) shows that, the first three week of a month, there is a trend of increasing traffic slightly and the last week of the month traffic increase more rapidly.

However, Table 4.30 summarizes the weekly flow variation on N-1 corridor for four years. The graphical representation is shown in Figure 4.68. Year wise weekly flow fluctuation charts for the other four years are given in Appendix B (Figure B19 to B22).

Table 4.30: Summary of Weekly Flow Variation (Both Direction)

Year	Weekly Flow Percentage			
	1st Week	2nd Week	3rd Week	4th Week
2006	24.81%	24.52%	25.17%	25.50%
2007	24.68%	24.89%	25.32%	25.11%
2008	25.30%	25.19%	24.13%	25.38%
2009	24.45%	25.10%	25.50%	24.95%
Average	24.81%	24.93%	25.03%	25.23%

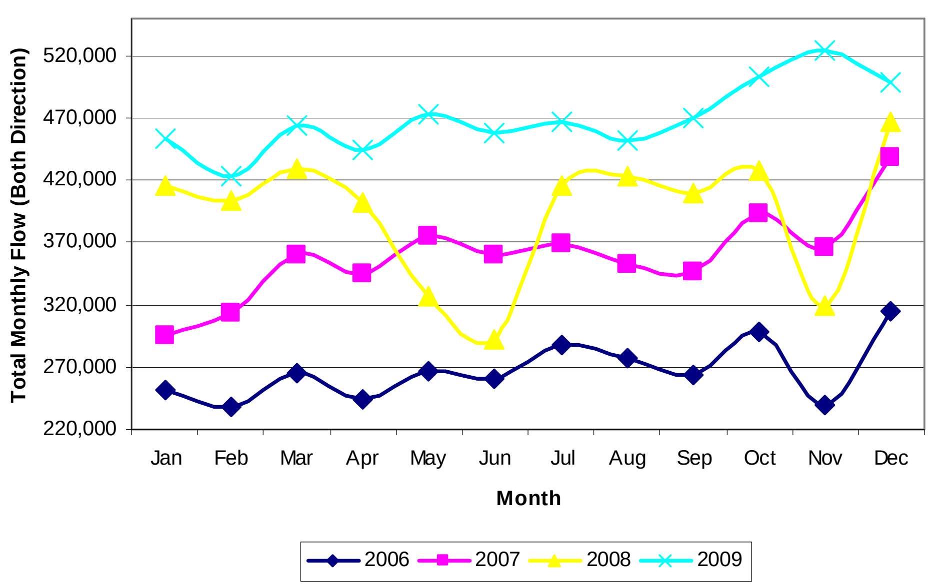


4.4.3 MONTHLY FLOW VARIATION

In the study of monthly flow variation, four years of traffic flow data on Meghna-Gomoti Bridge collected from RCL and MBEL-ATT JV have been used for analyses, which will give a thorough understanding of nature of traffic flow variation in different months of a year.

Characteristics curves showing monthly flow variation is shown in Figure 4.69. It can be seen that, monthly flow variation in every year shows very similar repetitive nature of flow fluctuation. The magnitude of flow has risen every year but the flow pattern remains same, which implies that month has influences over traffic flow along this corridor.

Figure 4.69: Monthly Flow Variation on Meghna-Gomoti Bridge Bothway, 2006-2009



The following table (Table 4.31) shows the monthly flow variation on N-1 corridor, in percentage of total yearly volume, for the years 2006 to 2009. The graphical representation is shown on Figure 4.70.

Table 4.32 shows the maximum and minimum monthly flow percentage, by sorting the above table. Maximum and minimum flow is marked in red and blue respectively.

Table 4.31: Monthly Bi-directional Flow Variation on Meghna-Gomoti Bridge, (2006-2009).

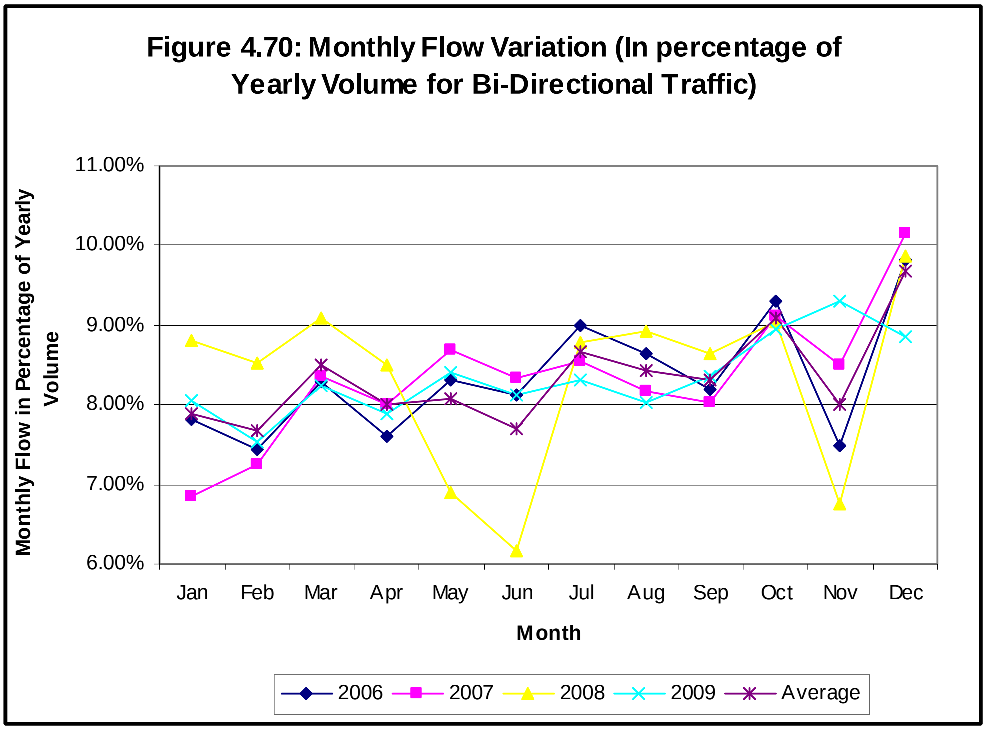
Month\Year	2006	2007	2008	2009
Jan	250,988	295,193	416,396	453,185
Feb	238,820	312,740	403,447	424,170
Mar	265,789	360,112	429,778	464,702
Apr	243,965	345,105	402,048	444,537
May	266,474	375,049	326,242	472,871
Jun	261,144	359,441	292,239	457,681
Jul	288,475	369,120	415,725	467,515
Aug	277,259	352,299	422,798	452,142
Sep	263,283	346,617	409,367	470,306
Oct	298,482	393,615	427,631	503,949
Nov	240,141	366,653	319,814	523,644
Dec	315,590	437,893	467,464	498,096
Yearly Volume	3,210,410	4,313,837	4,732,949	5,632,798

Source Data: RCL, MBEL-ATT JV.

Table 4.32: Maximum & Minimum Monthly Flow Table

Month\Year	2006	2007	2008	2009	Average
Jan	7.82%	6.84%	8.80%	8.05%	**7.88%**
Feb	7.44%	7.25%	8.52%	7.53%	**7.69%**
Mar	8.28%	8.35%	9.08%	8.25%	**8.49%**
Apr	7.60%	8.00%	8.49%	7.89%	**8.00%**
May	8.30%	8.69%	6.89%	8.39%	**8.07%**
Jun	8.13%	8.33%	6.17%	8.13%	**7.69%**
Jul	8.99%	8.56%	8.78%	8.30%	**8.66%**
Aug	8.64%	8.17%	8.93%	8.03%	**8.44%**
Sep	8.20%	8.04%	8.65%	8.35%	**8.31%**
Oct	9.30%	9.12%	9.04%	8.95%	**9.10%**
Nov	7.48%	8.50%	6.76%	9.30%	**8.01%**
Dec	9.83%	10.15%	9.88%	8.84%	**9.68%**
Total	100.00%	100.00%	100.00%	100.00%	**100.00%**
Max.	9.83%	10.15%	9.88%	9.30%	**9.68%**
Min.	7.44%	6.84%	6.17%	7.53%	**7.69%**

Source Data: RCL, MBEL-ATT JV.



It is found from above tables that, the average maximum monthly flow percentage occurs more frequently on November and December while the average maximum flow occurs on December. On the other hand, January, February and June carry minimum flow. Average minimum flow occurs in June (7.69%), which is reasonably surprising. Broadly, it is observed, as shown in Table 4.33, (graphically represented in Figure 4.72) that more flow occurs on rainy season (50.27%) than on the dry season (49.73%). Following are the possible reasons behind such distribution of monthly flow.

- In Bangladesh dry season is considered from November to April, and rainy season stays from May to October. Due to Chittagong port, more freight movement on waterways during the rainy season making the traffic flow percentage on roadway is higher. The seasonal distribution chart is as follows:

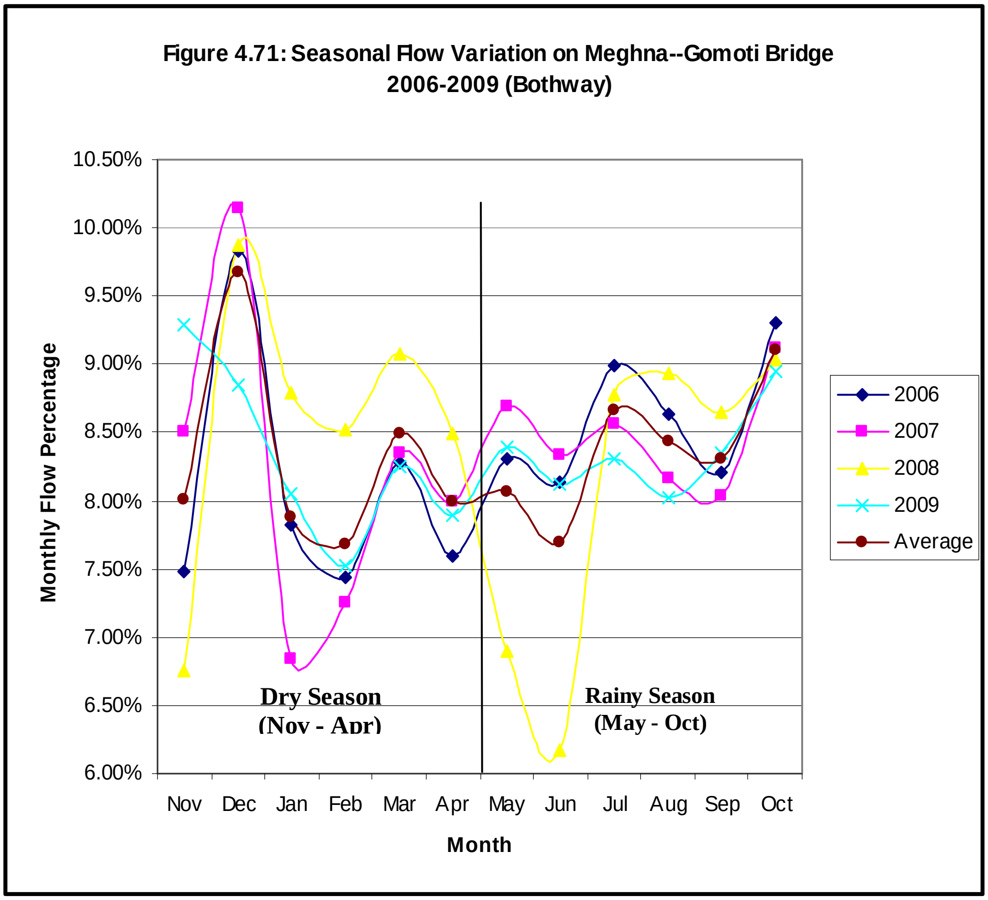


Table 4.33: Summarized Seasonal Flow Variation Table

Dry Season		Rainy Season	
Month	**Flow % in Season**	**Month**	**Flow % in Season**
Nov	8.01%	May	8.07%
Dec	9.68%	Jun	7.69%
Jan	7.88%	Jul	8.66%
Feb	7.69%	Aug	8.44%
Mar	8.49%	Sep	8.31%
Apr	8.00%	Oct	9.10%
Total	49.73%	Total	50.27%

Data Source: RCL, MBEL-ATT JV.

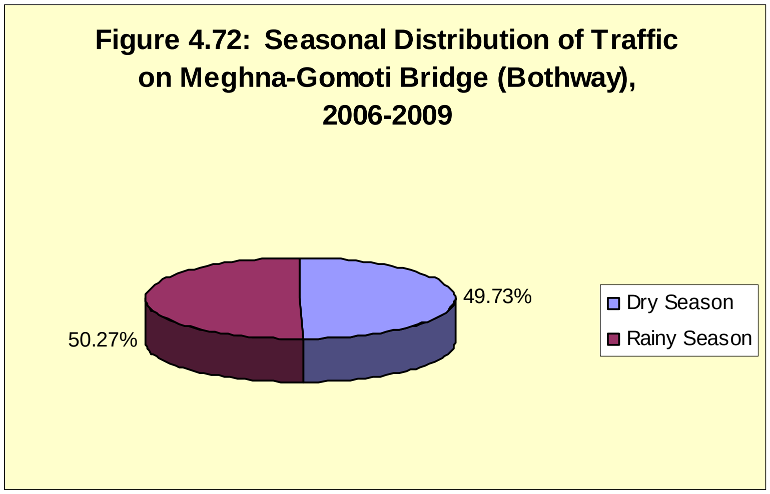


Figure 4.72: Seasonal Distribution of Traffic on Meghna-Gomoti Bridge (Bothway), 2006-2009

- The effect of Eid festivals is more pronounced on flow of light vehicles, which might be a contributing factor for higher traffic flow during the Eid seasons.

It is to be noted here that, February carries significantly lower volume of traffic. This may be because of lesser number of days in the month. Besides, in some years February has fallen between two Eids and thus carrying lower volume of traffic in comparison to adjacent months.

Seasonal flow variations of Large Bus, Medium Truck, Light Vehicles and Trailers are shown in the following diagrams.

Table 4.34: Monthly Flow Variation of Large Bus on Meghna-Gomoti Bridge

Year / Month	Total Monthly Flow of Large Bus (Both Direction)				Monthly Flow Percentage				
	2006	2007	2008	2009	2006	2007	2008	2009	**Average**
Jan	39,430	47,212	67,279	65,505	7.92%	6.94%	9.40%	8.31%	**8.14%**
Feb	37,241	51,373	65,945	64,022	7.48%	7.55%	9.22%	8.12%	**8.09%**
Mar	41,736	57,540	69,996	68,116	8.38%	8.46%	9.78%	8.64%	**8.82%**
Apr	39,100	54,511	64,917	63,910	7.85%	8.01%	9.07%	8.11%	**8.26%**
May	43,116	58,197	52,059	69,097	8.66%	8.55%	7.27%	8.77%	**8.31%**
Jun	40,261	55,662	29,420	65,824	8.09%	8.18%	4.11%	8.35%	**7.18%**
Jul	46,117	57,307	60,882	64,446	9.26%	8.42%	8.51%	8.18%	**8.59%**
Aug	44,523	55,240	64,131	62,180	8.94%	8.12%	8.96%	7.89%	**8.48%**
Sep	41,908	54,136	56,124	65,661	8.42%	7.96%	7.84%	8.33%	**8.14%**
Oct	45,669	63,751	69,332	67,669	9.17%	9.37%	9.69%	8.59%	**9.20%**
Nov	34,123	56,832	45,110	63,852	6.85%	8.35%	6.30%	8.10%	**7.40%**
Dec	44,714	68,652	70,423	67,867	8.98%	10.09%	9.84%	8.61%	**9.38%**
Total	**497,938**	**680,413**	**715,618**	**788,149**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**
Max. Flow	46,117	68,652	70,423	69,097	9.26%	10.09%	9.84%	8.77%	9.38%
Min. Flow	34,123	47,212	29,420	62,180	6.85%	6.94%	4.11%	7.89%	7.18%

Source Data: RCL, MBEL-ATT JV.

Table 4.35: Monthly Flow Variation of Medium Truck on Meghna-Gomoti Bridge

Year / Month	Total Monthly Flow of Medium Truck (Both Direction)				Monthly Flow Percentage				
	2006	2007	2008	2009	2006	2007	2008	2009	**Average**
Jan	80,294	93,145	140,186	146,805	6.79%	6.38%	8.79%	7.82%	**7.45%**
Feb	85,890	106,317	129,399	138,144	7.26%	7.28%	8.12%	7.36%	**7.51%**
Mar	99,433	127,266	144,124	154,634	8.41%	8.72%	9.04%	8.24%	**8.60%**
Apr	93,910	123,594	138,746	155,362	7.94%	8.47%	8.70%	8.28%	**8.35%**
May	100,827	134,161	133,692	154,829	8.53%	9.19%	8.38%	8.25%	**8.59%**
Jun	101,248	125,170	129,807	154,940	8.56%	8.58%	8.14%	8.26%	**8.38%**
Jul	110,651	130,501	145,267	161,375	9.36%	8.94%	9.11%	8.60%	**9.00%**
Aug	105,047	123,976	136,759	157,427	8.88%	8.49%	8.58%	8.39%	**8.59%**
Sep	99,327	126,721	140,838	132,695	8.40%	8.68%	8.83%	7.07%	**8.25%**
Oct	95,899	114,430	116,625	181,290	8.11%	7.84%	7.31%	9.66%	**8.23%**
Nov	96,837	128,117	120,372	173,051	8.19%	8.78%	7.55%	9.22%	**8.44%**
Dec	112,974	126,091	118,691	165,646	9.56%	8.64%	7.44%	8.83%	**8.62%**
Total	**1,182,337**	**1,459,489**	**1,594,506**	**1,876,198**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**
Max. Flow	112,974	134,161	145,267	181,290	9.56%	9.19%	9.11%	9.66%	9.00%
Min. Flow	80,294	93,145	116,625	132,695	6.79%	6.38%	7.31%	7.07%	7.45%

Source Data: RCL, MBEL-ATT JV.

Table 4.36: Monthly Flow Variation of Light Vehicles on Meghna-Gomoti Bridge

Year / Month	Total Monthly Flow of Light Vehicles (Both Direction)				Monthly Flow Percentage				
	2006	2007	2008	2009	2006	2007	2008	2009	Average
Jan	115,933	136,922	181,257	206,526	8.65%	7.27%	8.70%	8.01%	**8.16%**
Feb	100,329	136,028	179,909	190,832	7.49%	7.22%	8.64%	7.40%	**7.69%**
Mar	107,223	152,043	184,891	209,008	8.00%	8.07%	8.88%	8.11%	**8.26%**
Apr	95,413	142,494	168,795	192,663	7.12%	7.56%	8.10%	7.47%	**7.57%**
May	106,199	157,882	115,076	214,769	7.92%	8.38%	5.53%	8.33%	**7.54%**
Jun	104,687	154,489	110,316	203,461	7.81%	8.20%	5.30%	7.89%	**7.30%**
Jul	115,771	157,245	179,342	210,010	8.64%	8.35%	8.61%	8.15%	**8.44%**
Aug	111,421	147,856	191,567	201,390	8.31%	7.85%	9.20%	7.81%	**8.29%**
Sep	106,758	140,965	182,656	239,564	7.96%	7.48%	8.77%	9.29%	**8.38%**
Oct	139,371	186,608	210,032	219,738	10.40%	9.91%	10.08%	8.52%	**9.73%**
Nov	95,643	155,168	132,521	254,660	7.14%	8.24%	6.36%	9.88%	**7.90%**
Dec	141,651	215,947	246,422	235,196	10.57%	11.46%	11.83%	9.12%	**10.75%**
Total	**1,340,399**	**1,883,647**	**2,082,784**	**2,577,817**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**
Max. Flow	141,651	215,947	246,422	254,660	10.57%	11.46%	11.83%	9.88%	10.75%
Min. Flow	95,413	136,028	110,316	190,832	7.12%	7.22%	5.30%	7.40%	7.30%

Source Data: RCL, MBEL-ATT JV.

Table 4.37: Monthly Flow Variation of Trailers on Meghna-Gomoti Bridge

Year / Month	Total Monthly Flow of Trailers (Both Direction)				Monthly Flow Percentage				
	2006	2007	2008	2009	2006	2007	2008	2009	Average
Jan	2,909	4,672	8,755	11,966	6.13%	5.20%	8.59%	10.32%	**7.56%**
Feb	3,543	6,100	7,977	9,415	7.46%	6.79%	7.83%	8.12%	**7.55%**
Mar	4,323	8,357	8,329	9,377	9.10%	9.31%	8.18%	8.08%	**8.67%**
Apr	3,872	8,232	8,809	10,013	8.15%	9.17%	8.65%	8.63%	**8.65%**
May	3,974	7,591	9,043	10,938	8.37%	8.45%	8.88%	9.43%	**8.78%**
Jun	3,830	6,906	8,393	10,078	8.06%	7.69%	8.24%	8.69%	**8.17%**
Jul	3,861	7,008	10,633	8,420	8.13%	7.80%	10.44%	7.26%	**8.41%**
Aug	4,296	7,929	9,525	8,844	9.05%	8.83%	9.35%	7.62%	**8.71%**
Sep	3,571	8,820	9,772	7,196	7.52%	9.82%	9.59%	6.20%	**8.28%**
Oct	4,083	8,318	8,393	10,701	8.60%	9.26%	8.24%	9.23%	**8.83%**
Nov	4,330	9,509	4,594	8,710	9.12%	10.59%	4.51%	7.51%	**7.93%**
Dec	4,899	6,358	7,647	10,337	10.32%	7.08%	7.51%	8.91%	**8.45%**
Total	**47,491**	**89,800**	**101,870**	**115,995**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**
Max. Flow	4,899	9,509	10,633	11,966	10.32%	10.59%	10.44%	10.32%	8.83%
Min. Flow	2,909	4,672	4,594	7,196	6.13%	5.20%	4.51%	6.20%	7.55%

Source Data: RCL, MBEL-ATT JV.

Figure 4.73: Seasonal Flow Variation of Large Bus on N-1 Corridor (Both Direction), 2006-2009

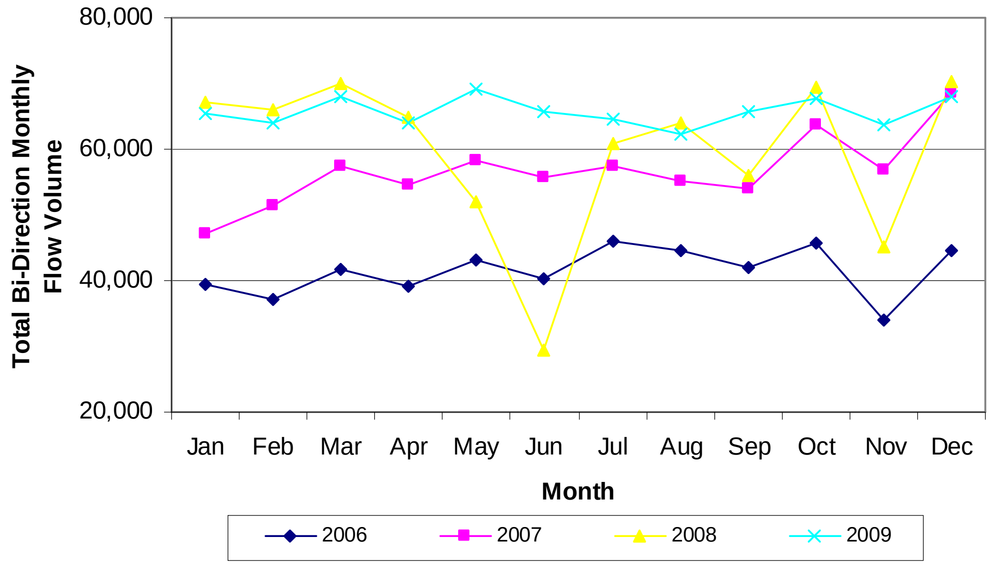
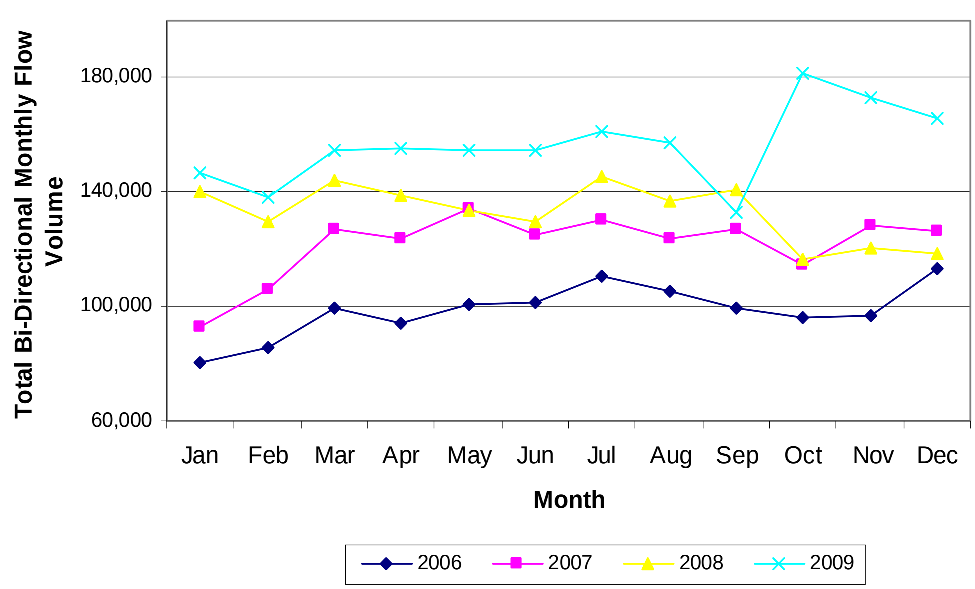
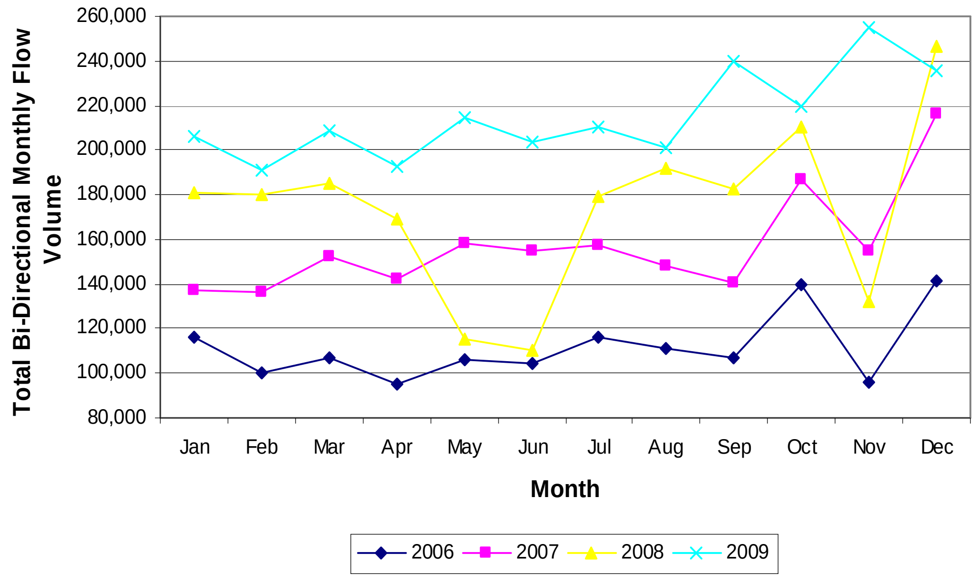


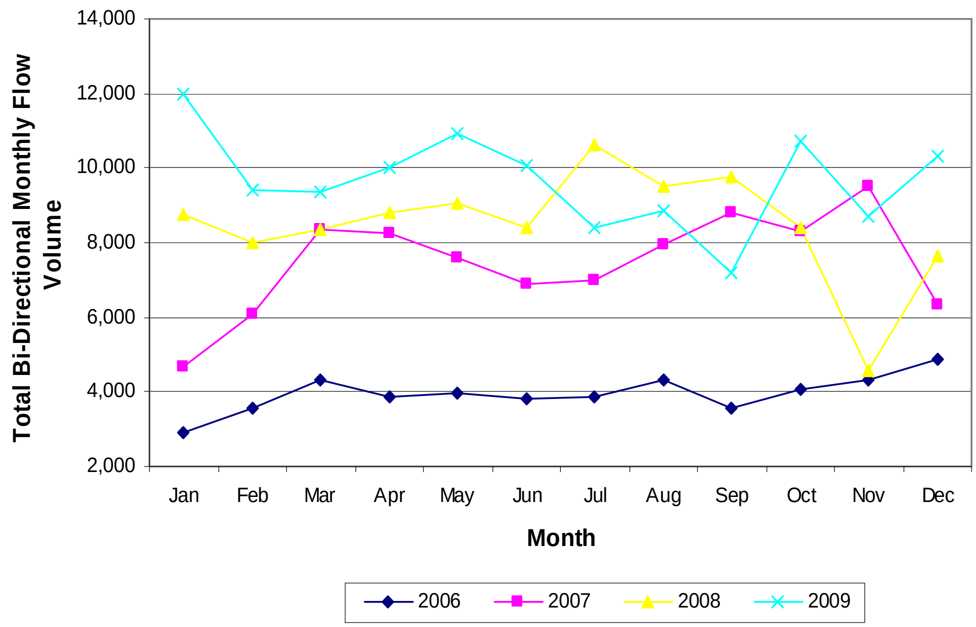
Figure 4.74: Seasonal Flow Variation of Medium Trucks on N-1 Corridor (Both Direction), 2006-2009



Fugure 4.75: Seasonal Flow Variation of Light Vehicles on N-1 Corridor (Both Direction), 2006-2009



Fugure 4.76: Seasonal Flow Variation of Trailer on N-1 Corridor (Both Direction), 2006-2009



Summary of Findings:

Following are the summarized findings from the seasonal flow analyses on Meghna-Gomoti Bridge.

Table 4.38: Summary Table - Seasonal Flow Variation (average of four years)

Vehicle Class	Maximum Flow		Minimum Flow	
	Month	Percentage of Yearly Volume	Month	Percentage of Yearly Volume
Total Traffic	December	9.68%	June	7.69%
Medium Truck	December	9.38%	June	7.18%
Large Bus	July	9.00%	January	7.45%
Light Vehicles	December	10.75%	June	7.30%
Trailer	October	8.83%	February	7.55%

4.4.4 TRAFFIC COMPOSITION

A very important parameter called Traffic Composition is an essential part of the design of pavement. Geometric and structural design of any road facility greatly depends on traffic composition.

In Megna and Gomoti bridges, total traffic is divided into eight classes considering vehicle size and capacity as follows.

1. Class 1: Motor Cycle
2. Class 2: Scooter / Tampu
3. Class 3: Car / Jeep
4. Class 4: Micro / Pickup
5. Class 5: Mini Bus / Coaster/ Mini Truck
6. Class 6: Bus
7. Class 7: Truck
8. Class 8: Trailer
9. Class 9: Toll Free

From the analyses of traffic composition on the Megna and Gomoti bridges, some important findings have been obtained which have been discussed in this section.

Figure 4.77 shows the classification wise yearly volume of traffic on Meghna and Gomoti bridges, while Figure 4.78 shows the traffic composition pattern from 2006 to 2009 on these two bridges. It can be seen from the Figure that most predominant vehicle classes are truck on N-1 corridor. Total yearly flow of trucks ranges from 12,00,000 to19, 00,000. On the other hand, the secod highest traffic category is bus, which produces 5,00,000 to 8,00,000 no of yearly trip that is 2.5 times lesser then truck. The graph indicates that special consideration should be taken at the time of pavement design, construction and maintenance of this corridor as the probability of pavement damage may be highest due to maximum movement of truck. The proportion of micro/ pick-up has increasing trend and it is the third largest trip producer. The trip quantity of Car/Jeep is also very rising. The percentage of trailer on N-1 corridor is very low but at an increasing trend.

Figure 4.77: Vehicle Class-wise Yearly Flow on Meghna-Gomoti Bridge

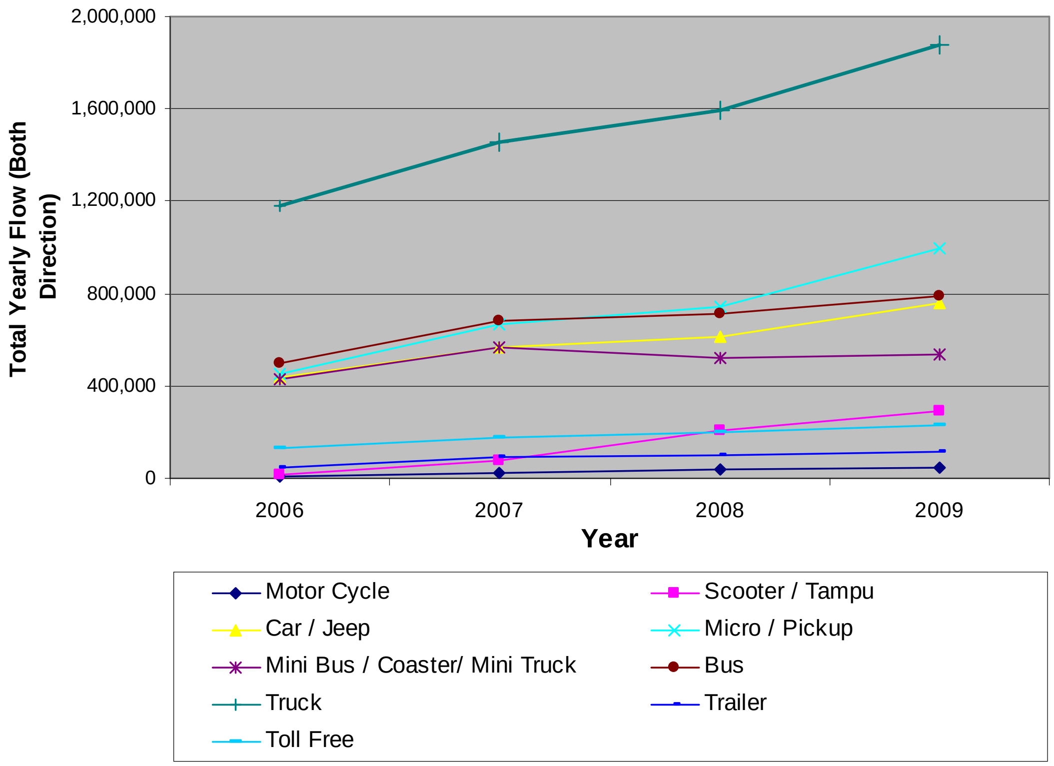
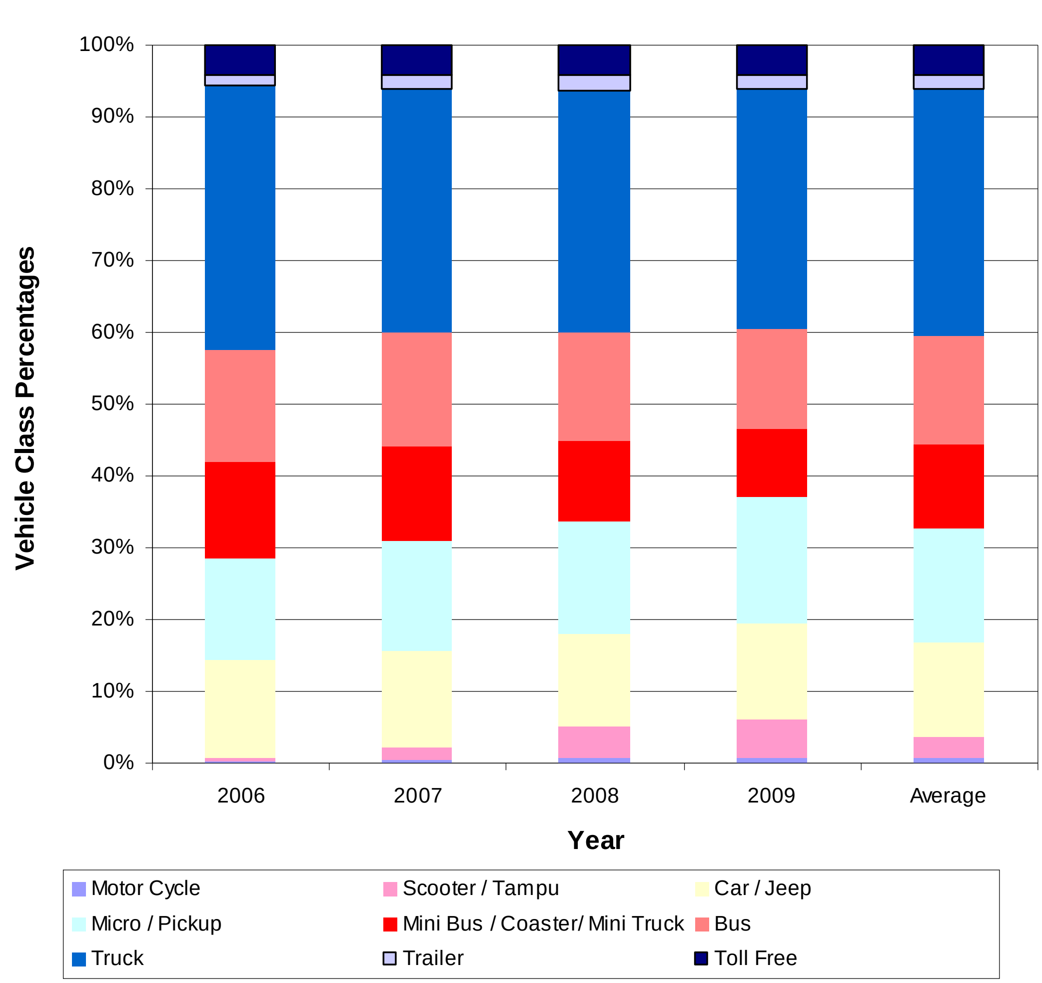


Figure 4.78: Traffic Composition Pattern on Meghna-Gomoti Bridge (in Percentage of Total Vehicle)



In Figure 4.78, vehicle class percentages on Meghna-Gomoti bridges are shown. It is found that, truck has the highest percentage in the traffic stream. In 2006, the percentage was 36.77% and during the next years the proportion is almost same. The average percentage of truck from 2006 to 2009 is 34.40%. The second highest percentage of vehicle class is Micro/Pick-up, the proportion of which was 14.20% in 2006 and 17.66% in 2009. The average percentage of Micro/Pick-up from 2006 to 2009 is 15.75%. The third highest contributing class to the total traffic flow is bus. In 2006, its percentage was 15.60% and it became 18.36% in the year of 2009, the average is found to be 15.12%. The fourth highest vehicle class is Car/Jeep, which has 13.53% in 2006 and 13.42% in 2009 making average from 2006 to 2009 is 13.26%. Analysing the traffic flow data on Meghna-Gomoti bridges from 2006 to

2009, it is found that these three pre-dominant vehicle classes comprise of total 78.53% of total traffic flow. Rest 21.47% is shared between minibus/coaster/Mini Truck (11.82%), motorcycle (0.61%), scooter/tampu (2.95%), trailer (1.94%) and toll free (4.15%). It is seen from the graph that the percentage of heavier vehicles especially Truck is increasing every year and lighter vehicles are decreasing.

Toll free vehicle have been taken into consideration in this analyses. The RHD vehicles, operator's vehicles and some other VVIP vehicles are not counted by the operator since they are toll exempted, although fair quantity (about 4.15% of tolled vehicles) of such vehicles pass the bridge every day.

4.4.5 HEAVY VEHICLES PERCENTAGE

Percentage of heavy vehicles refers to the percentage of truck and bus in a traffic stream. Heavier vehicles cause more damage to the roadway. For this reason, this is an important parameter for structural design of highway. Moreover, higher proportion of larger sized vehicles is important in the aspect of geometric design of highways as large vehicles are critical for the design of grade, turnings, road width, warrant for curve widening and auxiliary lane at vertical curve etc. The following section discusses the proportion of heavier vehicles on Meghna and Gomoti bridges flow and their travel pattern.

4.4.5.1 TRUCK PERCENTAGE

In Meghna and Gomoti bridges, according to the vehicle classification system used by the operators, vehicle having capacity of 5 ton to 8 ton are classed as trucks. This class is most common in Bangladesh and hence contributor of the highest percentage of traffic. Also, some trucks capacity is more than 8 ton and usually possesses more than two rear axles. It is observed from field survey that the toll collectors are often confused about the classification between the trucks falling near to boundary conditions.

However, from the analyses of traffic flow data from 2006 to 2009 on Meghna and Gomoti bridges, taking the average of these years, it is found that the percentage of all classes of trucks 36.34% of total vehicle. Among this, the percentages of trucks and trailers are 34.40% and 1.94% respectively (Figure 4.79). Table 4.39 shows the year-wise truck percentages. Figure 4.80 shows the growth pattern of trucks on North Bengal Corridor.

Table 4.39: Truck Percentages on Meghna-Gomoti Bridges (Both Direction)

Year	Truck	Trailer	Total Trucks & Trailers
2006	36.77%	1.47%	38.24%
2007	33.83%	2.08%	35.91%
2008	33.69%	2.15%	35.84%
2009	33.31%	2.06%	35.37%
Average	**34.40%**	**1.94%**	**36.34%**

Date Source: RCL, MBEL-ATT JV.

Figure 4.79: Annual Truck Percentages on Meghna-Gomoti Bridge (Average from 2006 to 2009)

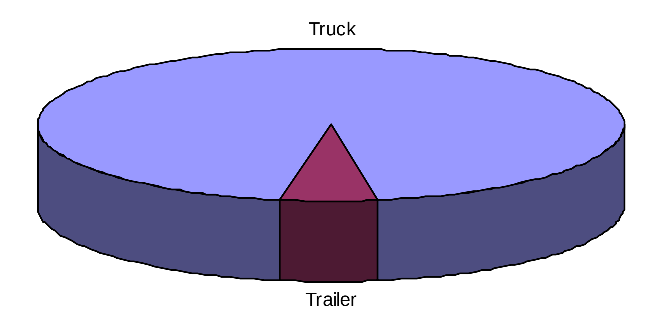
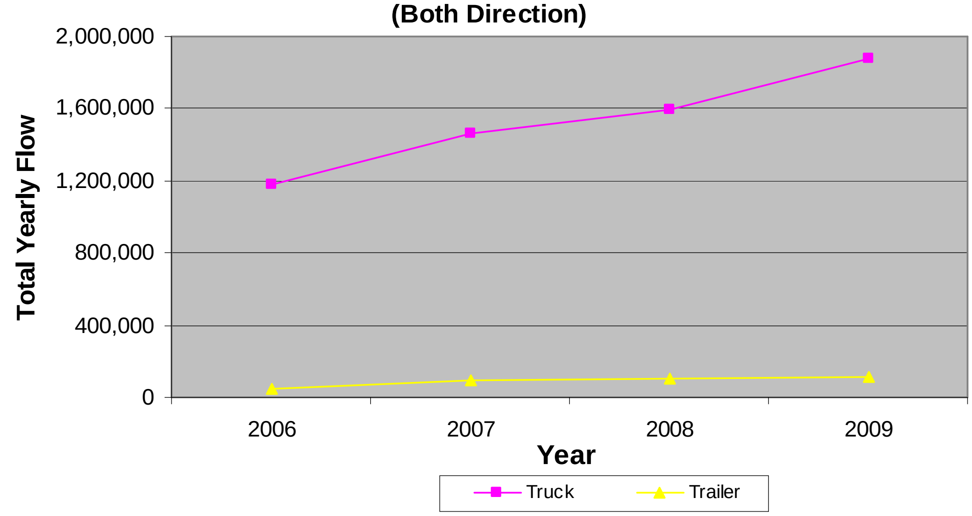


Figure 4.80: Yearly Flow of Trucks on Meghna-Gomoti Bridge (Both Direction)



4.4.5.2 BUS PERCENTAGE

Buses passing through Meghna and Gomoti bridges are classified into two groups namely Mini Bus/ Coaster/ Mini Truck and large Bus are called Bus. Buses having capacity of 30 seats of less are classed as mini bus and buses having more than 30 seats capacity are classed as Bus.

Table 4.40: Yearly Flow of Bus on Meghna-Gomoti Bridges (Both Direction)

Year	Mini Bus/ Coaster	Bus	Total Buses
2006	431,839	497,938	929,777
2007	570,851	680,413	1,251,264
2008	524,010	715,618	1,239,628
2009	535,970	788,149	1,324,119
Average	**515,668**	**670,530**	**1,186,197**

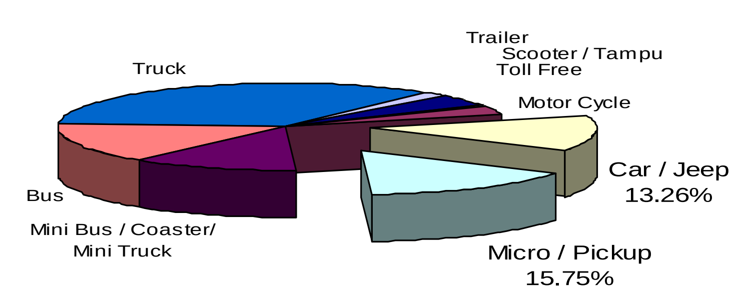
Date Source: RCL, MBEL-ATT JV.

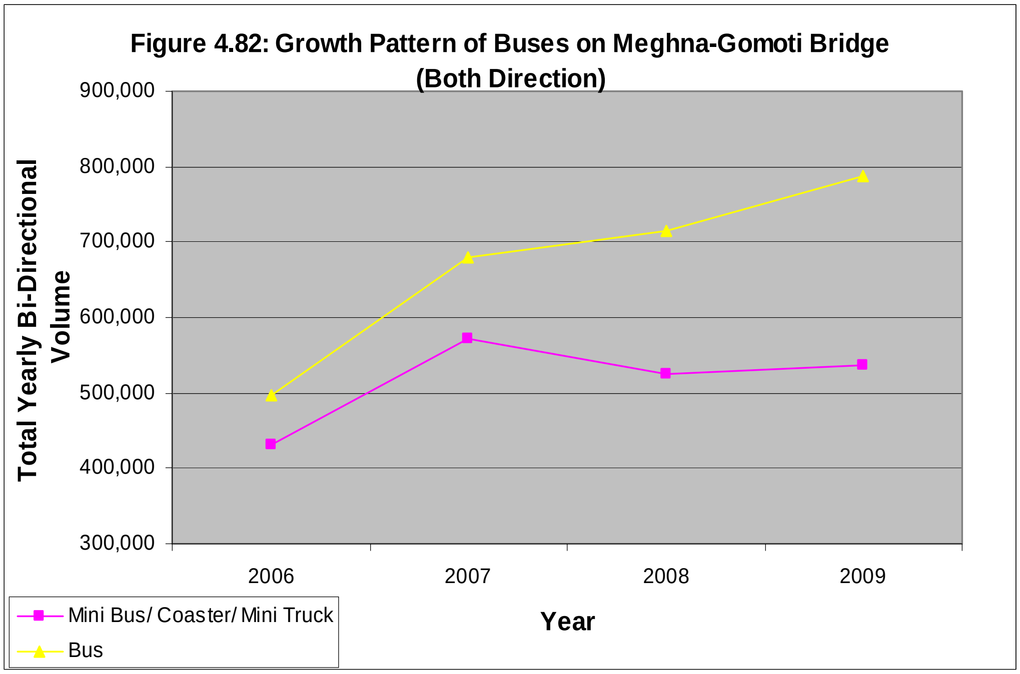
Table 4.41: Bus Percentages on Meghna-Gomoti Bridges (Both Direction)

Year	Mini Bus/ Coaster	Bus	Total Buses
2006	13.46%	15.60%	**29.06%**
2007	13.23%	15.77%	**29.01%**
2008	11.07%	15.12%	**26.19%**
2009	9.52%	13.99%	**23.51%**
Average	**11.82%**	**15.12%**	**26.94%**

Date Source: RCL, MBEL-ATT JV.

Figure 4.81: Annual Bus Percentages on Meghna-Gomoti Bridge (Averaged over 4 years)





From Figure 4.81, it is seen that total 26.94% of total annual flow (taking average from 2006 to 2009) comprises of buses. Among this, 15.12% is large bus and 11.82% is mini bus. Annual increase pattern of total number buses is shown in Figure 4.82. Although the total number is increasing at a quite high rate, but from Table 4.41, it can be seen that the percentage of bus has slightly decreasing with respect to total traffic (15.60% in 2006 and 13.99% in 2009). The growth factor of bus from the year 2006 to 2009 is respectedly 36.65%, 5.17%, and 10.14%. The percentage of bus has increased every year at an average rate of 17.32% per annum.

4.4.6 IMPACT OF EID FESTIVALS ON TRAFFIC FLOW

Eid festivals have significant impact on traffic flow in Meghna and Gomoti Bridges, which is projected in other corridors of Bangladesh as well. Due to the Eid festivals, different traffic flow parameters are greatly affected and thus the need for analyzing the extent of Eid Festivals' impact is deeply realized. Since, the traffic flow around an Eid is higher than usual traffic flow, it is easily understood that, a factor representing the impact of Eid festival should be determined by which the traffic flow around an Eid can be more precisely estimated, which is expected to be the critical flow value.

For these analyses, four years of continuous daily traffic flow data obtained from RCL and MBEL-ATT JV have been used. To identify the variation caused by Eid festivals, traffic flow in month containing Eid shall be compared with average yearly traffic flow or even traffic flow in other years for that particular month not containing Eid. By summarizing four years' continuous daily flow data, it is found that, taking the average daily flow on all months in successive four years, the average daily flow percentage is around 2.90% to 3.60% of corresponding monthly flow volume (Figure. 4.83).

Fig 4.83: Daily Traffic Flow Percentage Throughout The Year (Both Direction)

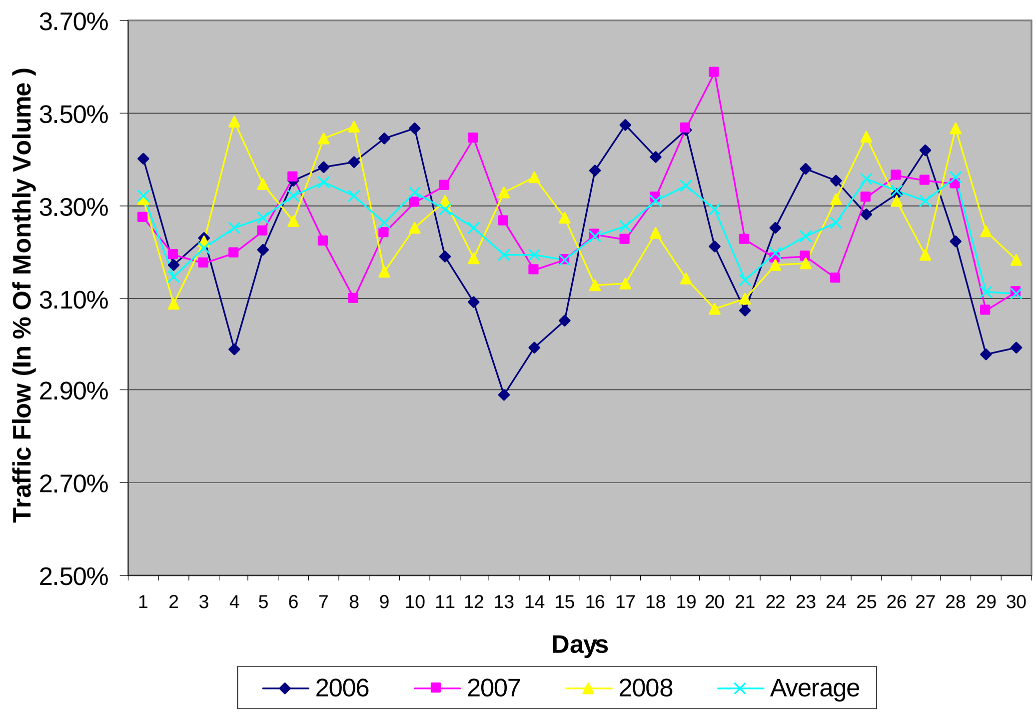


Table 4.42: Summarized Daily Flow Percentage Table (Both Direction)

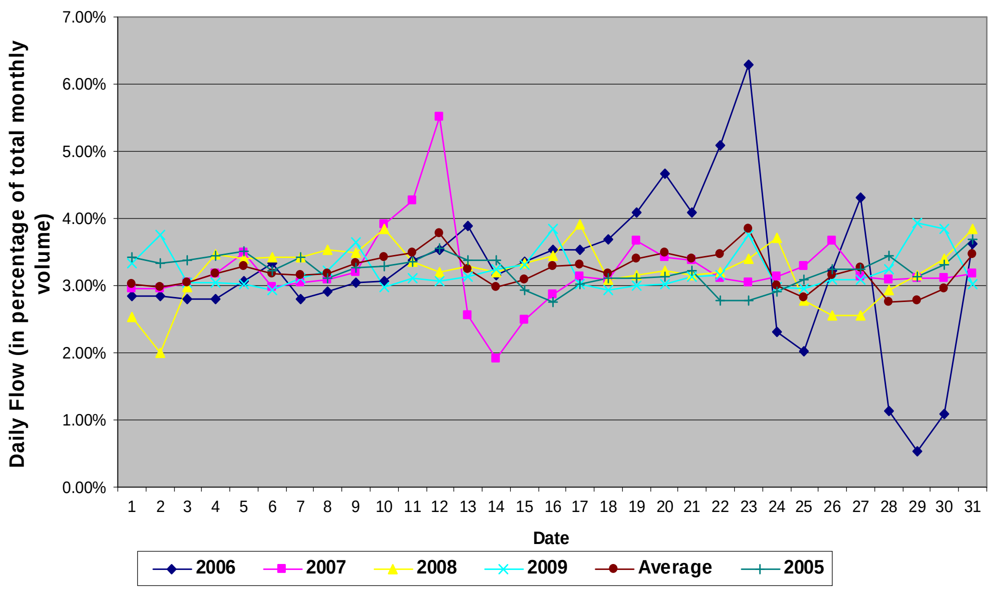
Date	Daily Flow Percentage (Averaged Over 12 Months)			
	2006	**2007**	**2008**	**Average**
1	3.40%	3.27%	3.31%	3.32%
2	3.17%	3.19%	3.09%	3.15%
3	3.23%	3.18%	3.22%	3.21%
4	2.99%	3.20%	3.48%	3.25%
5	3.21%	3.24%	3.35%	3.27%
6	3.35%	3.36%	3.27%	3.32%
7	3.38%	3.22%	3.44%	3.35%
8	3.39%	3.10%	3.47%	3.32%
9	3.44%	3.24%	3.16%	3.26%
10	3.47%	3.31%	3.25%	3.33%
11	3.19%	3.34%	3.31%	3.29%
12	3.09%	3.44%	3.19%	3.25%
13	2.89%	3.27%	3.33%	3.19%
14	2.99%	3.16%	3.36%	3.19%
15	3.05%	3.18%	3.27%	3.18%
16	3.38%	3.24%	3.13%	3.23%
17	3.47%	3.23%	3.13%	3.26%
18	3.41%	3.32%	3.24%	3.31%
19	3.46%	3.47%	3.14%	3.34%
20	3.21%	3.59%	3.08%	3.29%
21	3.07%	3.23%	3.10%	3.14%
22	3.25%	3.19%	3.17%	3.20%
23	3.38%	3.19%	3.17%	3.23%
24	3.35%	3.14%	3.31%	3.26%
25	3.28%	3.32%	3.45%	3.36%
26	3.32%	3.37%	3.31%	3.33%
27	3.42%	3.35%	3.19%	3.31%
28	3.22%	3.35%	3.47%	3.36%
29	2.98%	3.07%	3.24%	3.11%
30	2.99%	3.11%	3.18%	3.11%
	100.00%	100.00%	100.00%	100.00%
Average Daily Flow Percentage (Averaged Over 3 Years)				**3.26%**
Standard Deviation				**0.07%**

Data Source: RCL, MBEL-ATT JV.

In Table 4.42, daily both directional flows, in percentage of total monthly volume, averaged over 12 months, from 2006 to 2008, is shown. Here it is to be noted that, flow percentage in 31st day of month is excluded because of presence of 31st day in only seven months in a year. However, the average daily flow percentage comes to be 3.26% with an astonishing standard deviation of only 0.07%. This leads to a fact that, even with the effects of all external factors causing deviations in normal traffic flow, the average daily flow is quite predictable.

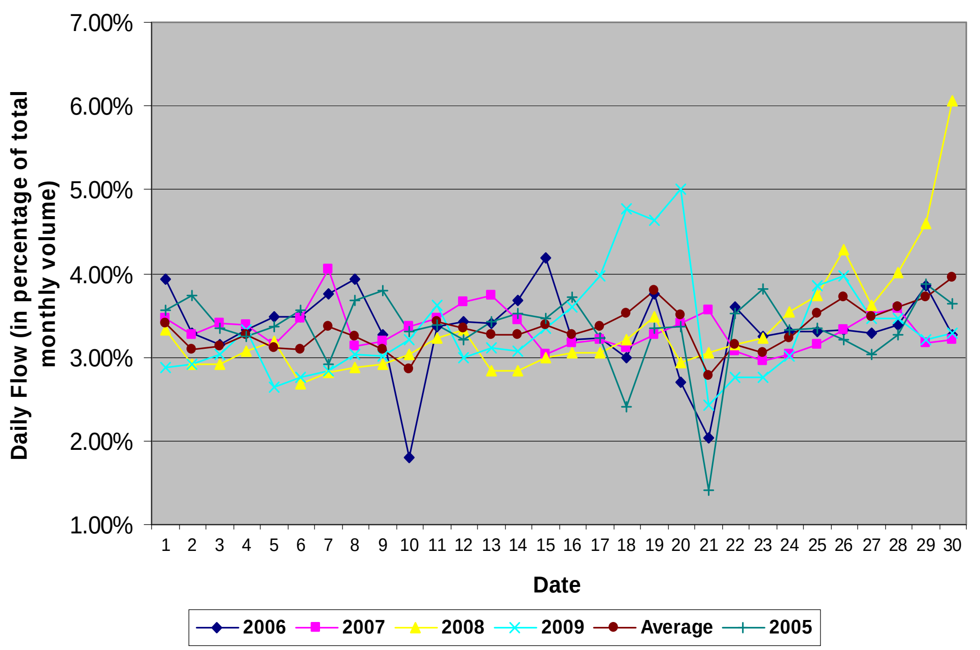
Now, for the years under consideration in this study, months from September to January have contained two Eid festivals. If an Eid month, say October is taken into account, the flow variation exhibits some remarkable facts, as shown in Figure 4.84.

Figure 4.84: Daily Flow Percentage on October



It can be clearly seen that, 2005 and 2009 year maintain near about 2.80% to 3.75% of daily flow percentage, since October did not contain any Eid during these years. On the contrary, for the years 2006 and 2007, distinct peaks followed by abrupt fall in traffic flow are observed. In all cases, the lowest traffic occurred on Eid day and the peak flow has taken place two days prior to Eid. Naturally one can understand that, this has happened because of increased passenger movement during Eid, as most city people usually spend Eid at their native town or village and the Eid vacation starts from the previous day of Eid day. So, the peak flow occurs two days prior to Eid. In 2008, Eid occurs on second October that does not reflect on traffic pattern rather reflects on September, as shown in Figure 4.85.

Figure 4.85: Daily Traffic Flow Percentage on September in N-1 Corridor



In this case, the Eid festivals have taken place on September in the years 2009. For the year 2008 and 2009, the flow rises to the peak before Eid and immediately falls on Eid day. Some other falls are also observed which might have occurred for strikes or Hartals. From the above analyses for all individual Eid months, it has been found that, the peak flow percentage raises upto 6.30% in October 2006. But in most of the cases the peak value stays within a range of 5.00% to 6.00%, which is approximately 70% higher than normal traffic flow.

Another approach can be made to see the impact of Eid festivals on daily traffic flow. If all the daily bi-directional flow in a particular year is sorted in the descending order, it is found that, most of the peak daily volume occurs within one week of Eid. In Table 4.43, the daily both directional traffic volumes in the year 2006 to 2009 has been sorted in descending order and highest 15 daily volumes are listed. It is observed that, most of the days carrying highest daily traffic in a year are within a week of an Eid.

It is also found that, the highest daily flow in a year caused by Eid event carries as much as 113.94% higher volume than AADT of that particular year. From these analyses, one can easily understand that, the highest daily flow in a particular year occurs at the time of Eid and the transportation planners should consider this fact while designing highways in Bangladesh.

Table 4.43: Highest Daily Traffic Flow within a Year

Sl. No. (In Descending Order of Daily Flow Volume)	2006 (AADT = 8765)			2007 (AADT = 11813)			2008 (AADT = 12925)			2009 (AADT = 15434)		
	Date	Total Bi-Directional Daily Flow	Percentage higher than AADT	Date	Total Bi-Directional Daily Flow	Percentage higher than AADT	Date	Total Bi-Directional Daily Flow	Percentage higher than AADT	Date	Total Bi-Directional Daily Flow	Percentage higher than AADT
1	10/23/06	18752	113.94%	12/20/07	23284	97.10%	12/08/08	24792	91.81%	11/26/09	26541	71.96%
2	10/22/06	15187	73.27%	10/12/07	21716	83.83%	09/30/08	24789	91.79%	11/27/09	24376	57.94%
3	10/20/06	13953	59.19%	12/19/07	21069	78.35%	12/07/08	22829	76.63%	09/20/09	23522	52.40%
4	01/10/06	13948	59.13%	12/14/07	17067	44.48%	12/05/08	20853	61.34%	09/18/09	22448	45.45%
5	10/27/06	12874	46.88%	12/18/07	16805	42.26%	09/29/08	18846	45.81%	11/25/09	22054	42.89%
6	10/19/06	12226	39.49%	10/11/07	16798	42.20%	12/06/08	18265	41.32%	09/19/09	21842	41.52%
7	10/21/06	12201	39.20%	12/28/07	16161	36.81%	09/26/08	17543	35.73%	11/24/09	20063	29.99%
8	01/09/06	11788	34.49%	12/16/07	15485	31.08%	12/04/08	17318	33.99%	12/01/09	19055	23.46%
9	10/18/06	10993	25.42%	10/10/07	15397	30.34%	12/13/08	17102	32.32%	09/17/09	18655	20.87%
10	10/31/06	10797	23.18%	12/25/07	15175	28.46%	12/03/08	16525	27.85%	09/26/09	18632	20.72%
11	11/01/06	10695	22.02%	12/15/07	15036	27.28%	09/28/08	16391	26.82%	11/23/09	18484	19.76%
12	10/26/06	9650	10.10%	10/19/07	14455	22.37%	12/16/08	15686	21.36%	09/25/09	18122	17.42%
13	01/08/06	9101	3.83%	12/26/07	14192	20.14%	12/14/08	15472	19.71%	11/22/09	17197	11.42%
14	01/06/06	8849	0.96%	12/17/07	13767	16.54%	12/12/08	15281	18.23%	09/16/09	16953	9.84%
15	01/07/06	8510	-2.91%	12/27/07	13582	14.98%	09/25/08	15271	18.15%	09/21/09	16391	6.20%

Data Source: RCL, MBEL-ATT Ltd.

Now, this is very unfortunate that directional split cannot be determined due to lack of preservation of data. Directional split is an important paramenter for geometric and structural design of highways. Concern authorities should be careful to preserve these important data.

Summary of Findings:

From the above analyses, it is clearly understood that, Eid festivals have crucial impact on traffic flow in N-1 Corridor. Therefore, for accurate estimation of AADT from short counts, not only expansion factors are sufficient for precise estimation, but also an Eid factor is to be determined and introduced, so that the peak hour flow can be correctly estimated.

- Duration of Eid Impact: 5 days before and 6 days after Eid day; total 11 days.
- Maximum Daily Flow Percentage: 6.30% (bothway) before Eid in October 2006.
- Average Daily Flow Percentage: 3.26%, Standard Deviation: 0.07%
- All highest Daily Volume in a year are within Eid effect range, carrying upto 113.94% more traffic than AADT.

4.4.7 TRAFFIC GROWTH PATTERN

This article analyzes the four years of traffic flow data from 2006 to 2009 to understand the true pattern of traffic growth in Dhaka- Chittagong (N-1) corridor. The traffic is increasing every year in this corridor and proper assessment of growth factor is very essential for the preservation and maintenance of this highway.

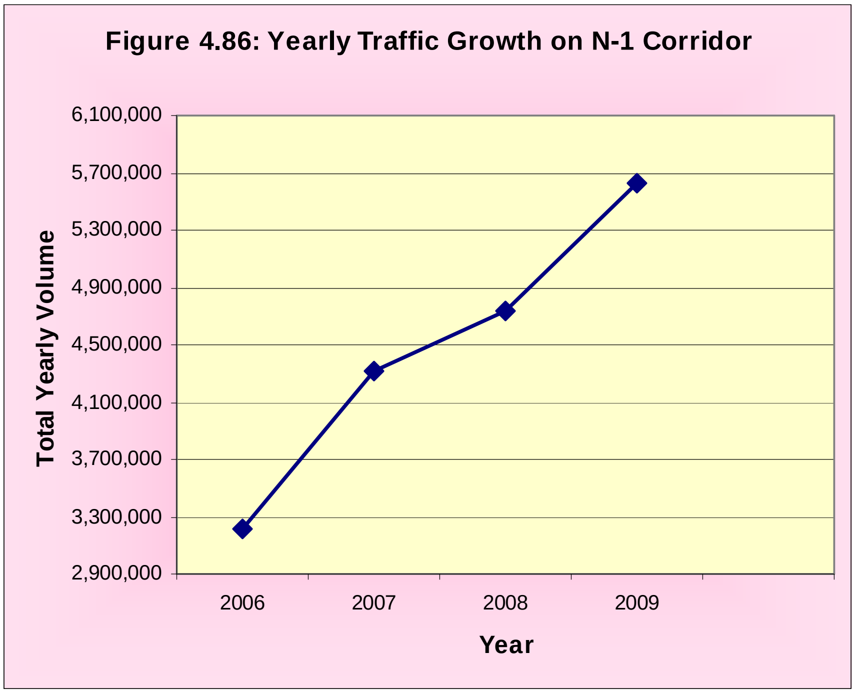
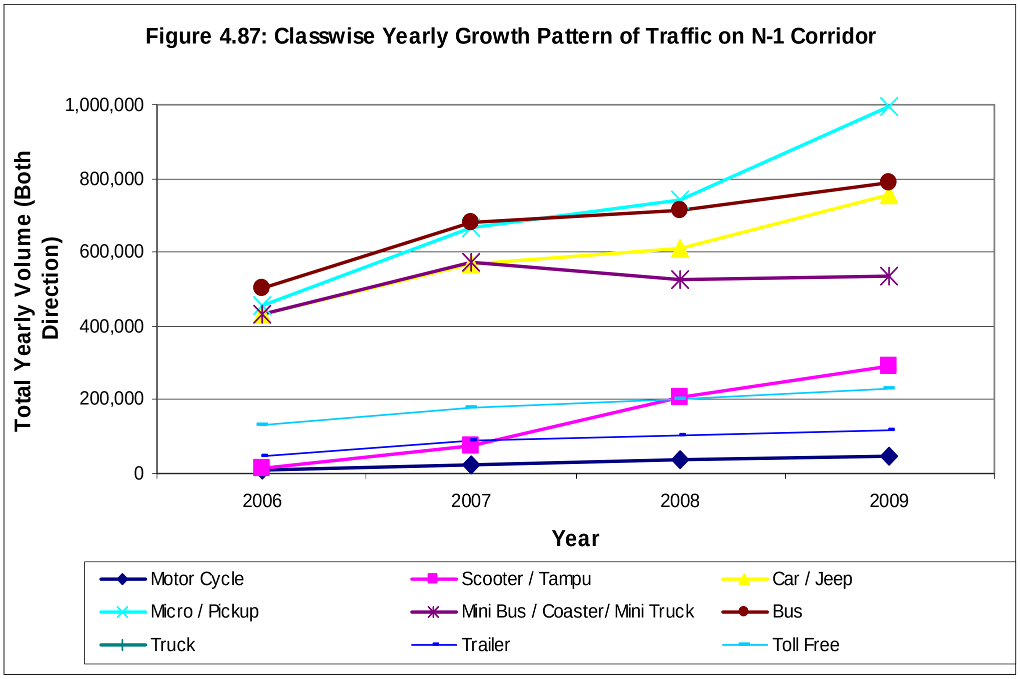
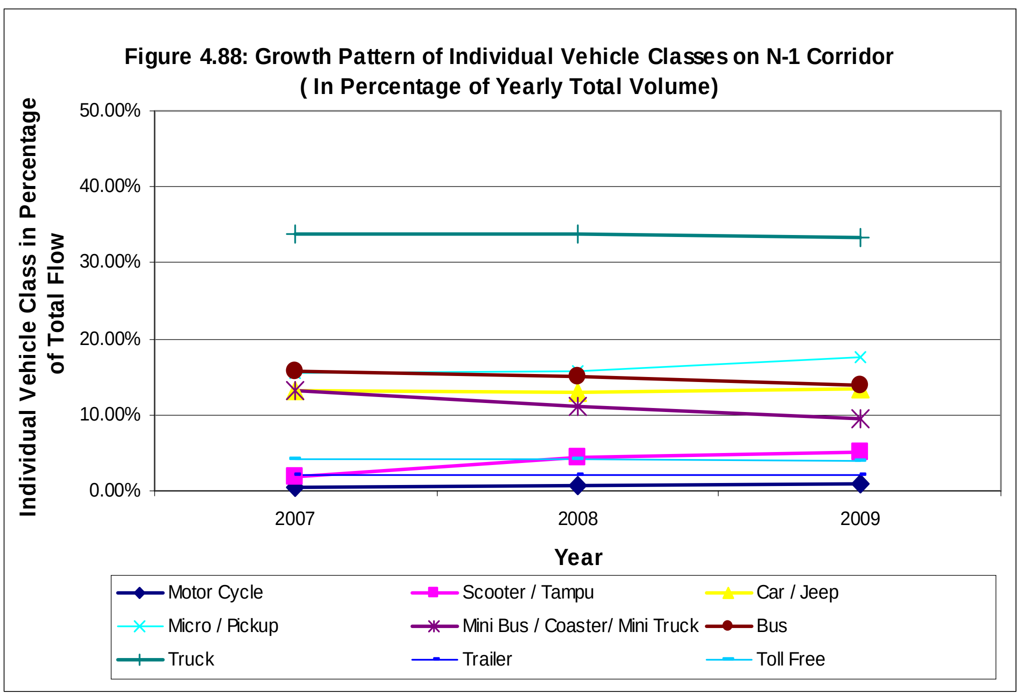


Figure 4.86 plots the total bi-directional yearly traffic volume on N-1 corridor against respective years from 2006 to 2009. From the graph, it is clearly seen that the yearly traffic growth is almost linear. In 2006, the total yearly traffic volume was 3,210,410. During the next three years it has gradually increased and has become near about five and half million (exact Figure – 5,632,798) in 2009. The average growth rate has been found to be 21.03% per annum, which is higher than average national growth rate (8-10%) used in the Roads and Highways design manual.

It is found from traffic flow analysis in this study that, percentage of various vehicle classes with respect to total yearly is not constant throughout the study period. Rather, they are changing from year to year at a significant rate. Some vehicle classes are increasing every year while some are decreasing. Therefore, it can be easily understood that, flat growth rate for total traffic is not representative of the actual scenario. This raises the need for traffic growth pattern analyzed individually for all vehicle classes.





In Figure 4.87, total yearly flow of all nine vehicle classes used in meghna-Gomoti bridge is plotted against respective years from 2006 to 2009, while Figure 4.88 shows the yearly variation in percentage of individual vehicle classes with respect to total yearly volume. The observations made from the above graphs, separately for each vehicle class, are described hereunder.

4.4.7.1 Motor Cycle:

In 2006, total yearly volume of this class was 9,743 and in 2009 it became 46,496. During the intermediate years total volume was within a range from 22 to 46 thousand per year. The average yearly volume derived from five years is 29,086. The total yearly volume of Motor Cycle and the percentage of motorcycle with respect to total volume has not changed to great extent during the study period. In 2006, the percentage was 0.30% and gradually increased slightly every year and became 0.83% in 2009. This has happened because of increase in total traffic. Taking the average value during the study period, percentage of motorcycle is only 0.61% within the traffic stream.

4.4.7.2 Scooter/Tampu:

From Figure 4.87, it can be seen that total yearly volume of Scooter/Tampu has increased from 15,976 in 2006 to 2, 91,080 in 2009. The percentage of this class has increased from 0.50% in 2006 to 5.17% in 2009. Average annual rise is 2.95% of total yearly volume. On an average, 1, 47,605 number of Scooter/Tampu move through the bridge annually.

4.4.7.3 Car/Jeep:

Car/Jeep has significant effect to produce traffic congestion on N-1 corridor. From Figure 4.87, it can be seen that total yearly volume of Car/Jeep has significantly increased from 4, 33,710 in 2006 to 7, 56,199 in 2009. But the percentage of Car/Jeep has remained almost same from 13.53% in 2006 to 13.42% in 2009. Taking the average value during the study period, percentage of Car/Jeep is 13.26% within the traffic stream.

4.4.7.4 Micro/Pickup:

From Figure 4.87, it can be seen that total yearly volume of Micro/Pickup has increased from 4,55,243 in 2006 to 9,94,568 in 2009. The percentage of this class has increased from 14.20% in 2006 to 17.66% in 2009. Average Micro/Pickup is

15.75% of total yearly volume. On an average, 7,14,750 number of Micro/Pickup move through the bridge annually.

4.4.7.5 Mini Bus/Coaster/Mini Truck:

In 2006 total volume of Mini Bus/Coaster/Mini Truck was 4, 31,617, while in 2009 it became 5,35,970. Annual percentage dropped from 13.46% to 9.52%. Average percentage of Mini Bus/Coaster/Mini Truck is 11.82% within the traffic stream from the year 2006 to 2009.

4.4.7.6 Bus:

Bus is the second highest traffic class in N-1 corridor. Total volume has increased from 5,00,227 to 7,88,149 during the four years under consideration. In average, 6,71,102 number of large bus trip generated each year from 2006 to 2009 on Meghna-Gomoti bridge. But the annual percentage has dropped from 15.60% to 13.99%, which indicates that number of buses have not increased proportionately with respect to total traffic from the year 2006 to 2009.

4.4.7.7 Trucks:

As discussed in article covering traffic composition, the class Truck contains the highest percentage of traffic on N-1 corridor. In Figure 4.87 and 4.88, annual growth of this class is also found to be quite significant. In the year 2006, total volume was 11,78,966 and it increased to more than 1.5 times during the next four years. Although due to consequent increase in total traffic, the growth in annual percentage is declining. From 2006 to 2009, the percentage has dropped from 36.77% to 33.31%. Ineffectiveness of axle load control station has promoted excess load carried by these truck frequently. Hence, the Dhaka-Chittagang highway is suffering extremely heavy loads then their design load.

4.4.7.8 Trailers:

Significant number of Trailers is present on N-1 corridor. Axle load of Trailer create severe damage on pavement. From the year 2006 to 2009, number of Trailer varies from 47,118 to 1,15,995. Average yearly number of Trailer trip is 88,696. The percentage of this class was 1.47% in 2006. After gradual increase, the same has become 2.06% in 2009.

4.4.7.9 Toll Free Vehicle:

From Figure 4.43, it can be seen that total yearly volume of Toll Free vehicle has increased from 1,33,677 in 2006 to 2,27,743 in 2009. The percentage of this class has remained same from 4.17% in 2006 to 4.04% in 2009.

Summary of Findings:

From the above analyses, it was firmly established that, consideration of flat growth rate for total vehicle is not correct. Rather, growth rate is to be determined for each individual class, which can be used more precisely for traffic flow prediction.

4.4.8 COMPARISON OF FLOW AMONG MEGHNA-GOMOTI BRIDGE, JAMUNA BRIDGE AND BHAIRAB BRIDGE

The high quality flow data is used in this study. This was initially predicted by seeing the repetitive nature of the curve, which is a usual phenomenon in all traffic flow. A framework has been developed in this study to compare traffic flow of different corridors.

During this study, one year of daily traffic flow data on N-1 and N-5 Corridors have been analyzed which is shown below.

Table 4.44: Flow comparison between Meghna-Gomoti Bridge and Jamuna Bridge

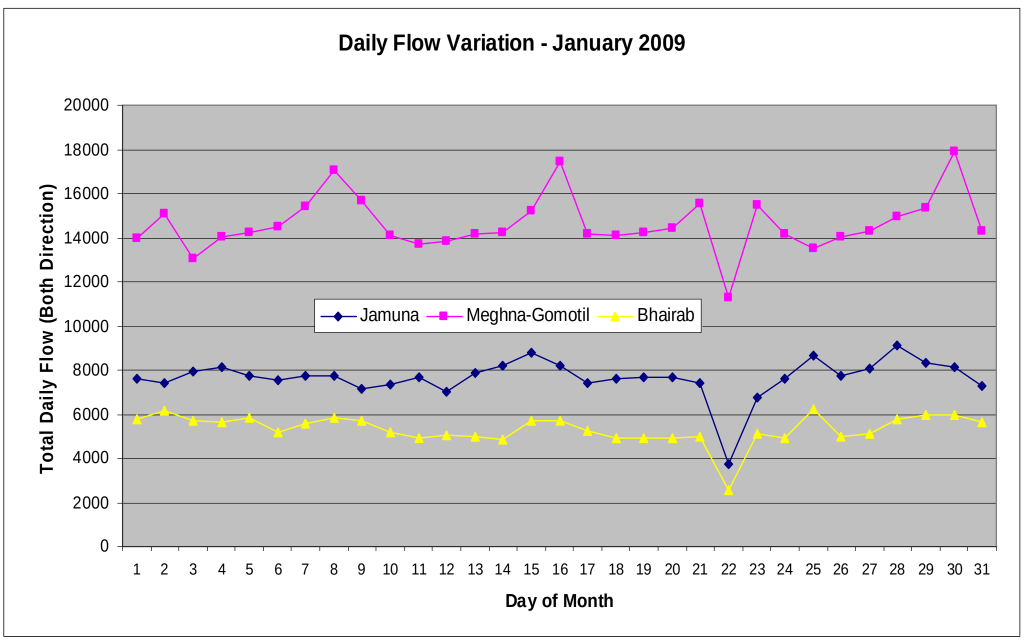
Month	Jamuna Bridge		Meghna-Gomoti Bridge		Meghna-Gomoti/ Jamuna - Percentage	Avg.	Standard Deviation
	Monthly Total Volume	Monthly Percentage	Monthly Total Volume	Monthly Percentage			
Jan-09	237,308	8.01	453,185	8.05	**190.97%**	**190.50%**	**7.92**
Feb-09	223,575	7.55	424,170	7.53	**189.72%**		
Mar-09	234,368	7.91	464,702	8.25	**198.28%**		
Apr-09	222,787	7.52	444,537	7.89	**199.53%**		
May-09	239,455	8.08	472,871	8.39	**197.48%**		
Jun-09	253,497	8.56	457,681	8.13	**180.55%**		
Jul-09	259,745	8.77	467,515	8.30	**179.99%**		
Aug-09	236,128	7.97	452,142	8.03	**191.48%**		
Sep-09	247,680	8.36	470,306	8.35	**189.88%**		
Oct-09	249,826	8.43	503,949	8.95	**201.72%**		
Nov-09	277,905	9.38	523,644	9.30	**188.43%**		
Dec-09	279,918	9.45	498,096	8.84	**177.94%**		

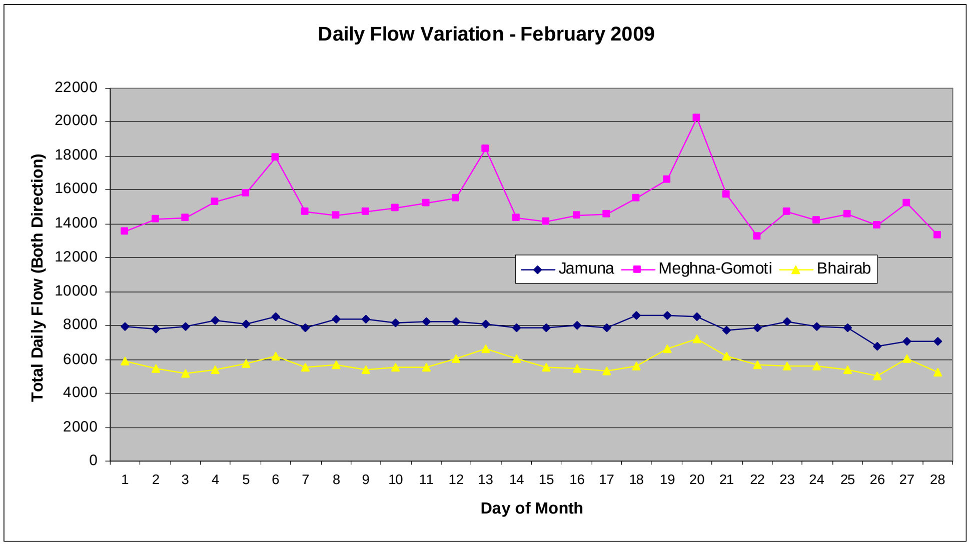
Data Source: MargaNet, RCL and MBEL-ATT JV.

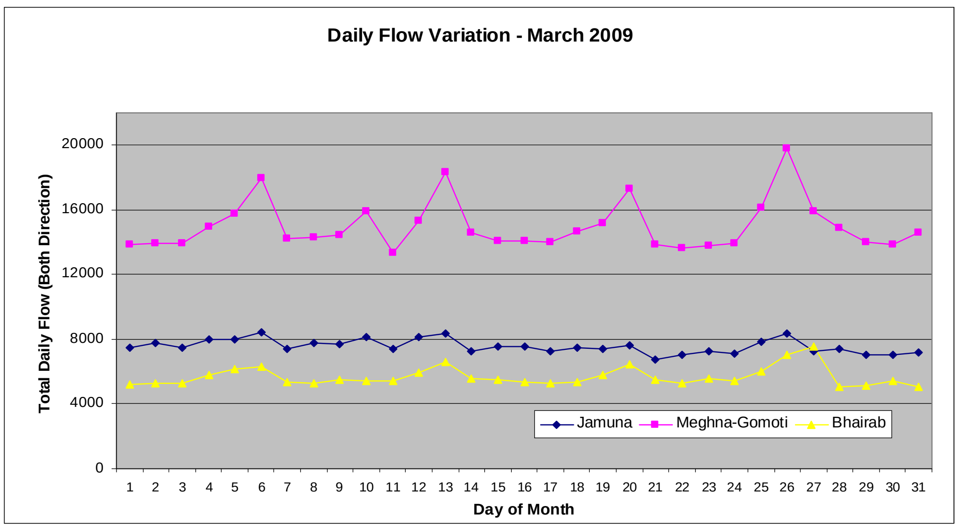
Table 4.45: Flow comparison between Meghna-Gomoti Bridge and Bhairab Bridge

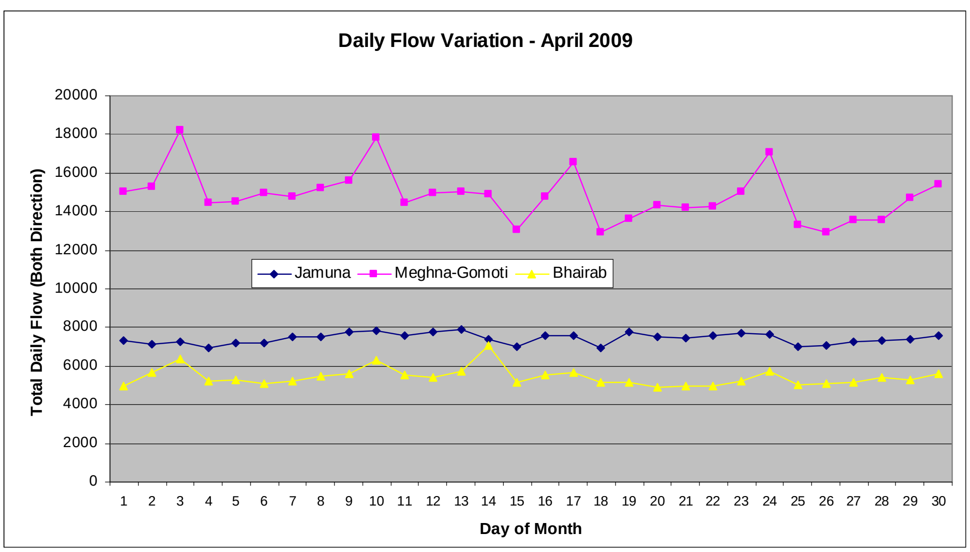
Month	Meghna-Gomoti Bridge		Bhairab Bridge		Meghna-Gomoti/ Bhairab - Percentage	Avg.	Standard Deviation
	Monthly Total Volume	Monthly Percentage	Monthly Total Volume	Monthly Percentage			
Jan-09	453,185	8.05	165,147	7.77	**274.41%**	**265.46%**	**9.48%**
Feb-09	424,170	7.53	160,869	7.57	**263.67%**		
Mar-09	464,702	8.25	175,773	8.27	**264.38%**		
Apr-09	444,537	7.89	162,958	7.67	**272.79%**		
May-09	472,871	8.39	173,608	8.17	**272.38%**		
Jun-09	457,681	8.13	172,284	8.11	**265.65%**		
Jul-09	467,515	8.30	180,520	8.50	**258.98%**		
Aug-09	452,142	8.03	176,987	8.33	**255.47%**		
Sep-09	470,306	8.35	175,972	8.28	**267.26%**		
Oct-09	503,949	8.95	182,337	8.58	**276.38%**		
Nov-09	523,644	9.30	193,099	9.09	**271.18%**		
Dec-09	498,096	8.84	204,986	9.65	**242.99%**		

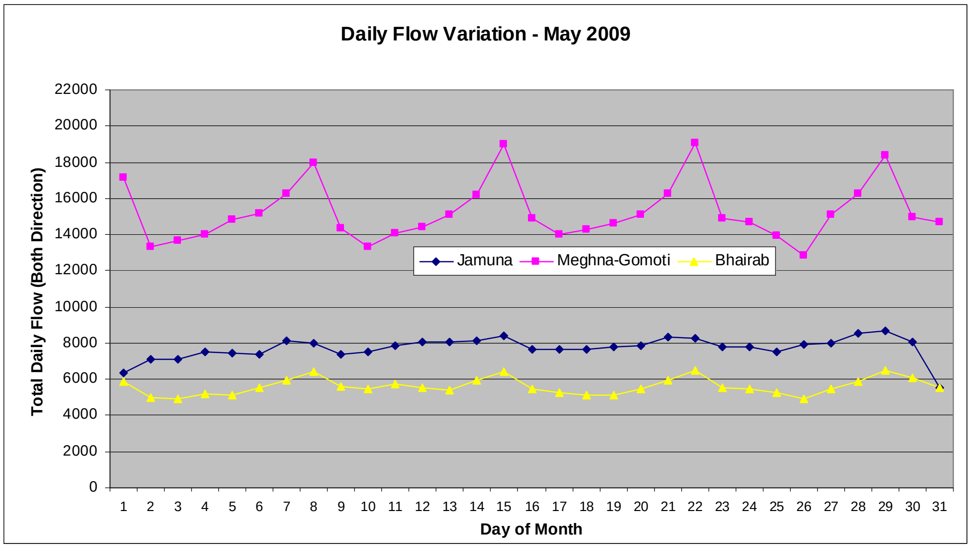
Data Source: RCL, MBEL-ATT JV, Sigma-RCL JV.

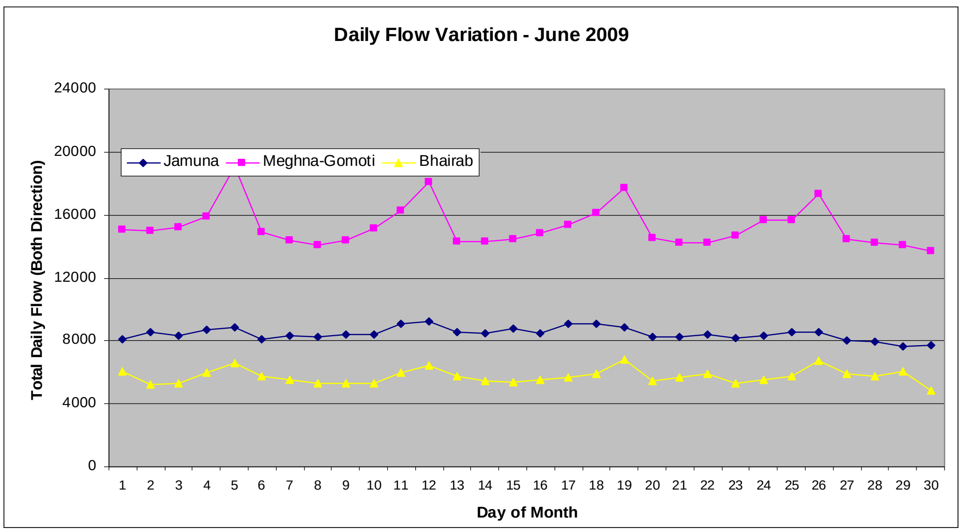


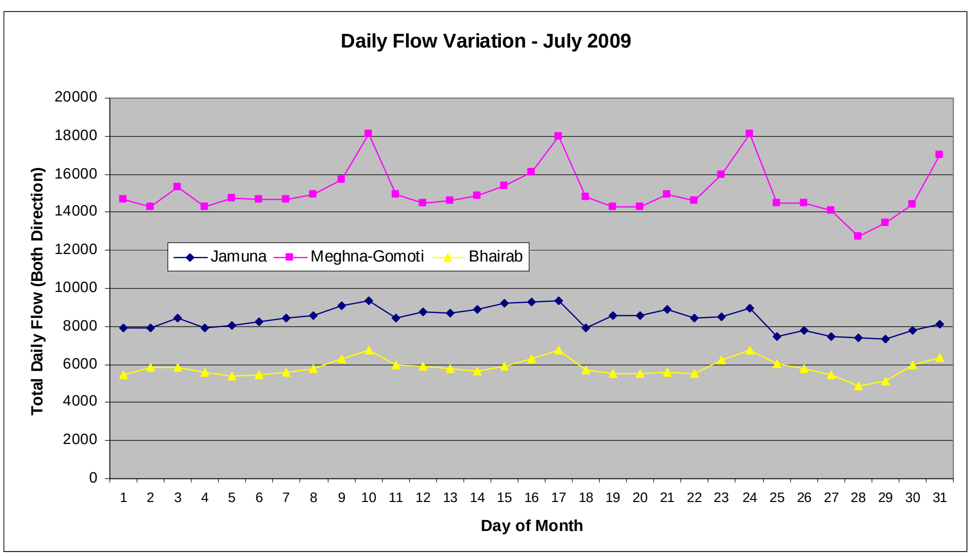

Daily Flow Variation - February 2009
Total Daily Flow (Both Direction)
Day of Month
Jamuna
Meghna-Gomoti
Bhairab
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
20000
22000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28

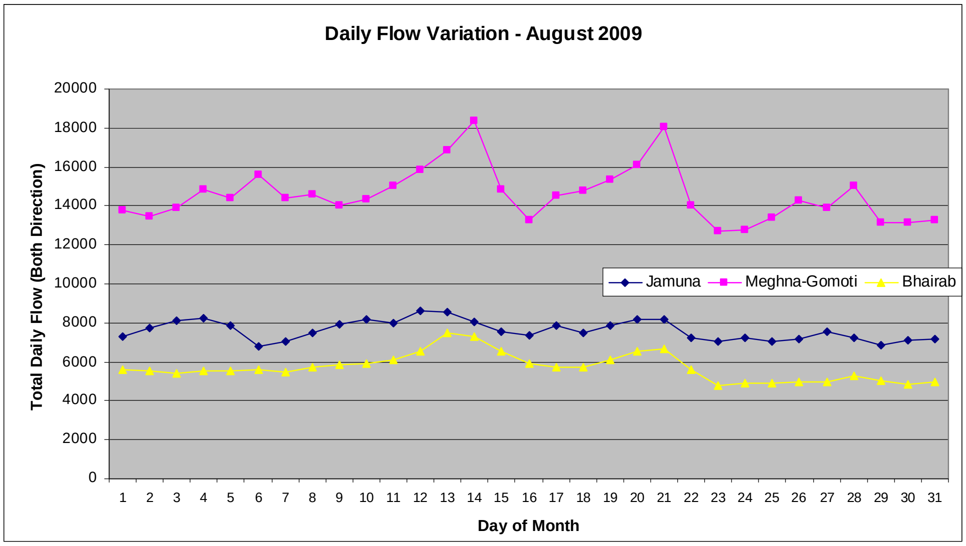

Daily Flow Variation - March 2009
Total Daily Flow (Both Direction)
Day of Month
Jamuna
Meghna-Gomoti
Bhairab
0
4000
8000
12000
16000
20000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31


Daily Flow Variation - April 2009
Total Daily Flow (Both Direction)
Day of Month
Jamuna
Meghna-Gomoti
Bhairab
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
20000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

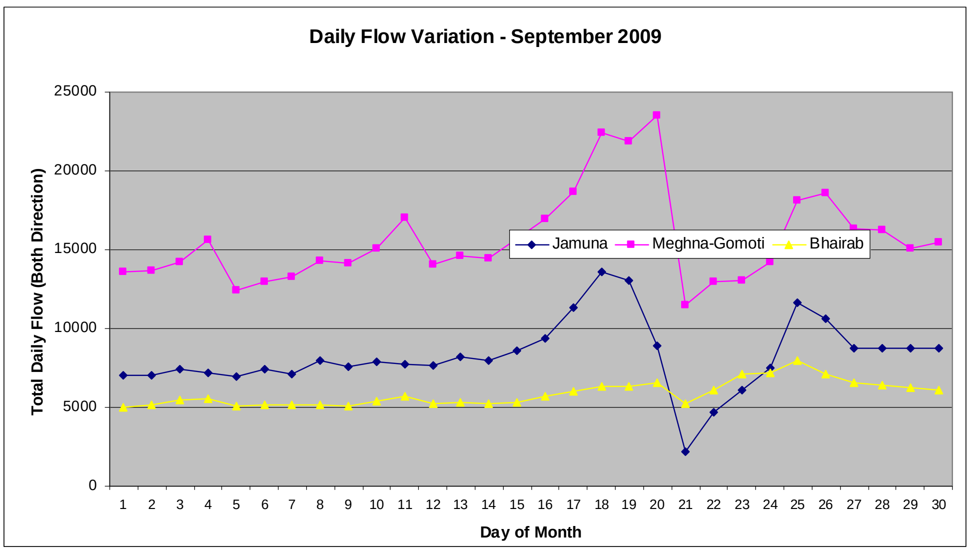

Daily Flow Variation - May 2009
Total Daily Flow (Both Direction)
Day of Month
Jamuna
Meghna-Gomoti
Bhairab
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31


Daily Flow Variation - June 2009
Total Daily Flow (Both Direction)
Day of Month
Jamuna
Meghna-Gomoti
Bhairab
24000
20000
16000
12000
8000
4000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

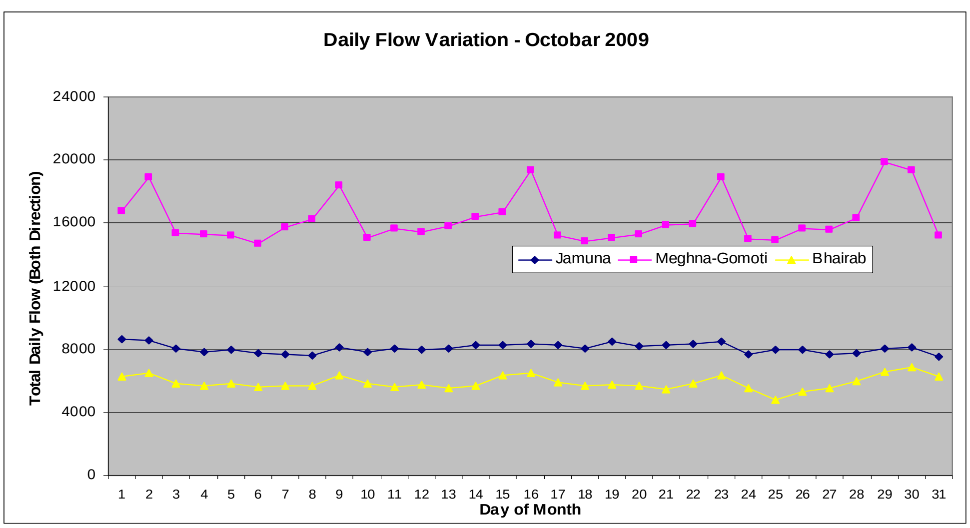

Daily Flow Variation - July 2009
Total Daily Flow (Both Direction)
Day of Month
Jamuna
Meghna-Gomoti
Bhairab
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31



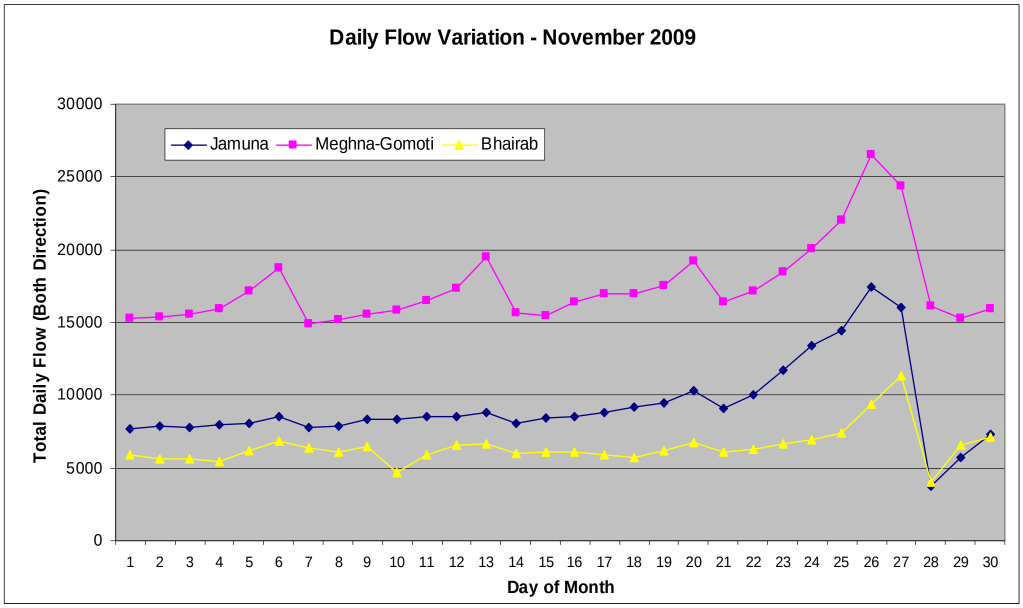
Daily Flow Variation - August 2009
Total Daily Flow (Both Direction)
Day of Month
Jamuna
Meghna-Gomoti
Bhairab

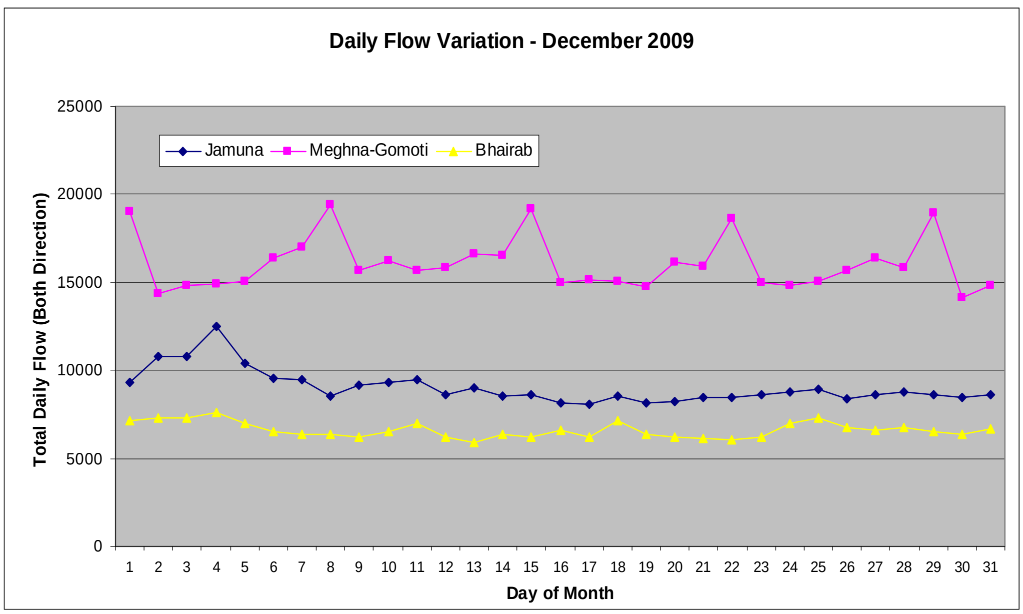


Daily Flow Variation - September 2009
Total Daily Flow (Both Direction)
Day of Month
Jamuna
Meghna-Gomoti
Bhairab

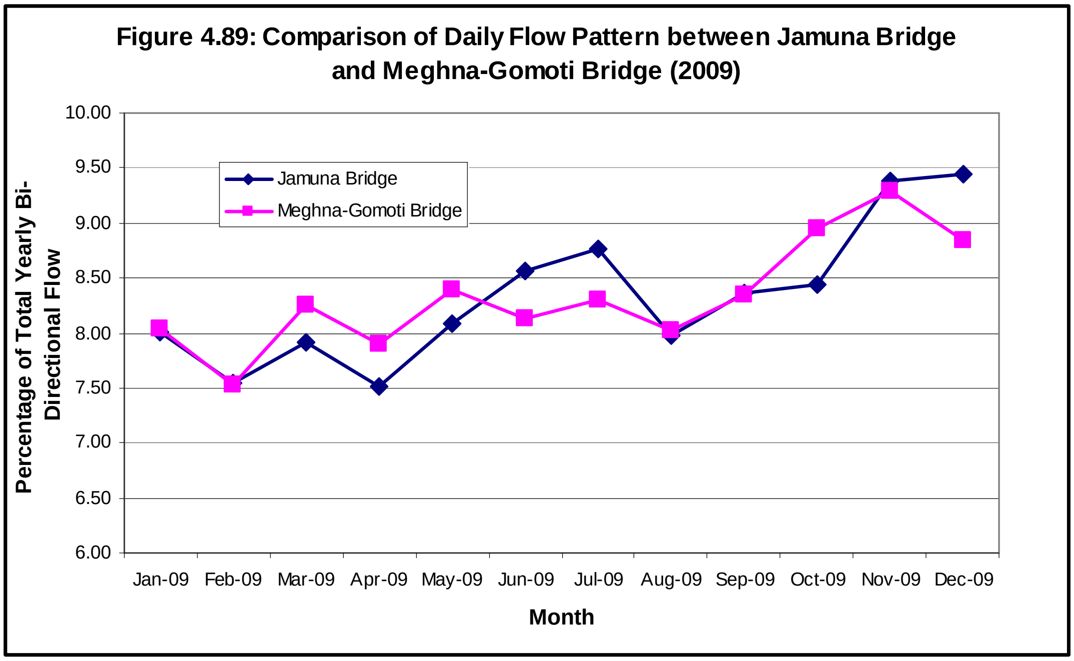


Daily Flow Variation - Octobar 2009
Total Daily Flow (Both Direction)
Day of Month
Jamuna
Meghna-Gomoti
Bhairab

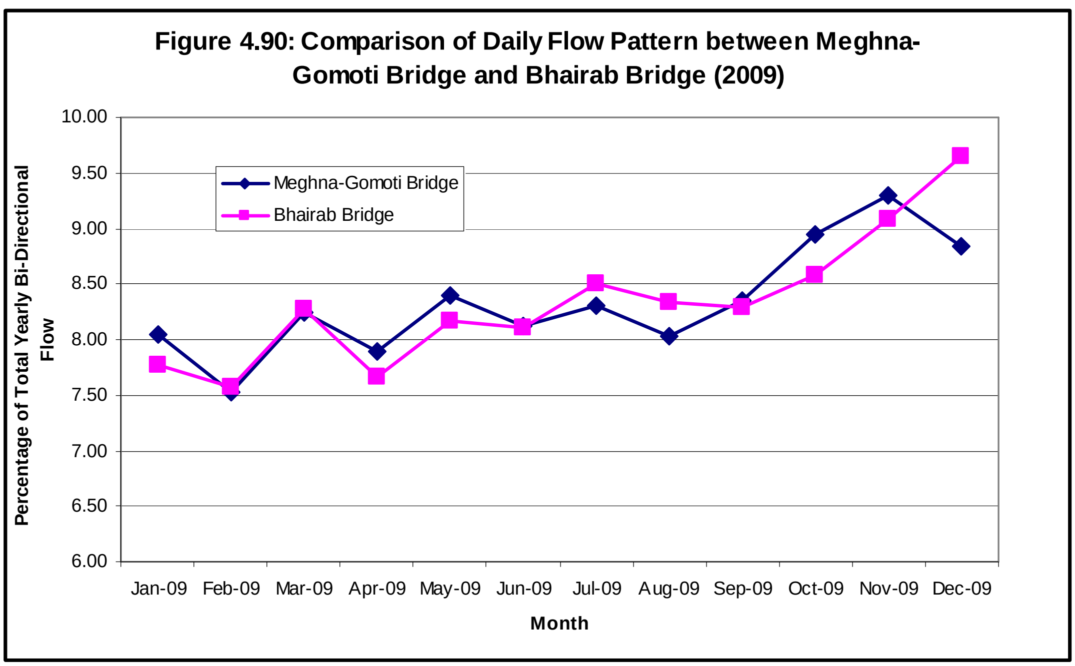




Despite different corridors, toll operators and authorities, the patterns are seen to have significant similarity, which implies that, traffic flows of national highways are related to natural calamaties, political conditions, and other factors. It is also found from the analyses that, N-1 corridors carries almost double traffic (190.50%) than N-5 corridors (as shown in Table 4.44) and almost double and half traffic (265.46%) than N-2 corridors (as shown in Table 4.45). Hence, structural design of highways of these corridors should not be the same. But Ministry of Communication and Planning Commission of Bangladesh are neglecting current traffic data that causes frequent structural failure of National highways especially in rainy seasons. This framework can also be used for independent auditing purpose also.



The above Figure (Figure 4.89) shows the comparison between daily traffic flow patterns recorded in Jamuna Bridge and Meghna-Gomoti bridge from January 2009 to December 2009.



The above Figure (Figure 4.90) shows the comparison between daily traffic flow patterns recorded in Meghna-Gomoti bridge and Bhairab bridge from January 2009 to December 2009.

It is found from both the Figures that, the two roads maintain very similar daily flow variation pattern.

4.5 ANALYSIS OF FLOW CHARACTERISTICS IN N-8 CORRIDOR (DHALESHARI BRIDGE)

Another important highway of Bangladesh is Dhaka-Mawa-Vanga-Potuakhali-Barisal commonly known as N-8 which connects southern portion of Bangladesh with the capital Dhaka. Evaluation of pavement design parameters in Dhaka-Mawa (N-8) highway portion is very urgent. The construction of Padma bridge will start soon and after the inauguration of the bridge, the N-8 highway will not be able to cope up with increasing traffic demand if measures are not taken immediately. However, no attempt has been made yet in these regards like linking up national highways related to Padma bridge, upgrading of two lane highways to four lane highways, etc. An axle load control station was established at 11th kilometer of Dhaka-Mawa highway portion, which is not functioning from decades. The toll collection system in First and Second Dhaleshari bridges are manual. It is a matter of regret that no electronic toll collection system is exists on that corridor. Roads and Highways Department is collecting toll through manual system. As a result, data relating to traffic have not been preserved by the concern department. However, limited amount of data is collected from Keranigonj Road Sub-division from October 2009 to September 2010 of the N-8 corridor. First and Second Dhaleshari bridge are situated on 13th and 14th km of Dhaka-Mawa highway. First Dhaleshari toll plaza collects toll from traffic moving towards Mawa ferry ghat and Second Dhaleshari toll plaza collects toll from traffic moving towards Dhaka.

4.5.1 DAILY FLOW VARIATION

Daily flow fluctuation on highways is an important parameter for pavement design

CHAPTER 6

GROWTH FACTOR AND TRAFFIC EXPANSION MODEL

6.1 INTRODUCTION

The determinations of expansion factors or equations on the selected corridors are very essential for this research to evaluate the pavement design parameters. AADT from the short counts can be made through these expansion factors or equations. This Chapter contains the determination of such factors using summarized traffic flow data on different corridors. For these purposes, 5 years' (2005 to 2009) continuous daily flow data from Jamuna bridge, 3 years' (2007 to 2009) uninterrupted daily flow data from Bhairab-Ashuganj bridge and 4 years' (2006 to 2009) nonstop daily flow data from Meghna-Gomoti bridge have been used.

6.2 EXPANSION OF SHORT COUNTS

It has already been discussed in Chapter 2 that, AADT can be estimated from short counts using two methods, namely – Factoring method and Regression Analysis. Both the methods have their own advantages and disadvantages. The accuracy level also varies depending on numerous parameters. The Factoring approach is mainly used in the United States to take the benefit of creating group factors to match the factors of short counts with data of permanent counters best reflecting those. Regression analysis uses best fit curve to match between short and long counts. However, in this study both factoring and regression analysis has been performed to estimate AADT from short counts.

6.3 ANALYSIS OF EXPANSION FACTORS IN DIFFERENT CORRIDORS

In this section daily and monthly expansion factors have been established from existing traffic database of Jamuna bridge, Bhairab bridge and Meghna-Gomoti bridge which can be used to estimate AADT from short counts.

6.3.1 DAILY EXPANSION FACTORS IN N-5 CORRIDOR

Continuous daily traffic flow data on Jamuna bridge from 2005 to 2009 have been used to determine Daily Expansion Factor. First the raw data has been summarized to determine the average daily flow for each of seven days of week individually for all 5 years. From those summarized data, daily expansion factors for each year have been determined by dividing average weekly by flow average weekday flow. Then, those daily expansion factors representing their respective years have again been averaged to achieve the average Daily Expansion Factors. Table 6.1 shows the daily expansion factors and yearly average flow on each weekday from 2005 to 2009. Summation of these daily flows for seven weekdays gives average weekly flow, which have been determined individually for every year. From these data, Daily Expansion Factors are calculated. Taking the mean value for daily expansion factors for the years 2005 to 2009, average daily expansion factors have been determined. The following formula is used to calculate the daily expansion factors.

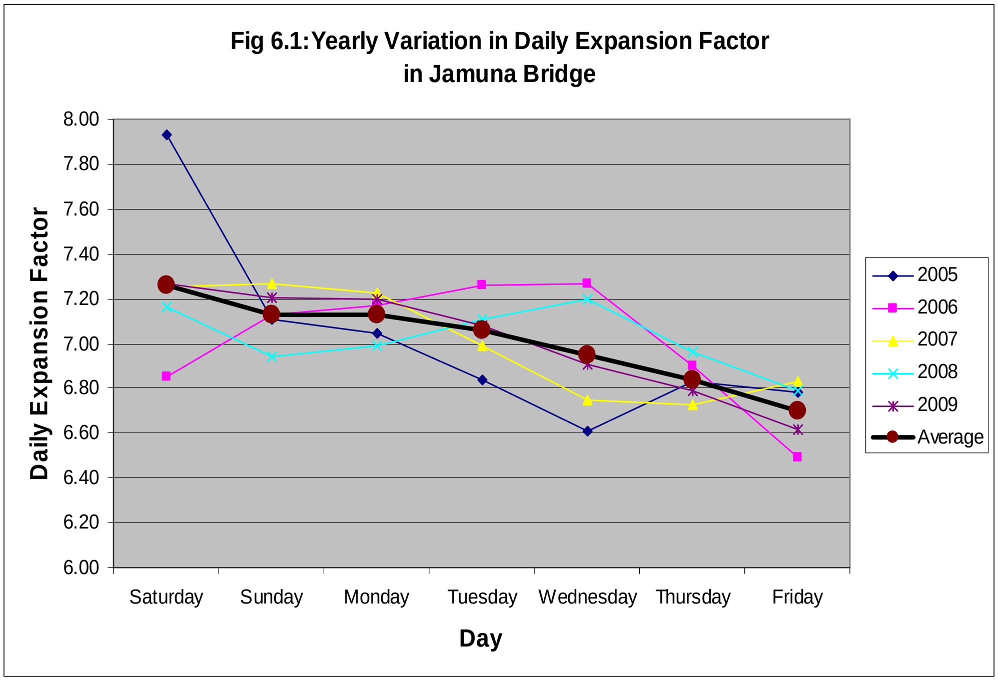
$$\text{Daily Expansion Factor, DEF} = \frac{\text{Average total weekly volume}}{\text{Average volume for particular day}}$$

Table 6.1: Daily Expansion Factors, DEF (for Bi-Directional Traffic)

Day \ Year	2005		2006		2007		2008	
	Avg. Flow	DEF	Avg. Flow	DEF	Avg. Flow	DEF	Avg. Flow	DEF
Saturday	4,669	7.93	5,825	6.85	6,214	7.26	7,074	7.16
Sunday	5,210	7.11	5,597	7.13	6,206	7.27	7,300	6.94
Monday	5,254	7.05	5,563	7.17	6,240	7.23	7,244	6.99
Tuesday	5,414	6.84	5,498	7.26	6,450	6.99	7,126	7.11
Wednesday	5,603	6.61	5,490	7.27	6,680	6.75	7,036	7.20
Thursday	5,422	6.83	5,783	6.90	6,700	6.73	7,273	6.96
Friday	5,460	6.78	6,147	6.49	6,599	6.83	7,460	6.79
Avg. Weekly Flow	37,032		39,902		45,088		50,647	

Day \ Year	2009		Average	
	Avg. Flow	DEF	Avg. Flow	DEF
Saturday	7,819	7.26	6,320	7.26
Sunday	7,885	7.20	6,439	7.13
Monday	7,893	7.20	6,439	7.13
Tuesday	8,027	7.08	6,503	7.06
Wednesday	8,223	6.91	6,606	6.95
Thursday	8,370	6.79	6,709	6.84
Friday	8,587	6.62	6,850	6.70
Avg. Weekly Flow	56,804		45,894	

To observe the variations in daily expansion factors from year to year, the same has been plotted for all five years in Figure 6.1. It is seen that the average highest DEF is on Saturday and average lowest DEF is on Friday, which implies that maximum flow occurs on Friday. This complies with the daily flow fluctuation analysis illustrated in Chapter 4. Accordingly the average DEF have furnished similar variation.



All vehicle classes do not exhibit similar daily flow fluctuation, so daily expansion factors need to be determined and used separately for each vehicle class. Table 6.2 shows the class wise daily expansion factors.

Table 6.2: Class-wise Daily Expansion Factors, DEF (for Bi-Directional Traffic)

Day	Large Bus	Medium Truck	Light Vehicles	Small Bus	Small Truck	Motor Cycle	Large Truck	Total Traffic
Saturday	6.97	7.63	6.96	7.33	7.46	6.71	7.59	**7.26**
Sunday	7.14	6.91	7.50	8.23	7.14	7.42	7.19	**7.12**
Monday	7.18	6.91	7.58	7.59	6.90	7.80	7.10	**7.12**
Tuesday	7.19	6.73	7.59	7.04	6.90	8.04	6.81	**7.05**
Wednesday	7.07	6.67	7.44	6.11	6.75	8.26	6.57	**6.94**
Thursday	6.84	6.95	6.64	6.70	6.76	6.45	6.83	**6.83**
Friday	6.66	7.29	5.74	6.43	7.15	5.33	7.00	**6.72**

Notes:

- The above DEF can be directly used to estimate average weekly volume.

It is to be noted here that, directional distribution does not have any major effect on daily expansion factors because, as found during daily directional distribution analysis, the range of directional split is 48% to 51.50%, which is not very significant. Therefore, the Average DEF's given in Table 6.2 may be used for estimation of AADT from short counts.

6.3.2 MONTHLY EXPANSION FACTORS IN N-5 CORRIDOR

Similar approach has been adopted to determine the monthly or seasonal expansion factors. At first monthly expansion factors for each of concerned year have been calculated. Then those seven factors have been averaged to determine the final monthly expansion factors. Table 6.3 (a, b, and c) below contains the monthly expansion factors on Jamuna Bridge corridor for each individual year (2005 to 2009), while the average values obtained from these are given in Table 6.4.

Table 6.3a: Monthly Expansion Factors in 2005 & 2006

Month \ Year	2005			2006		
	Flow	ADT	MEF	Flow	ADT	MEF
January	180,426	5,820	**0.909**	196,278	6,332	**0.897**
February	147,964	5,284	**1.001**	154,703	5,335	**1.065**
March	167,355	5,399	**0.980**	168,354	5,431	**1.046**
April	158,215	5,274	**1.003**	162,053	5,402	**1.052**
May	157,247	5,072	**1.043**	170,153	5,489	**1.035**
June	160,719	5,357	**0.987**	178,056	5,935	**0.957**
July	158,730	5,120	**1.033**	174,472	5,628	**1.009**
August	153,591	4,955	**1.068**	179,494	5,790	**0.981**
September	157,462	5,249	**1.008**	168,778	5,626	**1.010**
October	152,113	4,907	**1.078**	171,521	5,533	**1.027**
November	165,180	5,506	**0.961**	154,014	5,134	**1.107**
December	171,311	5,526	**0.957**	202,618	6,536	**0.869**
Total		63469			68170	
AADT		5289			5681	

Table 6.3b: Monthly Expansion Factors in 2007& 2008

Month \ Year	2007			2008		
	Flow	ADT	MEF	Flow	ADT	MEF
January	182,787	5,896	**1.092**	219,713	7,088	**1.024**
February	176,282	6,296	**1.023**	208,812	7,458	**0.973**
March	190,420	6,143	**1.048**	232,404	7,497	**0.968**
April	185,136	6,171	**1.043**	209,366	6,979	**1.040**
May	192,508	6,210	**1.037**	217,671	7,022	**1.033**
June	194,433	6,481	**0.993**	221,612	7,387	**0.982**
July	192,399	6,206	**1.037**	214,606	6,923	**1.048**
August	186,088	6,003	**1.073**	212,331	6,849	**1.059**
September	188,161	6,272	**1.027**	216,116	7,204	**1.007**
October	212,973	6,870	**0.937**	214,256	6,911	**1.050**
November	199,045	6,635	**0.970**	222,333	7,411	**0.979**
December	250,577	8,083	**0.797**	258,719	8,346	**0.869**
Total		77266			87074	
AADT		6439			7256	

Table 6.3c: Monthly Expansion Factors in 2009

Month \ Year	2009		
	Flow	ADT	MEF
January	237,308	7,655	**1.060**
February	223,575	7,985	**1.017**
March	234,368	7,560	**1.074**
April	222,787	7,426	**1.093**
May	239,455	7,724	**1.051**
June	253,497	8,450	**0.961**
July	259,745	8,379	**0.969**
August	236,128	7,617	**1.066**
September	247,680	8,256	**0.983**
October	249,826	8,059	**1.007**
November	277,905	9,264	**0.876**
December	279,918	9,030	**0.899**
Total		97405	
AADT		8117	

Table 6.4: Monthly Expansion Factors, MEF (for Bi-Directional Traffic)

Month	Avg. MEF
January	**0.996**
February	**1.016**
March	**1.023**
April	**1.046**
May	**1.040**
June	**0.976**
July	**1.019**
August	**1.049**
September	**1.007**
October	**1.020**
November	**0.979**
December	**0.878**

Notes:

- The above MEF can be directly used to estimate AADT from Avg. 24-hour volume.

The equation used for calculation of monthly expansion factors is:

$$\text{Monthly Expansion Factor, MEF} = \frac{\text{AADT}}{\text{ADT for particular month}}$$

It is noticeable in the above table that the expansion factors for rainy season months are higher than those for dry season month, which refers that traffic flow in rainy season is lower than in dry season.

It is to be noted here that, in this research it was found that no significant dissimilarities in pattern is observed for individual vehicle class and total vehicle. Therefore, monthly expansion factors for individual vehicle class is not necessarily to be used for AADT estimation, rather average factors may be effectively applied.

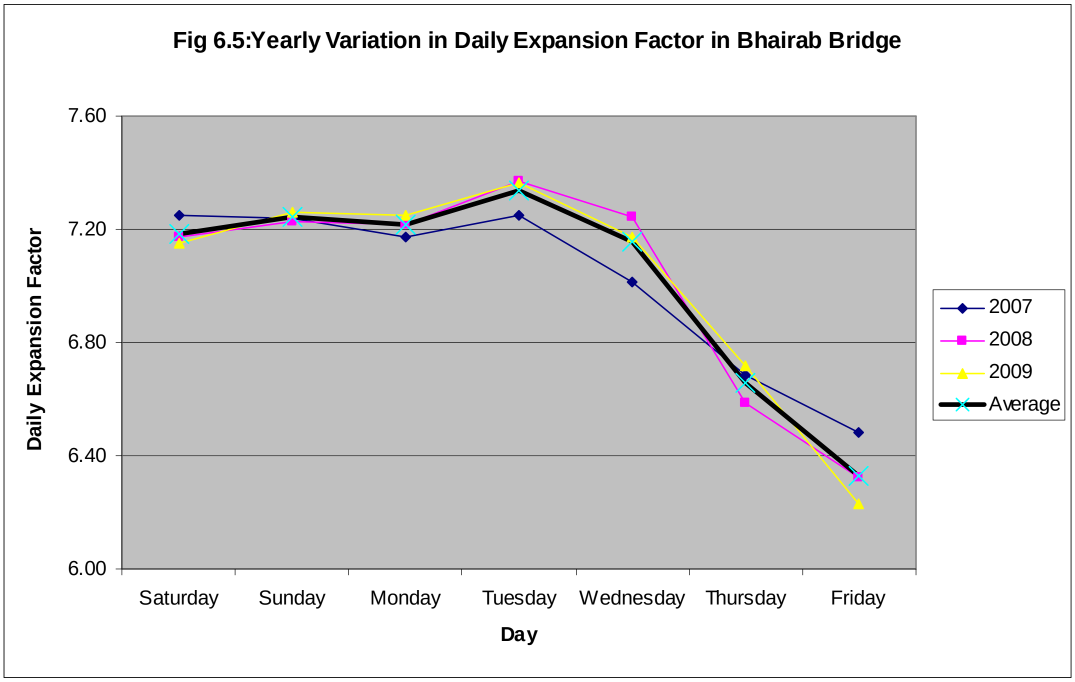
6.3.3 DAILY EXPANSION FACTORS IN N-2 CORRIDOR

Daily Expansion Factors are determined in N-2 corridor from continuous daily traffic flow data on Bhairab bridge from the year 2007 to 2009. First the raw data has been summarized to determine the average daily flow for each of seven days of week individually for all 3 years. From those summarized data, daily expansion factors for each year have been determined by dividing average weekly by flow average weekday flow. Then, those daily expansion factors representing their respective years have again been averaged to achieve the average Daily Expansion Factors. Table 6.5 shows the daily expansion factors and yearly average flow on each weekday from 2007 to 2009. Summation of these daily flows for seven weekdays gives average weekly flow, which have been determined individually for every year. From these data, Daily Expansion Factors are calculated. Taking the mean value for daily expansion factors for the years 2007 to 2009, average daily expansion factors have been determined.

Table 6.5: Daily Expansion Factors, DEF (for Bi-Directional Traffic)

Day \ Year	**2007**		**2008**		**2009**		**Average**	
	Avg. Flow	**DEF**	**Avg. Flow**	**DEF**	**Avg. Flow**	**DEF**	**Avg. Flow**	**DEF**
Saturday	3,833	7.25	5,775	7.17	5,697	7.15	5,102	7.18
Sunday	3,838	7.24	5,728	7.23	5,612	7.26	5,059	7.24
Monday	3,874	7.17	5,737	7.22	5,618	7.25	5,076	7.22
Tuesday	3,832	7.25	5,616	7.37	5,530	7.37	4,993	7.34
Wednesday	3,962	7.01	5,715	7.25	5,681	7.17	5,119	7.16
Thursday	4,156	6.68	6,289	6.58	6,063	6.72	5,503	6.66
Friday	4,286	6.48	6,547	6.32	6,539	6.23	5,791	6.33
Avg. Weekly Flow	27,782		41,406		40,740		36,643	

To observe the variations in daily expansion factors from year to year, the same has been plotted for all three years in Figure 6.5. It is seen that the average highest DEF is on Tuesday and average lowest DEF is on Friday, which implies that maximum flow occurs on Friday. This complies with the daily flow fluctuation analysis found in Chapter 4. Accordingly the average DEF have furnished similar variation.



All vehicle classes do not exhibit similar daily flow fluctuation, so daily expansion factors need to be determined and used separately for each vehicle class. Table 6.6 shows the class wise daily expansion factors.

Table 6.6: Class-wise Daily Expansion Factors, DEF (for Bi-Directional Traffic)

Day	Motor Cycle /Baby Taxi/ Mishuk	Maxi/ Pick-up/ Tampo	Car/ Jeep/ Station Wagon/ Micro	Coaster/ Tractor/ Tractor with Trailer	Mini bus/ Mini truck	Bus/ Truck/ Covered Truck 2 axle	Bus/ Truck/ Covered Truck 3 axle	Trailer Truck/ Const-ruction Equip-ment	Toll Free Vehicle	Total Traffic
Saturday	6.97	7.02	6.97	7.31	7.89	7.45	7.75	8.24	7.14	**7.21**
Sunday	7.18	7.53	7.59	7.40	7.24	7.11	6.96	7.15	7.13	**7.27**
Monday	7.30	6.87	7.80	7.13	6.78	7.02	6.71	7.01	6.79	**7.21**
Tuesday	7.42	7.18	8.08	6.73	6.99	6.98	7.02	7.44	6.94	**7.31**
Wednesday	7.36	7.23	7.49	7.39	6.84	6.88	6.52	6.43	6.95	**7.13**
Thursday	6.77	6.48	6.61	6.30	6.48	6.63	6.97	6.20	6.69	**6.64**
Friday	6.17	6.78	5.32	6.89	6.94	6.98	7.20	6.90	7.40	**6.35**

Notes:

- The above DEF can be directly used to estimate average weekly volume.

It is to be noted here that, directional distribution does not have any major effect on daily expansion factors because, as found during daily directional distribution analysis, the range of directional split is 47% to 53%, which is not very significant. Therefore, the Average DEF's given in Table 6.5 may be used for estimation of AADT from short counts.

6.3.4 MONTHLY EXPANSION FACTORS IN N-2 CORRIDOR

Each of concerned year have been calculated at first to determine monthly expansion factors. Then those seven factors have been averaged to determine the final monthly expansion factors. Table 6.7 (a and b) below contains the monthly expansion factors on Bhairab Bridge corridor for each individual year (2007 to 2009), while the average values obtained from these are given in Table 6.8.

Table 6.7a: Monthly Expansion Factors in 2007 & 2008

Month \ Year	2007			2008		
	Flow	**ADT**	**MEF**	**Flow**	**ADT**	**MEF**
January	111,264	3,589	**1.105**	142,849	4,608	**1.286**
February	108,794	3,886	**1.021**	143,810	5,136	**1.154**
March	119,673	3,860	**1.028**	178,453	5,757	**1.030**
April	112,696	3,757	**1.056**	153,613	5,120	**1.158**
May	115,816	3,736	**1.062**	204,053	6,582	**0.901**
June	112,770	3,759	**1.055**	214,629	7,154	**0.829**
July	125,261	4,041	**0.982**	166,635	5,375	**1.103**
August	118,221	3,814	**1.040**	178,741	5,766	**1.028**
September	109,984	3,666	**1.082**	157,233	5,241	**1.131**
October	130,364	4,205	**0.943**	189,231	6,104	**0.971**
November	129,286	4,310	**0.921**	236,827	7,894	**0.751**
December	154,420	4,981	**0.796**	198,370	6,399	**0.926**
Total		47603			71137	
AADT		3967			5928	

Table 6.7b: Monthly Expansion Factors in 2009

Month \ Year	2009		
	Flow	ADT	MEF
January	165,147	5,327	**1.093**
February	160,869	5,745	**1.013**
March	175,773	5,670	**1.027**
April	162,958	5,432	**1.072**
May	173,608	5,600	**1.039**
June	172,284	5,743	**1.014**
July	180,520	5,823	**1.000**
August	176,987	5,709	**1.019**
September	175,972	5,866	**0.992**
October	182,337	5,882	**0.990**
November	193,099	6,437	**0.904**
December	204,986	6,612	**0.880**
Total		69847	
AADT		5821	

Table 6.8: Monthly Expansion Factors, MEF (for Bi-Directional Traffic)

Month	Avg. MEF
January	**1.161**
February	**1.063**
March	**1.028**
April	**1.095**
May	**1.001**
June	**0.966**
July	**1.028**
August	**1.029**
September	**1.068**
October	**0.968**
November	**0.859**
December	**0.868**

Notes:

- The above MEF can be directly used to estimate AADT from Avg. 24-hour volume.

It is to be noted here that, from the analysis shown in Chapter 4 in this research it was found that no significant dissimilarities in pattern is observed for individual vehicle class and total vehicle. Therefore, monthly expansion factors for individual vehicle class is not necessarily to be used for AADT estimation, rather average factors may be effectively applied.

6.3.5 DAILY EXPANSION FACTORS IN N-1 CORRIDOR

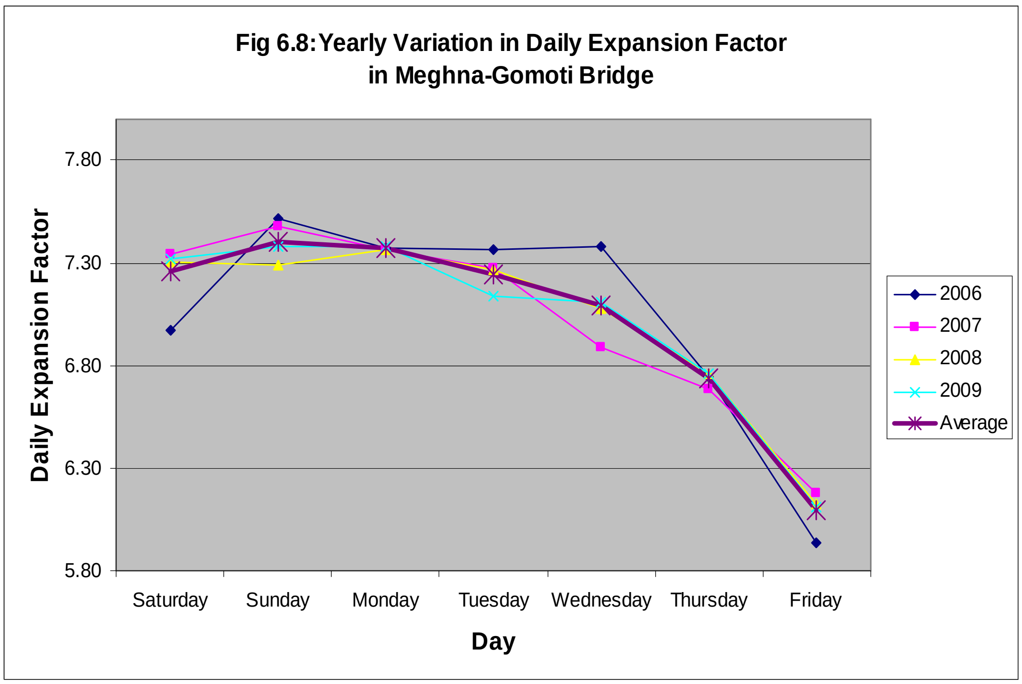
Continuous daily traffic flow data on Meghna-Gomoti bridge from 2006 to 2009 have been used to determine Daily Expansion Factor. First the raw data have been summarized to determine the average daily flow for each of seven days of week individually for all 4 years. From those summarized data, daily expansion factors for each year have been determined by dividing average weekly by flow average weekday flow. Then, those daily expansion factors representing their respective years have again been averaged to achieve the average Daily Expansion Factors. Table 6.9 shows the daily expansion factors and yearly average flow on each weekday from 2006 to 2009. Summation of these daily flows for seven weekdays gives average weekly flow, which have been determined individually for every year. From these data, Daily Expansion Factors are calculated. Taking the mean value for daily expansion factors for the years 2006 to 2009, average daily expansion factors have been determined.

Table 6.9: Daily Expansion Factors, DEF (for Bi-Directional Traffic)

Day \ Year	**2006**		**2007**		**2008**		**2009**	
	Avg. Flow	**DEF**	**Avg. Flow**	**DEF**	**Avg. Flow**	**DEF**	**Avg. Flow**	**DEF**
Saturday	8,824	**6.97**	11,274	**7.34**	12,391	**7.31**	14,758	**7.32**
Sunday	8,181	**7.52**	11,067	**7.48**	12,416	**7.29**	14,633	**7.38**
Monday	8,339	**7.38**	11,235	**7.36**	12,295	**7.36**	14,637	**7.38**
Tuesday	8,349	**7.37**	11,375	**7.27**	12,461	**7.27**	15,126	**7.14**
Wednesday	8,334	**7.38**	12,014	**6.89**	12,795	**7.08**	15,202	**7.11**
Thursday	9,116	**6.75**	12,378	**6.68**	13,390	**6.76**	15,978	**6.76**
Friday	10,358	**5.94**	13,399	**6.18**	14,784	**6.12**	17,681	**6.11**
Avg. Weekly Flow	61,502		82,742		90,533		108,016	

Average	
Avg. Flow	**DEF**
11,812	**7.26**
11,574	**7.40**
11,627	**7.37**
11,828	**7.25**
12,086	**7.09**
12,716	**6.74**
14,056	**6.10**
85,698	

To observe the variations in daily expansion factors from year to year, the same has been plotted for all four years in Figure 6.8. It is seen that the average highest DEF is on Sunday and average lowest DEF is on Friday, which implies that maximum flow occurs on Friday. This complies with the daily flow fluctuation analysis given in Chapter 4. Accordingly the average DEF have furnished similar variation.



All vehicle classes do not exhibit similar daily flow fluctuation, so daily expansion factors need to be determined and used separately for each vehicle class. Table 6.10 shows the class wise daily expansion factors.

Table 6.10: Class-wise Daily Expansion Factors, DEF (for Bi-Directional Traffic)

Day	Motor Cycle	Scooter/ Tampo	Car/ Jeep	Micro/ Pickup	Mini bus/ Coaster	Bus	Truck	Trailer	Toll Free Vehicle	Total Traffic
Saturday	6.49	6.94	6.50	6.87	6.71	6.58	8.68	9.24	6.38	**7.28**
Sunday	7.85	7.34	8.15	7.57	7.12	7.00	7.34	7.90	7.24	**7.40**
Monday	8.11	7.38	8.23	7.60	7.19	7.21	7.04	7.79	7.48	**7.36**
Tuesday	8.37	7.22	8.15	7.68	7.28	7.37	6.68	6.52	7.57	**7.23**
Wednesday	8.20	7.29	8.03	7.45	7.27	7.30	6.49	6.35	7.12	**7.08**
Thursday	6.64	6.74	6.95	6.97	6.72	6.81	6.52	6.17	6.82	**6.72**
Friday	4.92	6.24	4.74	5.46	6.77	6.80	6.69	6.10	6.58	**6.12**

6.3.6 MONTHLY EXPANSION FACTORS IN N-1 CORRIDOR

Each of concerned years has been calculated at first to determine monthly expansion factors. Then those seven factors have been averaged to determine the final monthly expansion factors. Table 6.11 (a and b) below contains the monthly expansion factors on Meghna-Gomoti Bridge corridor for each individual year (2006 to 2009), while the average values obtained from these are given in Table 6.12.

Table 6.11a: Monthly Expansion Factors in 2006 & 2007

Month \ Year	2006			2007		
	Flow	**ADT**	**MEF**	**Flow**	**ADT**	**MEF**
January	250,988	8,096	**1.083**	295,193	9,522	**1.241**
February	238,820	8,235	**1.064**	312,740	11,169	**1.058**
March	265,789	8,574	**1.022**	360,112	11,617	**1.017**
April	243,965	8,132	**1.078**	345,105	11,504	**1.027**
May	266,474	8,596	**1.020**	375,049	12,098	**0.976**
June	261,144	8,705	**1.007**	359,441	11,981	**0.986**
July	288,475	9,306	**0.942**	369,120	11,907	**0.992**
August	277,259	8,944	**0.980**	352,299	11,364	**1.040**
September	263,283	8,776	**0.999**	346,617	11,554	**1.022**
October	298,482	9,628	**0.910**	393,615	12,697	**0.930**
November	240,141	8,005	**1.095**	366,653	12,222	**0.967**
December	315,590	10,180	**0.861**	437,893	14,126	**0.836**
Total		105177			141761	
AADT		8765			11813	

Table 6.11b: Monthly Expansion Factors in 2008 & 2009

Month \ Year	2008			2009		
	Flow	**ADT**	**MEF**	**Flow**	**ADT**	**MEF**
January	416,396	13,432	**0.962**	453,185	14,619	**1.056**
February	403,447	13,912	**0.929**	424,170	15,149	**1.019**
March	429,778	13,864	**0.932**	464,702	14,990	**1.030**
April	402,048	13,402	**0.964**	444,537	14,818	**1.042**
May	326,242	10,524	**1.228**	472,871	15,254	**1.012**
June	292,239	9,741	**1.327**	457,681	15,256	**1.012**
July	415,725	13,410	**0.964**	467,515	15,081	**1.023**
August	422,798	13,639	**0.948**	452,142	14,585	**1.058**
September	409,367	13,646	**0.947**	470,306	15,677	**0.985**
October	427,631	13,795	**0.937**	503,949	16,256	**0.949**
November	319,814	10,660	**1.212**	523,644	17,455	**0.884**
December	467,464	15,079	**0.857**	498,096	16,068	**0.961**
Total		155104			185208	
AADT		12925			15434	

Table 6.12: Monthly Expansion Factors, MEF (for Bi-Directional Traffic)

Month	Avg. MEF
January	**1.085**
February	**1.017**
March	**1.000**
April	**1.028**
May	**1.059**
June	**1.083**
July	**0.980**
August	**1.006**
September	**0.988**
October	**0.932**
November	**1.040**
December	**0.879**

Notes:

- The above MEF can be directly used to estimate AADT from Avg. 24-hour volume.

No significant difference in pattern is observed for individual vehicle class and total vehicle in N-1 corridor. Therefore, monthly expansion factors for individual vehicle class is not necessarily to be used for AADT estimation, rather average factors may be effectively applied.

6.4 GROWTH FACTOR IN DIFFERENT CORRIDORS

In this research an attempt has been made to determine the growth factor on the selected corridors, using which future traffic flow can be estimated by extrapolation method. From the growth pattern analysis of different corridors, it has been found that the traffic growth trend is explicit on every corridor. In the Pavement Design Guide for Roads & Highways Department published in April 2005, traffic growth rate for national road is taken to be 10% per annum. According to this research, this pavement design parameter is not properly evaluated. Each corridor have it's own growth rate, which depends on various factors like type of vehicles, route for business, etc, and the growth rate is varying from year to year.

6.4.1 GROWTH FACTOR IN N-5 CORRIDOR

From the growth pattern analysis using daily traffic data from 2005 to 2009, as given in Chapter 4, it is seen that the traffic growth trend on Jamuna bridge corridor is higher then RHD standard design growth factor (10% per annum). From the analyses of five years data, it was found to be 11% per annum for this highway corridor. Furthermore, it has been found that, instead of using flat growth rate for total vehicle, separate growth rates for individual vehicle class should be used to improve accuracy of prediction.

Table 6.13: Class-wise Total Yearly Traffic in Both Direction (2005 to 2009)

Year	Large Bus	Medium Truck	Light Vehicle	Small Bus	Small Truck	Motor Cycle	Large Truck	Total Traffic
2005	632,938	771,500	289,910	30,720	134,709	42,155	28,381	**1,930,313**
2006	683,070	804,071	325,570	27,376	164,791	48,078	27,538	**2,080,494**
2007	754,136	905,213	367,540	25,362	243,766	36,380	18,412	**2,350,809**
2008	803,648	959,467	442,241	23,892	347,774	47,117	16,622	**2,640,761**
2009	855,390	1,042,748	543,832	16,025	423,137	60,012	21,048	**2,962,192**

Table 6.14: Class-wise Traffic Growth Factors

Year	Large Bus	Medium Truck	Light Vehicle	Small Bus	Small Truck	Motor Cycle	Large Truck	Total Traffic	Average
2005	-	-	-	-	-	-	-	**-**	
2006	8%	4%	12%	-11%	22%	14%	-3%	**8%**	
2007	10%	13%	13%	-7%	48%	-24%	-33%	**13%**	**11**
2008	7%	6%	20%	-6%	43%	30%	-10%	**12%**	
2009	6%	9%	23%	-33%	22%	27%	27%	**12%**	
Avg. GF	8%	8%	17%	-14%	34%	12%	-5%	**11%**	
Std. Dvtn.	2%	4%	5%	13%	14%	25%	25%	2%	

Table 6.13 shows total yearly volume of traffic in both directions for each vehicle class. From this table, the increase or decrease of a particular vehicle class in each year during the study period can easily be found. The amount of increase or decrease in one year expressed in percentage of base year value is the traffic growth rate for that particular year. The growth factors calculated in this manner are shown in Table 6.14. It can be seen that, not all vehicle class follow similar growth pattern. Taking the average value of four growth factors, it has been found that average growth rate of total traffic is 11% is pretty consistent during the study period showing standard deviation of only 2%. But, for individual class's growth factors, they have been found to be quite erratic which is reflected in their standard deviations. Larger values of standard deviation indicate that the growth factors for individual vehicle classes are not predictable. This may be because of the fact that since Bangladesh is a developing country, the traffic composition has not been stabilized yet. Availability of few more years of data could make it possible to understand a definite trend of class-wise traffic growth. However, from the existing database, it has been found that, growth rate for large truck and small bus is negative, while all other classes show positive growth rate. The above-determined growth factors may be used for prediction purpose, particularly for planning any transport facility along this highway corridor.

6.4.2 GROWTH FACTOR IN N-2 CORRIDOR

In Bhairab bridge corridor, it is found that the traffic growth pattern is much higher and a little bit unpredictable. The daily traffic data from the year 2007 to 2009 demonstrates that the growth factor in 2008 and 2009 accordingly 49% and -2%. From the analyses of three years data, cumulative growth factor was found to be 24% per annum for this highway corridor which is much higher than RHD design standard. A separate growth rate for individual vehicle class is shown below for more precision.

Table 6.15: Class-wise Total Yearly Traffic in Both Direction (2007 to 2009)

Year	Motor Cycle /Baby Taxi/ Mishuk	Maxi/ Pick-up/ Tampo	Car/ Jeep/ Station Wagon/ Micro	Coaster/ Tractor/ Tractor with Trailer	Mini bus/ Mini truck	Bus/ Truck/ Covered Truck 2 axle	Bus/ Truck/ Covered Truck 3 axle	Trailer Truck/ Const-ruction Equip-ment	Toll Free Vehicle	Total Traffic
2007	251,433	84,337	296,928	6,633	57,584	708,531	12,665	2,327	28,111	**1,448,549**
2008	412,924	292,489	486,878	7,514	67,012	848,230	15,346	6,257	27,794	**2,164,444**
2009	517,380	139,455	504,380	9,262	78,266	834,520	18,031	1,471	21,775	**2,124,540**

Table 6.16: Class-wise Traffic Growth Factors

Year	Motor Cycle /Baby Taxi/ Mishuk	Maxi/ Pick-up/ Tampo	Car/ Jeep/ Station Wagon/ Micro	Coaster/ Tractor/ Tractor with Trailer	Mini bus/ Mini truck	Bus/ Truck/ Covered Truck 2 axle	Bus/ Truck/ Covered Truck 3 axle	Trailer Truck/ Const-ruction Equip-ment	Toll Free Vehicle	Total Traffic	Average
2007	-	-	-	-	-	-	-	-	-	-	**24**
2008	64%	247%	64%	13%	16%	20%	21%	169%	-1%	49%	
2009	25%	-52%	4%	23%	17%	-2%	17%	-76%	-22%	-2%	
Avg. GF	**45%**	**97%**	**34%**	**18%**	**17%**	**9%**	**19%**	**46%**	**-11%**	**24%**	
Std. Dvtn.	**28%**	**212%**	**43%**	**7%**	**0%**	**15%**	**3%**	**174%**	**15%**	**36%**	

Table 6.15 shows total yearly volume of traffic in both directions for each vehicle class. Individual vehicle class wise growth factor is shown in Table 6.16. It is visible that, all vehicle class do not follow similar growth pattern. Taking the average value of two growth factors, it has been found that average growth rate of total traffic is 24% and standard deviation is 36%. Nevertheless for individual class's growth factors, they have been found to be quite erratic which is reflected in their standard deviations. Larger values of standard deviation indicate that the growth factors for

individual vehicle classes are not predictable. The traffic composition has not been stabilized yet in N-2 corridor. Availability of few more years of data could make it possible to understand a definite trend of class-wise traffic growth.

6.4.3 GROWTH FACTOR IN N-1 CORRIDOR

The average traffic growth pattern in N-1 corridor is double than the RHD design standard. Since the N-1 corridor is the most important transport route of Bangladeshi economy, but the concern Roads and Highways Department is neglecting traffic flow and thus, causing severe loss to the pavement of this highways. From the data analyses of the year 2006 to 2009, it is revealed that the average growth factor of this corridor is 21% per annum.

Table 6.17: Class-wise Total Yearly Traffic in Both Direction (2006 to 2009)

Year	Motor Cycle	Scooter/ Tampo	Car/ Jeep	Micro/ Pickup	Mini bus/ Coaster	Bus	Truck	Trailer	Toll Free Vehicle	Total Traffic
2006	9,743	15,976	433,710	455,243	431,617	500,227	1,178,966	47,118	133,677	**3,206,277**
2007	22,729	76,496	569,262	667,038	570,851	680,413	1,459,489	89,800	177,759	**4,313,837**
2008	36,975	206,866	609,759	742,149	524,010	715,618	1,594,506	101,870	201,196	**4,732,949**
2009	46,896	291,080	756,199	994,568	535,970	788,149	1,876,198	115,995	227,743	**5,632,798**

Table 6.18: Class-wise Traffic Growth Factors

Year	Motor Cycle	Scooter/ Tampo	Car/ Jeep	Micro/ Pickup	Mini bus/ Coaster	Bus	Truck	Trailer	Toll Free Vehicle	Total Traffic	Average
2006	-	-	-	-	-	-	-	-	-	-	
2007	133%	379%	31%	47%	32%	36%	24%	91%	33%	35%	
2008	63%	170%	7%	11%	-8%	5%	9%	13%	13%	10%	**21**
2009	27%	41%	24%	34%	2%	10%	18%	14%	13%	19%	
Avg. GF	74%	197%	21%	31%	9%	17%	17%	39%	20%	21%	
Std. Dvtn.	54%	171%	12%	18%	21%	17%	7%	44%	11%	13%	

Table 6.17 shows total yearly volume of traffic in both directions for each vehicle class and Individual vehicle class wise growth factor is shown in Table 6.18. Traffic growth rate from 2007 to 2009 is found accordingly 35%, 10% and 19%. The average standard deviation is 13%. However, for individual class's growth factors,

they have been found to be quite erratic which is reflected in their standard deviations. Determination of growth factor is an important pavement design parameter, and it should be updated every year. Government of Bangladesh should take immediate measures to upgrade this parameter.

6.5 REGRESSION ANALYSIS IN DIFFERENT CORRIDORS

An effort has been made to analyses data on different corridors by regression analysis. With the help of regression analysis, some equations have been derived, and also corresponding calibration curves have been drawn in order to calculate AADT using regression approach. The N-1, N-2, N-5 and N-8 corridors database has been sorted and summarized for this application. Using the summarized database, the regression analyses have been performed and models have been rendered. This article shows the equations and models derived by regression analyses in different corridors.

6.5.1 DAILY REGRESSION MODEL FOR N-5 CORRIDOR

The daily traffic flow data on Jamuna bridge from 2005 to 2009 collected by Marga Net One Ltd. and BBSO provides daily regression models for expansion of short counts. Total 298 weeks of daily flow data have been plotted against their respective weekly flow to achieve the linear regression models.

Table 6.19: Daily Regression Models

Day	Equation	R^2 value
Saturday	y = 4.6385x + 17526	0.5898
Sunday	y = 5.1371x + 13592	0.6912
Monday	y = 5.1049x + 13612	0.7361
Tuesday	y = 5.1643x + 12770	0.7511
Wednesday	y = 5.0814x + 12671	0.7598
Thursday	y = 4.9279x + 13278	0.7829
Friday	y = 4.6143x + 14931	0.6483

Where:

x = observed daily traffic

y = weekly traffic

The daily expansion equations are shown in the above table, while the corresponding curves are presented in the following pages.

6.5.2 MONTHLY REGRESSION MODEL FOR N-5 CORRIDOR

For the regression analysis of monthly or seasonal expansions, five years of flow data on Jamuna Bridge collected by Marga Net One Ltd. and BBSO have been used. Linear regression has been performed for each of twelve months by plotting monthly flow against respective yearly flow. The equations along with respective R^2 values are shown below in Table 6.20. It can be seen that in all the cases the R^2 values are quite reliable.

Table 6.20: Monthly Regression Models

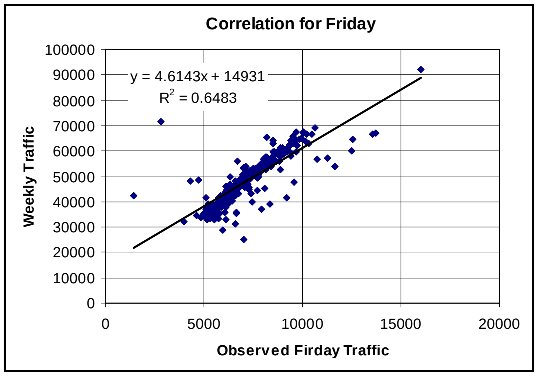
Month	Equation	R^2 value
January	y = 15.37x - 730493	0.8136
February	y = 12.552x + 106589	0.983
March	y = 12.153x - 19002	0.9209
April	y = 14.614x - 345888	0.9832
May	y = 12.432x - 34882	0.9984
June	y = 11.398x + 95765	0.9933
July	y = 10.511x + 292154	0.9745
August	y = 13.004x - 122292	0.9667
September	y = 11.415x + 161031	0.9948
October	y = 10.49x + 294876	0.9334
November	y = 8.1945x + 725164	0.9394
December	y = 8.9321x + 316486	0.8972

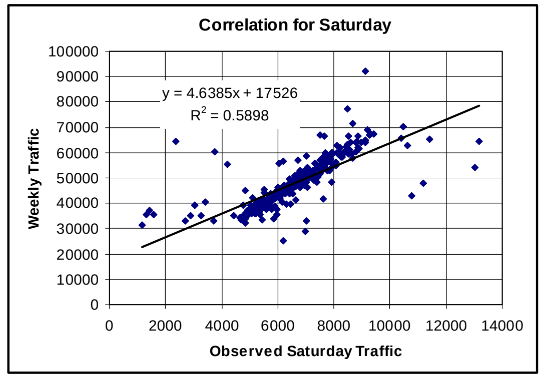
Where:

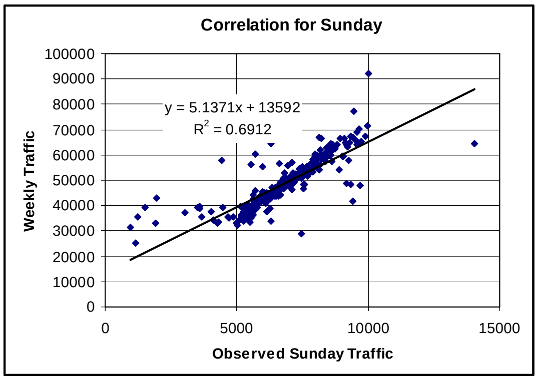
x = observed monthly traffic

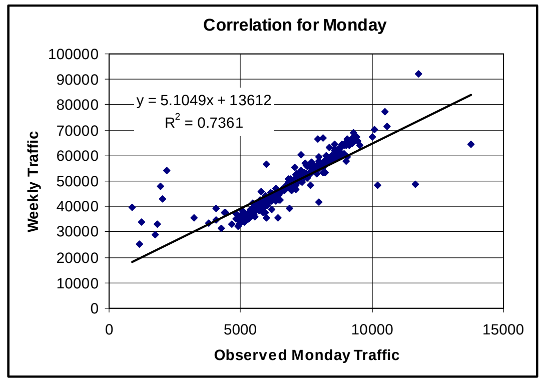
y = yearly traffic volume

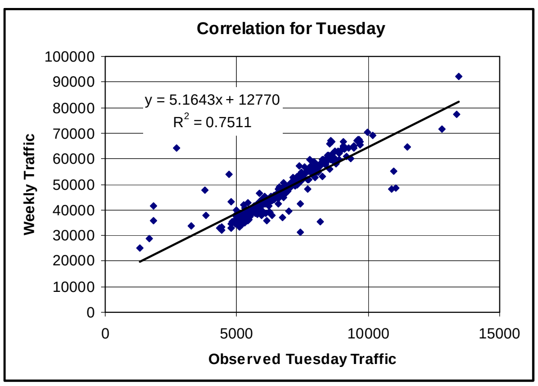
The linear regression curves are given on the following pages. These daily and monthly calibration curves can be directly used to estimate AADT from daily flow.

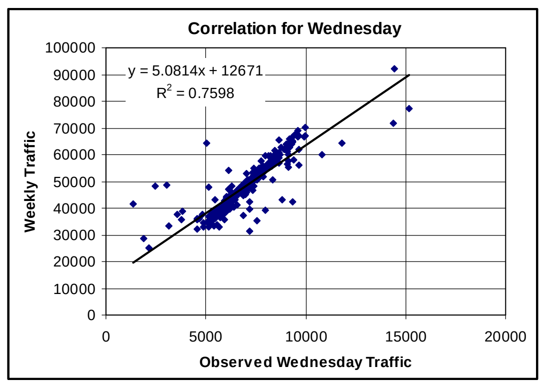

Correlation for Friday
y = 4.6143x + 14931
R2 = 0.6483
Weekly Traffic
Observed Firday Traffic
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
0
5000
10000
15000
20000

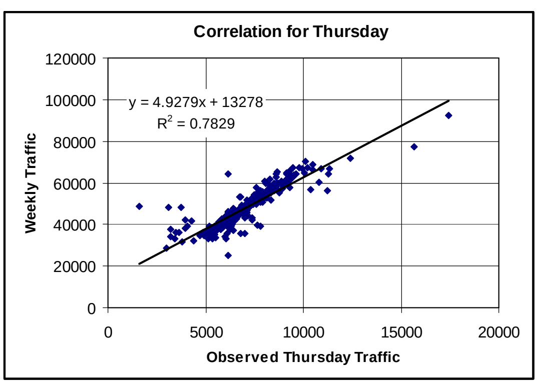

Correlation for Saturday
y = 4.6385x + 17526
R2 = 0.5898
Weekly Traffic
Observed Saturday Traffic
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
0
2000
4000
6000
8000
10000
12000
14000

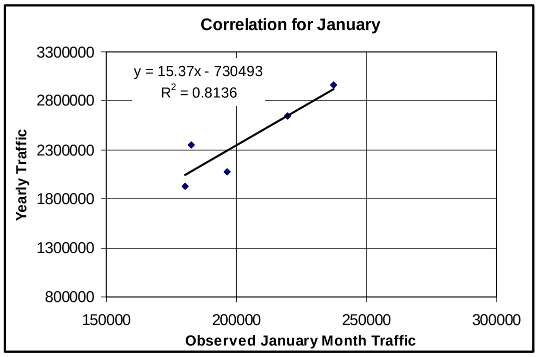

Correlation for Sunday
y = 5.1371x + 13592
R2 = 0.6912
Weekly Traffic
Observed Sunday Traffic
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
0
5000
10000
15000

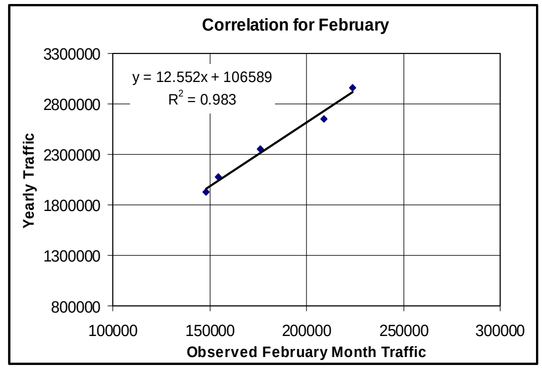

Correlation for Monday
y = 5.1049x + 13612
R2 = 0.7361
Weekly Traffic
Observed Monday Traffic
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
0
5000
10000
15000

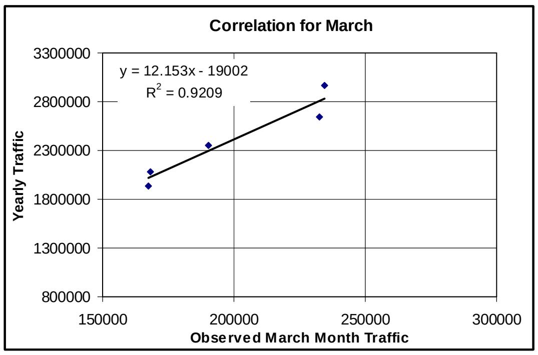

Correlation for Tuesday
y = 5.1643x + 12770
R2 = 0.7511
Weekly Traffic
Observed Tuesday Traffic
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
0
5000
10000
15000

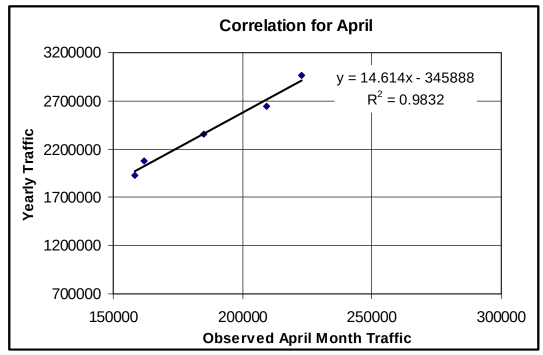

Correlation for Wednesday
y = 5.0814x + 12671
R2 = 0.7598
Weekly Traffic
Observed Wednesday Traffic
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
0
5000
10000
15000
20000

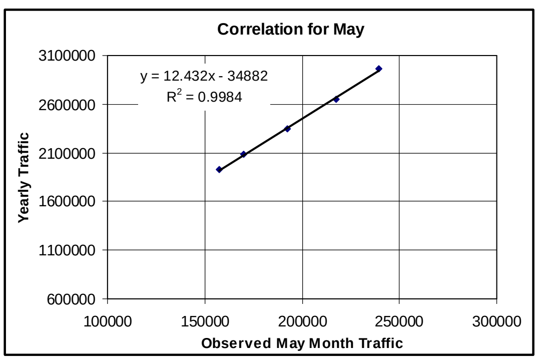

Correlation for Thursday
y = 4.9279x + 13278
R2 = 0.7829
Weekly Traffic
Observed Thursday Traffic
120000
100000
80000
60000
40000
20000
0
0
5000
10000
15000
20000

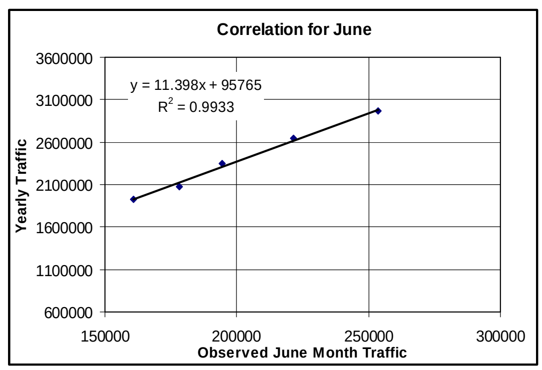

Correlation for January
y = 15.37x - 730493
R^2 = 0.8136
Yearly Traffic
Observed January Month Traffic

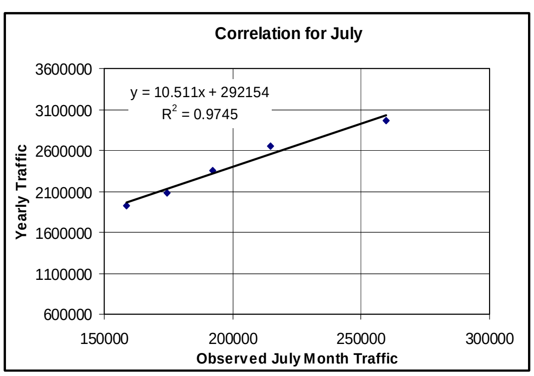

Correlation for February
y = 12.552x + 106589
R^2 = 0.983
Yearly Traffic
Observed February Month Traffic

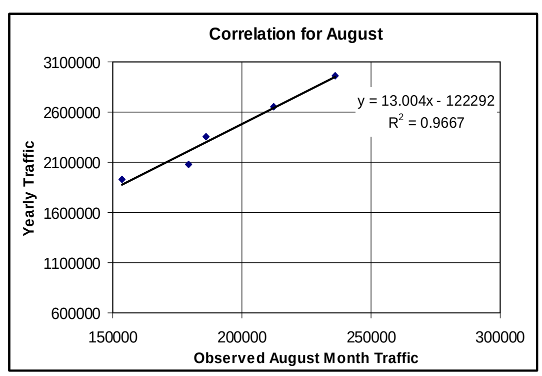

Correlation for March
y = 12.153x - 19002
R^2 = 0.9209
Yearly Traffic
Observed March Month Traffic

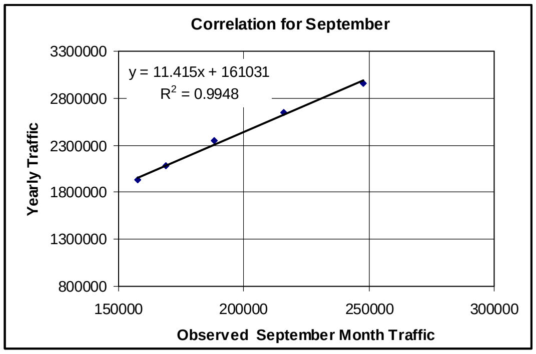

Correlation for April
y = 14.614x - 345888
R^2 = 0.9832
Yearly Traffic
Observed April Month Traffic

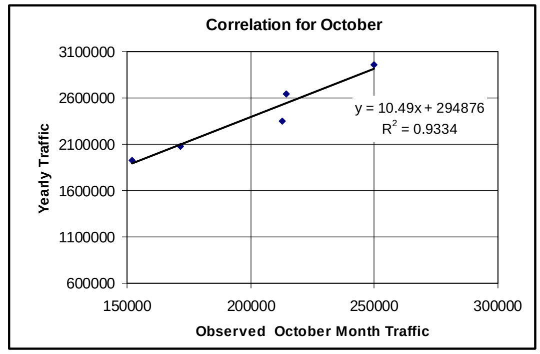

Correlation for May
y = 12.432x - 34882
R^2 = 0.9984
Yearly Traffic
Observed May Month Traffic

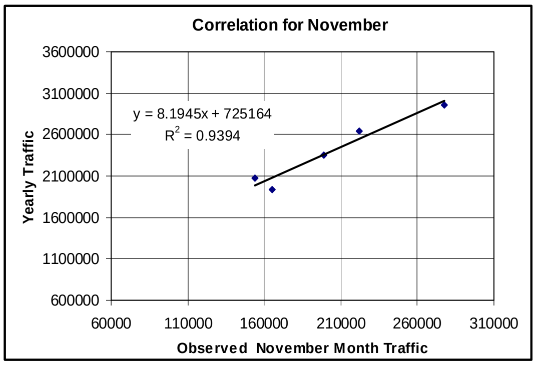

Correlation for June
y = 11.398x + 95765
R^2 = 0.9933
Yearly Traffic
Observed June Month Traffic

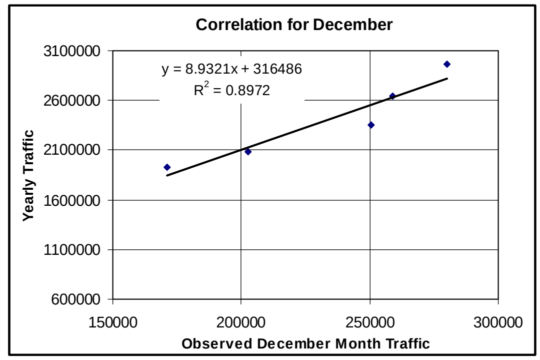

Correlation for July
y = 10.511x + 292154
R^2 = 0.9745
Yearly Traffic
Observed July Month Traffic


Correlation for August
y = 13.004x - 122292
R^2 = 0.9667
Yearly Traffic
Observed August Month Traffic









6.5.3 DAILY REGRESSION MODEL FOR N-2 CORRIDOR

The Daily regression models for expansion of short counts have been derived using daily traffic flow data on Bhairab bridge from 2007 to 2009 collected by Sigma-RCL JV. Total 155 weeks of daily flow data have been plotted against their respective weekly flow to achieve the linear regression models.

Table 6.21: Daily Regression Models

Day	Equation	R^2 value
Saturday	y = 6.0525x + 5658.5	0.7761
Sunday	y = 6.3097x + 4615.4	0.8261
Monday	y = 5.8646x + 6740.6	0.786
Tuesday	y = 6.1683x + 3029.1	0.7965
Wednesday	y = 6.5353x + 2994	0.8576
Thursday	y = 5.5329x + 6011.7	0.8245
Friday	y = 5.2268x + 6319.5	0.8497

Where:

x = observed daily traffic, y = weekly traffic

The daily expansion equations are shown in the above table, while the corresponding curves are presented in the following pages.

6.5.4 MONTHLY REGRESSION MODEL FOR N-2 CORRIDOR

For the regression analysis of monthly or seasonal expansions, three years of flow data on Bhairab Bridge collected by Sigma-RCL JV have been used. Linear regression has been performed for each of twelve months by plotting monthly flow against respective yearly flow. The equations along with respective R^2 values are shown below in Table 6.22. It can be seen that in all the cases the R^2 values are quite reliable.

Table 6.22: Monthly Regression Models

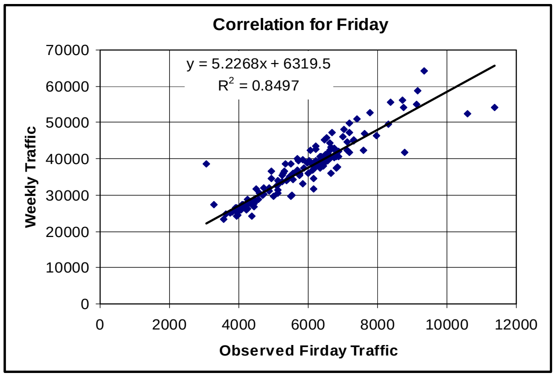
Month	Equation	R^2 value
January	y = 13.22x + 64905	0.7916
February	y = 14.091x - 29551	0.8647
March	y = 12.121x - 2123.1	0.9999
April	y = 14.669x - 186405	0.9501
May	y = 8.5832x + 500634	0.9144
June	y = 7.3099x + 694961	0.8645
July	y = 13.396x - 196999	0.9163
August	y = 11.676x + 67955	0.9994
September	y = 11.197x + 258389	0.8958
October	y = 12.48x - 175518	0.9967
November	y = 6.9444x + 618041	0.8715
December	y = 14.426x - 769601	0.9713

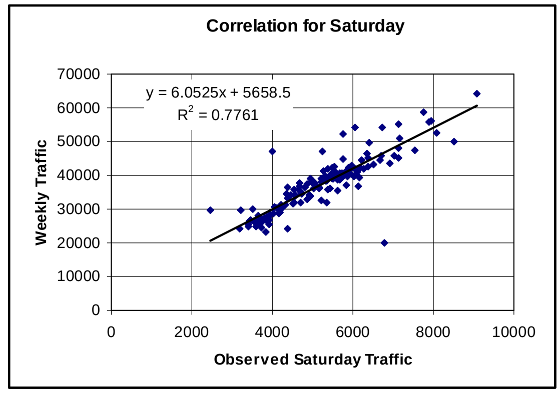
Where:

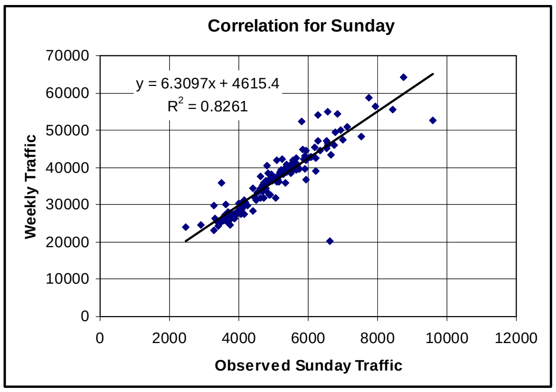
x = observed monthly traffic

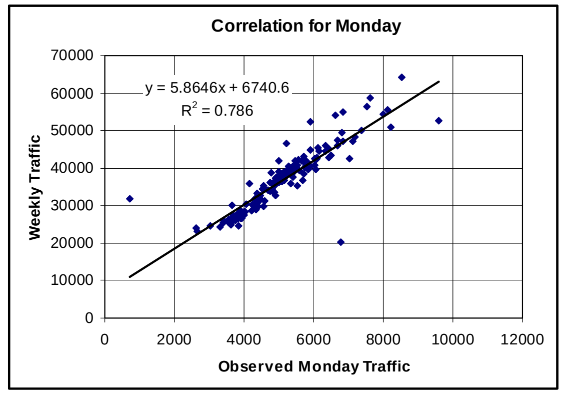
y = yearly traffic volume

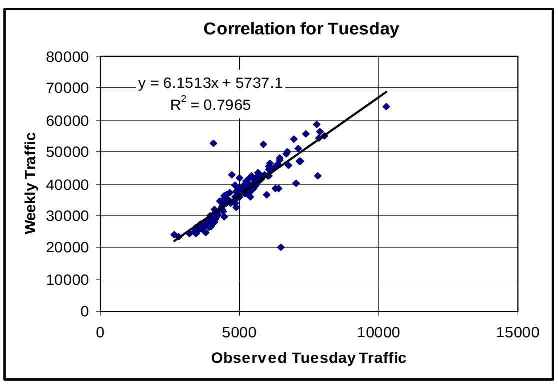
The linear regression curves are given on the following pages. These daily and monthly calibration curves can be directly used to estimate AADT from daily flow.

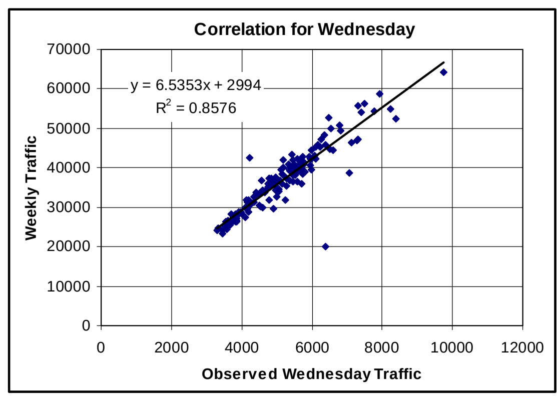

Correlation for Friday
y = 5.2268x + 6319.5
R2 = 0.8497
Weekly Traffic
Observed Firday Traffic

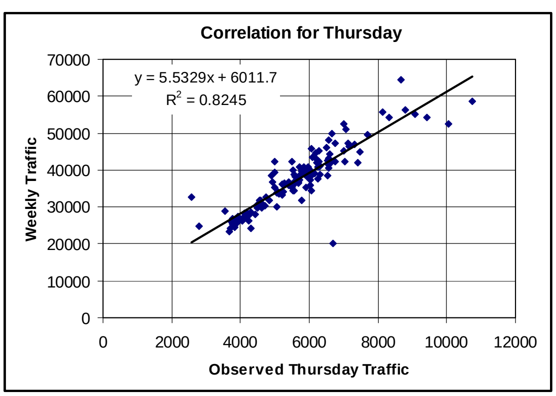

Correlation for Saturday
y = 6.0525x + 5658.5
R2 = 0.7761
Weekly Traffic
Observed Saturday Traffic

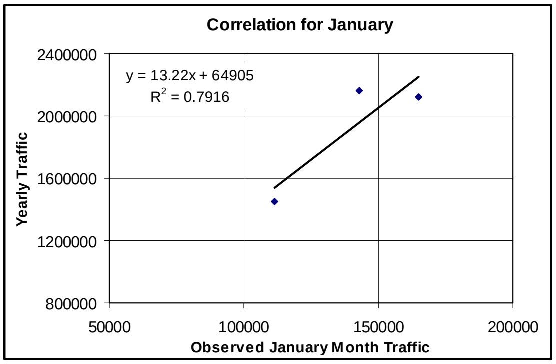

Correlation for Sunday
y = 6.3097x + 4615.4
R2 = 0.8261
Weekly Traffic
Observed Sunday Traffic

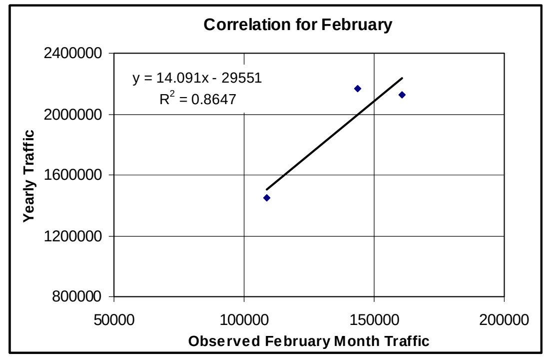

Correlation for Monday
y = 5.8646x + 6740.6
R2 = 0.786
Weekly Traffic
Observed Monday Traffic

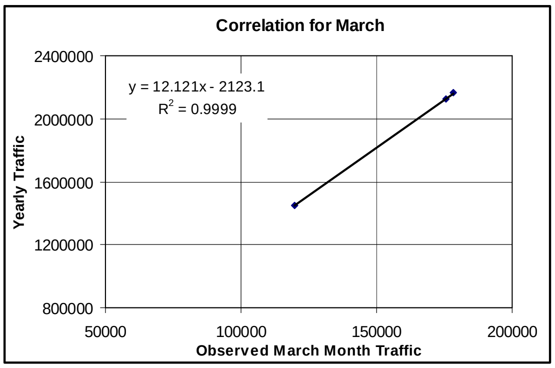

Correlation for Tuesday
y = 6.1513x + 5737.1
R2 = 0.7965
Weekly Traffic
Observed Tuesday Traffic

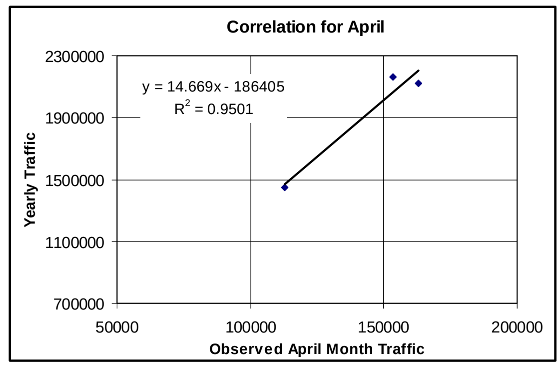

Correlation for Wednesday
y = 6.5353x + 2994
R2 = 0.8576
Weekly Traffic
Observed Wednesday Traffic

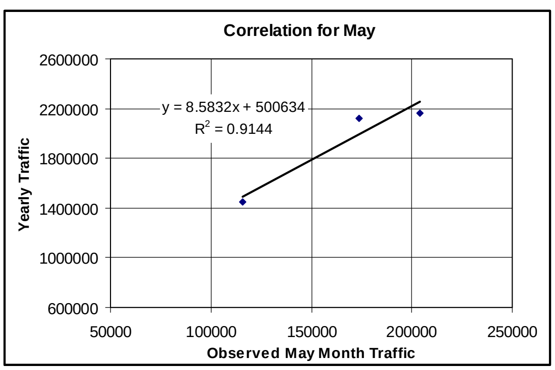

Correlation for Thursday
y = 5.5329x + 6011.7
R2 = 0.8245
Weekly Traffic
Observed Thursday Traffic

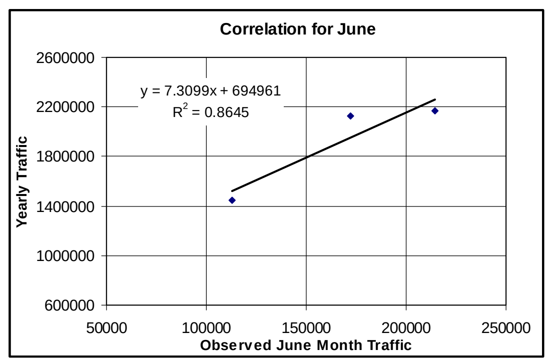

Correlation for January
y = 13.22x + 64905
R2 = 0.7916
Yearly Traffic
Observed January Month Traffic

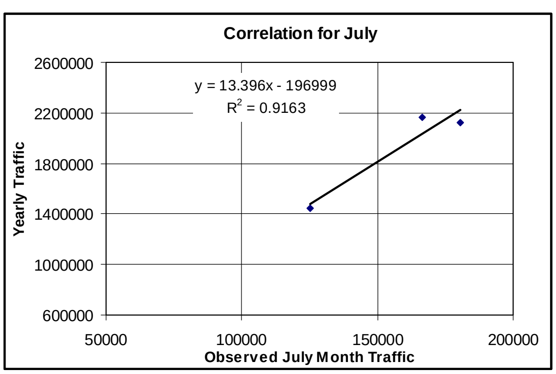

Correlation for February
y = 14.091x - 29551
R2 = 0.8647
Yearly Traffic
Observed February Month Traffic

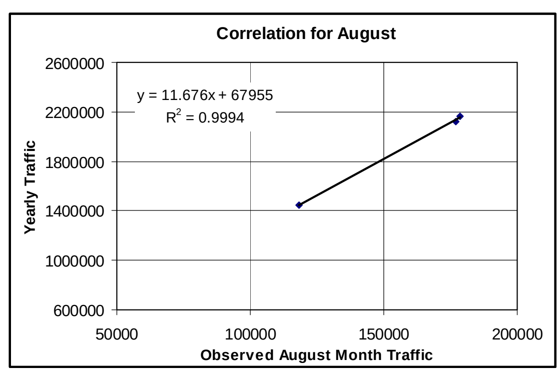

Correlation for March
y = 12.121x - 2123.1
R2 = 0.9999
Yearly Traffic
Observed March Month Traffic

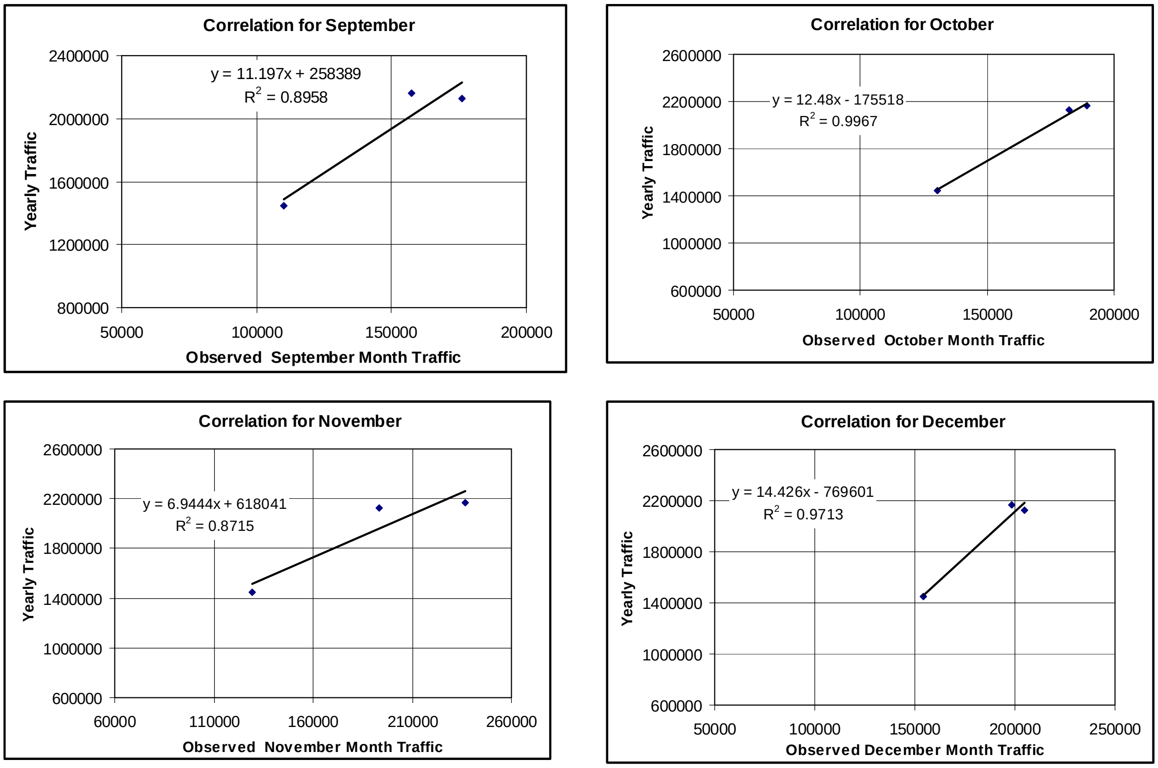

Correlation for April
y = 14.669x - 186405
R2 = 0.9501
Yearly Traffic
Observed April Month Traffic


Correlation for May
y = 8.5832x + 500634
R2 = 0.9144
Yearly Traffic
Observed May Month Traffic


Correlation for June
y = 7.3099x + 694961
R2 = 0.8645
Yearly Traffic
Observed June Month Traffic


Correlation for July
y = 13.396x - 196999
R2 = 0.9163
Yearly Traffic
Observed July Month Traffic


Correlation for August
y = 11.676x + 67955
R2 = 0.9994
Yearly Traffic
Observed August Month Traffic



6.5.5 DAILY REGRESSION MODEL FOR N-1 CORRIDOR

The Daily regression models for expansion of short counts have been derived using daily traffic flow data on Meghna-Gomoti bridge from 2006 to 2009 collected by RCL and MBEL-ATT JV. Total 207 weeks of daily flow data have been plotted against their respective weekly flow to achieve the linear regression models.

Table 6.23: Daily Regression Models

Day	Equation	R^2 value
Saturday	y = 6.677x + 6992.3	0.8286
Sunday	y = 5.6938x + 19946	0.8192
Monday	y = 5.6063x + 20454	0.7924
Tuesday	y = 5.6232x + 19282	0.8168
Wednesday	y = 5.9587x + 13624	0.8632
Thursday	y = 6.0384x + 13501	0.8599
Friday	y = 5.2834x + 11339	0.8104

Where:

x = observed daily traffic, y = weekly traffic

The daily expansion equations are shown in the above table, while the corresponding curves are presented in the following pages.

6.5.6 MONTHLY REGRESSION MODEL FOR N-1 CORRIDOR

For the regression analysis of monthly or seasonal expansions, five years of flow data on Meghna-Gomoti Bridge collected by RCL and MBEL-ATT JV have been used. Linear regression has been performed for each of twelve months by plotting monthly flow against respective yearly flow. The equations along with respective R^2 values are shown below in Table 6.24.

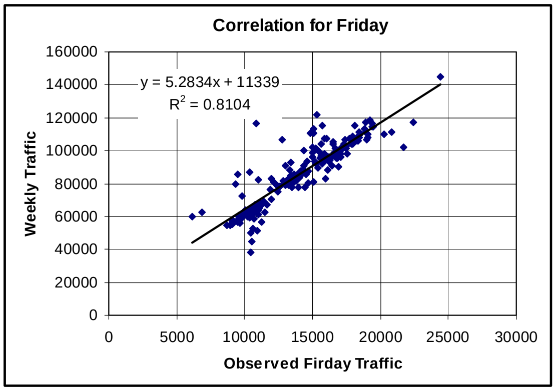
Table 6.24: Monthly Regression Models

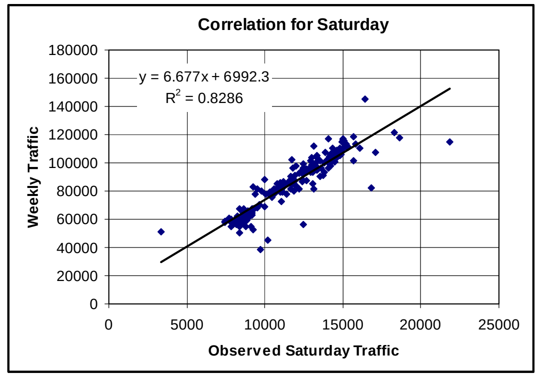
Month	Equation	R^2 value
January	y = 9.7363x + 1E+06	0.8691
February	y = 11.192x + 613541	0.9088
March	y = 11.196x + 216836	0.9547
April	y = 11.411x + 376796	0.9704
May	y = 10.407x + 724456	0.8162
June	y = 9.7162x + 1E+06	0.7067
July	y = 13.168x - 599781	0.9905
August	y = 12.51x - 232705	0.9444
September	y = 11.267x + 276807	0.9848
October	y = 11.8x - 317286	0.9999
November	y = 7.7054x + 2E+06	0.8377
December	y = 12.084x - 720559	0.9242

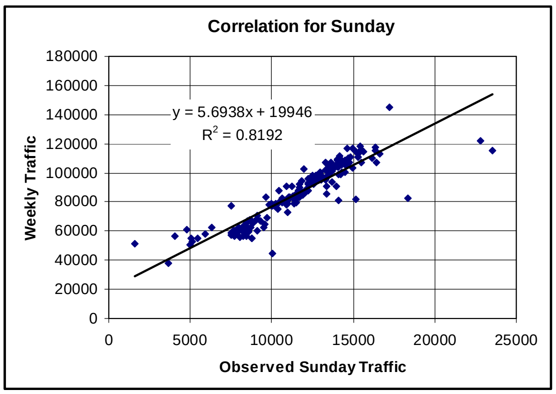
Where:

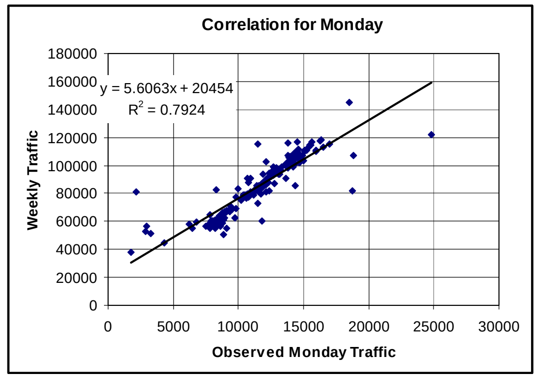
x = observed monthly traffic, y = yearly traffic volume

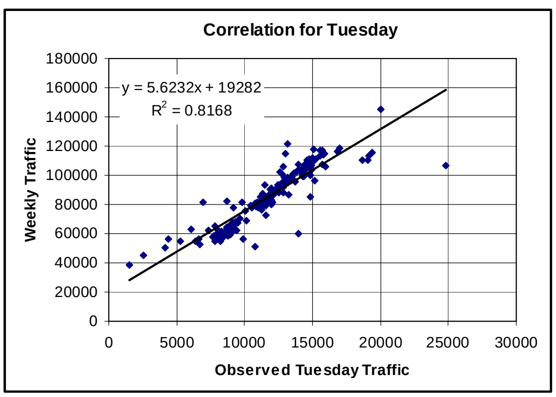
The linear regression curves are given on the following pages. These daily and monthly calibration curves can be directly used to estimate AADT from daily flow.

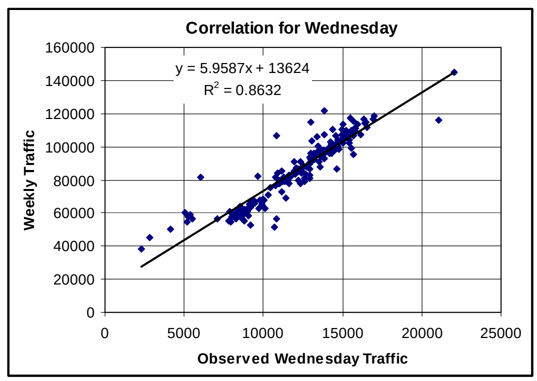

Correlation for Friday
y = 5.2834x + 11339
R2 = 0.8104
Weekly Traffic
Observed Firday Traffic

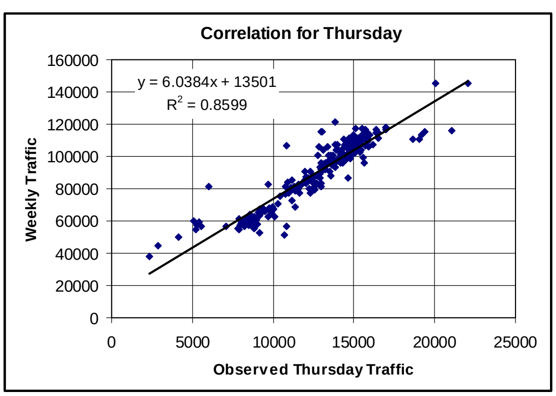

Correlation for Saturday
y = 6.677x + 6992.3
R2 = 0.8286
Weekly Traffic
Observed Saturday Traffic

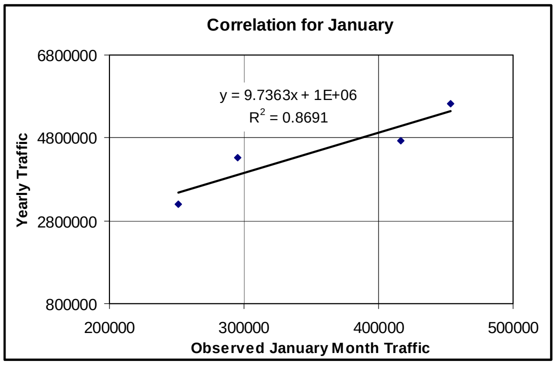

Correlation for Sunday
y = 5.6938x + 19946
R2 = 0.8192
Weekly Traffic
Observed Sunday Traffic

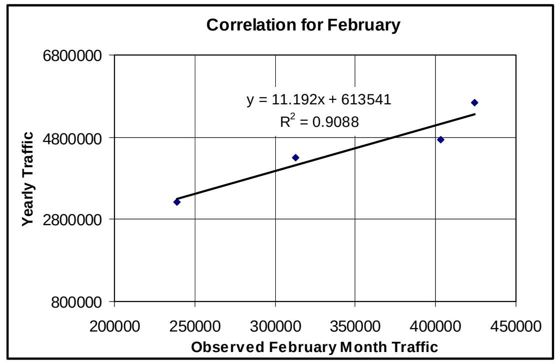

Correlation for Monday
y = 5.6063x + 20454
R2 = 0.7924
Weekly Traffic
Observed Monday Traffic

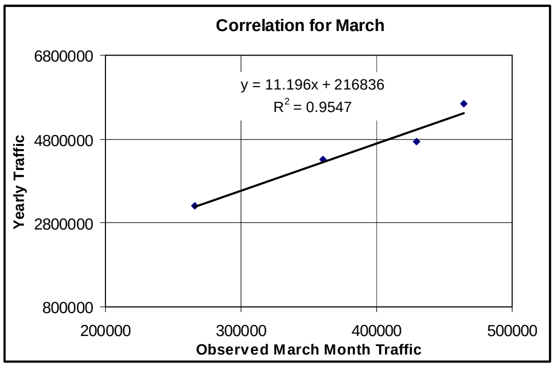

Correlation for Tuesday
y = 5.6232x + 19282
R2 = 0.8168
Weekly Traffic
Observed Tuesday Traffic

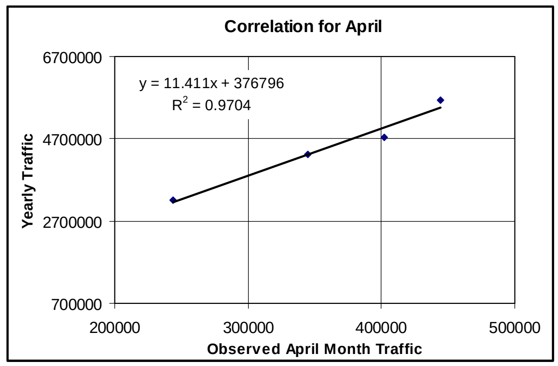

Correlation for Wednesday
y = 5.9587x + 13624
R2 = 0.8632
Weekly Traffic
Observed Wednesday Traffic

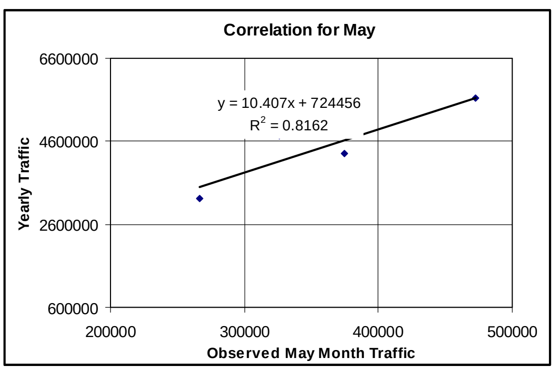

Correlation for Thursday
y = 6.0384x + 13501
R2 = 0.8599
Weekly Traffic
Observed Thursday Traffic

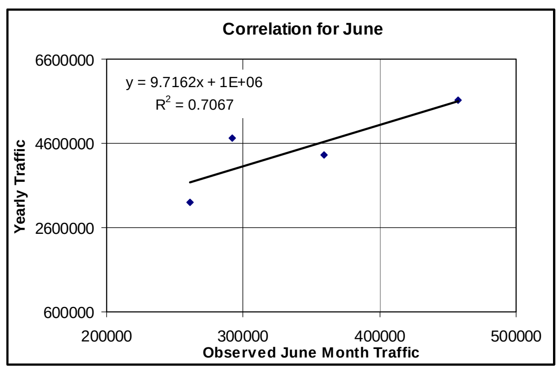

Correlation for January
y = 9.7363x + 1E+06
$R^2 = 0.8691$
Yearly Traffic
6800000
4800000
2800000
800000
200000
300000
400000
500000
Observed January Month Traffic

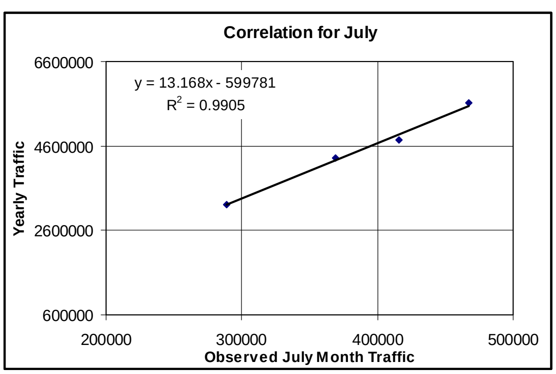

Correlation for February
y = 11.192x + 613541
$R^2 = 0.9088$
Yearly Traffic
6800000
4800000
2800000
800000
200000
250000
300000
350000
400000
450000
Observed February Month Traffic

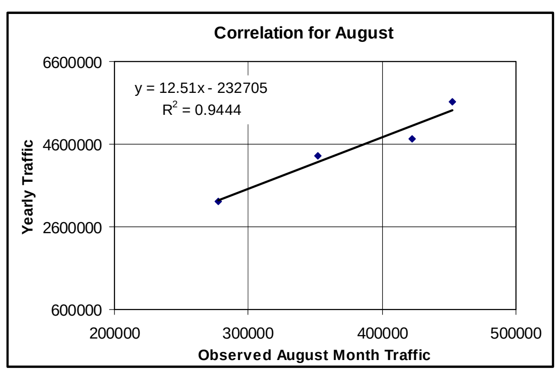

Correlation for March
y = 11.196x + 216836
$R^2 = 0.9547$
Yearly Traffic
6800000
4800000
2800000
800000
200000
300000
400000
500000
Observed March Month Traffic

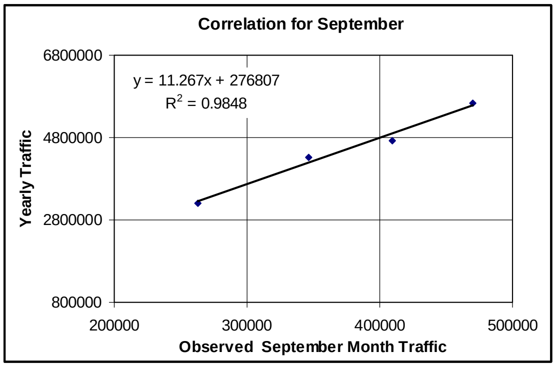

Correlation for April
y = 11.411x + 376796
$R^2 = 0.9704$
Yearly Traffic
6700000
4700000
2700000
700000
200000
300000
400000
500000
Observed April Month Traffic

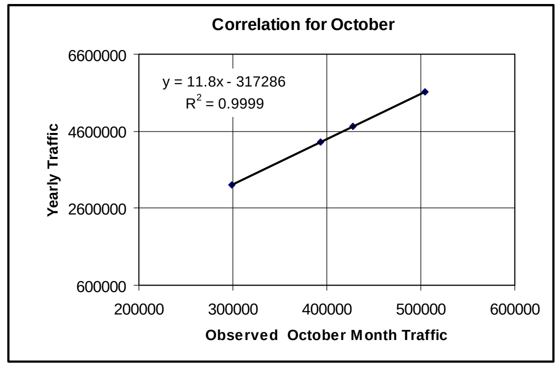

Correlation for May
y = 10.407x + 724456
$R^2 = 0.8162$
Yearly Traffic
6600000
4600000
2600000
600000
200000
300000
400000
500000
Observed May Month Traffic

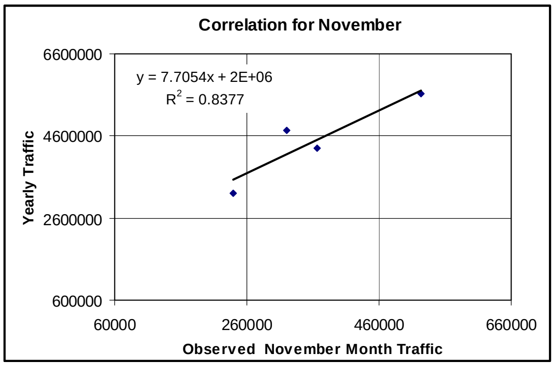

Correlation for June
y = 9.7162x + 1E+06
$R^2 = 0.7067$
Yearly Traffic
6600000
4600000
2600000
600000
200000
300000
400000
500000
Observed June Month Traffic

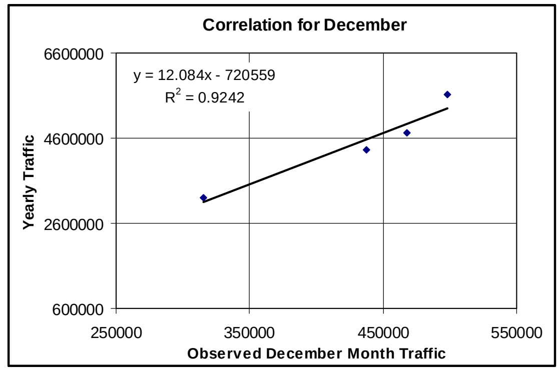

Correlation for July
y = 13.168x - 599781
$R^2 = 0.9905$
Yearly Traffic
6600000
4600000
2600000
600000
200000
300000
400000
500000
Observed July Month Traffic


Correlation for August
y = 12.51x - 232705
$R^2 = 0.9444$
Yearly Traffic
6600000
4600000
2600000
600000
200000
300000
400000
500000
Observed August Month Traffic









6.5.7 DAILY REGRESSION MODEL FOR N-8 CORRIDOR

The Daily regression models for expansion of short counts have been derived using daily traffic flow data on First and Second Dhaleshari bridge from October 2009 to September 2010 collected from Keraniganj Road Sub-Division, RHD. Total 52 weeks of daily flow data have been plotted against their respective weekly flow to achieve the linear regression models.

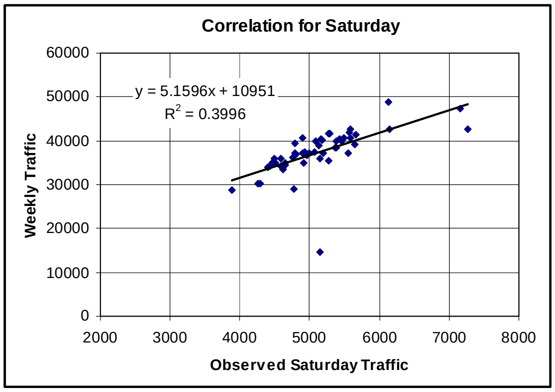
Table 6.25: Daily Regression Models

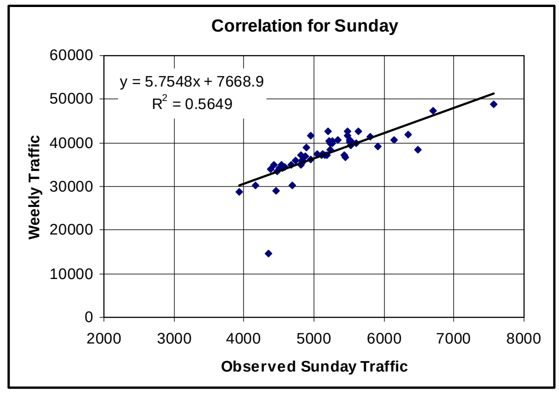
Day	Equation	R^2 value
Saturday	y = 5.1596x + 10951	0.3996
Sunday	y = 5.7548x + 7668.9	0.5649
Monday	y = 4.3384x + 13024	0.5396
Tuesday	y = 3.6094x + 14272	0.6922
Wednesday	y = 4.625x + 13326	0.341
Thursday	y = 4.7328x + 13596	0.381
Friday	y = 5.803x + 7691.8	0.3636

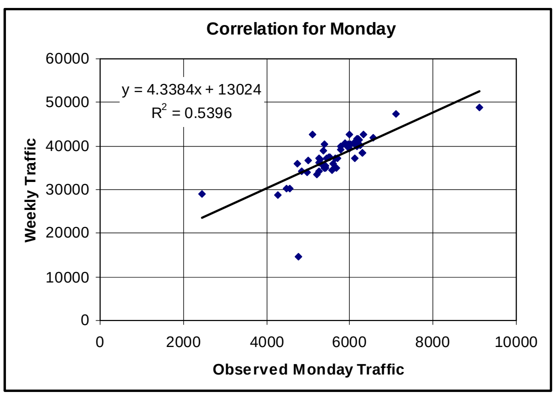
Where:

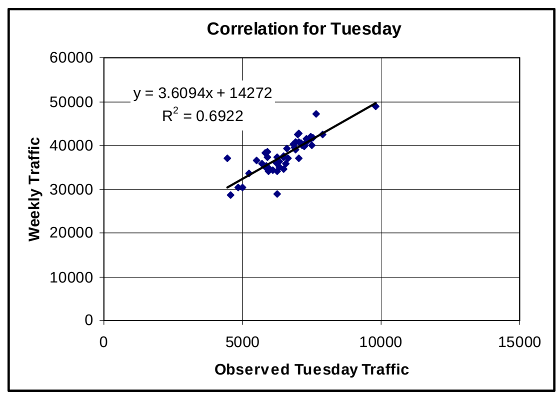
x = observed daily traffic, y = weekly traffic

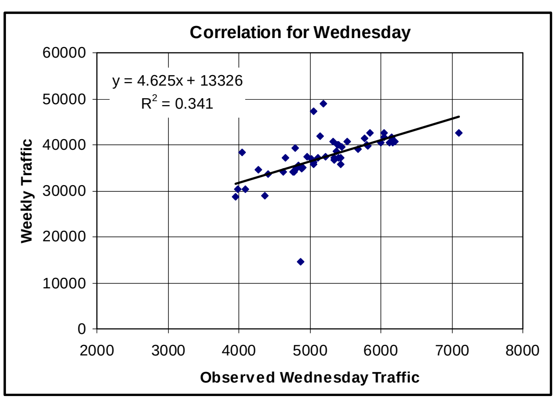
The daily expansion equations are shown in the above table, while the corresponding curves are presented in the following pages.

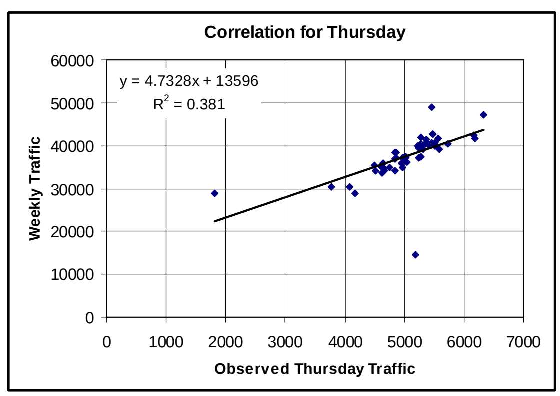


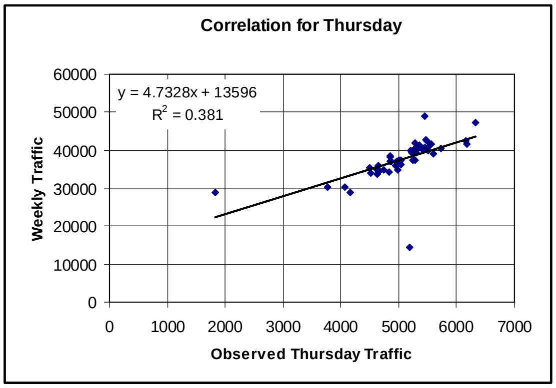












6.6 OVERVIEW

From the above analyses exposed in this Chapter, it is found that each corridor has its own characteristics and traffic flow styles. The daily and monthly expansion factors in different corridors are illustrated elaborately in this episode. Moreover, corridor wise traffic growth factor for individual vehicle class is also shown here, which will help traffic designer to forecast growth factor for individual vehicle class in these corridors. Additionally, daily and monthly regression model have been developed for AADT estimation for future traffic in different National Highways of Bangladesh. The next Chapter comes with summing up the findings of this research and recommendations for rational pavement design parameters based on actual road traffic conditions in Bangladesh.

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

7.1 INTRODUCTION

The main objectives of this research were to evaluate pavement design parameters of different National Highways of Bangladesh. Pavement design parameters including subgrade properties like soil resilient modulus, layer coefficient, drainage coefficient, etc. needs empirical observations, which is outside the scope of this work. In this research, an attempt has been made to update traffic flow related parameters used in different National Highways of Bangladesh. At present no such attempts are made to predict traffic flow related paramenters to be standardize in National Highways of Bangladesh. In addition, there is no tradition of preserving traffic flow related data in concern engineering departments of Bagladesh. Extensive effort was given in this research to find out traffic flow related parameters by collecting data from the toll operators of Jamuna bridge, Bhairab bridge, Meghna-Gomoti bridge and Dhaleshari bridge. Furthermore, comprehensive sets of axle load data were collected from two of the most important highways to acquire knowledge about recent axle load characteristics in Bangladesh such as Dhaka-Arich corridor and Dhaka-Chittagong corridor.

During this study, a wide-rang of analyses have been performed using the collected traffic and axle load data. Various significant findings are established about the traffic flow related parameters in different corridors of Bangladesh. This Chapter briefly presents the findings of this study and recommendations for rational pavement design parameters for actual road traffic conditions in Bangladesh.

7.2 SUMMARY OF THE FINDINGS

During this study, some important observations have been made related to the data collection, preservation, vehicle classification system, toll collection system, axle load control system, etc. From the analyses of traffic flow data, useful observations have been drawn. In a few words this section discusses the important finding from this study.

7.2.1 GENERAL FINDINGS

- Currently there is no standard vehicle classification system to be followed by the toll operators. Hence, the opportunity to compare class-wise traffic flow between the highways is not possible.
- Besides, the government has no policy to collect and preserve traffic flow data generated from different toll plazas of national highways which could be a vital source of long duration traffic data.
- Collection of hourly flow of traffic data is the most precious information of any corridor. Hourly flow pattern provides the genuine characteristics of traffic flow in a corridor. But unfortunately, no such data have been found from in any toll operators or concern RHD offices.
- Permanent counting stations should be established by RHD in major national highways of Bangladesh to preserve long duration traffic flow data.
- Axle load control station should be established in every important corridors of Bangladesh. The monitoring of overloading vehicles may be performed by RHD and highway police may work under supervision of RHD.
- Significant proportions of exceptionally heavily laden trucks are present in the RHD network. Thicker asphalt concrete layers resist excessive deformation under large traffic volumes and prolong the life of the pavement. Permitting the uncontrolled passage of grossly overloaded vehicles must be economically unsustainable since it would result either in high capital costs for heavily over designed pavements to cater for the illegal overloads or early deterioration of pavements designed for a legal range of vehicle loading leading to heavy premature periodic maintenance and rehabilitation costs.

7.2.2 FLOW CHARACTERISTICS ANALYSES

Several analyses on various traffic flow parameters have been rendered during this study. These include analyses of daily, weekly, monthly variation pattern of traffic flow, directional distribution, traffic composition, traffic growth pattern, impact of

Eid festivals on traffic flow pattern etc. The important findings from these analyses are summarized below.

7.2.2.1 DAILY FLOW VARIATION

For Jamuna Bridge (N-5 Corridor):

- Daily flow fluctuation is mainly governed by weekend factor; hence the analysis has been performed separately for each direction.
- For East to West direction, maximum and minimum daily flow occurs on Friday carrying 15.06% of weekly volume and Saturday carrying 13.38% of weekly volume respectively.
- For West to East direction also, maximum and minimum daily flow occurs on Friday carrying 14.82% of weekly volume and Tuesday carrying 14.00% of weekly volume respectively.
- In both the directions, the flow pattern sags on midweek.
- The daily variation of each vehicle class differs from that of total vehicle.

For Bhairab Bridge (N-2 Corridor):

- Daily flow fluctuation is ruled by weekend factor; hence the analysis has been performed separately for each direction.
- For East to West direction, maximum and minimum daily flow occurs on Friday carrying 15.99% of weekly volume and Tuesday carrying 13.60% of weekly volume respectively.
- For West to East direction also, maximum and minimum daily flow occurs on Friday carrying 14.54% of weekly volume and Saturday carrying 13.44% of weekly volume respectively.
- In both the directions, the flow pattern sags on midweek.
- The daily variation of each vehicle class differs from that of total vehicle.

For Meghna-Gomoti Bridge (N-1 Corridor):

- Friday possess maximum traffic flow of 16.37% of weekly volume.
- Sunday has the minimum traffic flow of 13.50% of the weekly volume
- The flow pattern sags on midweek.

For First and Second Dhaleshari Bridge (N-8 Corridor):

- Daily flow fluctuation is ruled by weekend factor; for this reason the analysis has been performed separately for each direction.
- From Dhaka to Mawa ferry ghat direction, maximum daily flow occurs on Friday carrying 17.49% of weekly volume and minimum daily flow occurs on Sunday carrying 13.22% of weekly volume.
- From Mawa ferry ghat to Dhaka direction also, maximum daily flow occurs on Friday carrying 17.02% of weekly volume and minimum daily flow occurs on Sunday carrying 13.44% of weekly volume.
- In both the directions, the flow pattern sags on midweek.
- The daily variation of each vehicle class differs from that of total vehicle.

7.2.2.2 WEEKLY FLOW VARIATION

For Jamuna Bridge (N-5 Corridor):

- The weekly patterns (i.e. four weeks of a month) of traffic flow on the selected corridor do not exhibit any definite pattern.
- It can be concluded that, individual week has no effect on traffic flow on this corridor.

For Bhairab Bridge (N-2 Corridor):

- There is a trend of increasing traffic in the second and third week of a month.
- The traffic volume decrease in the first and fourth week of a month.
- Individual week has its unique characteristics of traffic flow in N-2 corridor.

For Meghna-Gomoti Bridge (N-1 Corridor):

- There exists specific weekly flow variation pattern in N-1 corridor.
- There is a trend of increasing traffic in the first three weeks of a month.
- The traffic volume increase more rapidly in the last week of a month.

For First and Second Dhaleshari Bridge (N-8 Corridor):

- The weekly patterns of traffic flow on N-8 corridor do not reveal any specific pattern. However, traffic flow rises in every Thursday and Friday of weeks due to weekend factor and recreational spots near Padma River.
- Individual week has little effect of traffic flow on this corridor.

7.2.2.3 SEASONAL FLOW VARIATION

For Jamuna Bridge (N-5 Corridor):

- Dry season (Nov. to Apr.) carries 50.49% while Rainy season (May to Oct.) carries 49.51% of total yearly volume.
- From the investigation of 5 years traffic data, it was found that monthly flow pattern is repetitive in nature.
- Maximum flow occurs on December (9.70% of yearly volume)
- Minimum flow occurs on February (7.61% of yearly volume)
- Eid months carry considerably higher traffic than usual months.

For Bhairab Bridge (N-2 Corridor):

- Rainy season (May to Oct.) carries 50.15% while Dry season (Nov. to Apr.) carries 49.85% of total yearly volume.
- From the investigation of 3 years traffic data, it was found that monthly flow pattern is repetitive in nature.
- Maximum flow occurs on December (9.82% of yearly volume)
- Minimum flow occurs on February (7.24% of yearly volume)
- Eid months carry considerably higher traffic than usual months.

For Meghna-Gomoti Bridge (N-1 Corridor):

- Rainy season (May to Oct.) carries 50.27% while Dry season (Nov. to Apr.) carries 49.73% of total yearly volume.
- From the investigation of 4 years traffic data, it was found that monthly flow pattern is repetitive in nature.
- Maximum flow occurs on December (9.68% of yearly volume)
- Minimum flow occurs on June (7.69% of yearly volume)
- Eid months carry considerably higher traffic than usual months.

For First and Second Dhaleshari Bridge (N-8 Corridor):

- Dry season (Nov. to Apr.) carries 52.33% while Rainy season (May to Oct.) carries 47.67% of total yearly volume.
- From the investigation of 1 year traffic data, it was found that traffic flow is more in the month of March, May and December. Conversely, traffic flow is less from the month of June to October.
- Maximum flow occurs on March (9.21% of yearly volume)
- Minimum flow occurs on August (7.16% of yearly volume)

7.2.2.4 DIRECTIONAL DISTRIBUTION

For Jamuna Bridge (N-5 Corridor):

- The corridor has almost 50-50 directional split. Averaging all data in this study, it was found to be 50.09% in the direction West to East, and 49.91% in the direction East to West.
- Daily directional distribution varies from 48% to 51.50%.
- Since the toll amount is not weight basis, it is assumed that, even the empty trucks use the bridge instead of other low cost route.
- Weekend factor is predominant in daily directional distribution of traffic flow in this corridor. Maximum East to West flow (51.36%) occurs on Thursday while maximum West to East flow (51.34%) takes place on Saturday.
- Months do not have any significant affect on directional distribution on this corridor.

For Bhairab Bridge (N-2 Corridor):

- The corridor has almost 50-50 directional split. Averaging all data in this study, it was found to be 50.85% in the direction West to East, and 49.15% in the direction East to West.
- Daily directional distribution varies from 47% to 53%.
- Weekend factor is predominant in daily directional distribution of traffic flow in this corridor. Maximum West to East flow (52.22%) occurs on

Thursday while maximum East to West flow (50.89%) takes place on Saturday.

- Months do not have any significant affect on directional distribution on this corridor.

For First and Second Dhaleshari Bridge (N-8 Corridor):

- Averaging all data in this study, directional distribution was found to be 51.36% in the direction Dhaka to Mawa ferry ghat, and 48.64% in the direction of Mawa ferry ghat to Dhaka.
- Daily directional distribution varies from 47.45% to 52.55%.
- Weekend factor is predominant in daily directional distribution of traffic flow in this corridor. Maximum flow towards Southern part of the country from Dhaka is 52.55% occurs on Thursday while maximum flow towards Dhaka is 49.44% which takes place on Monday.

7.2.2.5 TRAFFIC COMPOSITION

For Jamuna Bridge (N-5 Corridor):

- In the toll collection of Jamuna bridge BBA divides total traffic into 7 vehicle classes – namely Motor cycle, Light Vehicle, Small Bus, Large Bus, Small Truck, Medium Truck and Large Truck.
- Three classes of vehicles dominate the traffic stream. They are – Medium Truck (37.73%), Large Bus (31.40%), and Light Vehicles (16.28%).
- The traffic composition is gradually changing every year where percentage of heavy vehicles is increasing phenomenally.

For Bhairab Bridge (N-2 Corridor):

- In the toll collection of Bhairab bridge, RHD divides total traffic into 8 vehicle classes – namely Motor cycle/Baby Taxi/Mishuk, Maxi/Pick-up Van/ Pick-up/Tampo, Car/Jeep/Station Wagon/Micro, Coaster/Tractor/Tractor with Trailer, Mini bus/Mini truck, Bus/Truck/Covered Truck 2 axle, Bus/Truck/Covered Truck 3 axle and Trailer Truck/Construction Equipment.

- Three classes of vehicles dominate the traffic stream. They are – Bus/Truck/Covered Truck 2 axle (42.46%), Motor Cycle/Baby Taxi/Mishuk (22.26%), and Car/Jeep/Station Wagon/Micro (22.24%).
- The amount and percentage of truck on N-2 corridor cannot be determined due to the faulty classification system.

For Meghna-Gomoti Bridge (N-1 Corridor):

- In the toll collection of Meghna-Gomoti bridge, RHD divides total traffic into 8 vehicle classes – namely Motor cycle, Scooter / Tampu, Car / Jeep, Micro / Pickup, Mini Bus / Coaster/ Mini Truck, Bus, Truck, and Trailer.
- Three classes of vehicles dominate the traffic stream. They are – Truck (34.40%), Micro/Pick-up (15.75%), and Bus (15.12%).
- The traffic composition is gradually changing every year where percentage of Truck is increasing astonishingly.

For First and Second Dhaleshari Bridge (N-8 Corridor):

- In the toll collection of Jamuna bridge RHD divides total traffic into 8 vehicle classes – namely Van/Bicycle, Motor Cycle, Tempo/ Auto Rickshaw, Jeep/ Car, Micro/ Pickup, Mini Bus, Bus and Truck.
- Three classes of vehicles dominate the traffic stream. They are – Mini Bus (30.35%), Jeep/ Car (26.02%), and Micro/ Pickup (17.86%).
- The percentage of light vehicle is much higher in this corridor. In addition, uncontrolled LGED/Rural road connections to the Dhaka-Mawa highway portion alluring increased number of accidents in this corridor day-by-day.

7.2.2.6 PERCENTAGE OF HEAVY VEHICLES

For Jamuna Bridge (N-5 Corridor):

- Heavy vehicles comprise of buses and trucks.
- Total percentage of trucks in the traffic stream in the year 2009 was 49.26%.
- Total percentage of buses in the traffic stream in the year 2009 was 32.49%.

For Bhairab Bridge (N-2 Corridor):

- Heavy vehicles comprise of buses and trucks.
- Total percentage of bus and trucks in the traffic stream in the year 2009 was 90.59%.

For Meghna-Gomoti Bridge (N-1 Corridor):

- Heavy vehicles comprise of buses and trucks.
- Total percentage of trucks in the traffic stream in the year 2009 was 36.34%.
- Total percentage of buses in the traffic stream in the year 2009 was 26.94%.

For First and Second Dhaleshari Bridge (N-8 Corridor):

- Heavy vehicles comprise of buses and trucks.
- Total percentage of trucks in the traffic stream in the year 2010 was 8.68%. It is to be mentioned here that, a main portion of truck use Dhaka-Aricha corridor for freight movement towards Southern part of Bangladesh causing truck percentage lower in Dhaka-Mawa corridor.
- Total percentage of buses in the traffic stream in the year 2010 was 37.23%.

7.2.2.7 TRAFFIC GROWTH PATTERN

For Jamuna Bridge (N-5 Corridor):

- Average growth rate of total traffic during the 5 years of study period is 11.17% per annum.
- Flat growth rate of total vehicle is not representative of all vehicle class. Thus growth rate of individual vehicle class should be considered.

For Bhairab Bridge (N-2 Corridor):

- Average growth rate of total traffic during the 3 years of study period is 23.79% per annum.

- Flat growth rate of total vehicle is not representative of all vehicle class. Thus growth rate of individual vehicle class should be considered.

For Meghna-Gomoti Bridge (N-1 Corridor):

- Average growth rate of total traffic during the 4 years of study period is 21.03% per annum.
- Flat growth rate of total vehicle is not representative of all vehicle class. Thus growth rate of individual vehicle class should be considered.

7.2.2.8 IMPACT OF EID FESTIVAL ON TRAFFIC FLOW

For Jamuna Bridge (N-5 Corridor):

- Duration of Eid festival impact on traffic stream: 5 days before and 6 days after Eid day, total around 11 days.
- Maximum Daily Flow Percentage: 5.90% (bothway) before Eid in December 2007.
- Average Daily Flow Percentage: 3.23%, Standard Deviation: 0.23%.
- All highest Daily Volume in a year are within Eid effect range, carrying upto 120% more traffic than AADT.
- Maximum Directional Distribution: 77.26%, East to West, November 2009.
- Average maximum Directional Distribution before Eid day: 71.71% (Averaged over 7 Eid occasions).

For Bhairab Bridge (N-2 Corridor):

- Duration of Eid festival impact on traffic stream: 5 days before and 5 days after Eid day, total around 10 days.
- Maximum Daily Flow Percentage: 4.90% (bothway) before Eid in December 2008.
- Average Daily Flow Percentage: 3.33%, Standard Deviation: 0.06%.
- All highest Daily Volume in a year are within Eid effect range, carrying upto 171.51% more traffic than AADT.
- Maximum Directional Distribution: 56.79%, West to East, September 2009.

- Average maximum Directional Distribution before Eid day: 50.64% (Averaged over 6 Eid occasions).

For Meghna-Gomoti Bridge (N-1 Corridor):

- Duration of Eid festival impact on traffic stream: 5 days before and 6 days after Eid day, total around 11 days.
- Maximum Daily Flow Percentage: 6.30% (bothway) before Eid in October 2006.
- Average Daily Flow Percentage: 3.26%, Standard Deviation: 0.07%.
- All highest Daily Volume in a year are within Eid effect range, carrying upto 113.94% more traffic than AADT.

For First and Second Dhaleshari Bridge (N-8 Corridor):

- Average Daily Flow Percentage: 3.33%, Standard Deviation: 0.05%.
- All highest Daily Volume in a year are within Eid effect range, carrying upto 81.40% more traffic than AADT.

7.2.3 AXLE LOAD CHARACTERISTICS ANALYSES

Analysis on axle loading pattern has been performed in this research. The important results are recapitulated below.

7.2.3.1 AXLE LOAD CHARACTERISTICS IN DHAKA-ARICHA HIGHWAYS (BATHOLI AXLE LOAD CONTROL STATION):

- Majority percent (25%) of trucks are absolutely overloaded with a range of six to eight tons.
- Out of 12490 samples, 43% of six wheeler truck is carrying upto 20-24 tons, 39% of the same truck is carrying upto 24-28 tons and 15% of the same is carrying upto 32 tons of load. Only 0.47% of truck has complied with allowable load limit of 15.5 tons.
- In the last two decades, the predominant loading pattern has increased in 6 folds.

- Significant weight range in Dhaka-Aricha corridor is varied from 18 tons to 35 tons per six wheeler truck and the modal weight for the frequency distribution of axle weight is 23 tons per six wheeler truck.
- The average weight of each truck is 29.94 tons.
- The 85th percentile design truck weight is 26.50 tons.
- The average ESAL per six wheeler truck is 32.41 tons.

7.2.3.2 AXLE LOAD CHARACTERISTICS IN DHAKA-CHITTAGONG HIGHWAYS (MEGHNA AXLE LOAD CONTROL STATION):

- Majority percent (30%) of trucks are absolutely overloaded with a range of six to eight tons.
- Out of 12096 samples, 48.27% of truck is carrying upto 20-24 tons, 13.21% of the same truck is carrying upto 24-28 tons and 4.85% of the same is carrying upto 32 tons of load. Only 18.30% of truck has complied with allowable load limit.
- In the last two decades, the predominant loading pattern has increased in 2 folds.
- Significant weight range in Dhaka-Aricha corridor is varied from 2.5 tons to 35 tons per truck and the modal weight for the frequency distribution of axle weight is 23 tons per truck.
- The average weight of each truck is 20.79 tons.
- The 85th percentile design truck weight is 23 tons.
- The average ESAL per truck is 14.90 tons.

7.2.3.3 AXLE LOAD CHARACTERISTICS IN DHAKA-CHITTAGONG HIGHWAYS (GOMOTI AXLE LOAD CONTROL STATION):

- Majority percent of trucks are absolutely overloaded with a range of eight to twelve tons.
- Among the samples, 50.73% of truck is carrying upto 20-24 tons, 25.02% of the same truck is carrying upto 24-28 tons and 7.14% of the same is carrying

upto 32 tons of load. Only 3.10% of truck has complied with allowable load limit.

- Significant weight range in Dhaka-Aricha corridor is varied from 18 tons to 43 tons per truck and the modal weight for the frequency distribution of axle weight is 26 tons per truck.
- The average weight of each truck is 27.96 tons.
- The 85th percentile design truck weight is 29.80 tons.
- Each truck is carrying more than 62.50% of overloading than the legal weight limit.

7.2.4 EXPANSION FACTORS AND REGRESSION MODELS

- Daily and monthly expansion factors have been established for N-1, N-2, N-5 and N-8 corridors in this research. Moreover, the factors have been determined separately for all vehicle classes.
- From regression analyses of the traffic data, linear equations have been determined.
- The developed linear regression equations resulted with more accuracy in estimating weekly ADT in comparison to expansion factors.
- The expansion factors and regression models developed in this study are given in Chapter 6.

7.3 LIMITATIONS OF THE STUDY

Some important features related to this research are stated below that could not be completed due to time and scope limitations.

- Valuable traffic flow parameters can be established if hourly flow data were found from toll operators.
- Pavement design parameters like sub grade soil properties, pavement layer co-efficient, etc. need empirical study and hence out of scope of this thesis.
- The developed factors and equations could be checked with more external data for further verification purpose.

- More comprehensive analyses on corridor flow characteristics relating to economic activities, agricultural cycle including harvesting time, etc. could be made.
- Development of the framework using advanced software such as Visual Basic interlinked with MS Access database in order to make it user friendly.
- The analyses in this research have done based on limited number of data. Accumulation of long term data will provide more stable and accurate results.

7.4 RECOMMENDATION FOR RATIONAL PAVEMENT DESIGN PARAMETERS CONSIDERING ACTUAL ROAD TRAFFIC CONDITIONS IN BANGLADESH

- Intensity of overloaded vehicle is increasing in all corridors of Bangladesh. Overload control station may be established in all strategic locations like sea port, land port, ferry ghat, etc. In other way, overload control station can be established in major truck terminals as a preventive measure to control axle load from source. Installing weighs scale in terminals and strategic locations have lots of benefits. The truck owner and driver should know how much load the vehicle is carrying. It is easy to control axle load at source. Otherwise, owner and driver of overloaded vehicle are always desperate to go to their destination at any means such as paying bribe to highway police.
- By using weight in motion technology, overloaded trucks may be identified from highway in motion and compel them to come towards axle load control station to measure weight again through permanent or static weight machine. Weight in motion technology has the advantage of not interrupting vehicles of legal weight limit moving in highways.
- Strict monitoring measures and enforcement is necessary on a daily basis to control overloading of vehicles in all National Highways of Bangladesh.
- Current legal axle load limit in Bangladesh can be upgraded based on realistic economic point of view and at the same time, import of multi axle vehicle should be encouraged.

- Initiative may be taken to instruct all Highway toll operators to keep flow records in hourly basis. A valuable traffic database can be generated in every corridor by introducing this technique.
- A specified data collection and preservation system in electronic format may be introduced by RHD to ensure proper data collection in tolled bridges without spending any money for data collection purpose.
- The transportation planners and designers may use the expansion factors and regression models established in this thesis for designing transportation facilities.
- A unified vehicle classification system may be set for all highways of Bangladesh. Without unified classification system, proper analysis among corridors cannot be possible. Like developed countries, the vehicle may classified in three categories such as Heavy vehicle, Medium vehicle and Light vehicle. These should be done based on axle loading of vehicles. Then, automation technology in toll collection can be established for the whole country.
- National highways should be planned and designed with respect to traffic flow. For instance, it is also found from the evaluation that, N-1 corridors carries almost double traffic (190.50%) than N-5 corridors and almost double and half traffic (265.46%) than N-2 corridors. Hence, structural design of highways of these corridors should not be the same. But Ministry of Communication and Planning Commission of Bangladesh are neglecting current traffic data that causes frequent structural failure of National highways especially in rainy seasons.
- For all National Highways of Bangladesh, growth factor of vehicle is considered 10% per year. But in this research, average growth rate of total traffic in N-1, N-2 and N-5 corridor is found to be accordingly 21.03%, 23.79% and 11.17%. Therefore, up gradation of growth factor parameter is necessary for all highways in Bangladesh. It is also to be mentioned that flat growth rate of total vehicle is not representative of all vehicle class and growth rate of individual vehicle class may be considered for more accuracy.

- In Eid festival period, traffic intensity is increased to a high range and cause severe traffic jam to the highways. In this study, from the past years of data it is revealed that traffic flow has increased up to 171.51% more traffic than AADT in case of N-2 corridor. Other corridors like N-1, N-5, etc. also have experience excessive traffic in Eid event. A panic is created through peoples of Bangladesh in the last couple of years during Eid festival for the dilapidated road condition and traffic jam in all highways. To cope up with this situation, transportation designer may consider the heavy traffic flow during Eid occasion, and upgrade the geometric and structural design of all National Highways and find out the position of bottleneck and its remedy. Also, RHD may try to use reversible lane with the help of highway police at the time of Eid festival to face heavy traffic.
- Structural design of all National Highways may be upgraded to resist heavy wheel loads and tire pressure. For example, in Dhaka-Aricha corridor, out of more than 12000 over weight vehicle samples, the average weight of each truck is found 29.94 tons and the 85^{th} percentile design truck weight is established 26.50 tons. However, strict axle load control in National Highways is equally important for the durability of pavement.
- Equivalency factor of vehicle category especially truck may be upgraded for the design of pavement in National Highways. At present according to RHD pavement design guide, the equivalency factor for medium truck is only 4.62. However, in this study the damage factor is found more than 200 for some vehicles that are much higher than anticipated.
- Evaluation of corridor specific pavement design parameters have been done in this research. Each corridor has its own characteristics and traffic demand. Hence, pavement design parameters should be corridor specific and the parameters should vary from corridor to corridor. Roads and Highways Department may take immediate measures to fix corridor specific pavement design parameters.
- Traffic volume characteristics is used by the traffic engineers to ascertain the current usage of traffic ways as an indication of improvement needs, as a consideration for the application of traffic control devices, and as a basis for

designing highway improvements and new construction. In this research, traffic volume information on the major corridors of Bangladesh has been comprehensively analyzed for the first time that will contribute to the future research work as a benchmark for evaluating pavement design parameters for actual road traffic conditions in Bangladesh.

CHAPTER 5

ANALYSES OF AXLE LOAD CHARACTERISTICS

5.1 INTRODUCTION

The unanticipated increase in vehicle population and heavy axle loads has brought the road network of Bangladesh to a crumbling stage. The network is grossly short of its structural capacity, highly distressed and has started showing signs of premature failure. The road network is unable and incapable to sustain high stresses caused due to heavy wheel loads and increased tyre pressures. Trucks in Bangladesh carry loads in excess of their capacity. There are standards available in Bangladesh of size, weights and dimensions of the truck body but these are, in general, not largely followed. The vehicle owners make changes and have wider and higher bodies so that a truck can carry more goods than permissible, thus producing a considerable reduction in haulage charges. Heavy traffic loading produces rapid differential compaction in the upper layers of pavement in addition to fracture of the asphalt surfacing. Implications of overloading on overall transport costs have been examined worldwide and it is evident that vehicle overloading seriously affects the improvements of road network in many developing countries including Bangladesh largely because of increased demands for maintenance and rehabilitation due to pavement's damage caused by heavy axles. This Chapter includes the detail axle load analyses like overloading trend, past and present overloading comparisons, frequency distribution of axle loads, damage factor, etc. for Dhaka-Aricha highway and Dhaka-Chittagong highway.

5.2 ANALYSES OF AXLE LOAD CHARACTERISTICS

Research on axle load intensity of vehicles especially truck is very urgent for developing countries like Bangladesh due to following reasons:

1. Overloading is rampant especially on National Highways and therefore axle load control is necessary.

2. There are too high a proportion of 2-axle medium trucks, which cause severe pavement damage. Government should actively encourage import/manufacture of multi-axle trucks and ban imports of 2-axle trucks above a certain weight.
3. Truck owners commonly strengthen the chassis and the suspension to enable carrying of extreme loads.
4. Standard buses are guilty of overloading too.
5. Pavements constructed to the highest standards show signs of distress well before the end of design life. This is even when normal overloading is taken into account in design.

The following legal axle load limits is imposed in Bangladesh: (1) Front 2-tyre single axle: 6 tons, 4-tyre single axle: 10.2 tons, 8-tyre tandem axle: 20 tons. But unfortunately no axle load control measures are taken practically in Bangladesh and pavements are exposed to severe axle loading, which will be revealed in this Chapter.

Two types of axle load weighing equipments are available in Bangladesh. There are the fixed type weighbridges like the Batholi axle load control station in Manikganj and the portable weighing pads like the one used for axle load control in Gomoti toll plaza in Narayanganj.

Fixed Weighbridges are fixed installations on the roadside where the entire vehicle is weighed. The distribution of load to the individual axles may be calculated from standard factors. These weighing scales have very high range and are accurate. As installation is expensive, the number and locations have to be selected judiciously.

Portable Weighing Pads can be inexpensive yet efficient. Pads are useful for spot weighing of the axle load directly. However, portability results in loss in accuracy to some extent. The pads are usually meant for static weighing, which is acceptable for most purposes. Portable weighbridges should be used to supplement the static weighbridges, and should be used at locations where temporary overloading is detected.

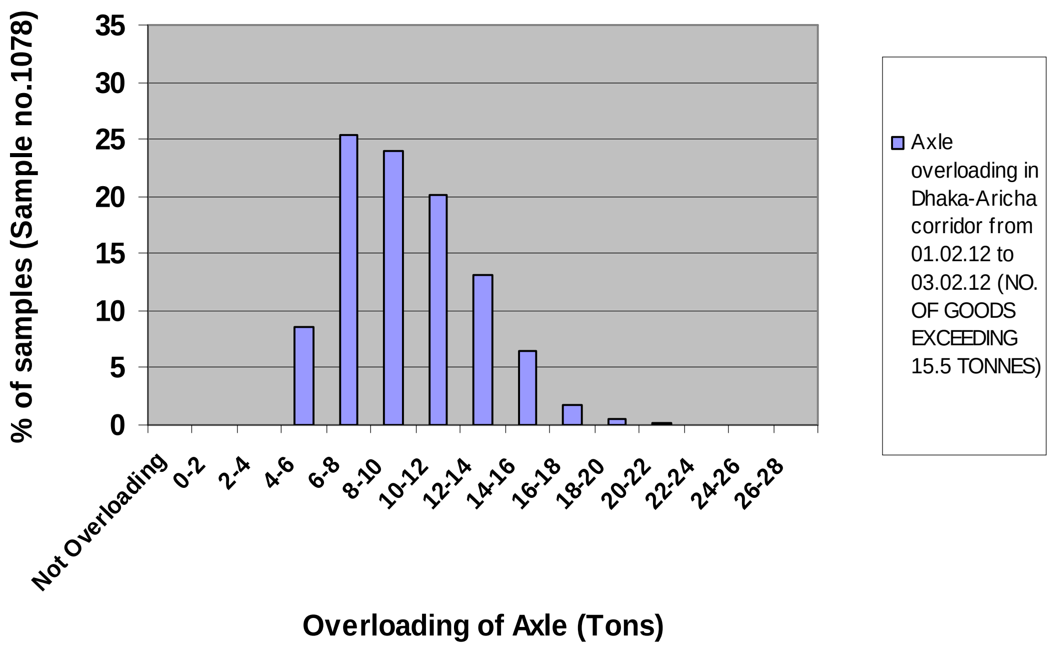
As mentioned earlier, the axle load data was collected from two axle load control stations, namely Batholi on Dhaka-Aricha highway and Meghna-Gomoti toll plaza on

Dhaka-Chittagong highway. Both of the two highways carries predominant vehicle class of Bangladesh and axle loading pattern of these two corridors can help to identify axle loading related design parameters on national highways in Bangladesh.

5.2.1 AXLE LOAD CHARACTERISTICS IN DHAKA-ARICHA CORRIDOR

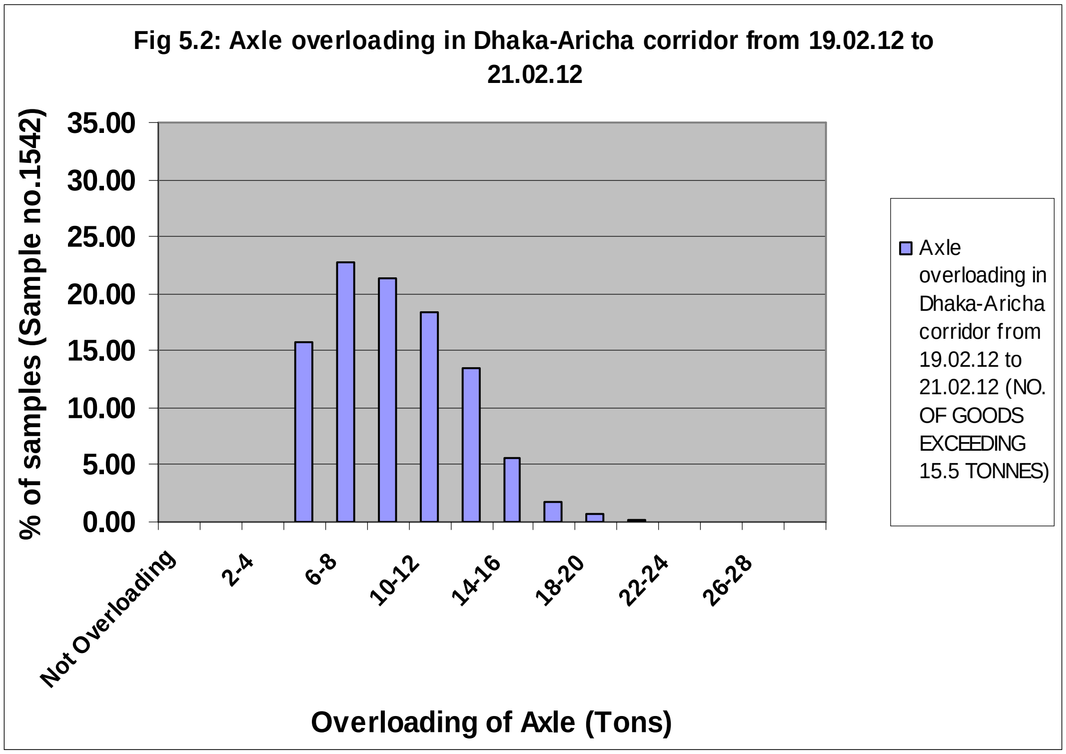
Data collected from axle load control stations in Batholi on Dhaka-Aricha highway for the month of February 2012 illustrate several loading pattern on highways. Initially data was seperated for three days to analyse more intensely to get specific loading pattern. Currently 15.5 ton weight is allowed for six wheelers in Bangladesh. In order to verify the findings, the collected data is analyzed by deducting allowable load to identify the overloading pattern.

Fig 5.1: Axle overloading in Dhaka-Aricha corridor from 01.02.12 to 03.02.12



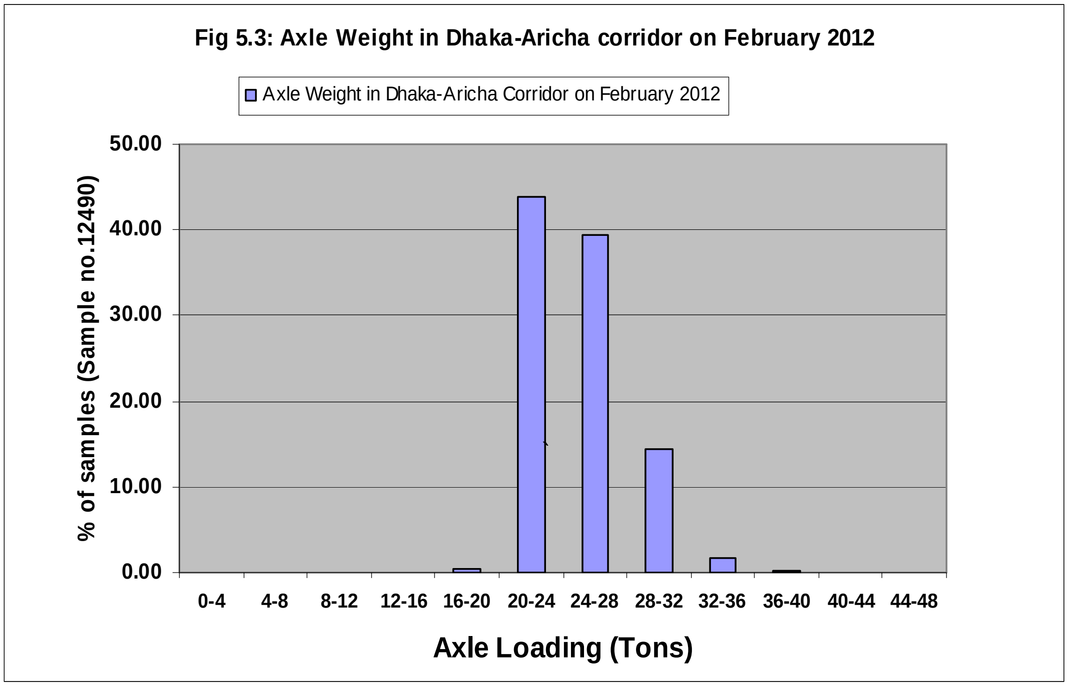
The above bar diagram illustrates that, out of 1078 data collected from 1st February to 3rd February, 25% vehicle is carrying overloading upto six to eight tons, 24% carrying overloading up to eight to ten tons and 6% vehicle carrying up to fourteen to sixteen tons then the allowable limit that is very alarming for the road structures.

In the same way, out of 1552 six wheeler truck data composed from the 19th February to 21th February, 26% vehicle is carrying overloading upto six to eight tons, 19% carrying overloading up to eight to ten tons and 2% vehicle carrying up to fourteen to sixteen tons. The remaining graphs are listed in Appendix B (From Figure B24 to Figure B30).



It is obvious from the bar diagram that the overloading range of six to eight ton is predominant on most of the diagram, which indicates that the majority vehicles specially trucks follow the trend of frequent overloading intensity in that range of six to eight tons.

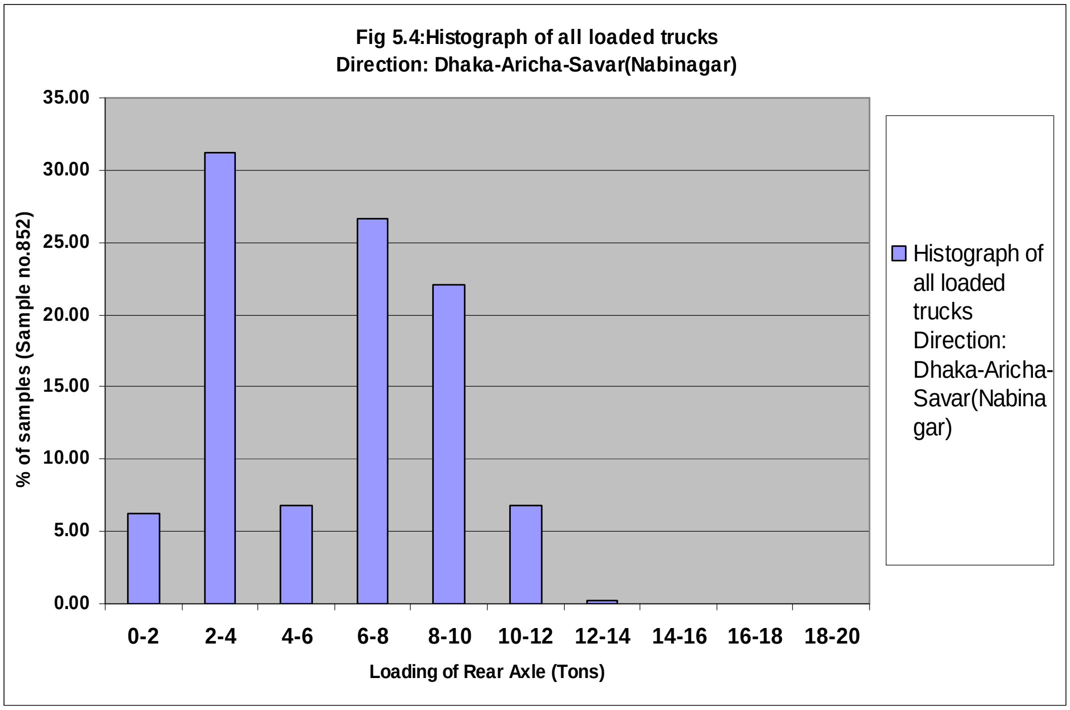
To put more light in the analysis, total 12490 numbers of data is combined for the month of February to get more details on loading characteristics in one bar diagram. It is found from figure 5.3 that 43% of six wheeler truck is carrying upto twenty to twenty four tons of goods, 39% of the same truck is carrying upto twenty four to twenty eight tons of goods and 15% of the same is carrying upto thirty two tons of load.



The above diagram discloses the fact that only 0.47% of truck in the axle load control station has comply with allowable load limit of 15.5 tons. However, out of 12490 samples in the month of February of 2012, 12423 samples exceed the legal weight limit, which is extremely alarming for the road structures of Dhaka-Aricha highway.

5.2.2 PAST AXLE LOAD CHARACTERISTICS IN DHAKA-ARICHA CORRIDOR

Now, in order to check the present loading pattern with the historic data with a view to observe the overloading changing patern over the years, an axle load survey report was collected from Roads and Highways Department that was published in 1994 with the help of European Economic Community, where data was collected from the same location of Dhaka-Aricha corridor is shown below.

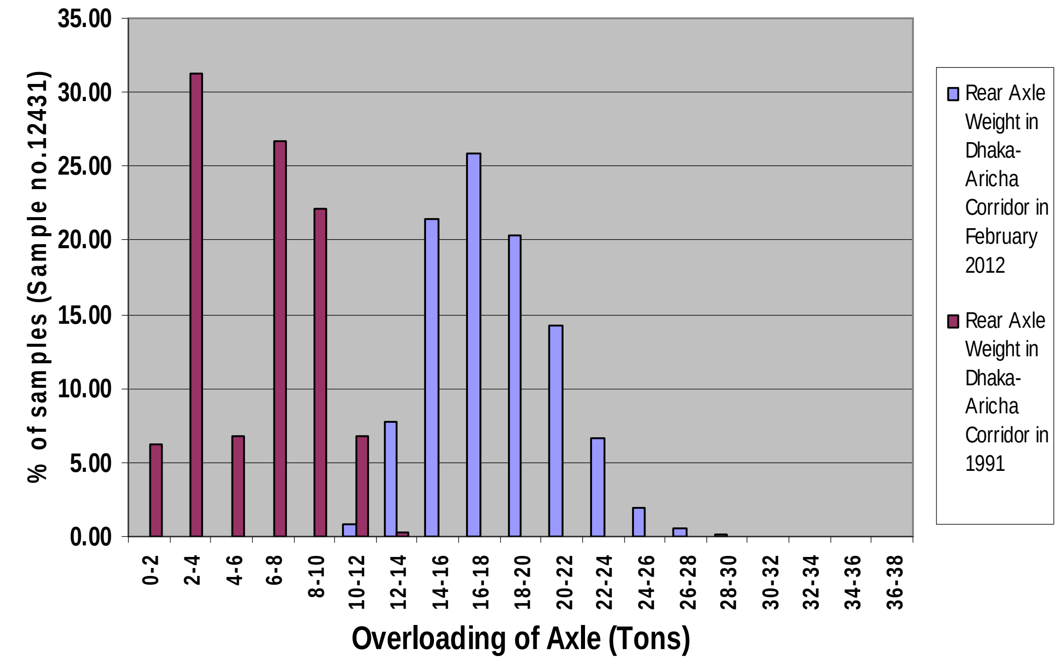


It is noted from the depicted histrogram that the data was analyzed for rear axle loads of trucks. Out of 852 data collected on 20-10-1991 to 23-10-1991, 30% sample were carried rear axle load from two to four tons, 26.5% sample were carried load from six to eight tons, 22% sample were carried load from eight to ten tons and 7% sample were carried load from ten to twelve tons.

5.2.3 COMPARISON OF AXLE LOAD CHARACTERISTICS IN DHAKA-ARICHA CORRIDOR BETWEEN PRESENT AND PAST DATA

Now, the past and present axle load data of the same corridor are superimposed in figure 5.5 to evaluate loading intensity changing pattern. The present 12431 numbers of data was collected in the same location in February 2012, where it is found that 22% vehicles carry fourteen to sixteen tons on their rear axle, 26% of the vehicles carry sixteen to eighteen tons, 20% vehicles carry eighteen to twenty tons, 14% carries twenty to twenty two tons, 7% carries twenty two to twenty four tons of load upon the highways, where as the legal limit for rear axle with four tyre is ten tons only.

Fig 5.5: Comparison of Rear Axle Weight in Dhaka-Aricha Corridor Between the year 2012 and 1991



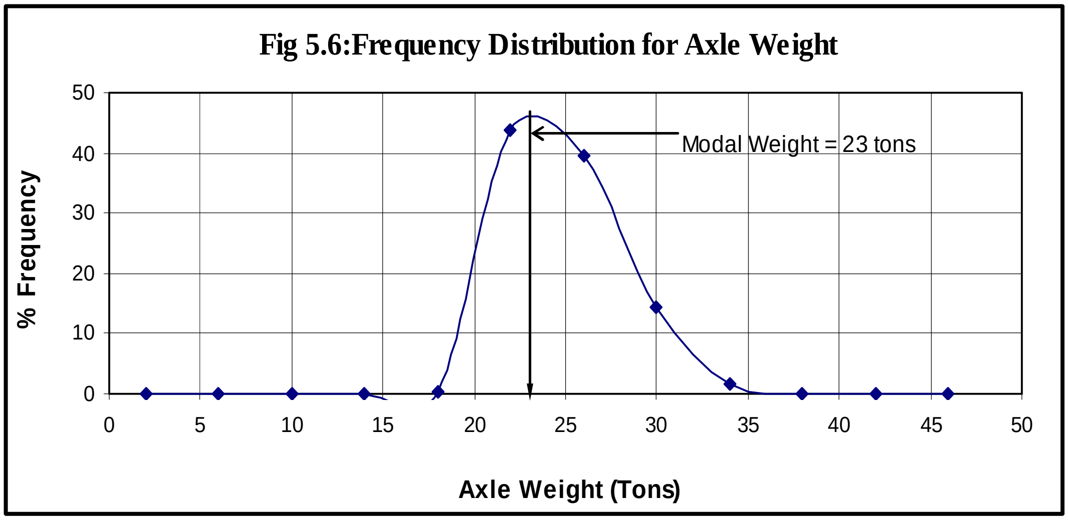
From the above pictorial presentation in fig 5.5, it is evident that in the last two decades the rear axle weight has increased with significant margin. In 1991, the predominant weight category range was two to four tons and in 2012, the predominant weight category range is sixteen to eighteen tons. Thus the predominant weight category pattern has increased by six folds in two decades. Moreover, the rear axle weight range was 2 to 12 tons in 1991, whereas that range has amplified to 12 to 32 tons in 2012. The lower weight range has increased six folds and the upper weight range has increased to three folds. The increased axle load has detrimental effect with geometric proportion called “damage factor”, which will be explored later in this Chapter. However, the traffic growth factor and axle load characteristics in every corridor of Bangladesh has incresed enormously but Roads and Highways department of Bangladesh has not upgraded their road design standards in the last couple of years to withstand the increased traffic load. It is also revealed that this pioneer department has not published any traffic or axle load related study in the last five years which may create awareness to policy makers to preserve the national road infrastructure assets. The national and regional highways are now porn to collapse due to heavy traffic loading and intensity.

But the communication ministry and Roads and Highways Department are not taking any measures to protect the road structures.

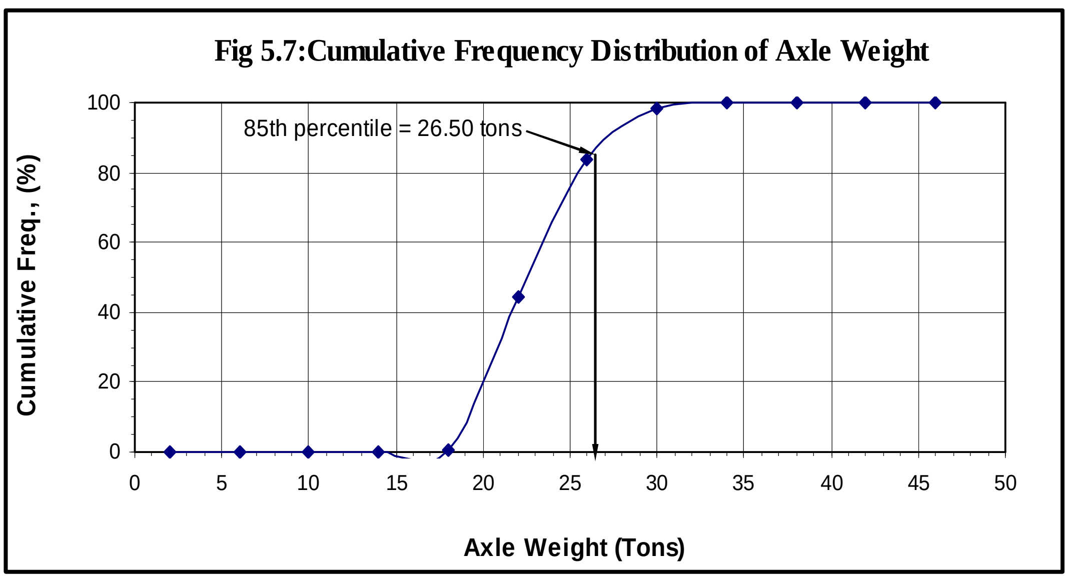
5.2.4 FREQUENCY DISTRIBUTION OF AXLE LOAD IN DHAKA-ARICHA CORRIDOR

In order to find more details about axle loading characteristics and relate these with pavement design parameters, the collected data is then seperated into various weight ranges to get a best fit curve and numbers of observed vehicles are classified into the range that gives the frequency of data. A frequency distribution analysis for axle weight is found in figure 5.6, from which it is seen that the considerable weight range in Dhaka-Aricha corridor is varied from 18 tons to 35 tons, which is far beyond the allowable weight limit of 15.5 tons. The modal weight for the frequency distribution of axle weight is found to be 23 tons. The average weight of each truck from the collected data is found to be 29.94 tons by using the statistics formula of W_{avg} = Sum (f X W)/Sum (f). The following table is representating more details about data characteristics and the graph below is formed by using weight range in horizontal axis and frequency in vertical axis.

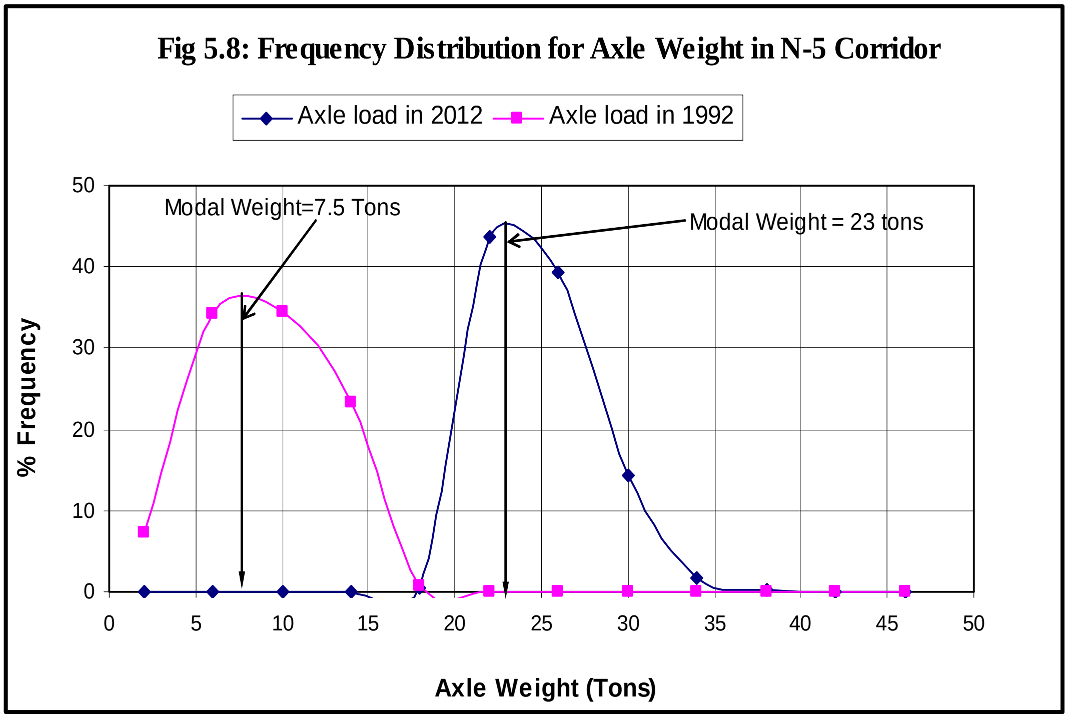
Weight Range (Tons)	No. of vehicle observed (f)	Mid-Weight, W (Tons)	Frequencies, (%)	Cumulative Frequencies, (%)
0-4	2	2	0.02	0.02
4-8	2	6	0.02	0.03
8-12	4	10	0.03	0.06
12-16	0	14	0.00	0.06
16-20	59	18	0.47	0.54
20-24	5466	22	43.76	44.30
24-28	4925	26	39.43	83.73
28-32	1792	30	14.35	98.08
32-36	219	34	1.75	99.83
36-40	16	38	0.13	99.96
40-44	5	42	0.04	100.00
44-48	0	46	0.00	100.00
Total	**12490**			



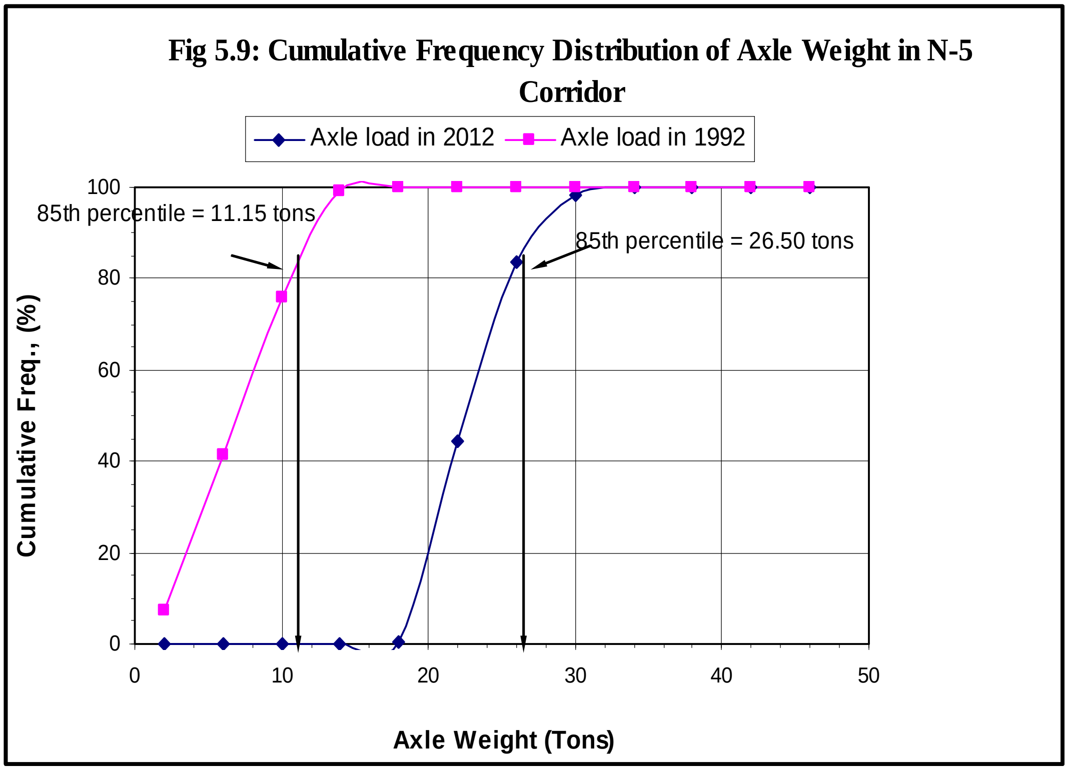
Another important observation is established from cumulative frequency distribution of axle weight below from figure 5.7, the 85th percent, which statistically represens the design truck weight, of vehicle is carrying weight more than 26.50 tons on that corridor.



Now, a comparison is made about frequency distribution for axle weight in Dhaka-Aricha corridor in the year of 2012 and 1992 in figure 5.8 and 5.9. It is seen from the diagrams that with the increase of time the axle load has increased significantly. From the graph of the year 2012, it is found that minimum considerable weight is 18 ton per vehicle and maximum considerable weight is 35 ton for 6 wheeler truck on

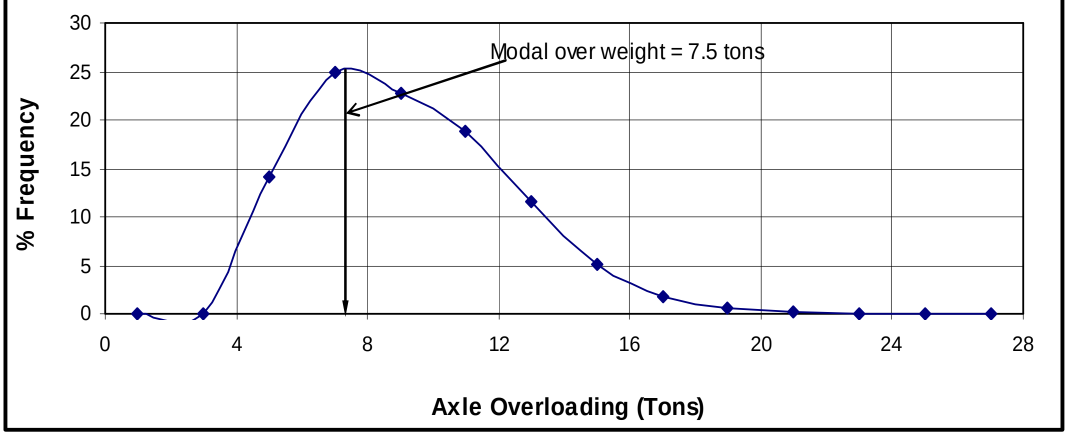


N-5 corridor. The range of axle weight is 18 to 35 tons per vehicle.The modal weight is 23 tons. From the graph of the year 1991, it is found that minimum considerable weight is 2.5 ton per vehicle and maximum considerable weight is 18 ton for 6 wheeler truck on N-5 corridor. The range of axle weight is found to be 2.5 to 18 tons per vehicle and the modal weight is found 7.5 tons. The average weight of trucks on N-5 corridor in the year 2012 is 24.94 tons and modal weight is 23 tons. The 85th percent of vehicle is carrying weight more than 26.50 tons. The average weight of trucks on N-5 corridor in the year 1991 was 9.04 tons, the modal weight is 7.5 tons and the 85th percent of vehicle is carrying weight more than 11.15 tons.



In order to find the absolute over weight magnitude of trucks by deducting the allowable load limit of 15.5 tons from each data collected for analysis on Dhaka-Aricha highways. A key observation is made in figure 5.10 where it is noted that absolute modal overweight is 7.5 tons and the statistical over weighted average is 9.31 tons of each vehicle. It indicates that each vehicle is carrying more than 60% overloading than the legal weight limit in N-5 corridor that is very alarming for the road structures and the overloaded vehicles habitually provokes more accidents due to lack of control.

Fig 5.10: Frequency Distribution for Axle Overloading in N-5



5.2.5 DETERMINATION OF DAMAGE FACTOR IN DHAKA-ARICHA CORRIDOR

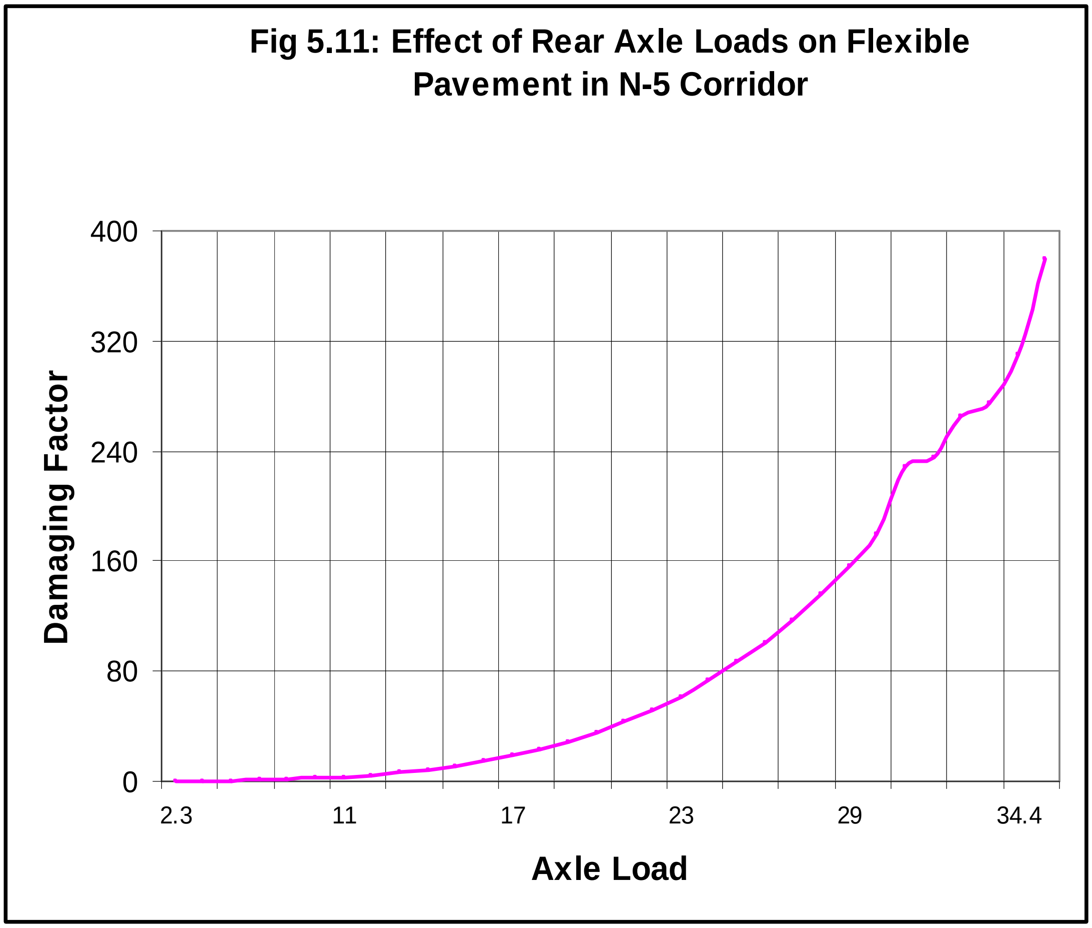
In order to distinguish the damage factor in terms of ESAL (Equivalent Standard Axle Load) units, the collected data have been used to draw the following figure in 5.11. It is to be mentioned that every pavement structural design requires a quantification of all expected loads that a pavement will encounter over its design life. Under the ESAL method, all loads (including multi-axle loads) are converted to an equivalent number of 8160 kg single axle loads, which is then used for design. A "load equivalency factor" represents the equivalent number of ESAL for the given weight-axle combination. As a rule-of-thumb, the load equivalency of a particular load (and also the pavement damage imparted by a particular load) is roughly related to the load by a power of four. For example, a 16,000 kg (16 T) single axle load will cause about 16 times the damage as an 8160 kg (8.16 T) single axle load.

The general 4th power classical relationship between ESAL for a 2-axle vehicle and the standard axle loads is:

$$ESAL = (FAW/6.6)^4 + (RAW/8.16)^4$$

Where, FAW = front axle weight and RAW = rear axle weight in tonnes.

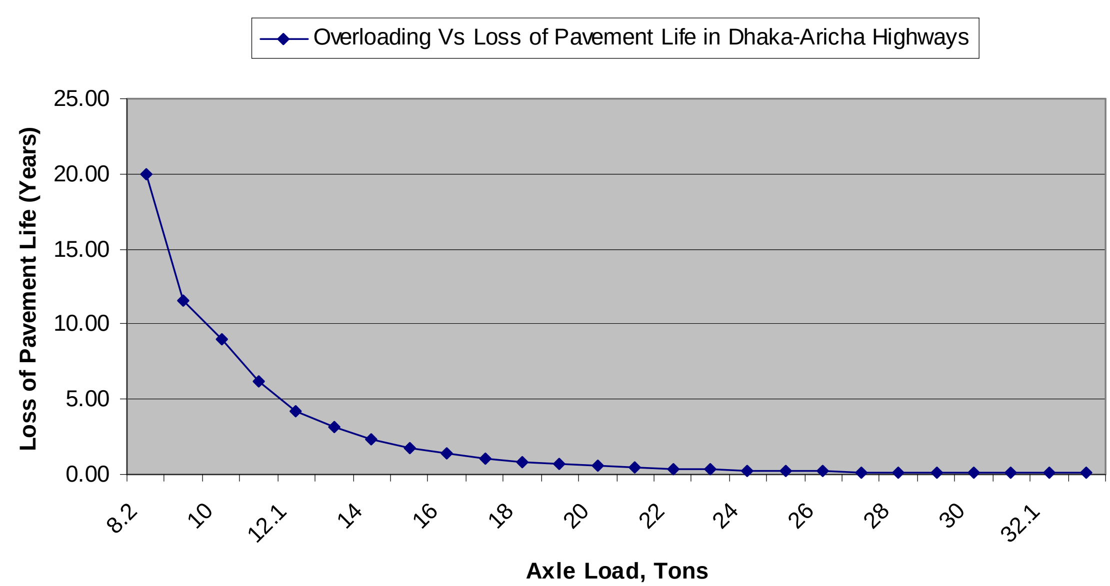
Standard axle loads used for calculating Equivalent Standard Axle Load (ESAL's) are front (steering) axle – 6.6 tons; rear single axle – 8.16 tons; and tandem axles - 15 tons.



The above figure in 5.11 illustrates the disproportionately large damage imparted to the pavement by every unit increase in overloading. One of the primary functions of a pavement is load distribution and the pavement design must account for the expected lifetime traffic loads. Since a pavement is designed for the cumulative repetition of equivalent axle loads likely to be imposed, the effect of increase in ESAL because of uncontrolled overloading would be reduction in the life of the pavement i.e. the pavement would fail earlier than it is designed for. The magnitude of axle load is very sensitive to the damage factor, such as from the beginning the detrimental effect is rapid and the trend becomes worse after 10 tonne overloading. It is observed from the graph that for 20 tons of axle load, the damage factor is 35.39, whereas for 25 tons of axle load the damage factor turn into double to 86.40. Furthermore, for 30 tons of axle load, the damage factor is converted into 179.16 and after only 2 ton increase of axle load, the damage factor becomes 234.84 and further increase of 2 ton axle load creates damage factor 309.73. In addition, the slowing down of loaded vehicles because of poor road condition accelerates the pavement failure process. The average ESAL in this corridor is found to be 32.41 per six wheeler truck by analyzing 12492 data for the month of February in 2012.

The above analysis of axle load can be related with durability of pavemet life. By using the formula of ESAL = (Axle load/Standard Axle Load)^4 , it is observed that for 8.16 tons of standard axle load, the damage factor is 1, which makes pavement life 20 years. Then with the increase of rear axle load, the durability of pavment life will decrease. The next figure is illustrating the reality of pavement life for the increase of rear axle load.

Fig 5.12: Rear Axle Load Vs Loss of Pavement Life in Dhaka-Aricha Highways



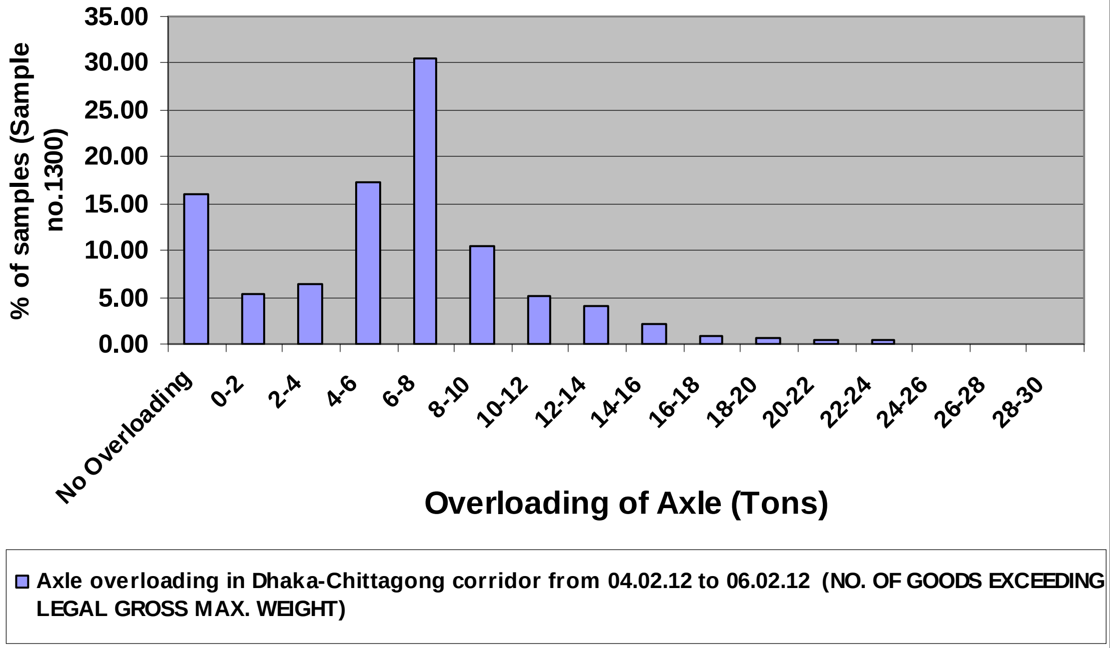
With the enhancement of vehicular axle load, how the pavement life is deteriorated is distinguished from the above graphic analysis for Dhaka-Aricha Highways. For 8.2 tons of axle load, the pavement life is 20 years, whereas for 10 tons of axle load, pavement life decreases to 9 years. Moreover, for 13 tons of axle load, pavement life declines to

6.32 years. Additionally, for 17 tons of axle load, pavement life becomes 1.08 years. In order to sustain the overloaded vehicles, the pavements have to be designed with higher thickness, which translates to higher cost of construction. However, increase of pavement thickness to resist overloading must not be a solution. Rather, enforcement of axle load control is mandatory for the welfare of national economy and road infrastructure. The subsequent paragraphs will disclose the axle load pattern of other important national highways of Bangladesh.

5.2.6 AXLE LOAD CHARACTERISTICS IN DHAKA-CHITTAGONG CORRIDOR (TOWARDS CHITTAGONG DIRECTION)

Data collected from axle load control stations in Meghna axle load control stations on Dhaka-Chittagong highway for the month of February 2012 depicts several loading pattern on highways. Primarily data was seperated for three days to analyse more intensely to get specific loading pattern. The collected data is analyzed by deducting allowable load to categorize the overloading pattern.

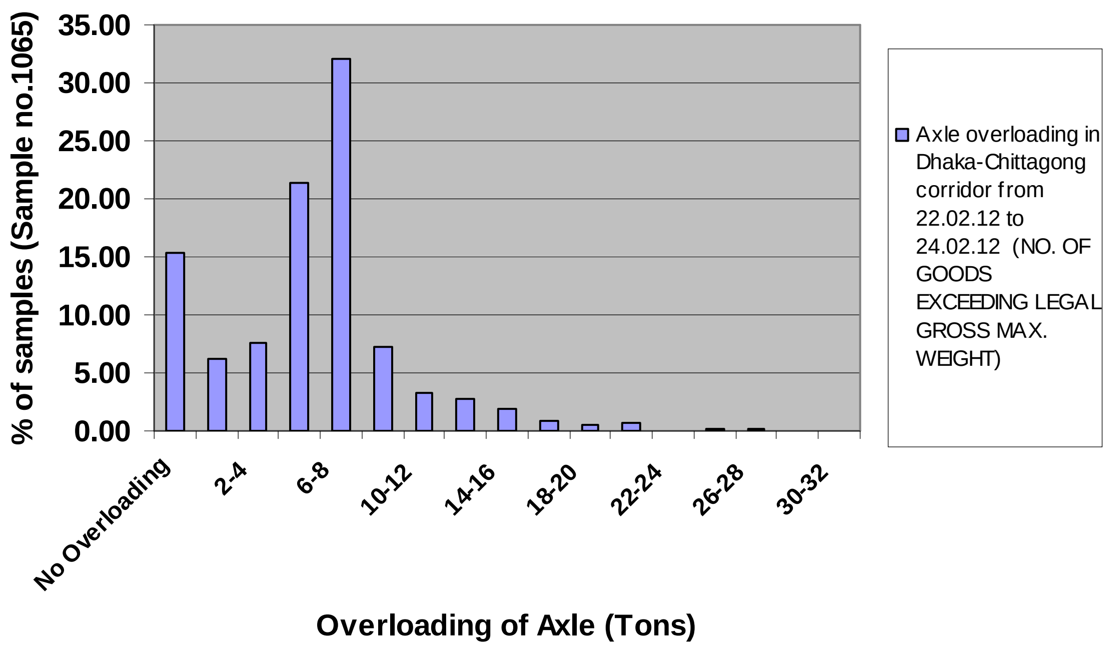
Figure 5.13: Axle overloading in Dhaka-Chittagong corridor from 04.02.12 to 06.02.12 (Towards Chittagong Direction)



The above bar diagram in figure 5.13 demonstrates that, out of 1300 data collected from 4th February to 6th February, 17.38% vehicle carrying up to four to six tons, 30.54% vehicle is carrying overloading upto six to eight tons and 10.46% carrying overloading up to eight to ten tons then the allowable limit that is very distressing for the road structures. It is also found that 16% of vehicle is not carrying overloading, which point out that legally weighted vehicles are also checked in this control station. In the developed countries, they use WIMP device to track overloaded vehicles from long distance and thus never create interruption to underloading vehicles.

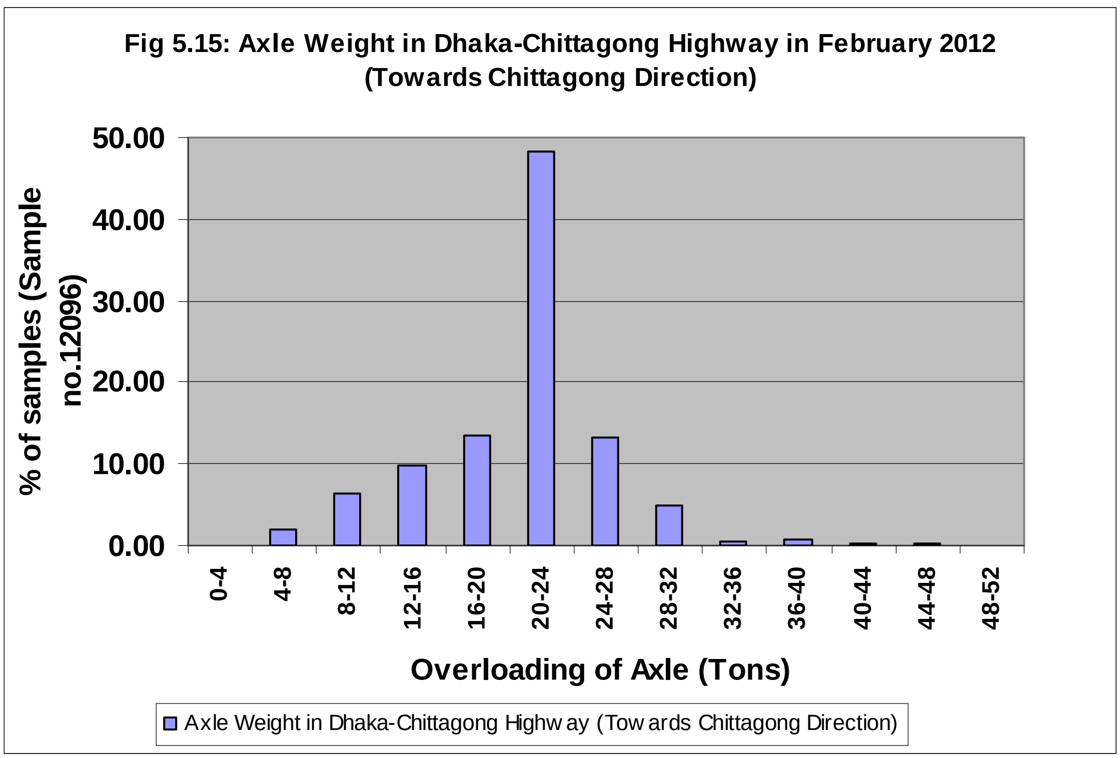
In the similar way, out of 1065 truck data composed from 22th February to 24th February in figure 5.14, 32.11% vehicle is carrying overloading upto six to eight tons, 21.31% carrying overloading up to four to six tons, 7.23% vehicle carrying up to eight to ten tons and 15.31% of vehicle is not carrying overloading. The remaining graphs are listed in Appendix B (Figure B31 to figure B37).

Figure 5.14: Axle overloading in Dhaka-Chittagong corridor from 22.02.12 to 24.02.12 (Towards Chittagong Direction)



It is apparent from the bar diagram that the overloading range of six to eight ton is predominant on most of the diagram like Dhaka-Aricha highway, which indicates that majority vehicles specially trucks follow the trend of frequent overloading intensity in that range of six to eight tons.

To put more light in the analysis, total 12096 numbers of data is gathered for the month of February to get more details on loading characteristics in one bar diagram. It is found from figure 5.13 that 13.56% of vehicle is carrying sixteen to twenty tons of load, 48.27% of vehicle is carrying upto twenty to twenty four tons of goods, 13.21% of the vehicle is carrying upto twenty four to twenty eight tons of goods and 4.85% of the same is carrying twenty eight to thirty two tons of load.

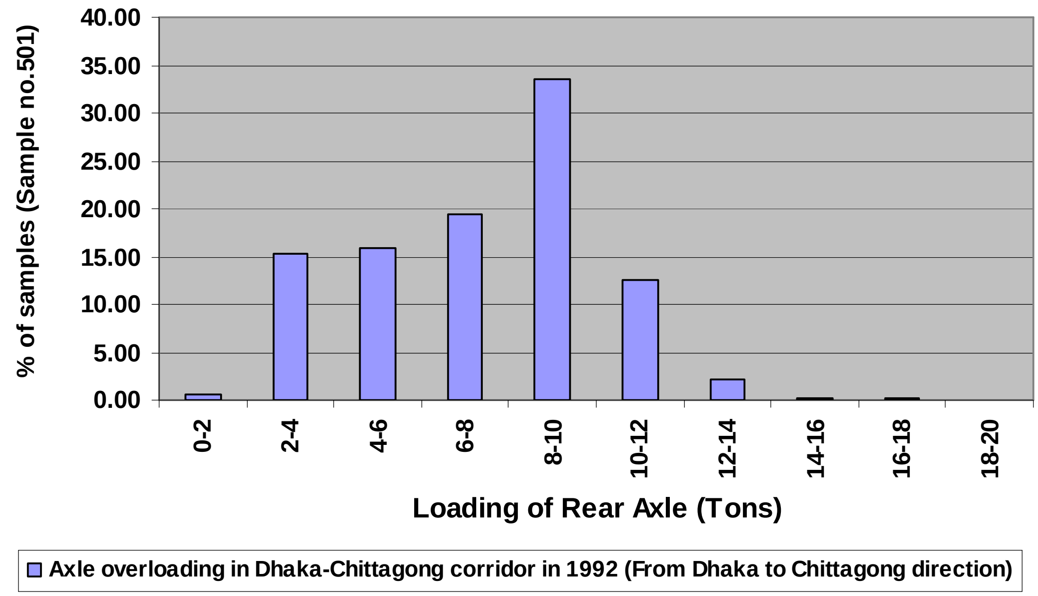


The above diagram in Figure 5.15 discloses the fact that only 18.30% of truck in the axle load control station has comply with allowable load limit. However, out of 12096 samples in the month of February of 2012, 9882 samples exceed the legal weight limit, which is enormously disturbing for the road structures of Dhaka-Chittagong highway.

5.2.7 PAST AXLE LOAD CHARACTERISTICS IN DHAKA-CHITTAGONG CORRIDOR (TOWARDS CHITTAGONG DIRECTION)

In order to check the present loading pattern with the historic data with a view to observe the overloading changing patern over the years, an axle load survey report was collected from Roads and Highways Department that was published in 1994, where data was collected from the same location of Dhaka-Chittagong corridor is shown below.

Fig 5.16: Histrogram of all loaded truck in 1992
Direction: Dhaka-Chittagong (N-1)

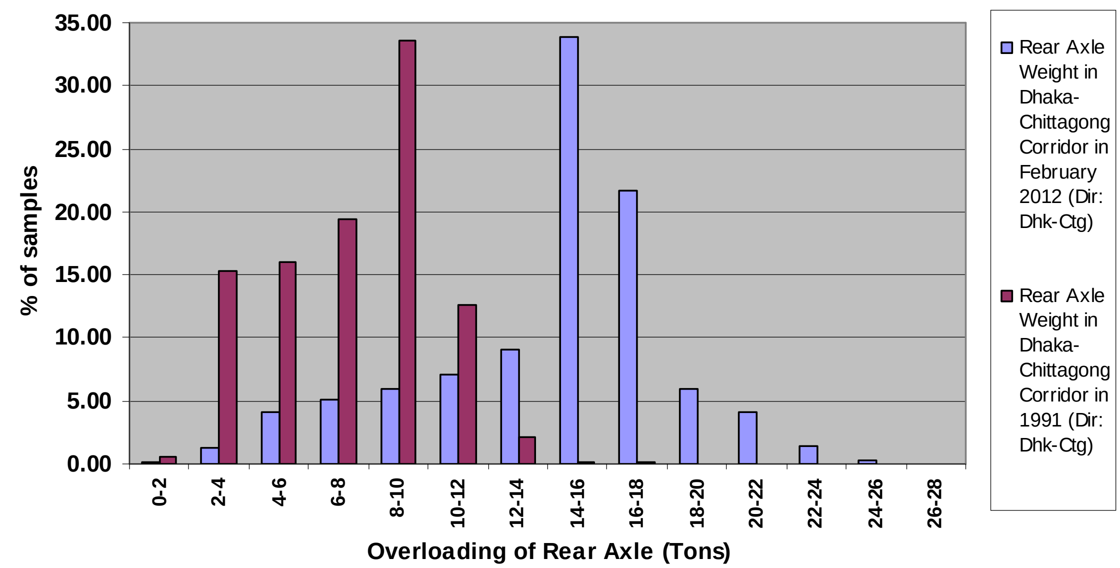


It is noted from the illustrated histogram in figure 5.16 that the data was analyzed for rear axle loads of trucks. Out of 501 data collected on 15-12-1991 to 16-12-1991, 15.37% sample were carried rear axle load from two to four tons, 15.97% sample were carried load from four to six tons tons, 19.36% sample were carried load from six to eight tons, 33.53% sample were carried load from eight to ten tons and 12.57% sample were carried load from ten to twelve tons.

5.2.8 COMPARISON OF AXLE LOAD CHARACTERISTICS IN DHAKA-CHITTAGONG CORRIDOR (TOWARDS CHITTAGONG DIRECTION) BETWEEN PAST AND PRESENT DATA

Now, the past and present axle load data of the same corridor are superimposed in figure 5.17 to evaluate loading intensity changing pattern. The present 12096 numbers of data was collected in the same location in February 2012, where it is found that 33.08% vehicles carry fourteen to sixteen tons on their rear axle, 21.62% of the vehicles carry sixteen to eighteen tons, 5.93% vehicles carry eighteen to twenty tons, 4.17% carries twenty to twenty two tons of load upon the highways, where as the legal limit for rear axle with four tyre is ten tons only.

Fig 5.17: Comparison of Rear Axle Weight in Dhaka-Chittagong Corridor Between the year 2012 and 1991 (Dir: Dhk-Ctg)

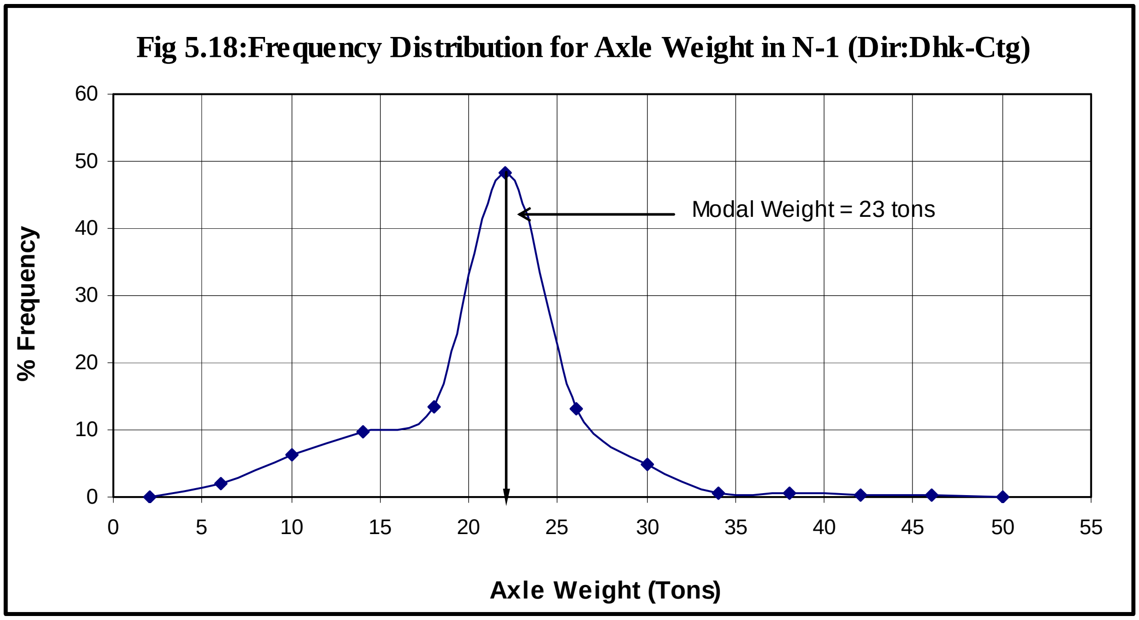


From the above pictorial presentation, it is evident from the figure 5.17 that in the last two decades the rear axle weight has increased with significant margin. In 1991, the predominant weight category range was eight to ten tons and in 2012, the predominant weight category range is fourteen to sixteen tons. Thus the predominant weight category pattern has increased by two folds in the last two decades. Moreover, the rear axle weight range was 2 to 12 tons in 1991, whereas that range has upgraded to 2.5 to 28 tons in 2012. The upper weight range has increased to two folds. The increased axle load has detrimental effect with geometric proportion called “damage factor”. However, the traffic growth factor and axle load characteristics in every corridor of Bangladesh has incresed enormously now-a-days.

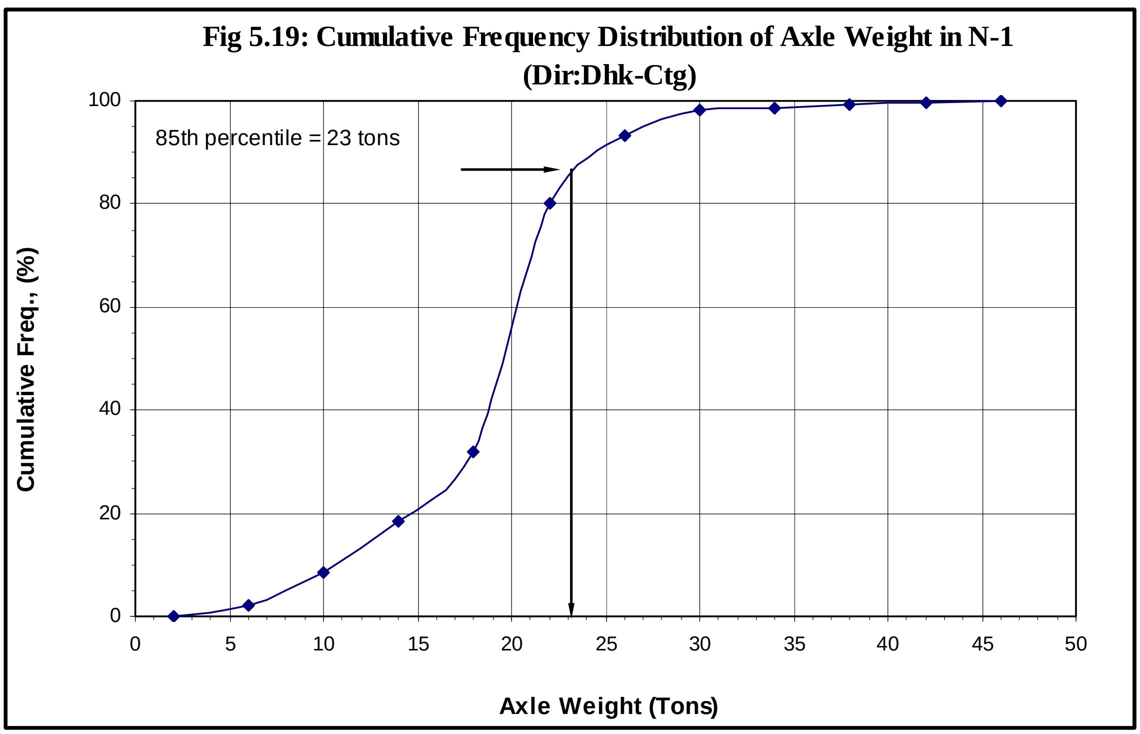
5.2.9 FREQUENCY DISTRIBUTION OF AXLE LOAD IN DHAKA-CHITTAGONG CORRIDOR (TOWARDS CHITTAGONG DIRECTION)

In order to explore more details about axle loading characteristics and relate these with pavement design parameters, the collected data is then seperated into various weight ranges to get a best fit curve and numbers of observed vehicles are classified into the range that gives the frequency of data. A frequency distribution analysis for axle weight is found in figure 5.18, from which it is seen that the considerable weight range in Dhaka-Chittagong corridor (Direction: from Dhaka to Chittagong) is varied from 2.5 tons to 35 tons, which is far beyond the allowable weight limit of 15.5 tons for 6 wheelers and 26 tons for 10 wheelers. The modal weight for the frequency distribution of axle weight is found to be 23 tons. The average weight of each truck from the collected data is found to be 20.79 tons by using the statistical formula of W_{avg} = Sum (f X W)/Sum (f). The following table is representating more details about data characteristics and the graph below is formed by using weight range in horizontal axis and frequency in vertical axis.

Weight Range (Tons)	No. of vehicle observed (f)	Mid-Weight, W (Tons)	Frequencies, (%)	Cumulative Frequencies, (%)
0-4	11	2	0.09	0.09
4-8	238	6	1.97	2.06
8-12	777	10	6.42	8.48
12-16	1188	14	9.82	18.30
16-20	1640	18	13.56	31.86
20-24	5839	22	48.27	80.13
24-28	1598	26	13.21	93.34
28-32	587	30	4.85	98.20
32-36	64	34	0.53	98.73
36-40	80	38	0.66	99.39
40-44	42	42	0.35	99.74
44-48	20	46	0.17	99.90
48-52	12	50	0.10	100.00
Total	**12096**			



Another important observation is established from cumulative frequency distribution of axle weight below from figure 5.19, the 85th percent, which statistically represens the design truck weight, of vehicle is carrying weight more than 23 tons on that corridor.



Now, a comparison is made about frequency distribution for axle weight in Dhaka-Chittagong corridor (Direction from Dhaka to Chittagong) in the year of 2012 and 1992 in figure 5.20 and 5.21. It is seen from the diagrams that with the increase of time the axle load has increased significantly. From the graph of the year 2012, it is found that minimum considerable weight is 2.5 ton per vehicle and maximum considerable weight is 35 ton for 6 wheeler and 10 wheeler trucks on N-1 corridor. The range of axle weight is 2.5 to 35 tons per vehicle.The modal weight is 22 tons. From the graph of the year 1991, it is found that minimum considerable weight is 2.5 ton per vehicle and maximum considerable weight is 20 ton for trucks on N-1 corridor. The range of axle weight is found to be 2.5 to 20 tons per vehicle and the modal weight is found 12.5 tons. The average weight of trucks on N-1 corridor in the year 2012 is 20.79 tons and modal weight is 22 tons. The 85^{th} percent of vehicle is carrying weight more than 23 tons. The average weight of trucks on N-1 corridor in the year 1991 was 10.63 tons, the modal weight is 12.5 tons and the 85th percent of vehicle is carrying weight more than 12.5 tons.

Fig 5.20: Comparison of Frequency Distribution for Axle Weight in 2012 and 1991 in N-1 corridor (Dir: Dhk to Ctg)

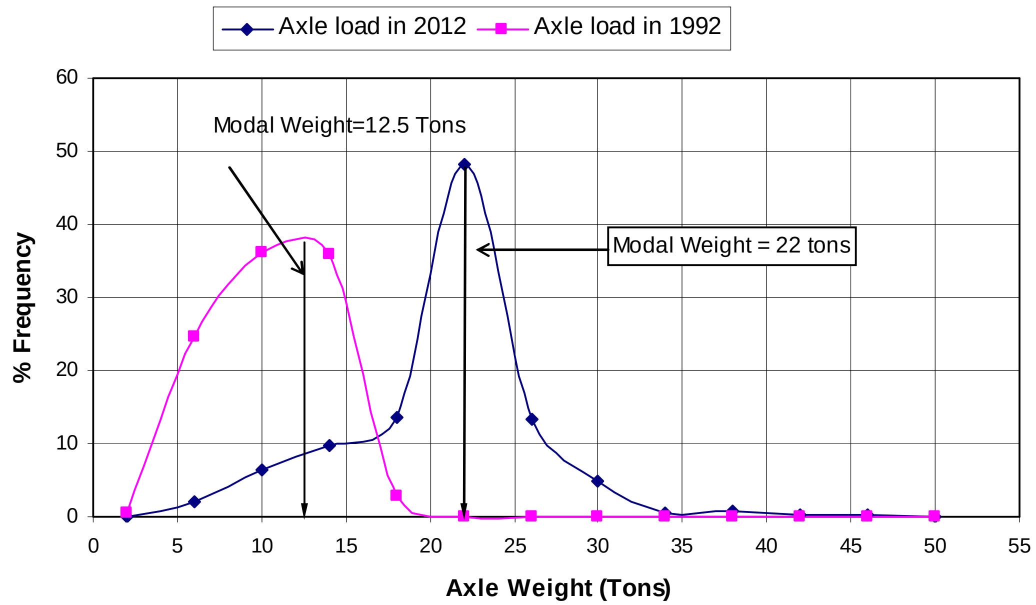
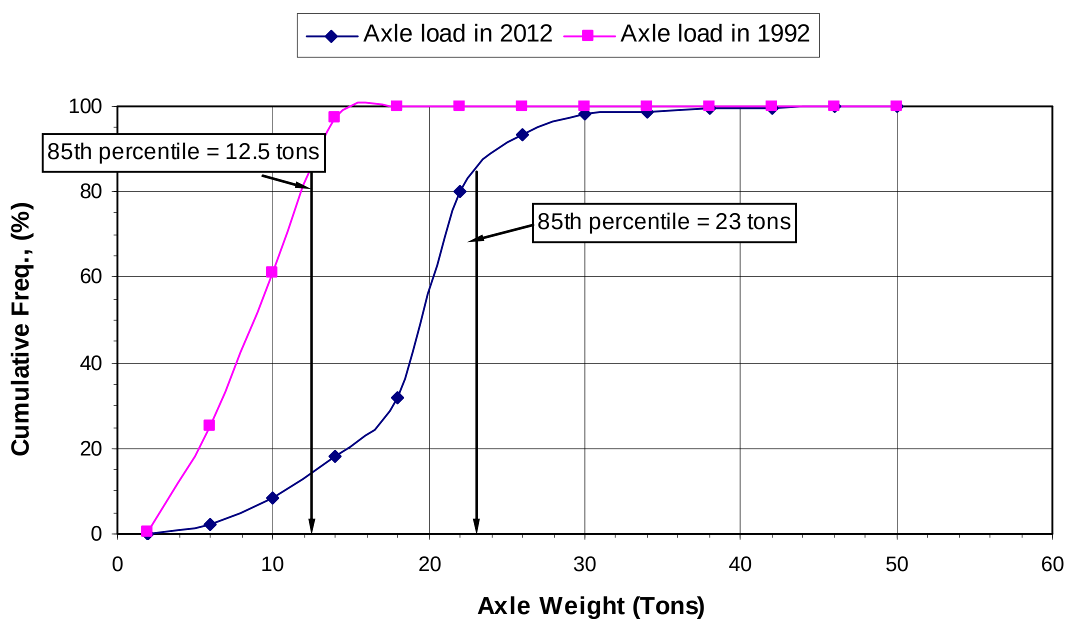
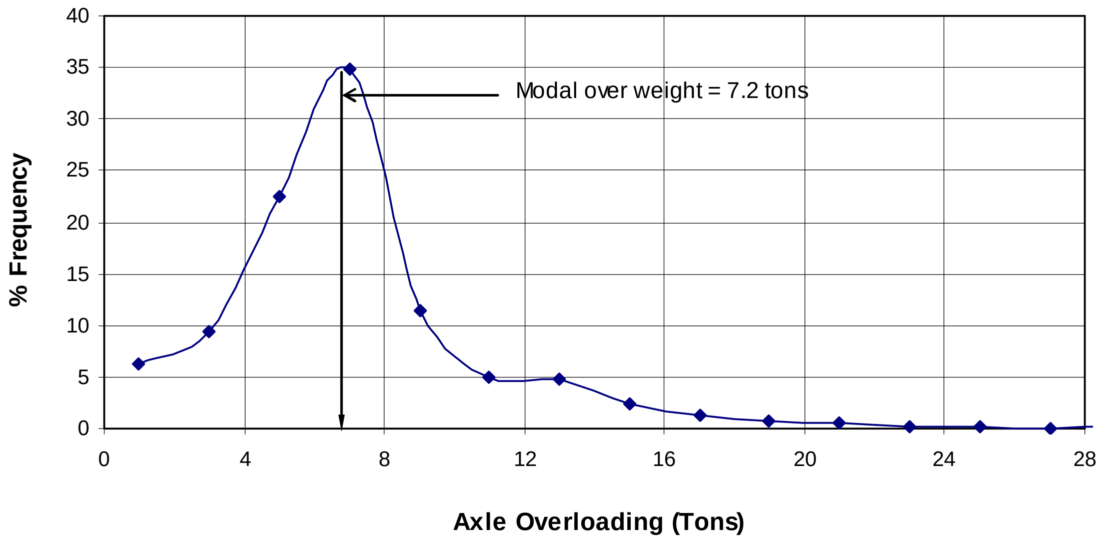


Fig 5.21: Comparison ofCumulative Frequency Distribution of Axle Weight in 2012 and 1991 in N-1 corridor (Dir: Dhk to Ctg)



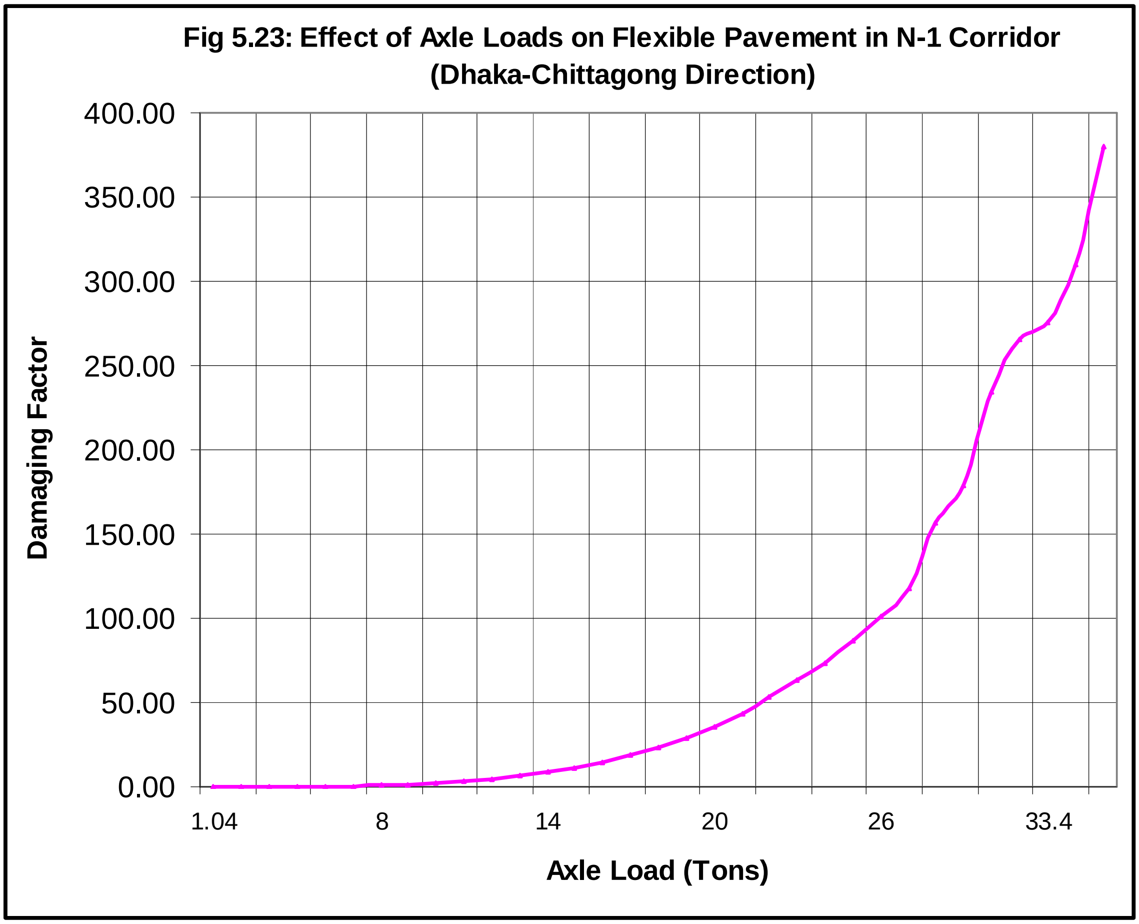
In order to find the absolute over weight magnitude of trucks by deducting the allowable load limit from each data collected for analysis on Dhaka-Chittagong highways (Direction: Dhaka-Chittagong). A key observation is made in figure 5.22 where it is noted that absolute modal overweight is 7.2 tons and the statistical over weighted average is 7.10 tons of each vehicle. It indicates that each vehicle is carrying more than 50% overloading than the legal weight limit in N-1 corridor that is very alarming for the road structures and the overloaded vehicles habitually attracts more accidents due to lack of control.

Fig 5.22: Frequency Distribution for Axle Overloading in N-1 (Dir: Dhk-Ctg)



5.2.10 DETERMINATION OF DAMAGE FACTOR IN DHAKA-CHITTAGONG CORRIDOR (TOWARDS CHITTAGONG DIRECTION)

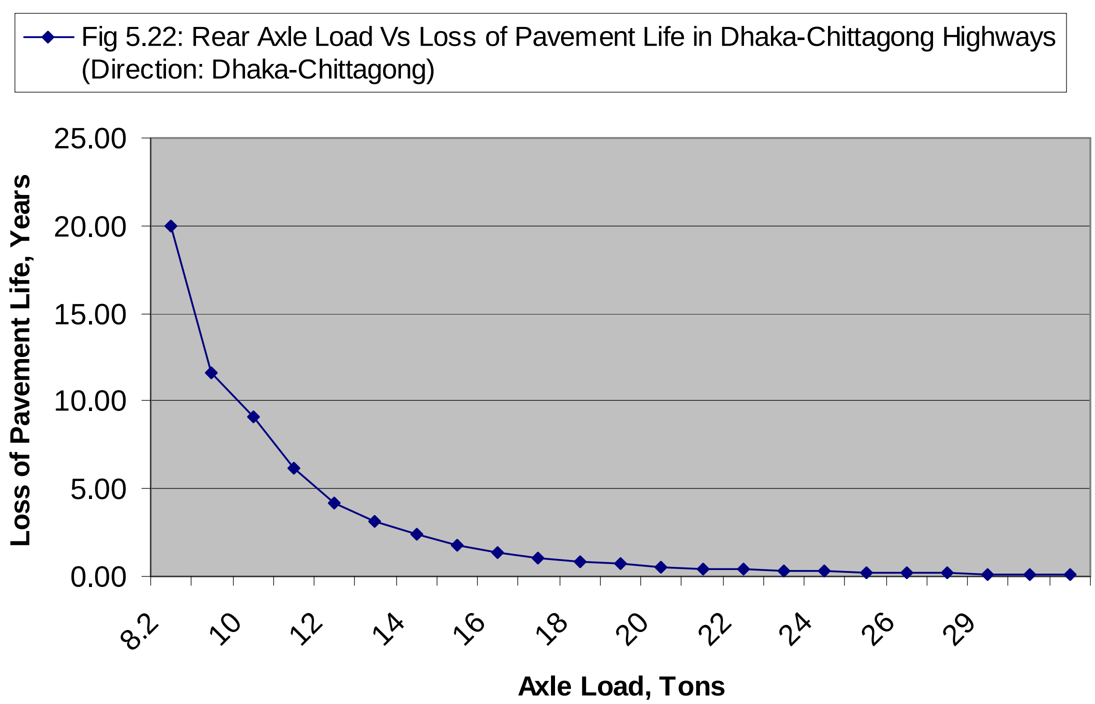
In order to distinguish the damage factor in terms of ESAL (Equivalent Standard Axle Load) units, the collected data have been used to draw the following figure in 5.23.



The above figure in 5.23 illustrates the disproportionately large damage imparted to the pavement by every unit increase in overloading. One of the primary functions of a pavement is load distribution and the pavement design must account for the expected lifetime traffic loads. Since a pavement is designed for the cumulative repetition of equivalent axle loads likely to be imposed, the effect of increase in ESAL because of uncontrolled overloading would be reduction in the life of the pavement i.e. the pavement would fail earlier than it is designed for. The magnitude of axle load is very sensitive to the damage factor, such as from the beginning the detrimental effect is rapid and the trend becomes worse after 12 tonne overloading. It is observed from the graph that for 20 tons of axle load, the damage factor is 36.09, whereas for 25 tons of axle load the damage factor turn into double to 73.38. Furthermore, for 30 tons of axle load, the damage factor is converted into 179.16 and after only 3 ton increase of axle load, the damage factor becomes 275.25. In addition, the slowing down of loaded vehicles because of poor road condition accelerates the pavement failure process. The average ESAL in this corridor is found to be 14.90 per truck by analyzing 12096 data for the month of February in 2012.

The above analysis of axle load can be related with durability of pavemet life. By using the formula of ESAL = (Axle load/Standard Axle Load)^4 , it is observed that for 8.16 tons of standard axle load, the damage factor is 1, which makes pavement life 20 years. Then with the increase of rear axle load, the durability of pavment life will decrease. The next figure 5.24 is illustrating the reality of pavement life for the increase of rear axle load.

Fig 5.24: Rear Axle Load Vs Loss of Pavement Life in Dhaka-Chittagong Highways (Direction: Dhaka-Chittagong)



With the enhancement of vehicular axle load, how the pavement life is deteriorated is distinguished from the above graphic analysis for Dhaka-Chittagong Highways. For 8.2 tons of axle load, the pavement life is 20 years, whereas for 10 tons of axle load, pavement life decreases to 8.87 years. Moreover, for 12 tons of axle load, pavement life declines to 4.28 years. Additionally, for 17 tons of axle load, pavement life becomes 1.06 years. In order to sustain the overloaded vehicles, the pavements have to be designed with higher thickness, which translates to higher cost of construction. However, increase of pavement thickness to resist overloading must not be a solution. Rather, enforcement of axle load control is mandatory for the welfare of national economy and road infrastructure. The successive paragraphs will divulge the axle load pattern of the same corridor with opposite direction, i.e. the direction from Chittagong to Dhaka.

5.2.11 AXLE LOAD CHARACTERISTICS IN DHAKA-CHITTAGONG CORRIDOR (TOWARDS DHAKA DIRECTION)

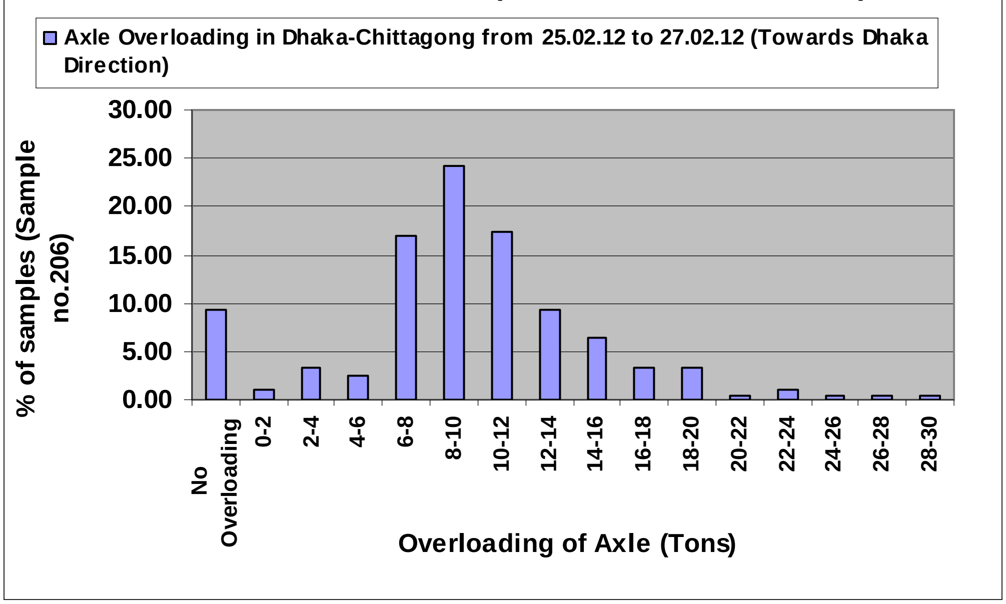
A portable axle load control machine is installed at Gomoti toll plaza to weight vehicles coming towards Dhaka in N-1 corridor. The portable axle load data collecting machine and collection booth is shown in figure 5.25 and 5.26 below.

Fig 5.25: Portable Axle Load Measure Unit in Gomoti Toll Plaza

Fig 5.26: Axle Load Data Collection Booth in Gomoti Toll Plaza

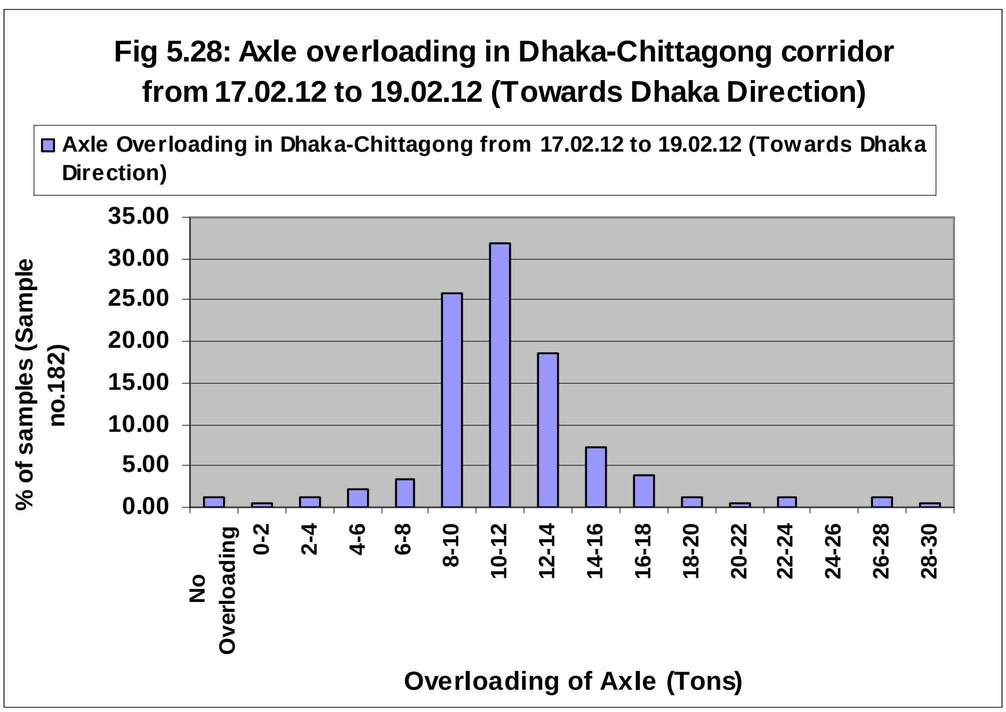
From the above data collection booth shown in figure 5.26, data was collected for the month of February, 2012. Primarily data was seperated for three days to analyse more intensely to get specific loading pattern. The collected data is analyzed by deducting allowable load to categorize the overloading pattern.

Fig 5.27: Axle overloading in Dhaka-Chittagonj corridor from 25.02.12 to 27.02.12 (Towards Dhaka Direction)



The above bar diagram in figure 5.27 demonstrates that, out of 206 data collected from 25th February to 27th February, 2.43% vehicle carrying up to four to six tons, 16.99% vehicle is carrying overloading upto six to eight tons, 24.28% carrying overloading up to eight to ten tons, 17.48% carrying overloading up to ten to twelve tons, 9.22% carrying overloading up to twelve to fourteen tons and 6.31% carrying overloading up to fourteen to sixteen tons then the allowable limit which is very stressful for the road structures. It is also found that 9.22% of vehicle is not carrying overloading, which point out that legally weighted vehicles are also checked in this control station.

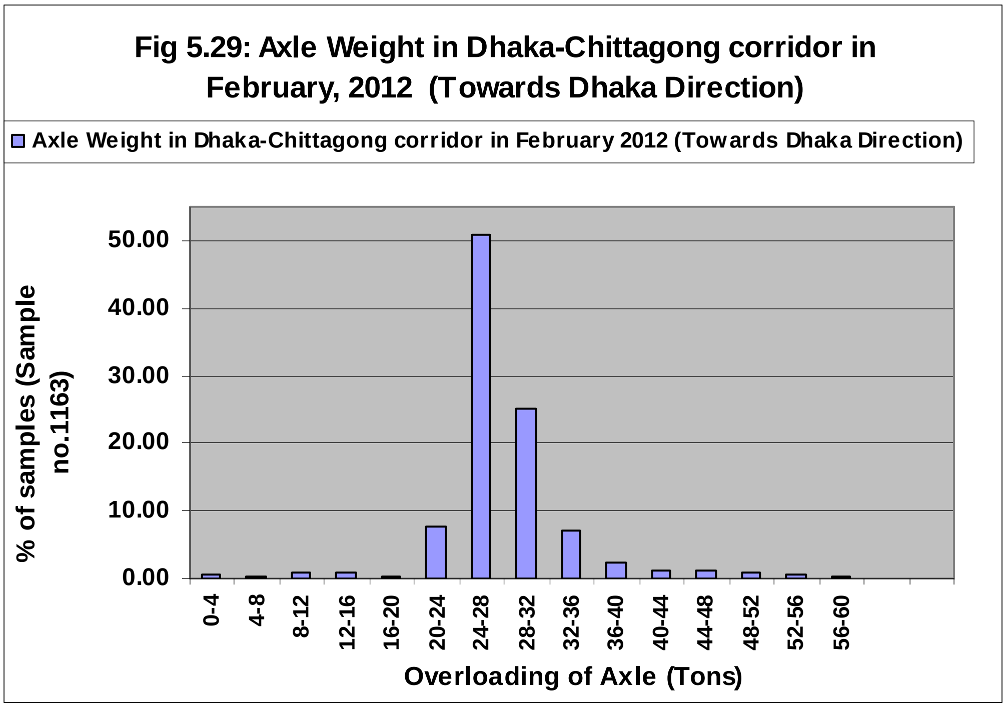
In the similar method, out of 182 truck data composed from 17th February to 19th February in figure 5.28, 25.82% vehicle is carrying overloading upto eight to ten tons, 31.87% carrying overloading up to ten to twelve tons, 18.68% vehicle carrying up to twelve to fourteen tons and 7.14% of vehicle is carrying overloading upto fourteen to sixteen tons. The remaining graphs are listed in Annexure B.



It is apparent from the above bar diagram that the overloading range of eight to twelve ton is predominant in Dhaka-Chittagong highway towards Dhaka direction and it is to be mentioned that overloading tendency is much higher towards Dhaka direction then

Chittagong direction. Trucks heavily loaded from Chittagong port is the main cause of overloading in Dhaka direction. Moreover, loading pattern in Dhaka direction indicates that majority vehicles specially trucks follow the trend of frequent overloading intensity in that range of eight to twelve tons.

To put more light in the analysis, total 1163 numbers of data is collected for the month of February to get more details on loading characteristics in one bar diagram. It is found from figure 5.29 that 50.73% of vehicle is carrying twenty four to twenty eight tons of load, 25.02% of vehicle is carrying upto twenty eight to thirty two tons of goods and 7.14% of the same is carrying thirty two to thirty four tons of load.

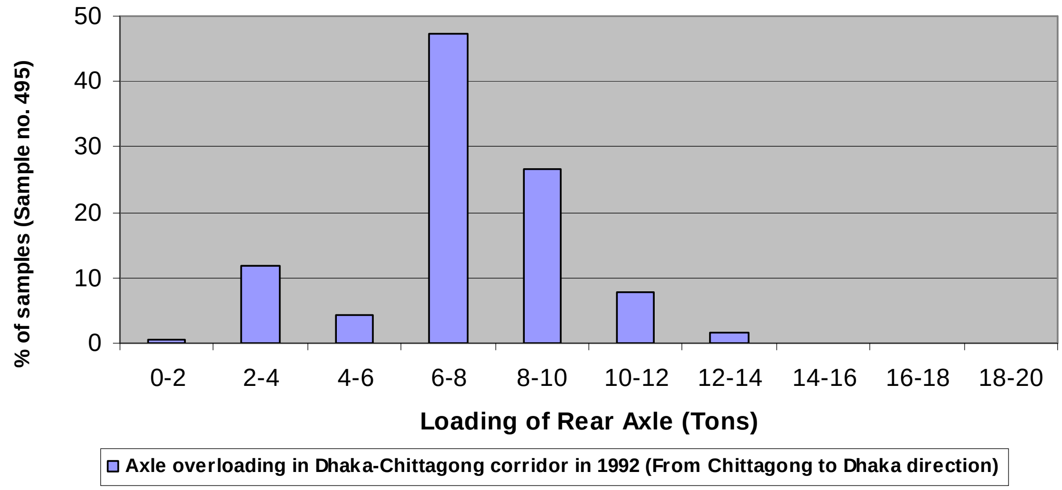


The above diagram in figure 5.29 discloses the fact that astonishingly only nominal percentage of truck in the axle load control station has complied with allowable load limit. However, out of 1163 samples in the month of February of 2012, 1128 samples exceed the legal weight limit, which is extremely disturbing for the road structures of Dhaka-Chittagong highway.

5.2.12 PAST AXLE LOAD CHARACTERISTICS IN DHAKA-CHITTAGONG CORRIDOR (TOWARDS DHAKA DIRECTION)

In order to check the present loading pattern with the historic data with a view to observe the overloading changing patern over the years, an axle load survey report was collected from Roads and Highways Department that was published in 1994, where data was collected from the same location of Dhaka-Chittagong corridor is shown below.

Fig 5.30: Histrogram of all loaded truck in 1992
Direction: Chittagong-Dhaka (N-1)



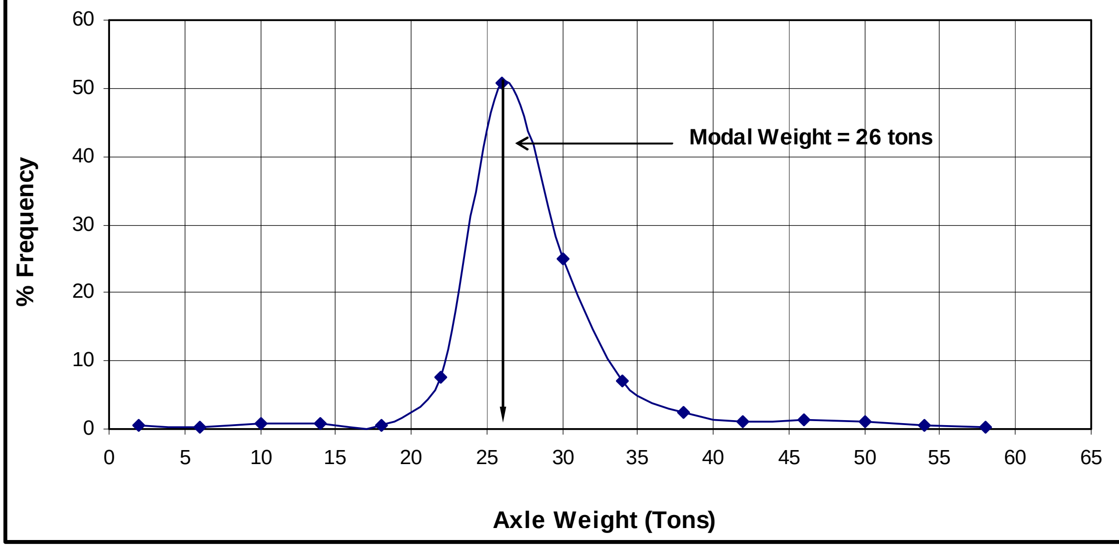
It is noted from the illustrated histrogram in figure 5.30 that the data was analyzed for rear axle loads of trucks. Out of 495 data collected on 17-12-1991 and 18-12-1991, 11.92% sample were carried rear axle load from two to four tons, 4.24% sample were carried load from four to six tons tons, 47.27% sample were carried load from six to eight tons, 26.67% sample were carried load from eight to ten tons and 7.68% sample were carried load from ten to twelve tons.

5.2.13 FREQUENCY DISTRIBUTION OF AXLE LOAD IN DHAKA-CHITTAGONG CORRIDOR (TOWARDS DHAKA DIRECTION)

In order to explore more details about axle loading characteristics and relate these with pavement design parameters, the collected data is then seperated into various weight ranges to get a best fit curve and numbers of observed vehicles are classified into the range that gives the frequency of data. A frequency distribution analysis for axle weight is found in figure 5.31, from which it is seen that the considerable weight range in Dhaka-Chittagong corridor (Direction: from Chittagong to Dhaka) is varied from 18 tons to 43 tons, which is far beyond the allowable weight limit of 15.5 tons for 6 wheelers and 26 tons for 10 wheelers. The modal weight for the frequency distribution of axle weight is found to be 26 tons. The average weight of each truck from the collected data is found to be 27.96 tons. The following table is representating more details about data characteristics and the graph below is formed by using weight range in horizontal axis and frequency in vertical axis.

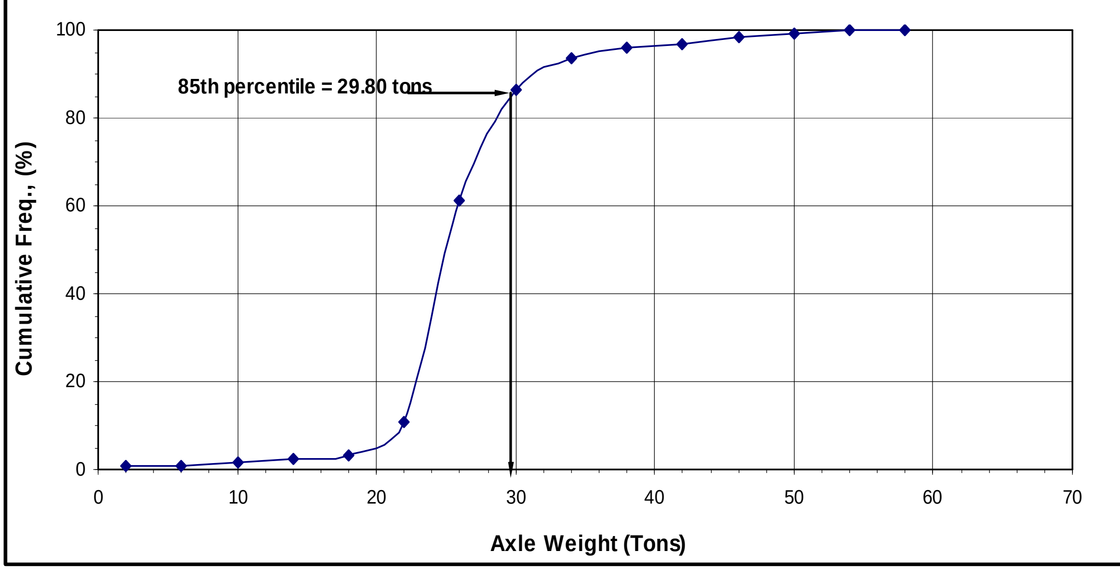
Weight Range (Tons)	No. of vehicle observed (f)	Mid-Weight, W (Tons)	Frequencies, (%)	Cumulative Frequencies, (%)
0-4	7	2	0.60	0.60
4-8	2	6	0.17	0.77
8-12	10	10	0.86	1.63
12-16	11	14	0.95	2.58
16-20	5	18	0.43	3.01
20-24	89	22	7.65	10.66
24-28	590	26	50.73	61.39
28-32	291	30	25.02	86.41
32-36	83	34	7.14	93.55
36-40	27	38	2.32	95.87
40-44	13	42	1.12	96.99
44-48	15	46	1.29	98.28
48-52	12	50	1.03	99.31
52-56	6	54	0.52	99.83
56-60	2	58	0.17	100.00
Total	**1163**			

Fig 5.31: Frequency Distribution for Axle Weight in N-1 (Dir:Ctg-Dhk)



Another important observation is established from cumulative frequency distribution of axle weight below from figure 5.32, the 85th percent, which statistically represens the design truck weight, of vehicle is carrying weight more than 29.80 tons on that corridor.

Fig 5.32: Cumulative Frequency Distribution of Axle Weight in N-1 (Dir: Ctg-Dhk)



Now, a comparison is made about frequency distribution for axle weight in Dhaka-Chittagong corridor (Direction from Chittagong to Dhaka) in the year of 2012 and 1992 in figure 5.33 and 5.34. It is seen from the diagrams that with the increase of time the axle load has increased significantly. From the graph of the year 2012, it is found that minimum considerable weight is 18 ton per vehicle and maximum considerable weight is 43 ton for 6 wheeler and 10 wheeler trucks on N-1 corridor. The range of axle weight is 18 to 43 tons per vehicle.The modal weight is 26 tons. From the graph of the year 1992, it is found that minimum considerable weight is 2.5 ton per vehicle and maximum considerable weight is 18 ton for trucks on N-1 corridor in the Dhaka direction of traffic. The range of axle weight is found to be 2.5 to 18 tons per vehicle and the modal weight is found 10 tons. The average weight of trucks on N-1 corridor in the year 2012 is 27.96 tons and modal weight is 26 tons. The 85th percent of vehicle is carrying weight more than 29.80 tons. The average weight of trucks on N-1 corridor in the year 1992 was 10.31 tons, the modal weight was 10 tons and the 85th percent of vehicle is carrying weight more than 10.50 tons.

Fig 5.33: Comparison of Frequency Distribution for Axle Weight in 2012 and 1992 in N-1 corridor (Dir: Ctg-Dhk)

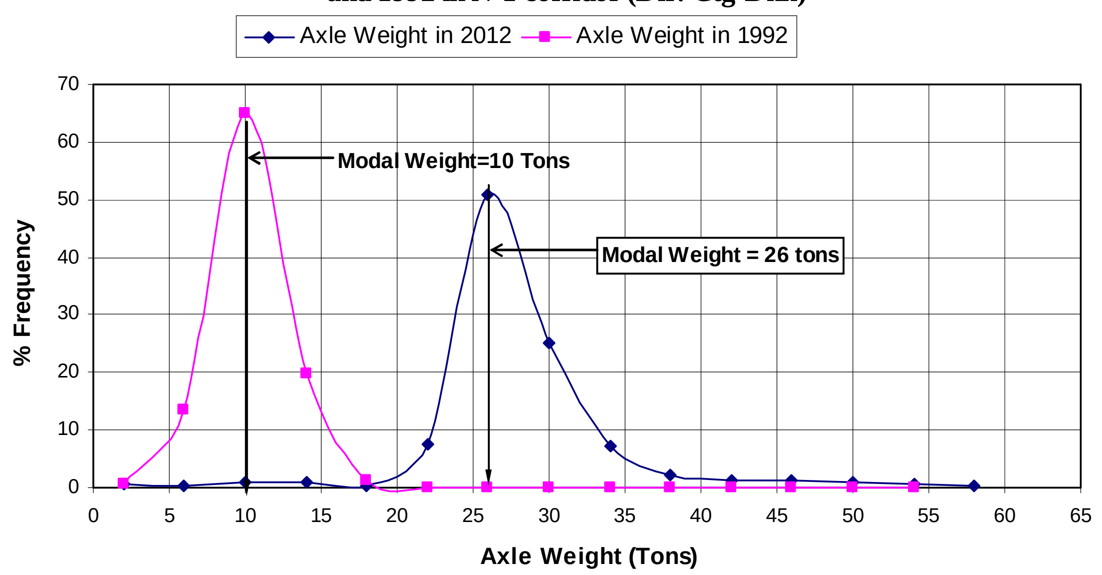
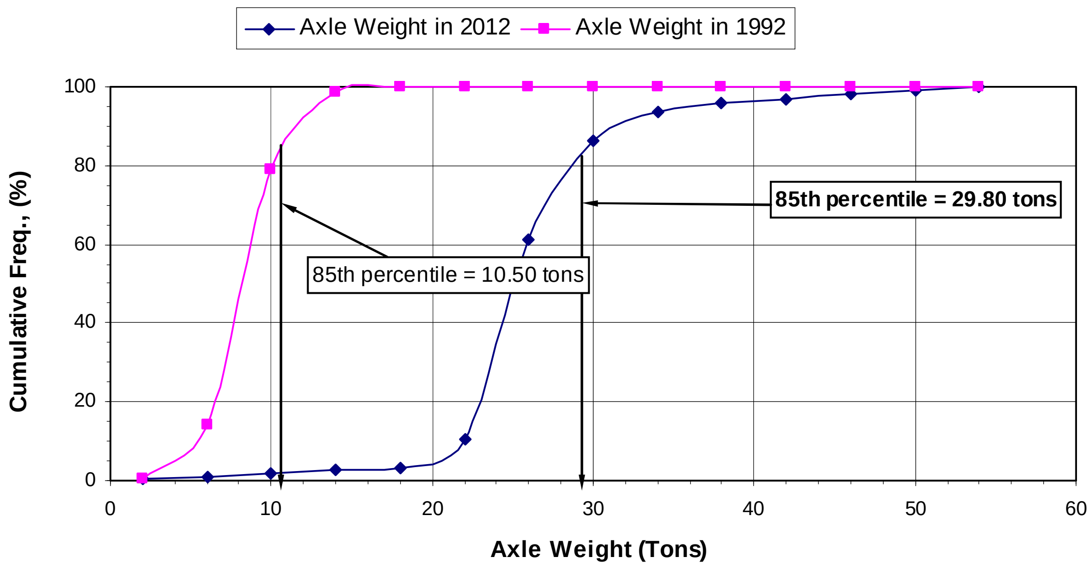
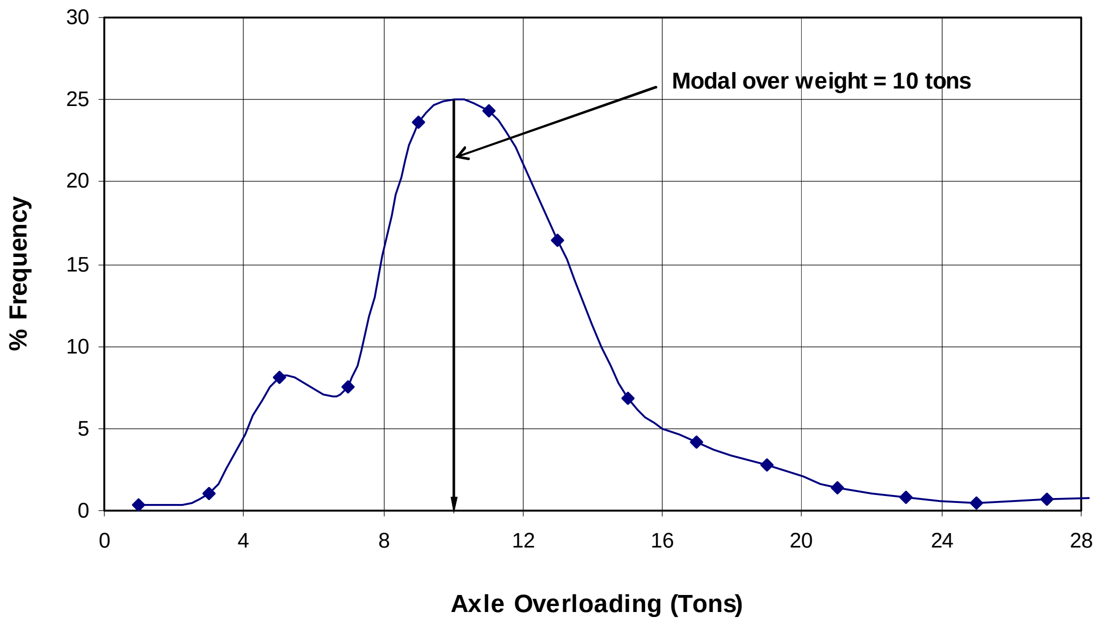


Fig 5.34: Comparison of Cumulative Frequency Distribution for Axle Weight in 2012 and 1992 in N-1 corridor (Dir: Ctg-Dhk)



In order to find the absolute over weight magnitude of trucks by deducting the allowable load limit from each data collected for analysis on Dhaka-Chittagong highways (Direction: Chittagong-Dhaka). A key observation is made in figure 5.35 where it is noted that absolute modal overweight is 10 tons and the statistical over weighted average is 11.38 tons of each vehicle. It indicates that each vehicle is carrying more than 62.50% overloading than the legal weight limit in N-1 corridor when they are coming towards Dhaka city. The overlaoding findings are very alarming for the road structures and the overloaded vehicles habitually attract more accidents due to lack of control.

Fig 5.35: Frequency Distribution for Axle Overloading in N-1 corridor (Dir: Ctg-Dhk)



5.3 OVERVIEW

Overloading of axle load is destructive for the road infrastructures. Overloading decrease the life of pavement and increase maintenance cost. Specially, poor country like Bangladesh has no option for wastage of money. Analyses from this research reveal that two important corridors like Dhaka-Aricha and Dhaka-Chittagong are subjected to overloading of vehicles. It is also visible that overloaded trucks are not following the rules and simultaneously, concern highway police are not performing their duties properly. However, due to limitation of this research, axle load characteristics of other corridors cannot be performed. But from the analyses of the above two corridors disclose the fact that other highways in Bangladesh are similarly vulnerable to overloading. At the same time, excessive growth factor of traffic has detrimental effects in pavement. The next Chapter will put light on growth factor and AADT of different National Highways of Bangladesh.

AASHTO, (1990) “A Policy on Geometric Design of Highway and Streets", USA.

Garber, N.J., and Hoel, L.A., (1999) "Traffic and Highway Engineering", Revised Second Edition, PWS Publishing, USA.

Erhunmwunsee, P.O., (1991) "Estimating Average Annual Daily Traffic Flow from Short Period Counts", Institute of Traffic Engineer (ITE), Jv 61 11 Nov p 23 – 30.

Sharma, S.C., (1989) "Prediction of Design Hourly Volume from Road Users Perspective", Transportation Engineering, v 115 n 5 p 646 – 660.

Kaub, A.R., (1988) "Design Guide for Auxillary Passing Lanes on Rural Two-lane Highways", Transportation Research Record n 1195 p 92 – 100.

Highway Research Record, (1981) "Development of Time Series Model for Projection of Traffic Volume", Number 9, General Report on Road Research Work, India.

Dorman, G.M., (1962) The extension to practice of a fundamental procedure for design of flexible pavements, “Proceedings of 1st International Conference of Structural Design of Asphalt Pavements, Ann. Arbor, Michigan, pp.785-793.

Design of Pavements of Roads (in Czech), (2004) VUT Brno, Faculty of Civil Engineering CTU, SSZ a.s., ODS a.s., TP 170.

Mulyono, A.T., and Rahim, R., Journal of the Eastern Asia Society for Transportation Studies, (2010) “Analysis of Loss Cost of Road Pavement Distress due to Overloading Freight Transportation”, Vol.8.

Pavement Design Guide, (2005) Roads and Highways Department, GOB.

Traffic Monitoring Guidelines, (2001) Federal Highway Administration, U.S. Department of Transport.

Robichaud, K., and Gordon, M., (2002) "An Assessment of Data Collection Techniques for Highway Agencies", British Columbia Ministry of Transportation.

Barewood, J.E., (1965) "Traffic Engineering Handbook", Third Edition, Institute of Traffic Engineers, Washington D.C., USA.

Rahman, S.K., (2002) "Study of Vehicular Flow Pattern on Jamuna Multipurpose Bridge Access Road", Dept. of Civil Engineering, MIST, Bangladesh.