7. Revised FS Daily Traffic Volume (Dinh – Cat Hai)

Revised FS Peak Hour Traffic Volume (Dinh Vu - Cat Hai)

Unit: pcu/peak hour

Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Cat Hai to Dinh Vu	927	1,040	1,154	1,267	1,381	1,494	1,545	1,596	1,647	1,697	1,748	1,799	1,850	1,900	1,951	2,002	2,055	2,106	[illegible]	2,214	[illegible]
Bicycle 1	195	212	228	243	257	269	258	246	232	217	201	183	165	144	123	100	90	80	69	58	45
Motorcycle 2	452	485	512	536	555	568	559	549	537	523	507	489	470	448	425	400	395	388	380	372	363
Car 3	91	121	155	193	235	281	307	335	362	392	423	455	488	521	556	593	618	644	671	698	725
Trucks of 2 axles and mini bus with less than 25 seats 4	80	93	106	119	134	149	161	172	184	197	210	223	237	251	265	280	298	316	335	354	374
Truck of more than 3 axles and large bus 5	100	120	141	162	186	212	244	276	311	348	386	425	466	509	552	599	623	648	673	699	725
Trailer and bus with trailer 6	9	10	12	13	14	15	17	18	20	20	23	23	26	27	29	30	31	32	32	33	34
Total	927	1041	1154	1266	1381	1494	1546	1596	1646	1697	1750	1798	1852	1900	1950	2002	2055	2106	2160	2214	2266
The percent of heavy vehicles	25.8%	26.9%	28.0%	28.7%	29.7%	30.7%	32.8%	34.5%	36.4%	38.2%	40.0%	41.5%	43.2%	44.8%	46.3%	47.8%	48.4%	49.1%	49.7%	50.4%	51.0%

Dinh Vu to Cat Hai	351	430	508	587	666	745	806	868	927	987	1,048	1,108	1,169	1,229	1,290	1,350	1,428	[illegible]	[illegible]	[illegible]	[illegible]
Bicycle 1	74	88	101	113	124	134	135	133	131	126	121	113	104	93	81	68	63	57	51	43	35
Motorcycle 2	171	200	226	248	268	283	292	298	302	304	304	301	297	290	281	270	274	277	279	279	278
Car 3	34	50	68	89	113	140	160	182	204	228	254	280	309	337	368	400	430	460	492	524	557
Trucks of 2 axles and mini bus with less than 25 seats 4	30	38	47	55	65	75	84	94	104	114	126	137	150	162	175	189	207	226	246	266	287
Truck of more than 3 axles and large bus 5	38	49	62	75	90	106	127	150	175	202	232	261	295	329	365	404	433	463	494	525	557
Trailer and bus with trailer 6	4	4	5	6	7	7	9	10	11	12	14	14	16	17	19	20	21	23	24	25	26
Total	351	429	509	586	667	745	807	867	927	986	1051	1106	1171	1228	1289	1351	1428	1506	1586	1662	1740
The percent of heavy vehicles	26.0%	26.7%	27.9%	28.8%	29.8%	30.8%	32.7%	34.6%	36.4%	38.1%	40.0%	41.5%	43.2%	44.8%	46.3%	47.8%	48.4%	49.1%	49.8%	50.4%	51.0%

Daily Traffic Volume: Dinh Vu-Cat Hai

Unit: vehicles/day

Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Bicycle 1	26,900	30,000	32,900	35,600	38,100	40,300	39,300	37,900	36,300	34,300	32,200	29,600	26,900	23,700	20,400	16,800	15,300	13,700	12,000	10,100	8,000
Motorcycle 2	41,533	45,667	49,200	52,267	54,867	56,733	56,733	56,467	55,933	55,133	54,067	52,667	51,133	49,200	47,067	44,667	44,600	44,333	43,933	43,400	42,733
Car 3	2,500	3,420	4,460	5,640	6,960	8,420	9,340	10,340	11,320	12,400	13,540	14,700	15,940	17,160	18,480	19,860	20,960	22,080	23,260	24,440	25,640
Trucks of 2 axles and mini bus with less than 25 seats 4	786	936	1,093	1,243	1,421	1,600	1,750	1,900	2,057	2,221	2,400	2,571	2,764	2,950	3,143	3,350	3,607	3,871	4,150	4,429	4,721
Truck of more than 3 axles and large bus 5	789	966	1,160	1,354	1,577	1,817	2,120	2,434	2,777	3,143	3,531	3,920	4,349	4,789	5,240	5,731	6,034	6,349	6,669	6,994	7,326
Trailer and bus with trailer 6	46	50	61	68	75	79	93	100	111	114	132	132	150	157	171	179	186	196	200	207	214
Total	72,554	81,039	88,874	96,172	103,000	108,949	109,336	109,141	108,498	107,311	105,870	103,590	101,236	97,956	94,501	90,587	90,687	90,529	90,212	89,570	88,634
The percent of heavy vehicles	3.6%	3.8%	4.1%	4.4%	4.7%	5.1%	5.7%	6.2%	6.8%	7.5%	8.2%	9.0%	9.8%	10.6%	11.5%	12.6%	13.0%	13.6%	14.1%	14.6%	15.2%

PCU Daily Traffic Volume: Dinh Vu-Cat Hai

Unit: PCU/day

Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Bicycle 1	5,380	6,000	6,580	7,120	7,620	8,060	7,860	7,580	7,260	6,860	6,440	5,920	5,380	4,740	4,080	3,360	3,060	2,740	2,400	2,020	1,600
Motorcycle 2	12,460	13,700	14,760	15,680	16,460	17,020	17,020	16,940	16,780	16,540	16,220	15,800	15,340	14,760	14,120	13,400	13,380	13,300	13,180	13,020	12,820
Car 3	2,500	3,420	4,460	5,640	6,960	8,420	9,340	10,340	11,320	12,400	13,540	14,700	15,940	17,160	18,480	19,860	20,960	22,080	23,260	24,440	25,640
Trucks of 2 axles and mini bus with less than 25 seats 4	1,572	1,872	2,186	2,486	2,842	3,200	3,500	3,800	4,114	4,442	4,800	5,142	5,528	5,900	6,286	6,700	7,214	7,742	8,300	8,858	9,442
Truck of more than 3 axles and large bus 5	1,973	2,415	2,900	3,385	3,943	4,543	5,300	6,085	6,943	7,858	8,828	9,800	10,873	11,973	13,100	14,328	15,085	15,873	16,673	17,485	18,315
Trailer and bus with trailer 6	184	200	244	272	300	316	372	400	444	456	528	528	600	628	684	716	744	784	800	828	856
Total	24,069	27,607	31,130	34,583	38,125	41,559	43,392	45,145	46,861	48,556	50,356	51,890	53,661	55,161	56,750	58,364	60,443	62,519	64,613	66,651	68,673

8. Daily Traffic Volume Based on Traffic Survey (Dinh – Cat Hai)
Unit:pcu/day

Year	Dinh Vu-Cat Hai Ferry and Ninh Tiep Ferry terminal									
	1	2	3	4	5	6	Port	Total	To Tan Vu IC Direction	To Cat Ba Direction
2010	33	192	22	237	22	0		506	278	228
2011	36	207	24	256	24	0		547	301	246
2012	39	224	26	276	26	0		591	325	266
2013	42	242	28	298	28	0		638	351	287
2014	45	261	30	322	30	0		688	378	310
2015	49	282	32	348	32	0	3,170	3,913	2,152	1,761
2016	53	305	35	376	35	0	5,658	6,462	3,554	2,908
2017	57	329	38	406	38	0	8,158	9,026	4,964	4,062
2018	62	355	41	438	41	0	10,678	11,615	6,388	5,227
2019	67	383	44	473	44	0	13,205	14,216	7,819	6,397
2020	72	414	48	511	48	0	15,748	16,841	9,263	7,578
2021	77	443	51	547	51	0	21,863	23,032	12,668	10,364
2022	82	474	55	585	55	0	26,035	27,286	15,007	12,279
2023	88	507	59	626	59	0	30,513	31,852	17,519	14,333
2024	94	542	63	670	63	0	35,315	36,747	20,211	16,536
2025	101	580	67	717	67	0	40,433	41,965	23,081	18,884
2026	108	621	72	767	72	0	32,103	33,743	18,559	15,184
2027	116	664	77	821	77	0	36,130	37,885	20,837	17,048
2028	124	710	82	878	82	0	40,378	42,254	23,240	19,014
2029	133	760	88	939	88	0	44,843	46,851	25,768	21,083
2030	142	813	94	1,005	94	0	49,555	51,703	28,437	23,266
2031	151	862	100	1,065	100	0	53,685	55,963	30,780	25,183
2032	160	914	106	1,129	106	0	58,048	60,463	33,255	27,208
2033	170	969	112	1,197	112	0	62,410	64,970	35,734	29,237
2034	180	1,027	119	1,269	119	0	66,768	69,482	38,215	31,267
2035	191	1,089	126	1,345	126	0	71,130	74,007	40,704	33,303

Year	Cat Hai Road									
	1	2	3	4	5	6	Port	Total	To Tan Vu IC Direction	To Cat Ba Direction
2010	129	202	29	221	26	0		607	334	273
2011	139	218	31	239	28	0		655	360	295
2012	150	235	33	258	30	0		706	388	318
2013	162	254	36	279	32	0		763	420	343
2014	175	274	39	301	35	0		824	453	371
2015	189	296	42	325	38	0	3,170	4,060	2,233	1,827
2016	204	320	45	351	41	0	5,658	6,619	3,640	2,979
2017	220	346	49	379	44	0	8,158	9,196	5,058	4,138
2018	238	374	53	409	48	0	10,678	11,800	6,490	5,310
2019	257	404	57	442	52	0	13,205	14,417	7,929	6,488
2020	278	436	62	477	56	0	15,748	17,057	9,381	7,676
2021	297	467	66	510	60	0	21,863	23,263	12,795	10,468
2022	318	500	71	546	64	0	26,035	27,534	15,144	12,390
2023	340	535	76	584	68	0	30,513	32,116	17,664	14,452
2024	364	572	81	625	73	0	35,315	37,030	20,367	16,664
2025	389	612	87	669	78	0	40,433	42,268	23,247	19,021
2026	416	655	93	716	83	0	32,103	34,066	18,736	15,330
2027	445	701	100	766	89	0	36,130	38,231	21,027	17,204
2028	476	750	107	820	95	0	40,378	42,626	23,444	19,182
2029	509	803	114	877	102	0	44,843	47,248	25,986	21,262
2030	545	859	122	938	109	0	49,555	52,128	28,670	23,458
2031	578	911	129	994	116	0	53,685	56,413	31,027	25,386
2032	613	966	137	1,054	123	0	58,048	60,941	33,518	27,423
2033	650	1,024	145	1,117	130	0	62,410	65,476	36,012	29,464
2034	689	1,085	154	1,184	138	0	66,768	70,018	38,510	31,508
2035	730	1,150	163	1,255	146	0	71,130	74,574	41,016	33,558

Year	Ben Got Ferry Terminal and Cat Hai-Cat Ba Ferry								
	1	2	3	4	5	6	Total	To Tan Vu IC Direction	To Cat Ba Direction
2010	47	176	28	152	36		439	241	198
2011	51	190	30	164	39	0	474	261	213
2012	55	205	32	177	42	0	511	281	230
2013	59	221	35	191	45	0	551	303	248
2014	64	239	38	206	49	0	596	328	268
2015	69	258	41	222	53	0	643	354	289
2016	75	279	44	240	57	0	695	382	313
2017	81	301	48	259	62	0	751	413	338
2018	87	325	52	280	67	0	811	446	365
2019	94	351	56	302	72	0	875	481	394
2020	102	379	60	326	78	0	945	520	425
2021	109	406	64	349	83	0	1,011	556	455
2022	117	434	68	373	89	0	1,081	595	486
2023	125	464	73	399	95	0	1,156	636	520
2024	134	496	78	427	102	0	1,237	680	557
2025	143	531	83	457	109	0	1,323	728	595
2026	153	568	89	489	117	0	1,416	779	637
2027	164	608	95	523	125	0	1,515	833	682
2028	175	651	102	560	134	0	1,622	892	730
2029	187	697	109	599	143	0	1,735	954	781
2030	200	746	117	641	153	0	1,857	1,021	836
2031	212	791	124	679	162	0	1,968	1,082	886
2032	225	838	131	720	172	0	2,086	1,147	939
2033	239	888	139	763	182	0	2,211	1,216	995
2034	253	941	147	809	193	0	2,343	1,289	1,054
2035	268	997	156	858	205	0	2,484	1,366	1,118

9. Daily Traffic Volume Based on Traffic Survey (Dinh – Cat Hai) Unit: Vehicles/day

Unit: Vehicles/day

Year	Dinh Vu-Cat Hai Ferry and Ninh Tiep Ferry terminal									
	1	2	3	4	5	6	Port	Total	To Tan Vu IC Direction	To Cat Ba Direction
2010	165	640	22	119	9	0		954	525	429
2011	178	691	24	128	10	0		1,031	567	464
2012	192	746	26	138	11	0		1,113	612	501
2013	207	806	28	149	12	0		1,202	661	541
2014	224	870	30	161	13	0		1,298	714	584
2015	242	940	32	174	14	0	1,268	2,670	1,469	1,202
2016	261	1,015	35	188	15	0	2,263	3,777	2,077	1,700
2017	282	1,096	38	203	16	0	3,263	4,898	2,694	2,204
2018	305	1,184	41	219	17	0	4,271	6,037	3,320	2,717
2019	329	1,279	44	237	18	0	5,282	7,189	3,954	3,235
2020	355	1,381	48	256	19	0	6,299	8,358	4,597	3,761
2021	380	1,478	51	274	20	0	8,745	10,948	6,021	4,927
2022	407	1,581	55	293	21	0	10,414	12,771	7,024	5,747
2023	435	1,692	59	314	22	0	12,205	14,727	8,100	6,627
2024	465	1,810	63	336	24	0	14,126	16,824	9,253	7,571
2025	498	1,937	67	360	26	0	16,173	19,061	10,484	8,577
2026	533	2,073	72	385	28	0	12,841	15,932	8,763	7,169
2027	570	2,218	77	412	30	0	14,452	17,759	9,767	7,992
2028	610	2,373	82	441	32	0	16,151	19,689	10,829	8,860
2029	653	2,539	88	472	34	0	17,937	21,723	11,948	9,775
2030	699	2,717	94	505	36	0	19,822	23,873	13,130	10,743

Unit: Vehicles/day

Year	Cat Hai Road									
	1	2	3	4	5	6	Port	Total	To Tan Vu IC Direction	To Cat Ba Direction
2010	645	673	291	111	10	0		1,730	952	779
2011	697	727	314	119	11	0		1,868	1,027	841
2012	753	785	339	129	12	0		2,018	1,110	908
2013	813	848	366	139	13	0		2,179	1,198	981
2014	878	916	395	150	14	0		2,353	1,294	1,059
2015	948	989	427	162	15	0	1,268	3,809	2,095	1,714
2016	1,024	1,068	461	175	16	0	2,263	5,007	2,754	2,253
2017	1,106	1,153	498	189	17	0	3,263	6,226	3,424	2,802
2018	1,194	1,245	538	204	18	0	4,271	7,470	4,109	3,362
2019	1,290	1,345	581	220	19	0	5,282	8,737	4,805	3,932
2020	1,393	1,453	627	238	21	0	6,299	10,031	5,517	4,514
2021	1,491	1,555	671	255	22	0	8,745	12,739	7,006	5,733
2022	1,595	1,664	718	273	24	0	10,414	14,688	8,078	6,610
2023	1,707	1,780	768	292	26	0	12,205	16,778	9,228	7,550
2024	1,826	1,905	822	312	28	0	14,126	19,019	10,460	8,559
2025	1,954	2,038	880	334	30	0	16,173	21,409	11,775	9,634
2026	2,091	2,181	942	357	32	0	12,841	18,444	10,144	8,300
2027	2,237	2,334	1,008	382	34	0	14,452	20,447	11,246	9,201
2028	2,394	2,497	1,079	409	36	0	16,151	22,566	12,411	10,155
2029	2,562	2,672	1,155	438	39	0	17,937	24,803	13,642	11,161
2030	2,741	2,859	1,236	469	42	0	19,822	27,169	14,943	12,226

Unit: Vehicles/day

Year	Ben Got Ferry Terminal and Cat Hai-Cat Ba Ferry								
	1	2	3	4	5	6	Total	To Tan Vu IC Direction	To Cat Ba Direction
2010	235	587	28	76	14		940	517	423
2011	254	634	30	82	16	0	1,016	559	457
2012	274	685	32	89	17	0	1,097	603	494
2013	296	740	35	96	18	0	1,185	652	533
2014	320	799	38	104	19	0	1,280	704	576
2015	346	863	41	112	21	0	1,383	761	622
2016	374	932	44	121	23	0	1,494	822	672
2017	404	1,007	48	131	25	0	1,615	888	727
2018	436	1,088	52	141	27	0	1,744	959	785
2019	471	1,175	56	152	29	0	1,883	1,036	847
2020	509	1,269	60	164	31	0	2,033	1,118	915
2021	545	1,358	64	175	33	0	2,175	1,196	979
2022	583	1,453	68	187	35	0	2,326	1,279	1,047
2023	624	1,555	73	200	37	0	2,489	1,369	1,120
2024	668	1,664	78	214	40	0	2,664	1,465	1,199
2025	715	1,780	83	229	43	0	2,850	1,568	1,283
2026	765	1,905	89	245	46	0	3,050	1,678	1,373
2027	819	2,038	95	262	49	0	3,263	1,795	1,468
2028	876	2,181	102	280	52	0	3,491	1,920	1,571
2029	937	2,334	109	300	56	0	3,736	2,055	1,681
2030	1,003	2,497	117	321	60	0	3,998	2,199	1,799

Unit: Vehicles/day

Year	Ben Got Ferry Terminal and Cat Hai-Cat Ba Ferry								
	1	2	3	4	5	6	Total	To Tan Vu IC Direction	To Cat Ba Direction
2010	235	587	28	76	14		940	517	423
2011	254	634	30	82	16	0	1,016	559	457
2012	274	685	32	89	17	0	1,097	603	494
2013	296	740	35	96	18	0	1,185	652	533
2014	320	799	38	104	19	0	1,280	704	576
2015	346	863	41	112	21	0	1,383	761	622
2016	374	932	44	121	23	0	1,494	822	672
2017	404	1,007	48	131	25	0	1,615	888	727
2018	436	1,088	52	141	27	0	1,744	959	785
2019	471	1,175	56	152	29	0	1,883	1,036	847
2020	509	1,269	60	164	31	0	2,033	1,118	915
2021	545	1,358	64	175	33	0	2,175	1,196	979
2022	583	1,453	68	187	35	0	2,326	1,279	1,047
2023	624	1,555	73	200	37	0	2,489	1,369	1,120
2024	668	1,664	78	214	40	0	2,664	1,465	1,199
2025	715	1,780	83	229	43	0	2,850	1,568	1,283
2026	765	1,905	89	245	46	0	3,050	1,678	1,373
2027	819	2,038	95	262	49	0	3,263	1,795	1,468
2028	876	2,181	102	280	52	0	3,491	1,920	1,571
2029	937	2,334	109	300	56	0	3,736	2,055	1,681
2030	1,003	2,497	117	321	60	0	3,998	2,199	1,799

Appendix-3: Standard and Criteria for Bridge Design

1. Design Standards

Basically, the bridges and structures in this project shall be designed with the Vietnamese Design Standard (22 TCN 272-05) and AASHTO-LRFD (Load and Resistance Factor Design, 3rd Edition 2004). However, the some items shall be considered in accordance with the other international standards.

The adopted items for this project are summarized in Table 1.

Table 1 Adopted Items for this Project

Item	Specification	Standard
Design Method	Limit State Design	Vietnamese
Design Life	100 years	Vietnamese
Design Lane Width	3600 mm or 3750 mm	Vietnamese
Load Combination		Vietnamese
Live Load	HL-93	Vietnamese
Dynamic Load Allowance, IM	0.25 for main part of bridge	Vietnamese
Wind Load	Depend on the site	Vietnamese
Vessel Collision Force	Depend on the site	Vietnamese
Earthquake	Depend on the site	Vietnamese/Japanese
Seismic Earth Pressure	Depend on the site	Vietnamese/Japanese
Stress Loss in Tendons		Vietnamese/Japanese
Creep & Shrinkage		Vietnamese/Japanese /CEB-FIP
Pile Foundation Analysis	Displacement Method	Vietnamese/Japanese
Train Load	T-26	Vietnamese

The items not fit for these standards, shall be determined referring to AASHTO (Allowable stress design method, 17th Edition 2002) or Japanese Standard of Highway Bridge (JSHB-96).

The highway cum railway bridge is planned in this project. The clause 1.1 of 22 TCN 272-05 described that " It is envisaged that a supplement on the design of railway bridges will be produced in the future." Accordingly, the design concept of the highway cum railway bridge will be established in accordance with AASHTO. The train load shall be taken from Vietnamese standards, which the Railway Projects Management Unit (RPMU) has applied for Hanoi - Ho Chi Minh City Railway Bridge Rehabilitation Project. Since the load combination is not specified in these standards, the Consultant will establish the load combination and load factors.

1.1. Limit State Design

The bridge and structures shall be designed for specified limit states in the Vietnamese Standard (22 TCN 272-05) to achieve the objectives of constructability, safety, and serviceability with due regard to issues of inspectibility, economy, and aesthetics in considering

with the design life of bridge and structures shall be 100 years.

1.1.1. Limit States

The bridge and structures shall be verified under the following limit states. And all limit states shall be considered of equal importance.

- Strength Limit State
- Extreme Event Limit State
- Service Limit State
- Fatigue Limit State

Each component and connection shall satisfy the following equation for service limit, fatigue and fracture limit, strength limit and extreme event limit states.

$$Q = \Sigma \eta_i \gamma_i Q_i \leq \phi R_n = R_r$$

where:

Q = factored load
Q_i = force effect
R_n = nominal resistance
R_r = factored resistance
γ_i = load factor
φ = resistance factor
η_i = load modifier

(1) ***Load Modifier (η_i)***

The load modifier for strength limit state is calculated by the following equation. Besides the load modifier for the other limit state should be 1.0.

$$\eta_i = \eta_D * \eta_R * \eta_I$$

where:

η_D = a factor relating to ductility
η_R = a factor relating to redundancy
η_I = a factor relating to operational importance

Table 2 Load Modifier

Factor	Category	Strength Limit State
η_D	For nonductile components and connections	>= 1.05
	For conventional designs and details complying with TVCN 22 TCN-272-05	1.00
	For components and connections for which additional ductile-enhancing measures have been specified beyond those required by TVCN 22 TCN-272-05	>= 0.95
η_R	For nonredundant members	>= 1.05
	For conventional levels of redundancy	1.00
	For exceptional levels of redundancy	>= 0.95
η_I	For important bridges	>= 1.05
	For typical bridges	1.00
	For relatively less important bridges	>= 0.95

(2) Limit States for the bridge and structures

The limit states for the bridge and structures are shown in Table 3.

Table 3 Limit States for the bridge and structures

Limit State	Outline of Limit State
Strength-I	Basic load combination relating to the normal vehicular use of the bridge without wind.
Strength-II	Load combination relating to the bridge exposed to wind velocity exceeding 25 m/s without live load.
Strength-III	Load combination relating to normal vehicular use of the bridge with wind of 25 m/s velocity.
Extrem Event	Load combination relating to earthquake, collision by vessels and vehicles, and certain hydraulic events with a reduced live load other than that which is part of the vehicular collision load, CT.
Service	Load combination relating to the normal use of the bridge with a 25 m/s wind and all loads taken at their normal values, to control deflections, crack width in RC and PC structure, yielding of steel structures and slip of slip critical connections due to vehicular live load, and to investigate slope stability.
Fatigue	Fatigue and fracture load combination relating to repetitive gravitational vehicular live load and dynamic responses under a single design truck.

1.2. Load Factor and Combination

1.2.1. Loads

The following permanent and transient loads shall be considered.

Table 4 Permanent and Transient Loads

Permanent Loads	DD = Downdrag DC = Dead load of structural components and nonstructural attachment DW = Dead load of wearing surfaces and utilities EH = Horizontal earth pressure load EL = Accumulated locked-in force effects resulting from the construction process, including the secondary forces from post-tensioning ES = Earth surcharge load EV = Vertical pressure from dead load of earth fill
Transient Loads	BR = Vehicular braking force CE = Vehicular centrifugal force CR = Creep CT = Vehicular collision force CV = Vessel collision force EQ = Earthquake FR = Friction IM = Vehicular dynamic load allowance LL = Vehicular live load LS = Live load surcharge PL = Pedestrian live load SE = Settlement SH = Shrinkage TG = Temperature gradient TL = Train Load TU = Uniform temperature WA = Water load and stream pressure WL = Wind on live load WS = Wind load on structure

1.2.2. Load Factor and Combination

The total factored force effect shall be taken as:

$$Q = \Sigma \eta_i * \gamma_i * Q_i$$

where:

Q_i = force effects from loads

γ_i = load factors specified in Tables 5 to 7

Table 5 Load Combinations and Factors

Load Combination / Limit State	DC DD DW EH EV ES	LL IM CE BR PL LS EL	TL	WA	WS	WL	FR	TU CR SH	TG	SE	Use One of These At a Time		
											EQ	CT	CV
Strength-I	γ_p	1.75	1.75	1.00	-	-	1.00	0.50/1.20	γTG	γSE	-	-	-
Strength-II	γ_p	-	-	1.00	1.40		1.00	0.50/1.20	γTG	γSE	-	-	-
Strength-III	γ_p	1.35	1.35	1.00	0.40	1.00	1.00	0.50/1.20	γTG	γSE	-	-	-
Extreme	γ_p	0.50	0.50	1.00	-	-	1.00	-	-	-	1.00	1.00	1.00
Service	1.00	1.00	1.00	1.00	0.30	1.00	1.00	1.00/1.20	γTG	γSE	-	-	-
Fatigue-LL,	-	0.75	0.75	-	-	-	-	-	-	-	-	-	-
IM&CE only													

Note: For checking crack widths in prestressed concrete structures at the service limit state, the load factor for live load may be reduced to 0.80

Table 6 Load Factors for Permanent Loads, γ_p

Type of Load			Load Factor	
			Maximum	Minimum
DC	:	Component and Attachments	1.25	0.90
DD	:	Downdrag	1.80	0.45
DW	:	Wearing Surfaces and Utilities	1.50	0.65
EH	:	Horizontal Earth Pressure		
		Active	1.50	0.90
		At Rest	1.35	0.90
EL	:	Locked-in Erection Stress	1.00	1.00
EV	:	Vertical Earth Pressure		
		Overall Stability	1.00	N/A
		Retaining Structures	1.35	1.00
		Rigid Buried Structures	1.30	0.90
		Rigid Frames	1.35	0.90
		Flexible Buried Structures other than Metal Box Culverts	1.95	0.90
		Flexible Metal Box Culverts	1.50	0.90
ES	:	Earth Surcharge	1.50	0.75

Table 7 Load Factor for Temperature Gradient, γ_{TG}

γ_{TG}	Conditions
0.00	at the strength and extreme event limit states
1.00	at the service limit state when live load is not considered
0.50	at the service limit state when live load is considered

1.3. Design Load

1.3.1. Dead Load: DC, DW and EV

Dead loads shall include the weight of all components of the structure, appurtenances and utilities attached thereto, earth cover, wearing surface and future overlays.

The following densities specified in Table 8 for each material is used for dead loads. And the weight of utilities shall be decided due to the site investigations.

Table 8 Densities

Material		Density (kg/m^3)
Aluminum Alloys		2800
Bituminous Wearing Surfaces		2250
Cinder Filling		960
Compacted Sand, Silt or Clay		Due to soil investigation
Concrete	Low-density	1775
	Sand-low-density	1925
	Normal	2400
Loose Sand, Silt or Gravel, Soft Clay		Due to soil investigation
Rolled Gravel, Macadam or Ballast		2250
Steel		7850
Stone Masonry		2725
Water	Fresh	1000
	Salt	1025

1.3.2. Live Loads

(1) ***Vehicular Live Load: LL***

1) Number of Design Lanes

The number of design lanes should be determined by taking the integer part of the ratio w/3600, where w is the clear roadway width in mm between curbs and/or barriers.

2) Multiple Presence Factor

The extreme live load force effect shall be determined by considering each possible combination of number of loaded lanes multiplied by a corresponding multiple presence factor to account for the probability of simultaneous lane occupation by the HL-93 design live load. The multiple presence factors are shown in Table 9.

For the purpose of determining the number of lanes when the loading condition includes the pedestrian loads combined one or more lanes of the vehicular live load, pedestrian loads may be taken to be one loaded lane.

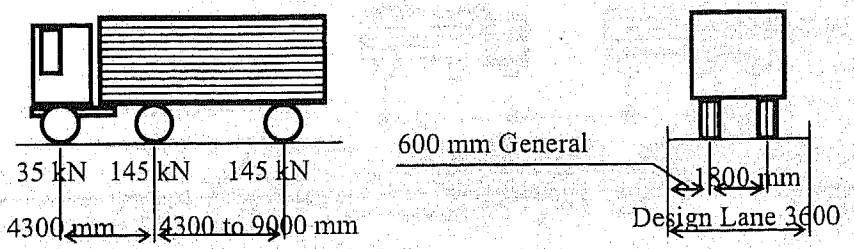
Table 9 Multiple Presence factors "m"

Number of Loaded Lanes	1	2	3	> 3
Multiple Presence Factors "m"	1.20	1.00	0.85	0.65

3) Design Vehicular Live Load

Vehicular live loading (HL-93) shall consist of a combination of the followings:

- Design Truck
- Design Tandem
- Design Lane Load



Note: For fatigue load, the distance between 145 kN axles shall be constant of 9000 mm

Figure 1 Design Truck

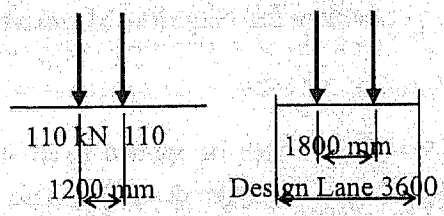


Figure 2 Design Tandem

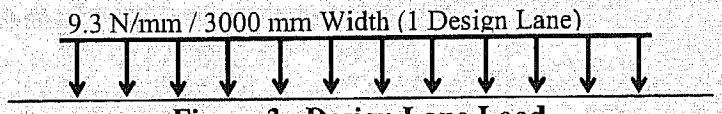


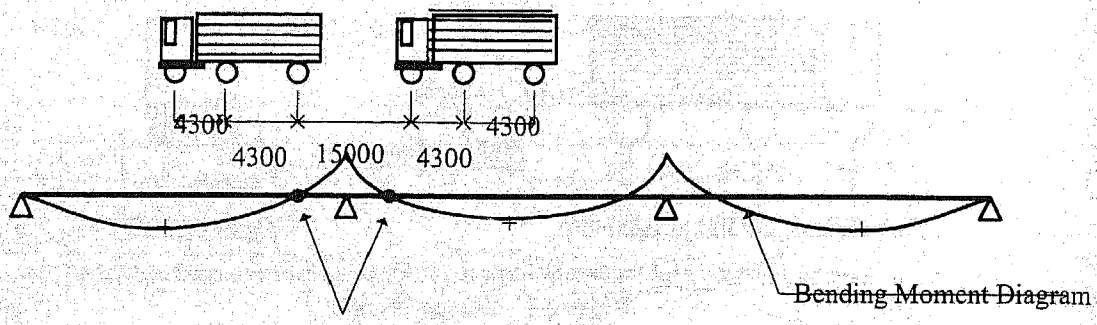
Figure 3 Design Lane Load

The extreme force effect shall be taken as the larger of the followings:

- The effects of Design Tandem and Design Lane Load
- The effects of Design Truck with variable axle spacing and Design Lane Load
- For both negative moment between points of contra flexure under a uniform load on all spans, and reaction at interior pier, 90% of the effect of two design trucks spaced a minimum 15000 mm between the lead axle of one truck and the rear axle of the other truck, combined with 90 % of the effect of the design lane load. The distance between the 145000 N axles of each truck shall be 4300 mm

And the extreme force effect shall be considered as follows:

- Longitudinally, the axles that do not contribute to the extreme force effect under consideration shall be neglected
- Transverse, both the design lanes and the 3000 mm loaded width in each lane shall be positioned to produce extreme force effects



Contra flexure Points under uniform load on all spans

Figure 4 Two Design Trucks Loadings for Negative Moment and Reaction at Intrior Pier

(2) ***Pedestrian Loads: PL***

A pedestrian load of 3×10^{-3} MPa shall be applied to all sidewalks wider then 600mm and considered simultaneously with the vehicular design live load.

(3) ***Dynamic Load Allowance: IM***

In case of the both of the design truck and tandem, the static effects shall be increased by the percentage specified in Table 10 for dynamic load allowance.

Table 10 Dynamic Load Allowance, IM

Component	Deck Joints - All Limit States	All Other Components	
		Fatigue and Fracture Limit State	All Other Limit States
IM	75 %	15 %	25 %

Dynamic load allowance need not be applied to:

- Retaining walls not subject to vertical reactions from the superstructure
- Foundation components that are entirely below ground level

For buried structures such as culverts, IM shall be taken as:

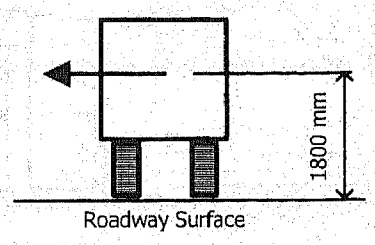
$IM = 33*(1.0-4.1*10^{-4}*DE) >= 0\ \%$

Where;

DE = Minimum depth of earth cover above the structure (mm).

(4) ***Centrifugal Forces: CE***

Centrifugal forces, which is to be applied horizontally at a distance 1800 mm above the roadway surface, shall be taken as the product of the axle weights of the design truck or tandem and the factor C, taken as:



Centrifugal Force

$$C = \frac{4v^2}{3gR}$$

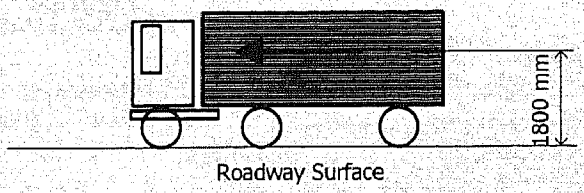
where:
v = highway design speed (m/s)
g = gravitational acceleration: 9.807 (m/s^2)
R = radius of curvature of traffic lane (m)

The multiple presence factors shall apply.

(5) ***Braking Force: BR***

The braking forces shall be taken as 25% of the axle weights of the design truck or tandem per lane placed in all design lanes which are carrying traffic headed in the same direction. Besides all design lanes shall be simultaneously loaded for bridges likely to become one-directional in the future.

These forces shall be assumed to act horizontally at a distance of 1800 mm above the roadway surface in either longitudinal direction to cause extreme force effects.



Braking Force

The multiple presence factors shall apply.

(6) ***Vehicular Collision Force: CT***

Unless protected as followings, abutments and piers located within a distance of 9000 mm to the edge of roadway, shall be designed for an equivalent static force of 1800 kN, which is assumed to act in any direction in a horizontal plane, at a distance of 1200 mm above ground.

- An embankment;
- A structurally independent, crashworthy ground mounted 1370 mm high barrier, located within 3000 mm from the component being protected
- A 1070 mm high barrier, located at more than 3000 mm from the component being protected