3.2 Summary of Soil Test Results

Table 3.2-1 Summary of Soil Test Results for Nguyen Trai Bridge Area (1)

Area	BH No.	Sample No.	Sample depth (Top)	Sample depth (Bottom)	Depth AV (m)	Elevation (m)	Wn	Gs	γ t (kN/m³)	Dry density	e	Sr	LL	PL	PI	Gravel	Sand	Silt	Clay&colloid
NGUYEN TRAI BRIDGE	BHNT-01	HP-1	4.00	5.00	4.50	-2.20	55.75	2.74	16.3	1.07	1.561	97.86	50.27	33.26	17.01	0	1.76	72.47	25.77
		HP-2	15.00	16.00	15.50	-13.20	37.59	2.69	17.8	1.32	1.038	97.42	38.48	25.03	13.45	0	3.42	80.78	15.80
		HP-3	23.00	24.00	23.50	-21.20	51.55	2.73	16.9	1.13	1.416	99.39	56	34.38	21.62	0	3.14	69.12	27.74
		SPT-10	11.00	11.45	11.23	-8.93	27.45	2.71	-	-	-	-	32.78	21.15	11.63	0	11.36	67.84	20.80
		SPT-35	38.00	38.45	38.23	-35.93	-	2.65	-	-	-	-	14.25	10.37	3.88	0	91.26	8.74	0.00
	BHNT-02	HP-1	4.00	5.00	4.50	-1.77	45.28	2.71	17.2	1.21	1.24	98.96	50.31	33.21	17.1	0	1.16	71.41	27.43
		HP-2	19.00	20.00	19.50	-16.77	42.09	2.75	17.2	1.23	1.236	93.65	41.26	31.28	9.98	0	3.80	85.18	11.02
		SPT-30	32.00	32.45	32.23	-29.50	18.65	2.65	-	-	-	-	-	-	-	1.39	88.75	4.86	5.00
		SPT-36	38.00	38.45	38.23	-35.50	11.47	2.65	-	-	-	-	13.98	10.25	3.73	11.00	53.30	13.70	22.00
	BHNT-03	HP-1	16.00	17.00	16.50	-14.23	47.49	2.72	17.1	1.18	1.305	98.98	50.01	32.55	17.46	0	1.94	72.29	25.77
		SPT-22	23.00	23.45	23.23	-20.96	51.28	2.67	-	-	-	-	59.24	32.07	27.17	0	2.41	77.79	19.80
		SPT-33	34.00	34.45	34.23	-31.96	22.89	2.65	-	-	-	-	14.01	10.36	3.65	0	83.91	16.09	0.00
	BHNT-04	HP-1	4.00	5.00	4.50	-8.83	51.76	2.74	16.9	1.13	1.425	99.52	36.88	27.25	9.63	0	63.80	33.68	2.52
		HP-2	15.00	16.00	15.50	-19.83	47.39	2.78	17.2	1.19	1.336	98.61	55.48	32.44	23.04	0	2.90	71.33	25.77
		SPT-4	6.00	6.45	6.23	-10.56	-	2.65	-	-	-	-	13.21	10.06	3.15	0	92.00	8.00	0.00
		SPT-24	27.00	27.45	27.23	-31.56	27.09	2.68	-	-	-	-	32.87	21.55	11.32	0	2.42	73.48	24.10
	BHNT-05	HP-1	4.00	5.00	4.50	-4.30	44.55	2.75	17.3	1.22	1.254	97.7	51.55	33.97	17.58	0	3.62	69.31	27.07
		HP-2	19.00	20.00	19.50	-19.30	36.96	2.71	18.0	1.34	1.022	98.01	41.69	29.34	12.35	0	42.36	51.82	5.82
		SPT-10	11.00	11.45	11.23	-11.03	29.93	2.74	-	-	-	-	29.12	19.18	9.94	0	32.04	60.60	7.36
		SPT-25	27.00	27.45	27.23	-27.03	35.60	2.75	-	-	-	-	38.05	23.38	14.67	0	3.52	70.71	25.77
	BHNT-06	HP-1	2.00	3.00	2.50	0.38	52.72	2.71	16.7	1.11	1.441	99.15	50.21	35.56	14.65	0	4.08	78.42	17.50
		HP-2	6.00	7.00	6.50	-3.62	54.74	2.68	16.4	1.08	1.481	99.06	54.99	36.76	18.23	0	11.98	68.75	19.27
		SPT-11	13.00	13.45	13.23	-10.35	54.14	2.67	-	-	-	-	34.13	27.48	6.65	0	31.96	60.65	7.39
		SPT-34	36.00	36.45	36.23	-33.35	28.27	2.79	-	-	-	-	50.71	28.57	22.14	0	3.04	67.50	29.46
	BHNT-07	HP-1	3.00	4.00	3.50	-1.40	40.73	2.74	17.5	1.27	1.157	96.46	48.26	29.79	18.47	0	1.80	69.14	29.06
		HP-2	10.00	11.00	10.50	-8.40	51.56	2.69	16.5	1.11	1.423	97.47	54.82	33.99	20.83	0	9.60	64.13	26.27
		SPT-25	27.00	27.45	27.23	-25.13	39.02	2.77	-	-	-	-	43.41	25.93	17.48	0	6.04	67.83	26.13
		SPT-34	36.00	36.45	36.23	-34.13	24.94	2.65	-	-	-	-	13.57	10.42	3.15	0	81.50	18.50	0.00
	BHNT-08	HP-1	8.00	9.00	8.50	-6.77	59.85	2.7	16.1	1.03	1.621	99.69	58.73	35.62	23.11	0	1.68	72.29	26.03
		HP-2	13.00	14.00	13.50	-11.77	46.48	2.71	17.2	1.19	1.277	98.64	41.33	27.94	13.39	0	1.50	79.35	19.15
		SPT-28	30.00	30.45	30.23	-28.50	27.62	2.78	-	-	-	-	36.7	21.3	15.4	0	3.02	67.53	29.45
		SPT-39	41.00	41.45	41.23	-39.50	20.1	2.68	-	-	-	-	19.77	16.77	3	0	35.22	57.35	7.43

Table 3.2-2 Summary of Soil Test Results for Nguyen Trai Bridge Area (2)

Area	BH No.	D60	D10	Soil description by Laboratory of TEC	ASTM classification	Pc (kPa)	Cc	Cr	Unconfined Compression Strength qu (kPa)	qu/2 (kPa)	Strain at failure (%)	CBR (%)	Remarks
NGUYEN TRAI BRIDGE	BHNT-01			Darkish grey Elastic silt	MH	80	0.538	0.079	37.79	18.89	15.00		
				Brownish grey Silt	ML	135	0.37	0.05	35.62	17.81	15.00		
				Brownish grey Elastic silt	MH	152	0.563	0.071	41.39	20.69	6.09		
				Yellowish grey Lean clay	CL								
		0.2099	0.0769	Yellowish grey Poorly - graded sand with silt	SP-SM								
	BHNT-02			Brownish grey Elastic silt	MH	101	0.45	0.05	46.06	23.03	15.00		
				Brownish grey Silt	ML	188	0.62	0.083	81.01	40.51	4.27		
		0.463	0.089	Grey Poorly - graded sand	SP								
		1.307	0.060	Grey Silty sand	SM								
	BHNT-03			Brownish grey Elastic silt	MH	148	0.42	0.063	23.85	11.92	14.43		
				Grey Elastic silt	MH								
		0.186	0.066	Grey Silty sand	SM								
	BHNT-04			Brown Silty sand	SM	53	0.477	0.055	28.29	14.14	6.50		
				Bluish grey Elastic silt	MH	233	0.829	0.109	119.10	59.55	3.27		
		0.201	0.078	Poorly - graded sand with silt	SP-SM								
				Lean clay	CL								
	BHNT-05			Brownish grey Elastic silt	MH	89	0.30	0.025	18.29	9.15	11.05		
				Darkish grey Sandy silt	ML	162	0.269	0.019	21.76	10.88	10.41		
				Darkish grey Sandy lean clay	CL								
				Grey Lean clay	CL								
	BHNT-06			Brownish grey Elastic silt	MH	54	0.391	0.045	21.83	10.92	15.00		
				Brownish grey Elastic silt	MH	67	0.479	0.054	19.69	9.84	12.96		
				Darkish grey Sandy silt	ML								
				Yellowish grey Elastic silt	MH								
	BHNT-07			Brownish grey Silt	ML	74	0.386	0.045	32.11	16.06	12.56		
				Brownish grey Elastic silt	MH	85	0.565	0.084	42.73	21.36	9.05		
				Grey Lean clay	CL								
		0.181	0.063	Grey Silty sand	SM								
	BHNT-08			Brownish grey Elastic silt	MH	49	0.49	0.076	21.52	10.76	11.26		
				Brownish grey Silt	ML	95	0.49	0.076	61.09	30.54	12.80		
				Grey Lean clay	CL								
				Darkish grey Sandy silt	ML								

Table 3.2-3 Summary of Soil Test Results for Vu Yen Bridge Area (1)

Area	BH No.	Sample No.	Sample depth (Top)	Sample depth (Bottom)	Depth AV (m)	Elevation (m)	Wn	Gs	γ t (kN/m³)	Dry density	e	Sr	LL	PL	PI	Gravel	Sand	Silt	Clay&colloid
VU YEN BRIDGE	BHVY-01	HP-1	6.00	7.00	6.50	-4.12	54.46	2.7	15.6	1.03	1.621	90.71	50.04	31.91	18.13	0	10.02	76.07	13.91
		HP-2	8.00	9.00	8.50	-6.12	49.09	2.71	16.4	1.12	1.42	93.69	49.35	28.17	21.18	0	6.40	81.31	12.29
		SPT-15	18.00	18.45	18.23	-15.85	28.68	2.72	-	-	-	-	39.93	22.52	17.41	0	2.84	68.08	29.08
		SPT-26	29.00	29.45	29.23	-26.85	31.54	2.7	-	-	-	-	31.44	20.25	11.19	0	49.22	48.20	2.58
	BHVY-02	HP-1	4.00	5.00	4.50	-2.48	42.73	2.72	17.3	1.24	1.194	97.34	38.74	23.07	15.67	0	4.62	76.21	19.17
		HP-2	7.00	8.00	7.50	-5.48	46.77	2.7	16.1	1.12	1.411	89.5	39.86	24.97	14.89	0	11.60	77.54	10.86
		HP-3	12.00	13.00	12.50	-10.48	55.82	2.67	16.0	1.05	1.543	96.59	51.82	28.2	23.62	0	21.52	67.74	10.74
		SPT-12	15.00	15.45	15.23	-13.21	34.07	2.65	-	-	-	-	30.28	23.38	6.90	0	69.24	28.19	2.57
		SPT-31	34.00	34.45	34.23	-32.21	18.88	2.65	-	-	-	-	20.15	14.25	5.90	0	62.56	34.87	2.57
	BHVY-05	HP-1	4.00	5.00	4.50	-2.10	44.16	2.74	16.8	1.19	1.303	92.86	45.2	27.00	18.20	0	5.22	69.01	25.77
		HP-2	8.00	9.00	8.50	-6.10	32.39	2.75	17.4	1.34	1.052	84.67	33.55	25.56	7.99	0	28.82	68.51	2.67
		SPT-13	15.00	15.45	15.23	-12.83	26.27	2.75	-	-	-	-	35.06	20.84	14.22	0	0.90	69.67	29.43
		SPT-38	40.00	40.45	40.23	-37.83	23.87	2.61	-	-	-	-	23.32	18.80	4.52	0	39.50	58.14	2.36
	BHVY-06	HP-1	3.00	4.00	3.50	-4.95	48.1	2.74	16.2	1.11	1.468	89.78	43.18	25.86	17.32	0	4.04	80.26	15.70
		HP-2	5.00	6.00	5.50	-6.95	47.53	2.77	17.0	1.17	1.368	96.24	45.73	27.47	18.26	0	4.00	77.04	18.96
		SPT-22	24.00	24.45	24.23	-25.68	44.50	2.75	-	-	-	-	49.86	28.73	21.13	0	1.00	79.79	19.21
		SPT-32	34.00	34.45	34.23	-35.68	20.38	2.62	-	-	-	-	25.93	15.33	10.6	0	32.22	62.10	5.68
	BHVY-07	HP-1	6.00	7.00	6.50	-6.12	62.67	2.68	15.8	0.99	1.707	98.39	63.91	35.37	28.54	0	2.96	74.41	22.63
		SPT-17	18.00	18.45	18.23	-17.85	40.78	2.7	-	-	-	-	46.25	30.81	15.44	0	6.38	72.62	21.00
		SPT-30	31.00	31.45	31.23	-30.85	23.34	2.69	-	-	-	-	36.43	20.95	15.48	0	5.80	70.09	24.11
	BHVY-08	HP-1	3.00	4.00	3.50	-2.27	29.18	2.69	18.8	1.49	0.805	97.51	26.42	21.59	4.83	0	58.78	38.67	2.55
		HP-2	9.00	10.00	9.50	-8.27	27.86	2.79	19.2	1.53	0.824	94.33	35.61	23.73	11.88	0	6.02	73.41	20.57
		SPT-19	21.00	21.45	21.23	-20.00	42.47	2.73	-	-	-	-	48.02	28.14	19.88	0	7.82	81.37	10.81
		SPT-33	35.00	35.45	35.23	-34.00	20.38	2.68	-	-	-	-	19.75	14.83	4.92	0	52.92	44.59	2.49
	BHVY-09	HP-1	5.00	6.00	5.50	-4.57	46.05	2.68	17.1	1.19	1.252	98.57	49.51	31.09	18.42	0	9.78	67.78	22.44
		SPT-16	17.00	17.45	17.23	-16.30	48.69	2.72	-	-	-	-	55.92	33.00	22.92	0	1.70	72.81	25.49
		SPT-33	34.00	34.45	34.23	-33.30	-	2.65	-	-	-	-	14.25	10.63	3.62	0	85.87	14.13	0.00
	BHVY-10	HP-1	6.00	7.00	6.50	-5.49	55.4	2.78	16.4	1.07	1.598	96.38	48.17	33.63	14.54	0	7.64	64.95	27.41
		HP-2	16.00	17.00	16.50	-15.49	47.46	2.79	17.3	1.2	1.325	99.93	51.75	31.99	19.76	0	2.52	68.45	29.03
		SPT-12	13.00	13.45	13.23	-12.22	27.21	2.75	-	-	-	-	42.40	25.45	16.95	0	7.86	63.08	29.06
		SPT-26	28.00	28.45	28.23	-27.22	15.75	2.67	-	-	-	-	21.33	13.78	7.55	0	42.62	49.99	7.39
	BHVY-11	HP-1	5.00	6.00	5.50	-5.03	39.00	2.71	17.4	1.28	1.117	94.62	43.04	28.84	14.2	0	18.36	67.45	14.19
		HP-2	10.00	11.00	10.50	-10.03	36.18	2.82	17.9	1.34	1.104	92.42	31.72	19.3	12.42	0	11.50	67.94	20.56
		SPT-30	32.00	32.45	32.23	-31.76	-	2.65	-	-	-	-	13.76	10.52	3.24	0	90.80	9.20	0.00
		SPT-33	35.00	35.45	35.23	-34.76	21.59	2.7	-	-	-	-	28.04	19.63	8.41	0	8.70	83.75	7.55
	BHVY-12	HP-1	3.00	4.00	3.50	-2.97	30.25	2.72	18.0	1.41	0.929	88.57	26.49	20.02	6.47	0	37.06	55.49	7.45
		HP-2	8.00	9.00	8.50	-7.97	38.49	2.74	17.2	1.26	1.175	89.76	35.44	21.04	14.4	0	51.08	39.71	9.21
		HP-3	12.00	13.00	12.50	-11.97	43.83	2.72	16.6	1.17	1.325	89.98	43.32	27.71	15.61	0	1.70	75.58	22.72
		SPT-21	24.00	24.45	24.23	-23.70	31.99	2.7	-	-	-	-	34.19	22.34	11.85	0	2.40	69.89	27.71
		SPT-31	34.00	34.45	34.23	-33.70	17.23	2.67	-	-	-	-	18.08	12.17	5.91	0	60.04	37.40	2.56
	BHVY-13	HP-1	4.00	5.00	4.50	-2.62	44.72	2.73	17.1	1.2	1.275	95.75	37.62	24.47	13.15	0	37.28	48.48	14.24
		HP-2	12.00	13.00	12.50	-10.62	42.33	2.74	17.2	1.24	1.21	95.85	41.17	26.15	15.02	0	2.42	71.49	26.09
		SPT-19	21.00	21.45	21.23	-19.35	28.66	2.7	-	-	-	-	40.92	24.21	16.71	0	2.10	73.55	24.35
		SPT-26	28.00	28.45	28.23	-26.35	-	2.65	-	-	-	-	13.96	10.45	3.51	0	88.05	11.95	0.00
	BHVY-14	HP-1	5.00	6.00	5.50	-5.17	27.41	2.74	18.8	1.51	0.815	92.15	24.48	19.55	4.93	0	58.14	36.00	5.86
		HP-2	11.00	12.00	11.50	-11.17	54.87	2.73	16.0	1.05	1.6	93.62	50.15	31.63	18.52	0	2.22	61.68	36.10
		SPT-6	7.00	7.45	7.23	-6.90	25.7	2.73		-	-	-	36.5	21.79	14.71	0	4.40	72.86	22.74
		SPT-22	24.00	24.45	24.23	-23.90	38.79	2.74		-	-	-	39.35	23.17	16.18	0	2.12	78.44	19.44
	BHVY-15	HP-1	4.00	5.00	4.50	-5.05	39.34	2.68	17.7	1.3	1.062	99.28	37.81	24.71	13.1	0	25.58	58.76	15.66
		HP-2	10.00	11.00	10.50	-11.05	45.34	2.77	16.9	1.18	1.347	93.24	44.00	26.66	17.34	0	2.30	69.91	27.79
		SPT-16	18.00	18.45	18.23	-18.78	50.44	2.66	-	-	-	-	53.17	28.92	24.25	0	1.50	86.05	12.45
		SPT-23	25.00	25.45	25.23	-25.78	-	2.6	-	-	-	-	14.25	10.75	3.5	0	82.92	17.08	0.00
	BHVY-16	HP-1	3.00	4.00	3.50	-2.38	60.62	2.68	15.6	0.99	1.707	95.17	52.14	34.09	18.05	0	7.88	69.49	22.63
		SPT-19	20.00	20.45	20.23	-19.11	51.21	2.76	-	-	-	-	57.91	33.05	24.86	0	6.51	73.04	20.45
		SPT-31	32.00	32.45	32.23	-31.11	20.15	2.63	-	-	-	-	13.25	10.17	3.08	6.76	85.95	7.29	0.00
	BHVY-17	HP-1	3.00	4.00	3.50	-2.59	51.34	2.67	16.7	1.12	1.384	99.04	40.92	27.3	13.62	0	27.20	62.04	10.76
		HP-2	6.00	7.00	6.50	-5.59	50.51	2.73	16.6	1.12	1.438	95.89	48.49	33.52	14.97	0	1.96	72.27	25.77
		SPT-10	12.00	12.45	12.23	-11.32	48.49	2.72	-	-	-	-	51.33	30.09	21.24	0	3.70	78.59	17.71
		SPT-19	21.00	21.45	21.23	-20.32	18.06	2.68	-	-	-	-	17.20	13.26	3.94	0	31.30	66.20	2.50
	BHVY-18	HP-1	4.00	5.00	4.50	-1.61	33.03	2.72	18.2	1.4	0.943	95.27	35.36	28.61	6.75	0	41.12	56.27	2.61
		SPT-25	26.00	26.45	26.23	-23.34	44.92	2.7	-	-	-	-	48.4	27.73	20.67	0	1.02	78.19	20.79
		SPT-38	39.00	39.45	39.23	-36.34	25.78	2.7	-	-	-	-	21.78	16.42	5.36	0	39.98	54.22	5.80

Table 3.2-4 Summary of Soil Test Results for Vu Yen Bridge Area (2)

Area	BH No.	D60	D10	Soil description by Laboratory of TEC	ASTM classification	Pc (kPa)	Cc	Cr	Unconfined Compression Strength qu (kPa)	qu/2 (kPa)	Strain at failure (%)	CBR (%)	Remarks
VU YEN BRIDGE	BHVY-01			Brownhish grey Elastic silt	MH	60	0.501	0.069	28.86	14.43	7.53		
				Brownhish grey Silt	ML	89	0.542	0.09	37.89	18.95	9.81		
				Brown Lean clay	CL								
				Yellowwish grey Sandy lean clay	CL								
	BHVY-02			Bluish grey Lean clay	CL	81	0.388	0.043	43.77	21.89	9.16		
				Bluish grey Lean clay	CL	97	0.53	0.064	42.56	21.28	8.86		
				Brownish grey Fat clay with sand	CH	108	0.629	0.088	38.22	19.11	9.91		
				Grey Silty sand	SM								
				Yellowish grey Silty clayey sand	SC-SM								
	BHVY-05			Brownhish grey Silt	ML	93	0.474	0.068	40.74	20.37	7.6		
				Bubble grey Silt with sand	ML	137	0.39	0.047					
				Yellowwish brown Lean clay	CL								
				Grey Sandy silty clay	CL-ML								
	BHVY-06			Grey Lean clay	CL	44	0.475	0.067	22.12	11.06	9.29		
				Brownhish grey Silt	ML	58	0.479	0.051	28.13	14.06	8.81		
				Grey Silt	ML								
				Grey Sandy lean clay	CL								
	BHVY-07			Bluish grey Elastic silt	MH	77	0.818	0.132	51.91	25.95	4.36		
				Grey Silt	ML								
				Brownish yellow Lean clay	CL								
	BHVY-08			Grey Silty clayey sand	SC-SM	138	0.193	0.011	58.24	29.12	5.51		
				Reddish brown Lean clay	CL	127	0.253	0.032	41.36	20.68	7.00		
				Bluish grey Silt	ML								
				Bluish grey Silty clayey sand	SC-SM								
	BHVY-09			Brownish grey Silt	ML	125	0.544	0.066	61.84	30.92	5.76		
				Brown Elastic silt	MH								
		0.227	0.068	Light grey Silty sand	SM								
	BHVY-10			Bluish grey Silt	ML	75	0.661	0.078	37.76	18.88	6.49		
				Bluish grey Elastic silt	MH	265	0.785	0.100	139.98	69.99	6.56		
				Brownish yellow Lean clay	CL								
				Bluish grey Sandy lean clay	CL								
	BHVY-11			Bluish grey Silt with sand	ML	151	0.403	0.045	45.86	22.93	6.5		
				Bluish grey Lean clay	CL	111	0.372	0.038	69.81	34.90	4.94		
		0.224	0.076	Yellow Poorly - graded sand with silt	SP-SM								
				Grey Lean clay	CL								
	BHVY-12			Brownish grey, bluish grey Sandy silty clay	CL-ML	137	0.252	0.02	36.33	18.16	6.99		
				Bluish grey Clayey sand	SC	101	0.487	0.075	54.39	27.20	5.78		
				Brownish grey Silt	ML	225	0.634	0.085	129.26	64.63	6.73		
				Bluish grey Lean clay	CL								
				Grey Silty clayey sand	SC-SM								
	BHVY-13			Brownish grey Sandy lean clay	CL	104	0.407	0.048	34.95	17.48	6.29		
				Bluish grey Silt	ML	245	0.581	0.072	133.54	66.77	7.00		
				Yellowish grey Lean clay	CL								
		0.201	0.072	Grey Poorly - graded sand with silt	SP-SM								
	BHVY-14			Brownish grey Silty clayey sand	SC-SM	165	0.203	0.012	36.91	18.46	3.97		
				Brownish grey Elastic silt	MH	174	0.753	0.099	93.72	46.86	6.43		
				Yellowwish grey Lean clay	CL								
				Grey Lean clay	CL								
	BHVY-15			Brownish grey, bluish grey Lean clay with sand	CL	136	0.3	0.028	28.16	14.08	7.81		
				Bluish grey Silt	ML	186	0.621	0.079	102.41	51.21	5.71		
				Grey Fat clay	CH								
		0.203	0.064	Yellowwish grey Silty sand	SM								
	BHVY-16			Darkish grey Elastic silt	MH	63	0.549	0.071	13.07	6.53	10.98		
				Grey Elastic silt	MH								
		0.976	0.094	Yellowish grey Well - graded sand with silt	SW-SM								
	BHVY-17			Darkish grey Silt with sand	ML	54	0.396	0.06	26.07	13.03	10.51		
				Yellowish grey Silt	ML	109	0.523	0.088	38.57	19.28	15.00		
				Grey Elastic silt	MH								
				Yellowish grey Sandy silt	ML								
	BHVY-18			Grey Sandy silt	ML	142	0.258	0.013	42.76	21.38	6.1		
				Grey Silt	ML								
				Darkish grey Sandy silty clay	CL-ML								

Table 3.2-5 Summary of Soil Test Results for Vu Yen Bridge Area and Borrow Pit (1)

Area	BH No.	Sample No.	Sample depth (Top)	Sample depth (Bottom)	Depth AV (m)	Elevation (m)	Wn	Gs	γ t (kN/m³)	Dry density	e	Sr	LL	PL	PI	Gravel	Sand	Silt	Clay&colloid
RING ROAD 3	BHRR-01	HP-1	3.00	4.00	3.50	-2.04	47.65	2.67	16.6	1.14	1.342	94.8	48.78	32.28	16.5	0	11.68	77.56	10.76
		SPT-9	10.00	10.45	10.23	-8.77	44.88	2.67	-	-	-	-	45.69	27.27	18.42	0	6.65	73.95	19.40
		SPT-16	17.00	17.45	17.23	-15.77	23.1	2.67	-	-	-	-	27.27	16.69	10.58	0	33.91	54.47	11.62
	BHRR-02	SPT-1	1.00	1.45	1.23	-0.41	45.5	2.7	-	-	-	-	43.57	26.97	16.6	0	7.16	68.73	24.11
		SPT-6	6.00	6.45	6.23	-5.41	51.18	2.67	-	-	-	-	46.37	29.05	17.32	0	5.24	68.77	25.99
		SPT-12	12.00	12.45	12.23	-11.41	-	2.62	-	-	-	-	13.98	10.52	3.46	0	94.45	5.55	0.00
		SPT-15	15.00	15.45	15.23	-14.41	-	2.63	-	-	-	-	-	-	-	27.27	53.64	4.54	14.55
	BHRR-03	HP-1	6.00	7.00	6.50	-3.85	43.29	2.72	17.2	1.22	1.23	95.73	47.85	30.47	17.38	0	2.04	70.23	27.73
		SPT-7	8.00	8.45	8.23	-5.58	55.51	2.67	-	-	-	-	53.99	28.08	25.91	0	4.78	81.01	14.21
		SPT-11	12.00	12.45	12.23	-9.58	21.94	2.67	-	-	-	-	30.49	20.61	9.88	0	20.17	65.65	14.18
	BHRR-04	HP-1	5.00	6.00	5.50	-2.89	41.46	2.67	17.4	1.26	1.119	98.93	46.25	29.36	16.89	0	6.84	79.16	14.00
		SPT-2	2.00	2.45	2.23	0.39	19.11	2.67	-	-	-	-	25.38	16.35	9.03	0	34.98	57.32	7.70
		SPT-12	13.00	13.45	13.23	-10.62	19.77	2.68	-	-	-	-	24.74	15.54	9.2	0	15.22	65.51	19.27
	BHRR-05	HP-1	6.00	7.00	6.50	-3.98	51.34	2.71	16.8	1.13	1.398	99.52	44.62	28.62	16	0	21.64	59.21	19.15
		SPT-7	8.00	8.45	8.23	-5.71	21.83	2.67	-	-	-	-	23.53	16.47	7.06	0	61.77	35.60	2.63
		SPT-10	11.00	11.45	11.23	-8.71	25.25	2.7	-	-	-	-	32.68	21.54	11.14	0	10.08	63.76	26.16
	BHRR-06	HP-1	1.00	2.00	1.50	0.35	43.28	2.71	16.9	1.2	1.258	93.23	43.31	27.97	15.34	0	4.66	74.31	21.03
		HP-2	6.00	7.00	6.50	-4.65	31.15	2.72	18.9	1.47	0.85	99.68	32.95	21.79	11.16	0	11.30	77.78	10.92
		SPT-8	9.00	9.45	9.23	-7.38	42.27	2.67	-	-	-	-	36.18	20.78	15.4	0	15.67	67.66	16.67
		SPT-12	13.00	13.45	13.23	-11.38	-	2.65	-	-	-	-	-	-	-	0	95.35	4.65	0.00
	BHRR-07	HP-1	5.00	6.00	5.50	-4.29	50.37	2.68	16.8	1.14	1.351	99.92	48.96	37.02	11.94	0	9.92	77.54	12.54
		SPT-9	11.00	11.45	11.23	-10.02	26.02	2.79	-	-	-	-	37.3	23.62	13.68	0	5.20	60.87	33.93
		SPT-13	15.00	15.45	15.23	-14.02	26.44	2.7	-	-	-	-	39.4	25.08	14.32	0	3.91	67.79	28.30
	BHRR-08	HP-1	7.00	8.00	7.50	-5.46	43.17	2.71	16.5	1.17	1.316	88.9	45.29	30.71	14.58	0	13.56	70.76	15.68
		HP-2	9.00	10.00	9.50	-7.46	51.97	2.72	16.7	1.12	1.429	98.92	49.15	34.25	14.9	0	2.5	68.4	29.10
		SPT-12	14.00	14.45	14.23	-12.19	-	2.65	-	-	-	-	14.58	11.03	3.55	0	94.66	5.34	0.00
		SPT-19	21.00	21.45	21.23	-19.19	36.29	2.79	-	-	-	-	40.62	24.78	15.84	0	6.54	64.00	29.46
Borrow Pit			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 3.2-6 Summary of Soil Test Results for Vu Yen Bridge Area and Borrow Pit (2)

Area	BH No.	D60	D10	Soil description by Laboratory of TEC	ASTM classification	Pc (kPa)	Cc	Cr	Unconfined Compression Strength qu (kPa)	qu/2 (kPa)	Strain at failure (%)	CBR (%)	Remarks
RING ROAD 3	BHRR-01			Yellowish grey Silt	ML	50	0.364	0.046	15.45	7.73	15.00		
				Grey Silt	ML								
				Yellowish grey Sandy lean clay	CL								
	BHRR-02			Brownish grey Silt	ML								
				Grey Silt	ML								
		0.222	0.082	Yellowish grey Poorly - graded sand with silt	SP-SM								
		2.229	0.101	Whitish grey Poorly - graded sand with gravel	SP								
	BHRR-03			Brownish grey, darkish grey Silt	ML	114	0.445	0.056	35.05	17.52	10.96		
				Grey Fat clay	CH								
				Yellowish grey Lean clay with sand	CL								
	BHRR-04			Brownish grey, darkish grey Silt	ML	111	0.388	0.058	49.80	24.90	13.22		
				Yellowish grey Sandy lean clay	CL								
				Grey Lean clay with sand	CL								
	BHRR-05			Brownish grey Silt with sand	ML	91	0.525	0.084	24.48	12.24	10.13		
				Yellowish grey Clayey sand	SC								
				Grey Lean clay	CL								
	BHRR-06			Grey Silt	ML	109	0.449	0.069	28.26	14.13	14.57		
				Grey, yellowish grey Lean clay	CL	143	0.267	0.033	90.78	45.39	13.65		
				Grey Lean clay with sand	CL								
		0.203	0.077	Grey Poorly - graded sand	SP								
	BHRR-07			Darkish grey Silt	ML	105	0.475	0.062	56.65	28.33	13.37		
				Yellowish grey Lean clay	CL								
				Grey Lean clay	CL								
	BHRR-08			Brownish grey Silt	ML	85	0.496	0.078	33.40	16.70	12.42		
				Brownish grey Silt	ML	113	0.511	0.088	38.22	19.11	15.00		
		0.256	0.083	Yellowish grey Poorly - graded sand with silt	SP-SM								
				Brownish grey Lean clay	CL								
Borrow Pit		-	-	-	-	-	-	-	-	-	-	2.08	

3.3 Soil Profile

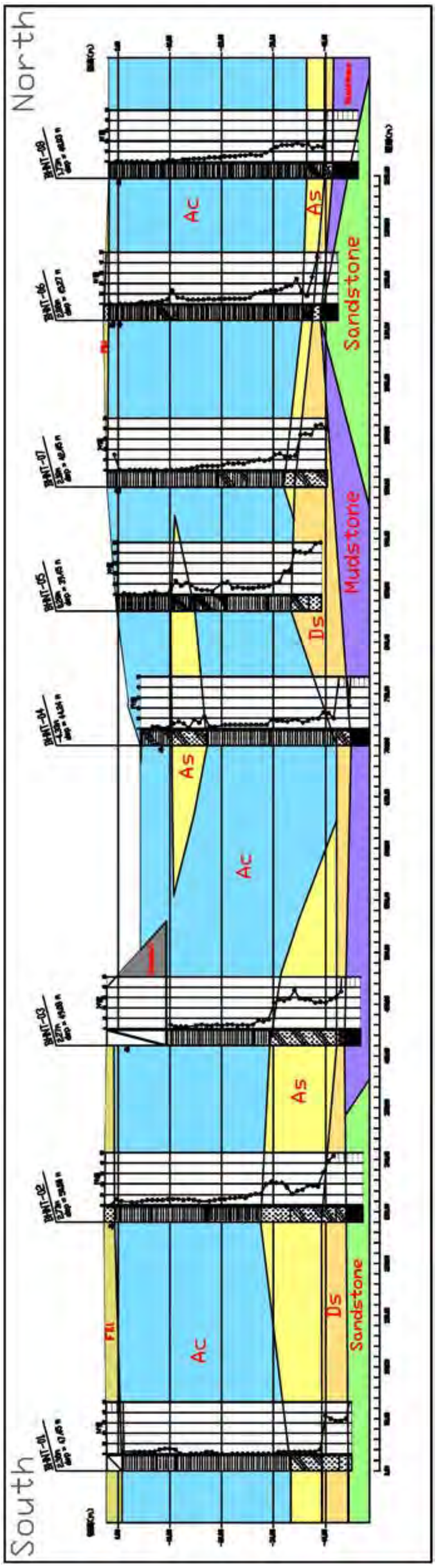


Figure 3.3-1 Soil Profile for Nguyen Trai Bridge Site

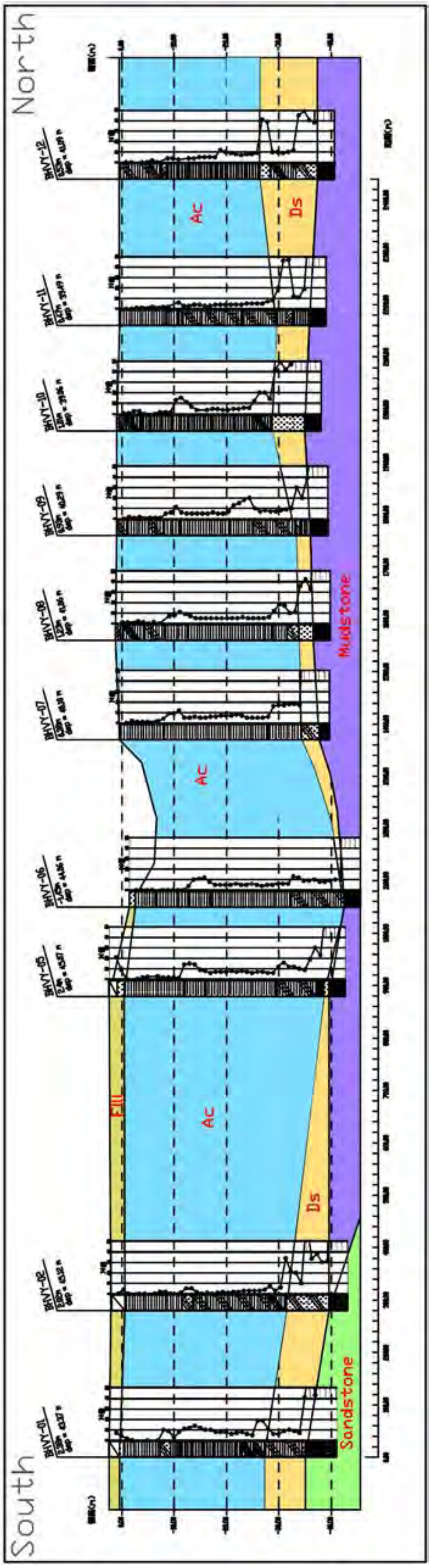


Figure 3.3-2 Soil Profile for Vu Yen Bridge Site (from VY-01 to VY-12)

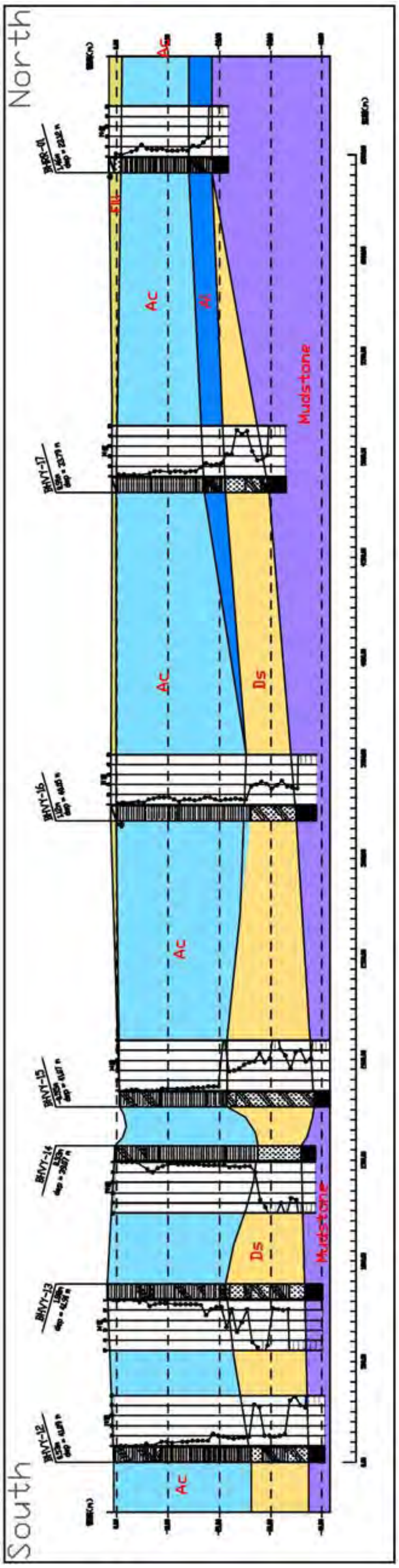


Figure 3.3-3 Soil Profile for Vu Yen Bridge Site (from VY-12 to VY-17)

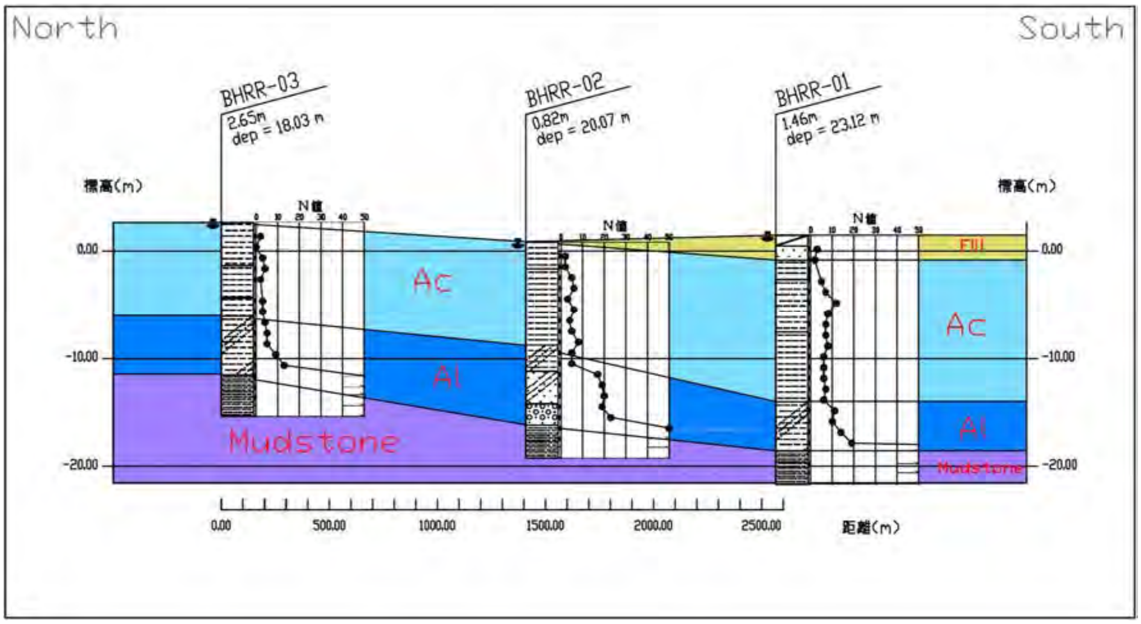


Figure 3.3-4 Soil Profile for Ring Road 3 Route (from RR-01 to RR-03)

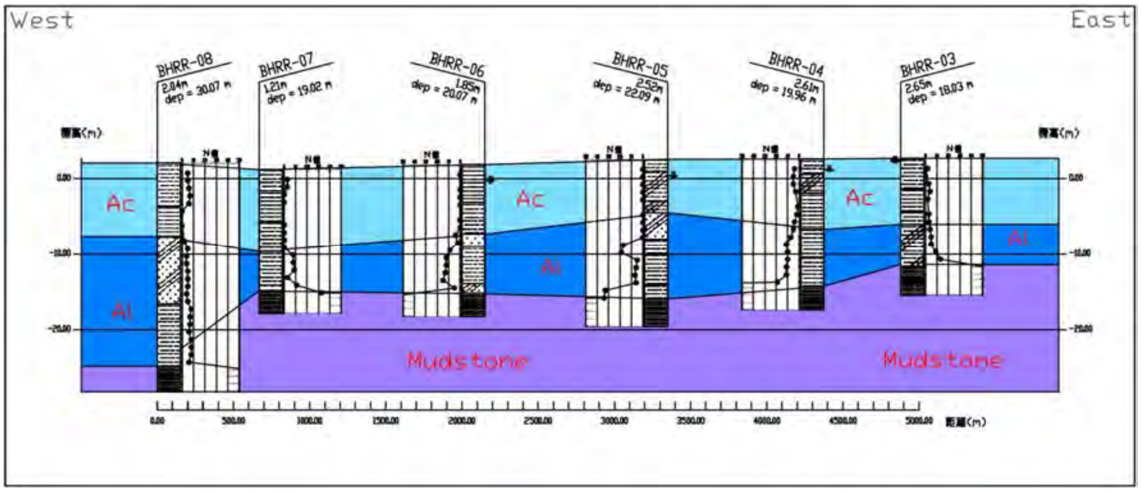


Figure 3.3-5 Soil Profile for Ring Road 3 Route (from RR-03 to RR-08)

3.4 Properties of Each Soil Layer

This section describes properties of soil layer based on the results of Standard Penetration Test (SPT) and laboratory soil tests.

<Standard Penetration Test Results, N-Value >

Figure 3.4-1 shows N-value versus depth and elevation. Ranges of the N-value for each layer at each site were summarized in Table 3.4-1.

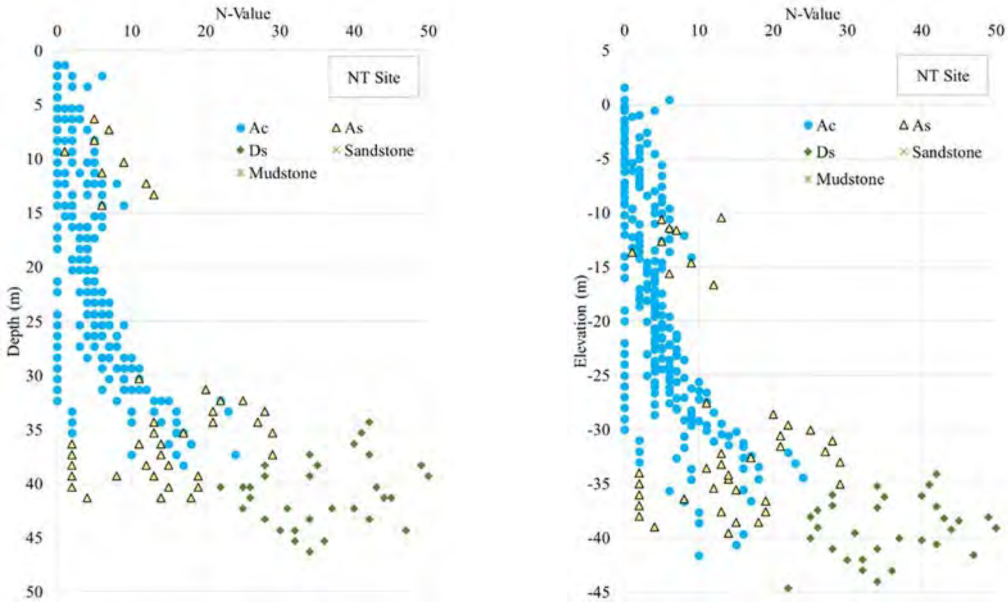
Most of the N value of Ac layer ranges from 0 to 8 in overall. Some different trends are observed depend on the elevation ranges. The value ranges from 0 to 4 (very soft to soft) from MSL +2.0m to about MSL-13m. It is 4 to 8 (medium stiff) with a trend of increasing with depth from about MSL-13m to MSL-30m. The value in the layer deeper than MSL-30m ranges from 8 to 30 (stiff to very stiff). The ranges of the value in Ac layer are not much different among the sites.

The value in Al layer ranges from 2 to 20. It has wider range than Ac layer and As layer at same elevation. The range of the value in Al layer at VY site is lower than that of RR site. This is because the Al layer at VY site is consisted of mostly cohesive soil, besides sandy soil layer is dominant at RR site.

As layers are found at NT site only. Most of the value of As layer ranges from 0 to 10 (very loose to loose) at upper layer and ranges from 10 to 30 (medium dense to dense) at lower layer.

The value of Ds layer ranges mostly over 30 (dense to very dense) at all the sites. The value at VY site has wider range than that of NT site, of which variety may be resulted from wider distribution of the layer at VY site than that of NT site.

The value of Sandstone and Mudstone ranges mostly over 50 (medium strong) at all the sites.



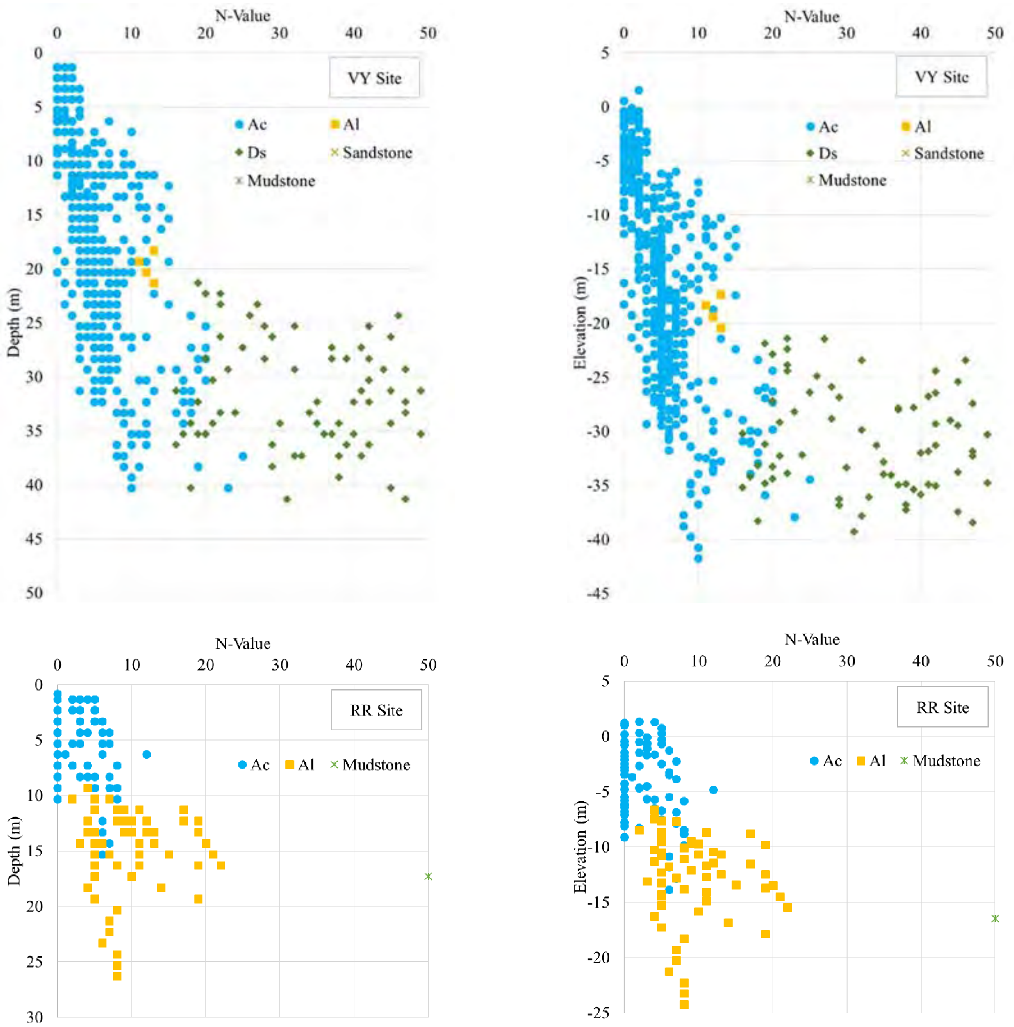


Figure 3.4-1 N Value versus depth and elevation

Table 3.4-1 Range of N-value for each layer

Layer		Range			Average		
		NT	VY	RR	NT	VY	RR
Ac	-13m*<MSL<+2m	0 to 4	0 to 4	0 to 4	2	3	3
	-30m<MSL<-13m*	4 to 8	4 to 8	6	8	8	6
	< MSL-30m	8 to 30	8 to 30	-	14	12	-
Al		-	10 to 15	2 to 20	-	12	9
As	Upper layer	0 to 10	-	-	7	-	-
	Lower layer	10 to 30	-	-	18	-	-
Ds		>20	>20	-	41	35	-
Sandstone		>50	>50	-	>50	>50	-
Mudstone		>50	>50	>50	>50	>50	>50

*There is difference of elevation range for each site

**Excluded some exceptional points in the evaluation.

<Natural Water Content, Wn>

Figure 3.4-2 shows natural water content versus depth and elevation. Ranges of the content are summarized in Table 3.4-2.

Water content of Ac layer tends to be lower with depth from 60% to 20%. Water content of Al layer ranges from 20% to 30%. These ranges are not much different among the sites.

Some data were obtained on samples from As and Ds layers also. The content of As layer ranges from 10% to 25% and those of Ds layer ranges from 15% to 25%.

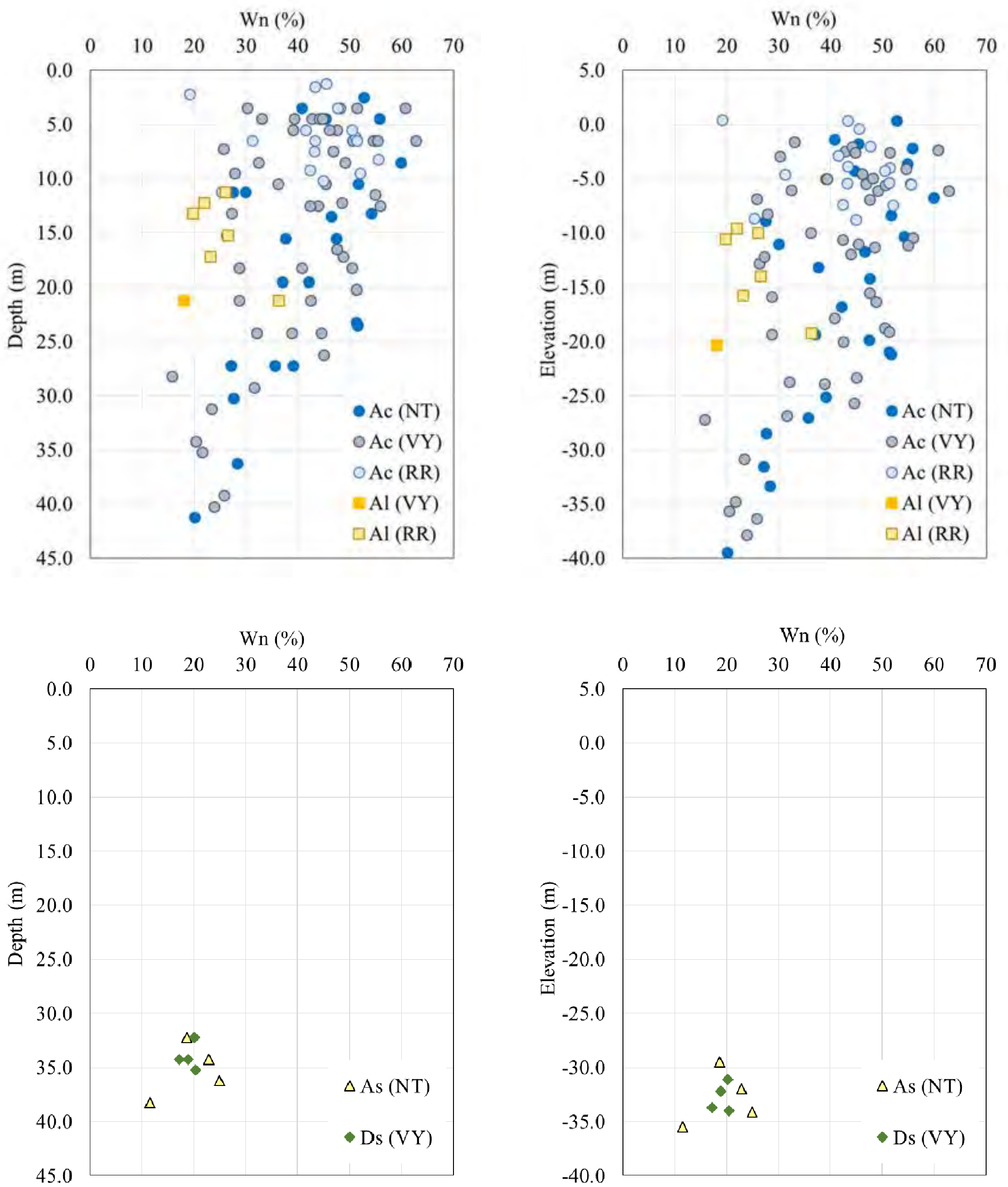


Figure 3.4-2 Water Content versus Depth and Elevation

Table 3.4-2 Range of Water Content

Layer	Range			Average		
	NT	VY	RR	NT	VY	RR
Ac	27 to 60	15 to 63	19 to 56	44	41	43
Al	-	*18	19 to 37	-	*18	26
As	11 to 25	-	-	19	-	-
Ds	-	17 to 21	-	-	19	-

*one sample only

<Atterberg Limits, LL, PL, PI>

Figure 3.4-3 shows a Plasticity Chart, Liquid Limit versus Plasticity Index for samples from Ac layer. The results were plotted in zones of MH, ML or CL. Liquid limit ranges from 20% to 60% and the Plasticity index ranges from 5 to 30. The ranges of Atterberg limits are summarized in Table 3.4-3. These ranges are not much different among the sites.

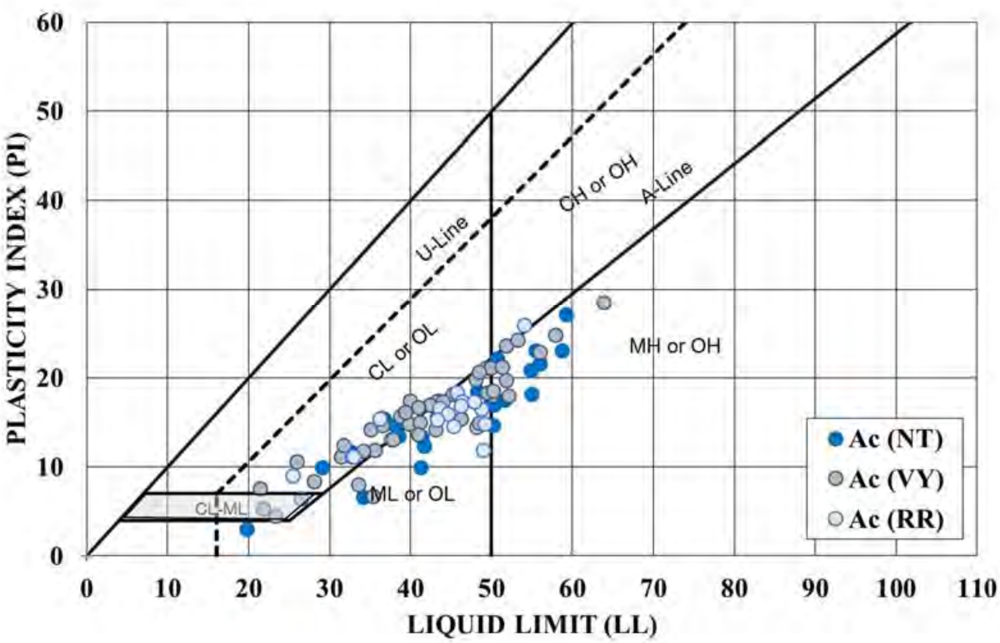


Figure 3.4-3 Liquid Limit versus Plasticity Index

Table 3.4-3 Range of Atterberg Limit Test Results

Item	Ac Layer		
	NT	VY	RR
Liquid Limit, LL	32 to 60	21 to 64	25 to 54
Plastic Limit, PL	21 to 37	13 to 36	16 to 38
Plasticity Index, PI	6 to 28	4 to 29	9 to 26

<Unit Weight, γ_t>

Figure 3.4-4 shows unit weight versus depth and elevation for samples from Ac layer. Ranges of the unit weight are summarized in Table 3.4-4.

The unit weight of NT site ranges from 16kN/m³ to 18kN/m³, of VY site ranges from 15kN/m³ to 19kN/m³ and of RR site ranges from 16kN/m³ to 19kN/m³. Average for all sites is 17kN/m³. Compering the range of each site, there are not much difference among the sites.

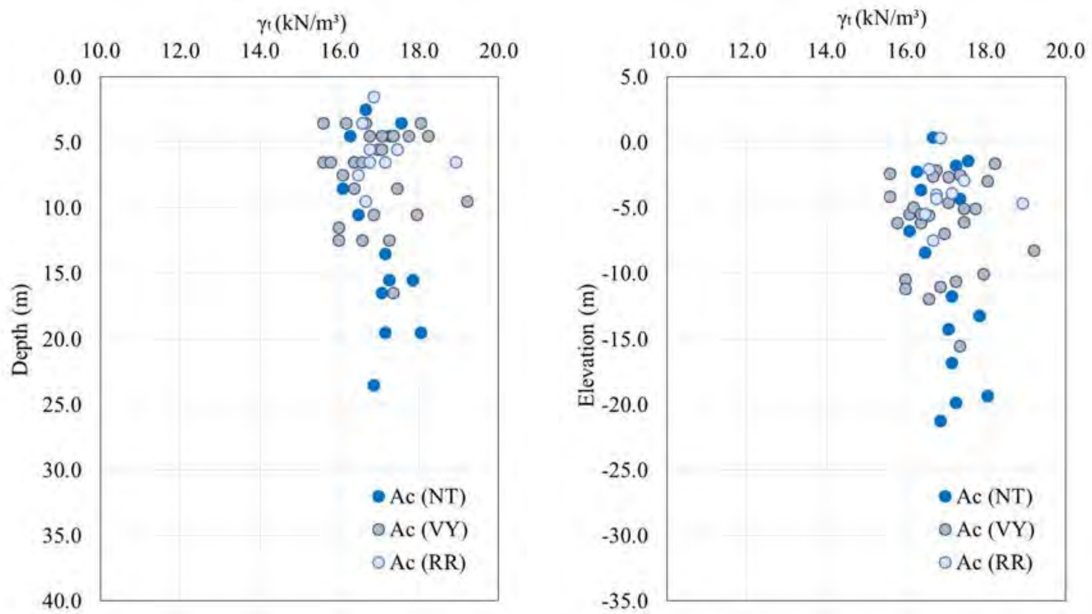


Figure 3.4-4 Unit Weight versus Depth and Elevation

Table 3.4-4 Range of Unit Weight

Layer	Range (kN/m³)			Average (kN/m³)		
	NT	VY	RR	NT	VY	RR
Ac	16 to 18	15 to 19	16 to 19	17	17	17

<Half of Unconfined Compression Strength, qu/2>

As an indication of undrained shear strength of saturated soft cohesive soil, half of the unconfined compression strength (qu/2) is generally accepted.

Figure 3.4-5 shows the qu/2 versus depth and elevation for samples from Ac layer. The ranges of qu/2 are summarized in Table 3.4-5.

The strength of Ac layer tends to be higher with depth. The strength of NT site ranges from 9kPa to 60kPa, of VY site ranges from 6kPa to 70kPa and of RR site ranges from 7kPa to 46kPa. Comparing the range of the strength for each site, there are not much difference among the sites up to 10m deep. Those of NT site deeper than10m tend to be lower than those of VY site.

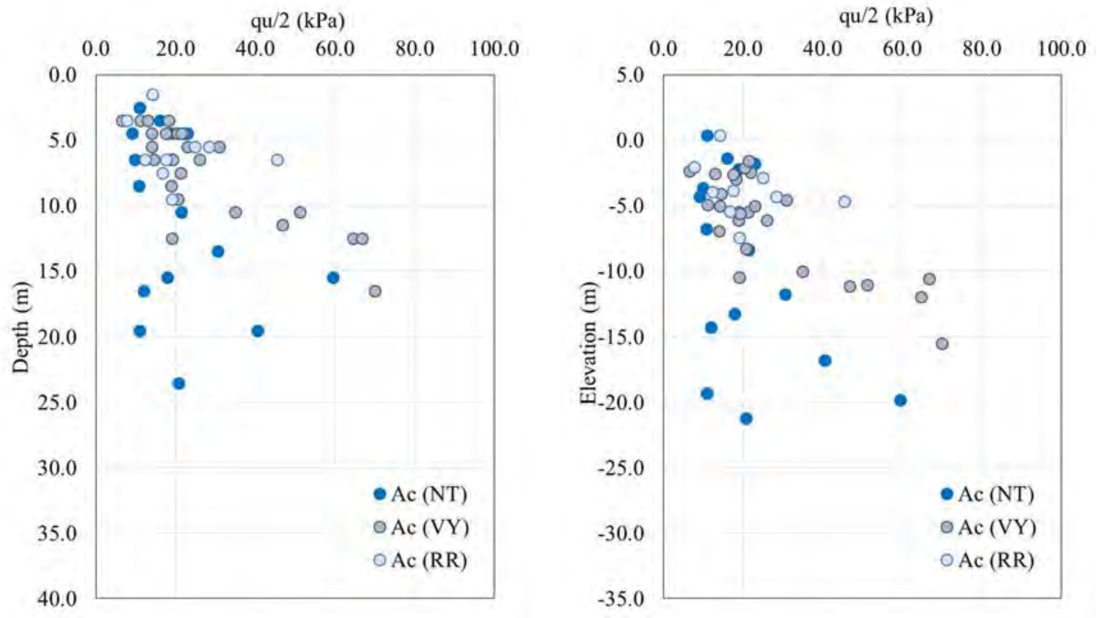


Figure 3.4-5 qu/2 versus Depth and Elevation

Table 3.4-5 Range of Half Unconfined Compression Strength

Layer	Range (kPa)			Average (kPa)		
	NT	VY	RR	NT	VY	RR
Ac	9 to 60	6 to 70	7 to 46	21	27	21

< Preconsolidation Pressure, Pc >

Figure 3.4-6 shows the Preconsolidation Pressure, Pc versus depth and elevation for samples from Ac layer. The ranges of preconsolidation pressure are summarized in Table 3.4-6.

The pressure tends to be higher with depth. The pressure of NT site ranges from 49kPa to 234kPa, of VY site ranges from 44kPa to 265kPa and of RR site ranges from 49kPa to 143kPa. Comparing the ranges among the sites, that of NT site tends to be lower than the other sites.

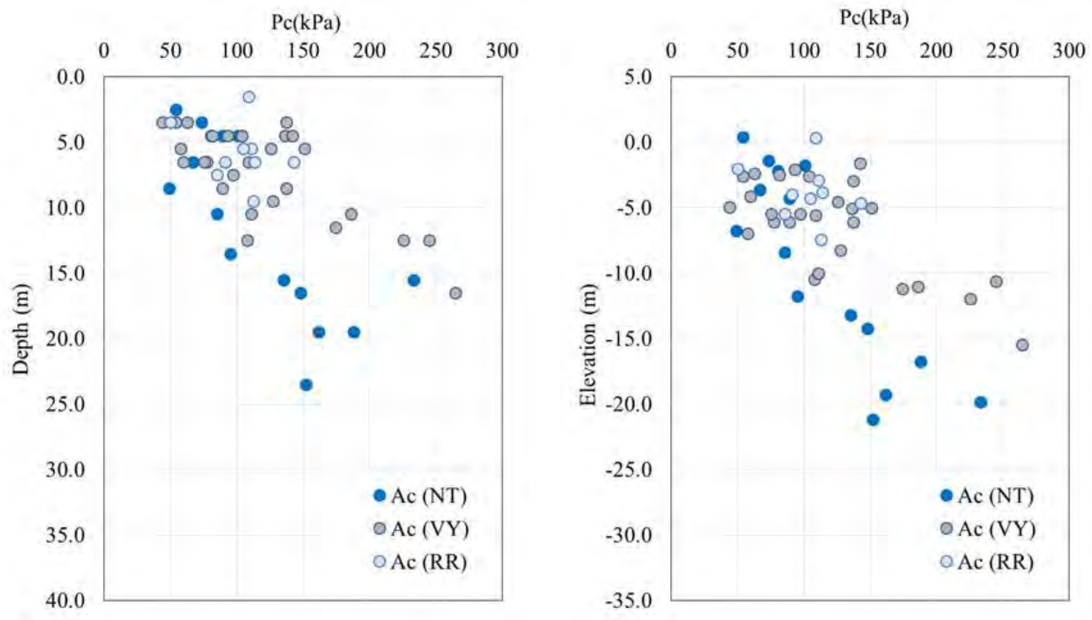


Figure 3.4-6 Pc versus Depth and Elevation

Table 3.4-6 Range of Preconsolidation Pressure

Layer	Range (kPa)			Average (kPa)		
	NT	VY	RR	NT	VY	RR
Ac	49 to 234	44 to 265	49 to 143	114	121	102

<Compression Index, Cc >

Figure 3.4-7 shows compression Index versus depth and elevation for samples from Ac layer. Ranges of the index were summarized in Table 3.4-7.

The index ranges from 0.2 to 0.8, most index falls between 0.4 and 0.6. Compering the ranges among the sites, there are not much difference.

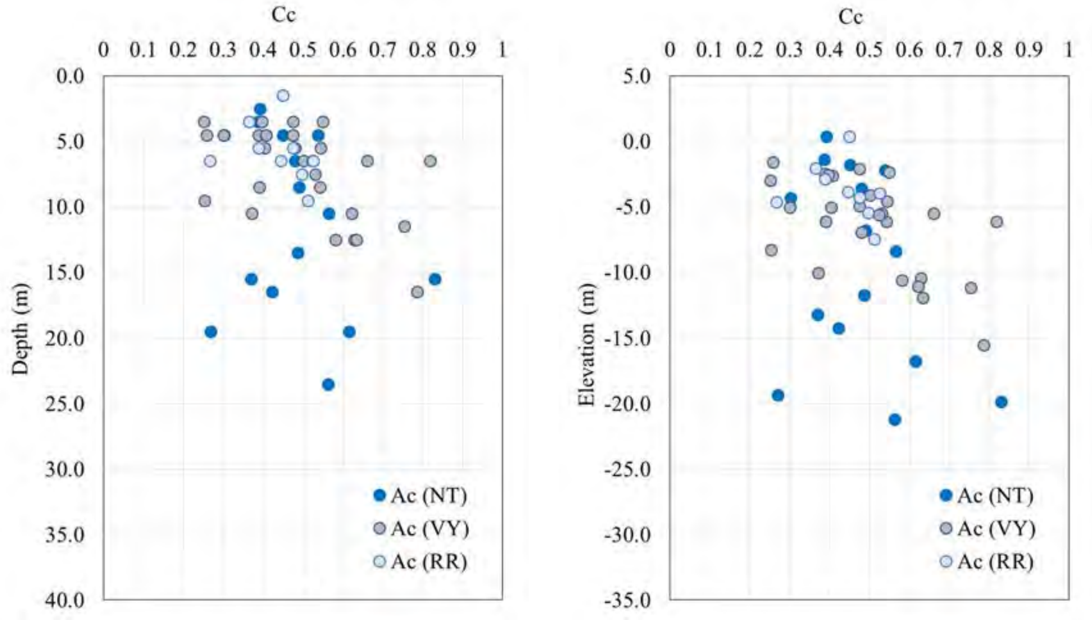


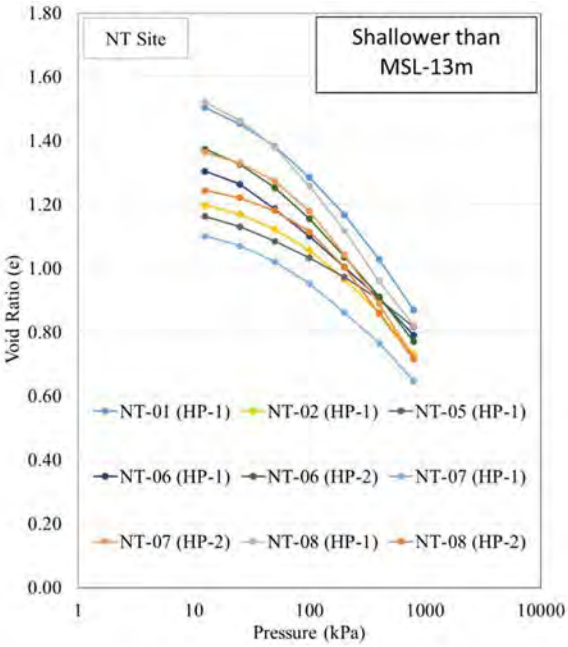
Figure 3.4-7　Cc versus Depth and Elevation

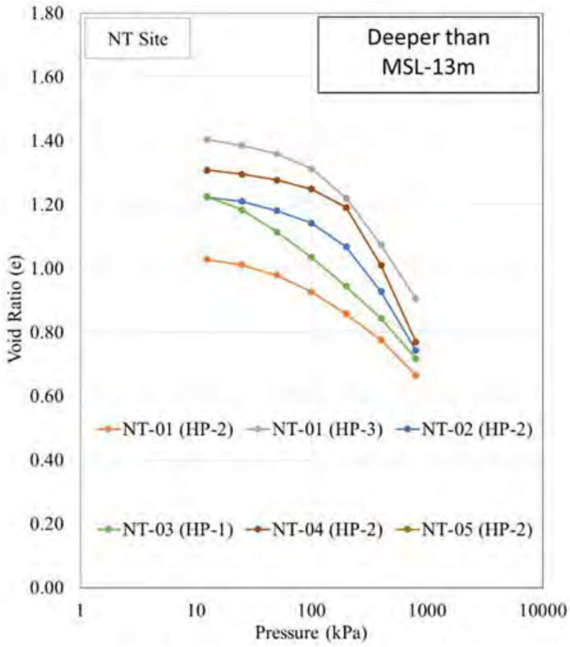
Table 3.4-7　Range of Compression Index

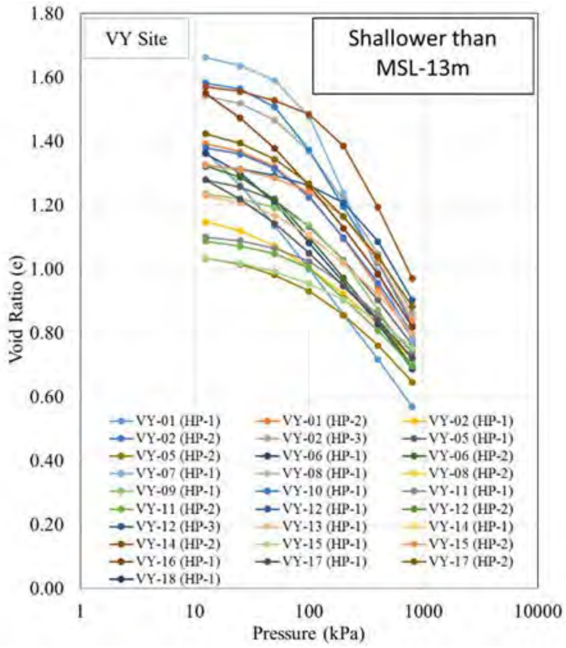
Layer	Range (kPa)			Average (kPa)		
	NT	VY	RR	NT	VY	RR
Ac	0.2 to 0.8	0.2 to 0.8	0.2 to 0.6	0.5	0.5	0.4

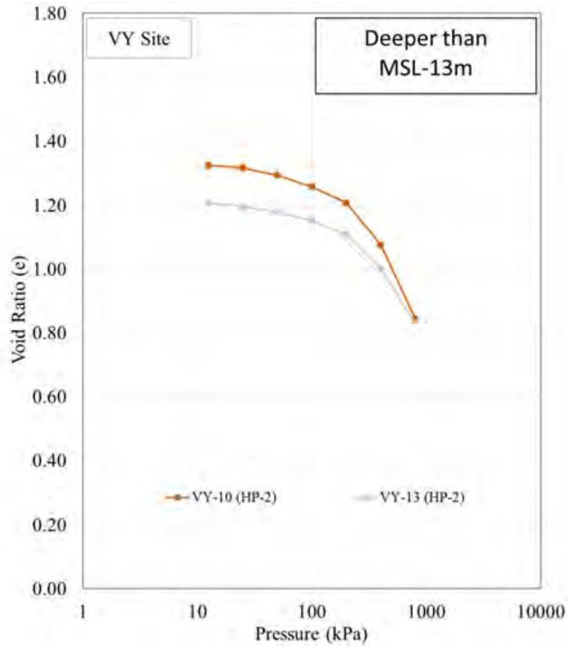
<Void Ratio, e>

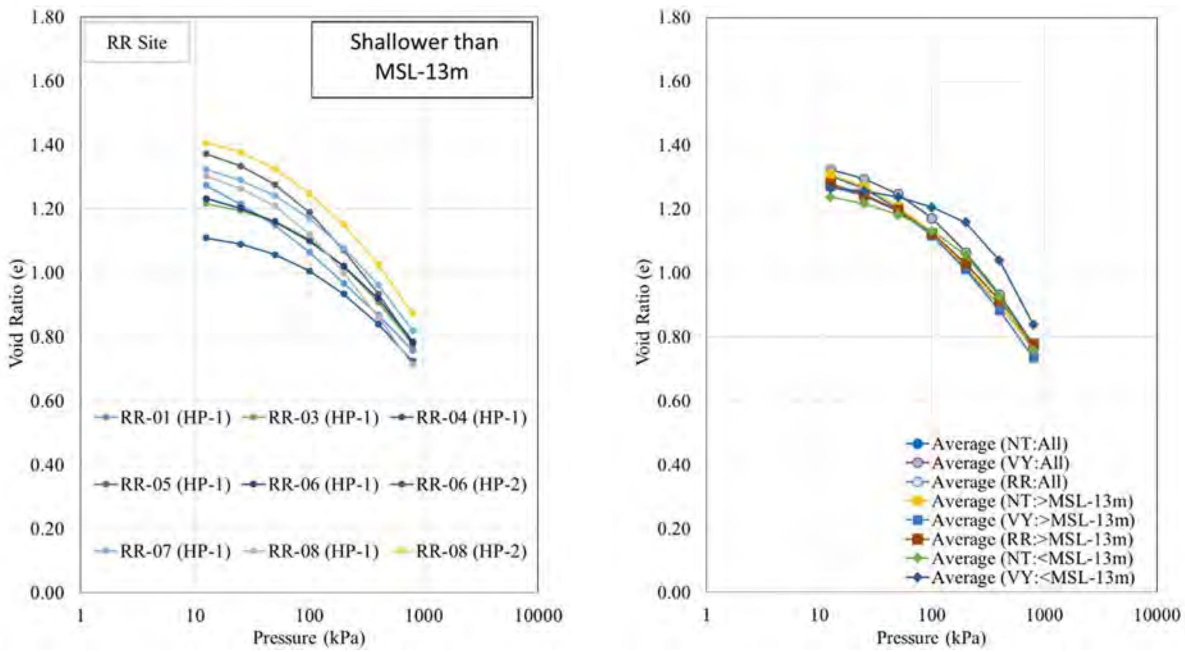
Figure 3.4-8 shows e-log P curves for samples from Ac layer. The curves were shown separately by sampling elevation of shallower than MSL-13m and deeper than MSL-13m. Comparing the shallower samples and deeper samples, preconsolidation pressure of shallower samples is lower than deeper samples and the void ratio of the samples is reduced greatly by applied pressure. There weren’t much different among the sites.


NT Site
Shallower than MSL-13m
Void Ratio (e)
Pressure (kPa)
NT-01 (HP-1)
NT-02 (HP-1)
NT-05 (HP-1)
NT-06 (HP-1)
NT-06 (HP-2)
NT-07 (HP-1)
NT-07 (HP-2)
NT-08 (HP-1)
NT-08 (HP-2)


NT Site
Deeper than MSL-13m
Void Ratio (e)
Pressure (kPa)
NT-01 (HP-2)
NT-01 (HP-3)
NT-02 (HP-2)
NT-03 (HP-1)
NT-04 (HP-2)
NT-05 (HP-2)


VY Site
Shallower than MSL-13m
Void Ratio (e)
Pressure (kPa)
VY-01 (HP-1)
VY-01 (HP-2)
VY-02 (HP-1)
VY-02 (HP-2)
VY-02 (HP-3)
VY-05 (HP-1)
VY-05 (HP-2)
VY-06 (HP-1)
VY-06 (HP-2)
VY-07 (HP-1)
VY-08 (HP-1)
VY-08 (HP-2)
VY-09 (HP-1)
VY-10 (HP-1)
VY-11 (HP-1)
VY-11 (HP-2)
VY-12 (HP-1)
VY-12 (HP-2)
VY-12 (HP-3)
VY-13 (HP-1)
VY-14 (HP-1)
VY-14 (HP-2)
VY-15 (HP-1)
VY-15 (HP-2)
VY-16 (HP-1)
VY-17 (HP-1)
VY-17 (HP-2)
VY-18 (HP-1)


VY Site
Deeper than MSL-13m
Void Ratio (e)
Pressure (kPa)
VY-10 (HP-2)
VY-13 (HP-2)



Note: Some curves of samples containing sand more than 35% were omitted.

Figure 3.4-8 e-log P Curve for Each Area

< Summary, Properties of Each Layer >

Table 3.4-8 summarized properties of each layer.

Table 3.4-8 Soil Property of Each Layer

Area	Layer	Relative Density or Consistency	Material	N value	Thickness of Layer (m)	Color	Wn (%)	Unit Weight (kN/m³)	Gs	Grained Size Gravel (%)	Grained Size Sand (%)	Grained Size Silt (%)	Grained Size Clay and Colloid (%)	LL	PL	PI	qu/2 (kPa)	e	Pc (kPa)	Cc
Nguyen Trai Bridge	Fill	-	Sandy Soil, Rock Fragments	0 or >50	1.00 to 11.50	Brownish Grey	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Ac Layer	Very Soft to Soft	Cohesive Soil	0 to 4	20.00 to 38.20	Light Grey, Blackish Grey, Brownish Grey, Yellowish Grey	27 to 60	16 to 18	2.6 to 2.8	0	1 to 43	51 to 86	19 to 28	32 to 60	21 to 37	6 to 28	9 to 60	1.0 to 1.7	49 to 234	0.2 to 0.8
	As Layer	Very Loose to Medium Dense	Sandy Soil	0 to 30	2.00 to 12.80	Grey, Light Grey, Blackish Grey	11 to 25	-	2.7	0 to 11	53 to 92	4 to 19	0 to 22	13 to 15	10 to 11	3 to 4	-	-	-	-
	Ds Layer	Medium Dense to Very Dense	Sandy Soil	>20	1.60 to 6.25	Grey, Whitish Grey, Light Grey, Blackish Grey	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Sandstone	Medium Strong	Sandstone	>50	3.08	Reddish Brown, Bluish Grey	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Mudstone	Medium Strong	Mudstone	>50	3.20 to 4.93	Reddish Brown	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vu Yen Bridge	Fill	-	Cohesive Soil, Sandy Soil, Rock Fragments	0 to 21	0.80 to 2.60	Blackish Grey, Dark Grey, Yellowish Grey	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Ac Layer	Very Soft to Soft	Cohesive Soil	0 to 4	21.00 to 39.90	Grey, Light Grey, Dark Grey, Bluish Grey, Yellowish Grey	15 to 63	15 to 19	2.6 to 2.9	0	0 to 42	48 to 86	2 to 37	21 to 64	13 to 36	4 to 29	6 to 70	0.8 to 1.7	44 to 265	0.2 to 0.8
	Al Layer	Stiff	Cohesive Soil	10 to 15	4.10	Yellowish Grey	18	-	2.7	0	31	66	3	17	13	5	-	-	-	-
	Ds Layer	Medium Dense to Very Dense	Sandy Soil	>20	1.00 to 16.45	Grey, Light Grey, Dark Grey, Brownish Grey	17 to 21	-	2.6 to 2.7	0 to 7	52 to 91	7 to 45	0 to 3	13 to 21	10 to 15	3 to 6	-	-	-	-
	Sandstone	Medium Strong	Sandstone	>50	3.52 to 5.97	Reddish Brown	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Mudstone	Medium Strong	Mudstone	>50	2.00 to 5.97	Reddish Brown	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ring Road 3	Fill	-	Cohesive Soil, Sandy Soil, Rock Fragments	2 to 3	2.30	Grey	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Ac Layer	Very Soft to Soft	Cohesive Soil	0 to 4	8.70 to 13.20	Grey, Whitish Grey, Blackish Grey, Brownish Grey	19 to 56	16 to 19	2.6 to 2.8	0	2 to 35	57 to 81	7 to 30	25 to 54	16 to 38	9 to26	7 to 46	0.8 to 1.5	49 to 143	0.2 to 0.6
	Al Layer	Soft to Very Stiff, Loose to Medium Dense	Cohesive Soil, Sandy Soil	2 to 20 4 to 20	4.50 to 17.10	Blackish Grey, Yellowish Grey, Reddish Brown	19 to 37	-	2.6 to 2.8	0 to 28	3 to 96	4 to 68	0 to 34	13 to 41	10 to 25	3 to16	-	-	-	-
	Mudstone	Medium Strong	Mudstone	>50	3.02 to 3.83	Reddish Brown	-	-	-	-	-	-	-	-	-	-	-	-	-	-

3.5 Estimation of High Water Level

3.5.1 Datum of the Cam River

Table 3.3-1 shows a record of the monthly highest and lowest high water level (H.W.L.) at Cua Cam station on the Cam River from 2000 to 2014. Water level is based on average sea tide level in Vietnam.

Table 3.5-1 Record of Monthly Highest and Lowest H.W.L. (2000-2014)

Trạm : Cửa Cấm

Thành Phố: Hải Phòng — Đơn vị: cm

STT	Năm	Yếu tố	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1	2000	Hmax (cm)	180	152	152	147	173	170	194	182	176	171	177	187
		Ngày xh	22	18	18	14	9	6	4	1	10	20	18	15
		Hmin (cm)	-140	-143	-133	-127	-126	-137	-117	-140	-134	-108	-137	-137
		Ngày XH	24	7	29	27	8	5	2	29	10	23	17	14
2	2001	Hmax (cm)	180	171	147	159	173	190	203	194	174	178	201	176
		Ngày xh	12	9	8	30	27	25	22	19	15	12	8	6
		Hmin (cm)	-148	-143	-134	-123	-127	-95	-43	-96	-102	-115	-117	-142
		Ngày XH	11	7	7	4	26	22	21	31	15	9	18	31
3	2002	Hmax (cm)	168	160	146	140	181	189	190	186	169	169	187	183
		Ngày xh	30	27	26	30	29	13	12	20	6	29	10	8
		Hmin (cm)	-145	-143	-138	-132	-130	-103	-95	-71	-137	-119	-125	-142
		Ngày XH	1	24	6	20	2	1	22	31	16	1	9	7
4	2003	Hmax (cm)	173	170	147	148	166	185	190	186	169	184	197	179
		Ngày xh	4	1	2	21	20	16	14	27	8	31	28	25
		Hmin (cm)	-147	-131	-141	-135	-139	-121	-111	-100	-99	-128	-126	-141
		Ngày XH	3	28	27	21	8	16	2	10	22	29	27	25
5	2004	Hmax (cm)	171	144	145	144	174	208	210	214	183	188	186	191
		Ngày xh	23	20	16	11	9	7	31	1	24	21	18	15
		Hmin (cm)	-151	-160	-134	-138	-118	-105	-110	-93	-107	-102	-133	-137
		Ngày XH	21	3	18	13	8	5	3	26	22	19	15	28
6	2005	Hmax (cm)	189	159	145	149	178	189	237	192	234	192	182	199
		Ngày xh	11	9	8	30	27	25	31	18	27	12	18	5
		Hmin (cm)	-149	-147	-141	-145	-134	-119	-111	-90	-119	-108	-123	-138
		Ngày XH	13	9	10	13	1	23	21	21	27	21	9	31
7	2006	Hmax (cm)	191	159	144	157	192	176	191	205	175	187	190	200
		Ngày xh	3	27	26	23	17	14	12	9	6	1	9	7
		Hmin (cm)	-144	-142	-139	-140	-145	-120	-113	-86	-113	-103	-119	-123
		Ngày XH	1	28	7	3	2	11	11	5	16	11	12	20
8	2007	Hmax (cm)	175	159	151	154	153	189	191	189	178	207	194	196
		Ngày xh	3	17	1	21	20	16	14	9	8	31	28	26
		Hmin (cm)	-141	-142	-132	-134	-137	-126	-102	-106	-97	-112	-141	-143
		Ngày XH	31	1	27	21	6	4	1	23	25	29	27	24
9	2008	Hmax (cm)	183	144	156	163	171	197	205	204	205	190	221	198
		Ngày xh	20	17	16	12	9	6	31	1	25	20	16	16
		Hmin (cm)	-136	-140	-131	-127	-135	-116	-85	-79	-97	-96	-90	-123
		Ngày XH	8	18	14	11	10	4	4	25	24	20	29	14
10	2009	Hmax (cm)	188	170	153	186	203	188	212	183	194	185	179	187
		Ngày xh	12	8	8	29	27	24	22	19	12	11	6	6
		Hmin (cm)	-134	-125	-129	-115	-97	-110	-89	-97	-87	-92	-122	-126
		Ngày XH	9	9	7	14	1	24	4	16	1	21	17	31
11	2010	Hmax (cm)	182	153	130	141	161	177	187	186	159	174	167	168
		Ngày xh	2	27	27	4	17	14	17	9	6	2	10	6
		Hmin (cm)	-140	-120	-127	-131	-110	-116	-99	-60	-54	-87	-78	-93
		Ngày XH	3	27	24	23	2	27	11	1	9	25	8	24
12	2011	Hmax (cm)	189	170	148	155	163	167	209	156	161	183	180	170
		Ngày xh	3	1	18	21	19	17	30	12	24	31	1	25
		Hmin (cm)	-90	-95	-100	-100	-102	-105	-93	-100	-98	-98	-105	-118
		Ngày XH	21	27	16	10	5	3	14	10	5	29	28	25
13	2012	Hmax (cm)	168	165	131	133	159	197	182	188	150	211	171	186
		Ngày xh	22	20	17	28	23	7	31	1	27	29	18	14
		Hmin (cm)	-116	-83	-110	-117	-107	-112	-100	-76	-87	-79	-117	-122
		Ngày XH	7	16	15	12	9	22	6	31	23	31	17	30
14	2013	Hmax (cm)	162	163	118	155	177	232	183	175	152	155	172	162
		Ngày xh	13	10	7	30	28	23	22	3	15	14	8	5
		Hmin (cm)	-119	-107	-120	-117	-99	-114	-76	-85	-71	-93	-97	-123
		Ngày XH	14	6	8	18	1	23	8	19	15	24	21	5
15	2014	Hmax (cm)	165	135	129	129	141	172	164	152	191	166	153	153
		Ngày xh	2	12	26	19	18	15	12	10	17	30	11	24
		Hmin (cm)	-127	-115	-102	-96	-106	-106	-98	-94	-88	-85	-108	-112
		Ngày XH	4	1	1	22	28	28	12	9	16	2	25	21

Source: The Northeast Meteorologic Hydrologic Centre

3.5.2 Probability Analysis of the Cam River Water Level

The Study Team calculated a probability distribution of the water level at Cua Cam station based on records of the highest water level each year (see Table 3.5-2).

Among the wide variety of probability distribution models, the following turned out to be a good fit:

1. Gumbel distribution
2. Generalized Extreme Value distribution (GEV I)
3. Log Pearson type III distribution (LOGP3)
4. SQRT-exponential type maximum distribution (SQRT-ET)

In this distribution, the value of SLSC to evaluate fitness less than 0.04 is only 2 (GEV I).

Table 3.5-3 shows the results of the water level probability analysis, and Figure 3.5-1 shows that 2 (GEV I) best matches the probabilities for the water level at Cua Cam in the distribution graph.

Table 3.5-2 Highest Water Level per year at Cua Cam

Year	Highest Water Level (cm)	Day/Month
2000	194	4/July
2001	203	22/July
2002	190	12/July
2003	190	14/July
2004	214	1/August
2005	237	31/July
2006	205	9/August
2007	191	14/July
2008	221	16/November
2009	212	22/July
2010	187	17/July
2011	209	30/July
2012	211	29/October
2013	232	23/July
2014	191	17/October

Table 3.5-3 Results of Water Level Probability Analysis at Cua Cam

Cam River-Cua Cam

Conformity degree evaluation calculation list

Exceedence probability;Water Level(cm)

Item \ Method		GUMBEL	GEV*I	LOGP3	SQRT-ET	
Return・Period	2-Year	203.62	202.84	203.42	202.81	
	5-year	220.52	217.66	217.75	216.49	
	10-year	231.70	227.68	226.88	225.78	
	20-year	242.42	237.44	235.42	234.87	
	25-year	245.82	240.57	238.09	237.79	
	30-year	248.61	243.12	240.26	240.18	
	50-year	256.33	250.30	246.26	246.90	
	100-year	266.73	260.10	254.28	256.10	
	200-Year	277.11	270.02	262.25	265.44	
	300-Year	283.16	275.88	266.91	270.97	
	500-Year	290.79	283.33	272.79	278.00	
SLSC		0.0412	0.0385	0.0422	0.0445	
Correlation Coefficient		0.9803	0.9800	0.9811	0.9799	
Estimate value		259.03	258.49	252.40	257.63	
Estimate error		13.1	19.3	12.3	13.6	
Candidate for adoption			○			

Number of sample N=15 **Maximum value=237cm**

Note1 :SLSC is Standard least-squares criterion regarding 100-Year Probability.

Note2 :Estimate value and error is a value by Jackknife Method regarding 100-year.

⇒ Method for evaluating the stability of probability model.

Note3 :○- Shall meet the SLSC≦0.04.

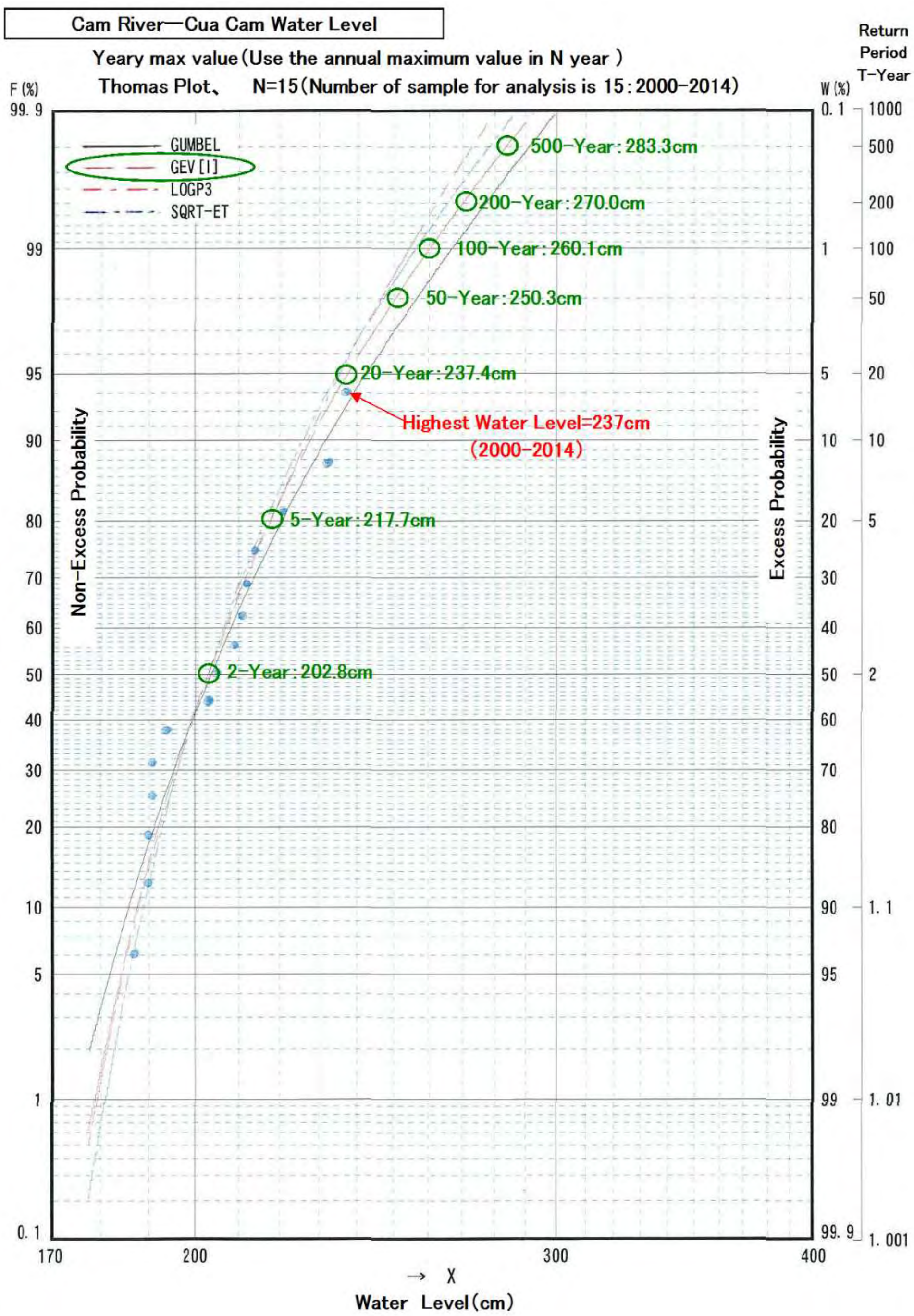


Figure 3.5-1 Cua Cam Water Level Probabilities Plotted on Distribution Graph

3.6 Scour Depth Calculation Methods

3.6.1 Method 1: Farraday and Charlton Equations

Basic Equations:

$y_2 = 0.38(V_1 \cdot y_1)^{0.67} \times D_{50}^{-0.17}$ (Sand Bed Channels)

$y_2 = 0.47(V_1 \cdot y_1)^{0.8} \times D_{90}^{-0.12}$ (Gravel Bed Channels)

$$y_2 = 51.4 n^{0.86} \times (V_1 \cdot y_1)^{0.86} \times \tau_C^{-0.43}$$ (Cohesive Bed Channels)

y_2 : Average Depth of General Scour (m)

y_1 : Average Flow Depth (m)

V_1 : Average Flow Velocity (m/s)

D_{50} : Size of the bed material D_{50} (mm)

D_{90} : Size of the bed material D_{90} (mm)

n : Manning's roughness coefficient

τ_C : Critical Tractive Stress – Refer to Table 3.2-1

Table 3.6-1 Critical Tractive Stress for Cohesive Bed Materials

Void Ratio	2.0–1.2	1.2–0.6	0.6–0.3	0.3–0.2
Dry Bulk Density (kg/m^3)	880–1,220	1,200–1,650	1,650–2,030	2,030–2,211
Saturated Bulk Density (kg/m^3)	1,550–1,740	1,740–2,030	2,030–2,270	2,270–2,370
Type of Soil	Critical Tractive Stress, N/m^2			
Sandy Clay	1.9	7.5	15.7	30.2
Heavy Clay	1.5	6.7	14.6	27.0
Clay	1.2	5.9	13.5	25.4
Loam Clay	1.0	4.6	10.2	16.8

Table 3.6-2 Multipliers for Estimating Total Scour Depth

Nature of Location	Multiplier
Nose of groynes or abutments	2.0 to 2.75
Flow imping at right angles on bank	2.25
Flow parallel to bank	1.5 to 2.0

Source: Farraday, R.V. and F.G. Charlton ; HYDRAULIC FACTORS IN BRIDGE DESIGN ; Hydraulics Research Station Limited, Wallingford, England ; 1983

3.6.2 Method 2: Blench Equations

Basic Equations:

$$y_2 = (q^2/F_b)^{0.33}$$

y_2 : Average Depth of General Scour (m)

q : Average Design Unit Discharge = $V_1 \cdot y_1$ (m^3/s)

F_b : "Zero Bed Factor" (m/s^2) - Find from graph below

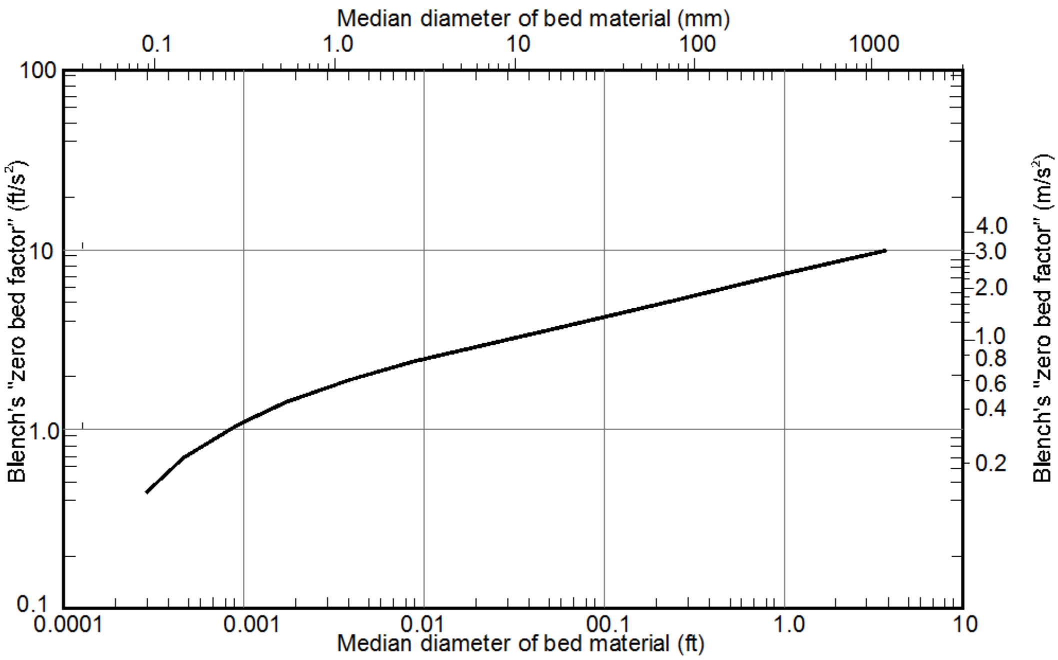


Figure 3.6-1 Relation of Blench's "Zero Bed Factor" to Size of Bed Material

Source: Blench, T. ; MOBILE-BED FLVIOLOGY ; University of Alberta Press ; Edmonton, Canada ; 1969.

3.7 Estimation of Design Wind Speed

3.7.1 Observation Data and Analysis of Wind Velocity

For wind direction and velocity, data from 1995 to 2014 at Phu Lien/Kien An is used as seen in Table 3.7-1.

Table 3.7-1 Wind Direction and Velocity Datum (1995-2014)

TỐC ĐỘ GIÓ
CAO NHẤT THÁNG HƯỚNG VÀ NGÀY XUẤT HIỆN
MAXIMUM WIND SPEED MONTHLY IN DIRECTION AND DATE
Trạm Phù Liễn , Kiến An, Hải Phòng / Station: Phu Lien, Kien An district, Hai Phong
Đơn vị tính : m/s Unit: m/s

Year \ Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Maximum
1995 dd	NW	N	SE	S	NE	S	SSE	NW	ENE	N	NNW	NNE	NW
FxFx	7	7	8	9	8	8	8	25	12	15	12	8	25
Date	4	2	1	20	4	7	7	4	29	3	7	28	4-VIII
1996	NE	SE	SE	S	S	SE	SSE	ESE	N	S	NE	NW	SSE
FxFx	7	7	11	10	10	10	38	35	12	8	10	7	38
Date	1	15	16	19	4	5	24	23	21	7	4	17	24-VII
1997	NNE	N	NE	NW	NW	NW	SE	NW	N	NE	NE	NE	NW
FxFx	7	6	8	24	9	18	9	33	10	7	10	10	33
Date	23	1	2	21	9	22	3	23	25	27	16	7	23-VIII
1998	E	SE	E	WNW	SW	N	SSE	NE	N	N	N	E	N
FxFx	8	9	8	20	18	21	10	10	30	8	8	10	30
Date	5	16	8	8	3	9	10	8	10	5	21	1	10-IX
1999	NE	ESE	SE	S	NNE	SE	NW	W	NE	SE	NNE	NNE	NW
FxFx	7	6	7	8	9	10	23	17	14	17	15	13	23
Date	9	4	9	23	4	14	25	27	20	16	1	22	25-VII
2000	SSE	SE	NNE	W	SE	SE	S	E	ENE	ESE	ENE	ENE	E
FxFx	12	10	10	14	13	15	19	24	14	18	13	11	24
Date	15	20	21	26	29	21	31	22	10	12	20	10	22-VIII
2001	SSE	NE	NE	NW	WSW	WNW	SW	NW	NE	W	NNE	N	WSW
FxFx	13	10	12	23	28	18	20	17	15	18	15	11	28
Date	7	24	8	29	9	10	16	25	12	26	5	10	9-V
2002	SSE	SE	SSE	SSE	NW	SSE	NNE	NNW	NE	N	N	NNE	NW
FxFx	10	11	12	14	19	16	16	14	16	13	10	16	19
Date	17	25	24	15	14	7	10	18	7	6	9	8	14-V
2003	NE	SSE	SSE	SE	NNW	NW	S	SSW	NE	NNE	S	NE	NW
FxFx	14	11	14	15	18	22	22	22	13	11	11	12	22
Date	6	9	5	10	18	14	22	26	8	14	7	19	14-VI
2004	S	NE,S	SE	S	SE,SSE	S	S	NW	NE	N	SE	NE	NE
FxFx	12	7	7	10	10	14	14	11	10	12	8	16	16
Date	15	3.14	3 ng	11,16	4 ,ng	26	18	29	8	2	3ng	18	18-XII
2005	E	SE	NE	NW	NW	NW	ESE	NW	ESE	SE	NE	NNE	ESE
FxFx	8	8	8	8	12	14	28	18	18	7	7	12	28
Date	21	14	4	4	28	23	31	16	19	20	15	22	31-VII
2006	SE	SSE	NNE	W	NNW	NW	SW	WNW	NE	N	NW	NW	SW
FxFx	10	8	8	16	11	13	16	10	10	9	13	6	16
Date	20	13	13	28	14	9	14	4	25	1	21	4	14 VII
2007	NE	SSE	SE	NW	SE	NW	SSW	NW	W	NNE	NNE	SSE	SE
FxFx	7	7	7	10	13	10	12	13	11	12	8	8	13
Date	4	18	2	18	19	16	5	12	3	2	27	21	19-V
2008	NNW	NNW	ESE	SE	N	SW	SW	NW	NW	SE	NE	NE	SW
FxFx	6	6	6	7	11	16	12	18	14	9	7	7	16
Date	6	8	18	16	10	27	6	24	4	31	20	5	27 VI
2009	NE	S	NE	SE	SE	NW	SSN	SSN	NNE	NW	NNE	N	SSN
FxFx	6	7	12	10	8	10	8	13	9	10	8	8	13
Date	9	16	13	12	1	3	4	16	8	14	2	27	16-VIII
2010	NE	SSE	NNE	NW	NW	NE	NE	SE	W	N	NW	NE	NE
FxFx	5	8	12	8	16	10	22	14	14	7	7	7	22
Date	11	10	25	22	15	11	17	24	22	3	3	16	17-VII
2011	NE	SE	NE	E	SE	NE	WNW	NW	NNW	WNW	NNE	N	NNW
FxFx	5	5	10	5	6	10	16	14	17	8	6	6	17
Date	1	10	16	5	2	24	8	24	30	1	8	1	30-IX
2012	NNE	SE	NNE	NNW	NNW	NNE	WNW	WNW	N	W	SE	NNE	W
FxFx	5	5	7	13	10	10	12	12	8	20	8	7	20
Date	4	1	23	7	15	19	23	18	13	29	17	2	29-X
2013	ESE	ESE	WNW	SSE	NW	NNW	SSE	SW	N	N	NW	NWN	NW
FxFx	6	10	11	9	12	10	10	15	10	7	18	7	18
Date	31	25	31	3	29	22	3	3	4	8	11	16	11-XI
2014	N	NE	SSE	W	SSW	SW	WNW	SSE	NW	N	NE	NE	NW
FxFx	7	7	8	9	9	9	8	10	18	9	7	17	18
Date	13	18	30	7	19	7	19	29	17	5	2	16	17-IX

Source: The Northeast Meteorologic Hydrologic Centre

(1) Characteristics of Wind Direction

Figure 3.7-1 shows a summary of the wind direction ratio when maximum wind velocity occurred during the 20-year record period, and Figure 3.7-2 shows a summary of the maximum wind velocity in each direction.

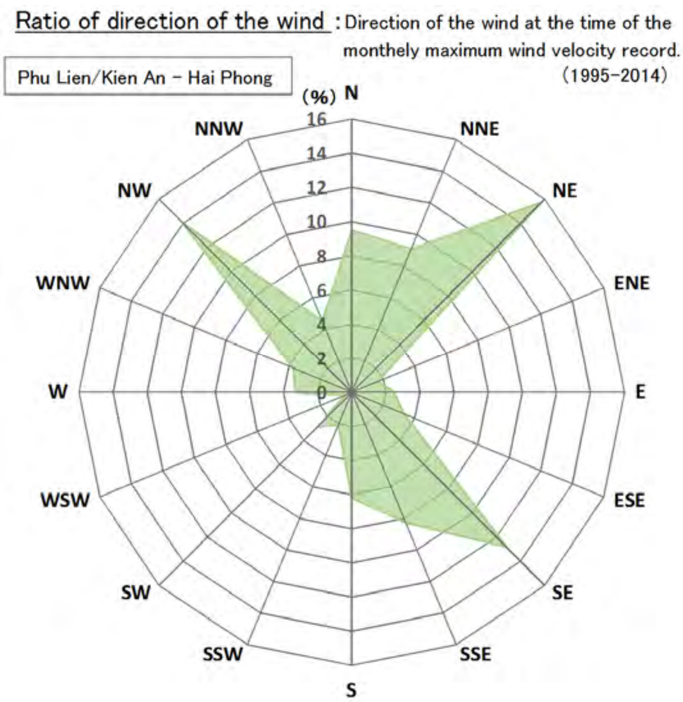


Figure 3.7-1 Wind Direction Ratio

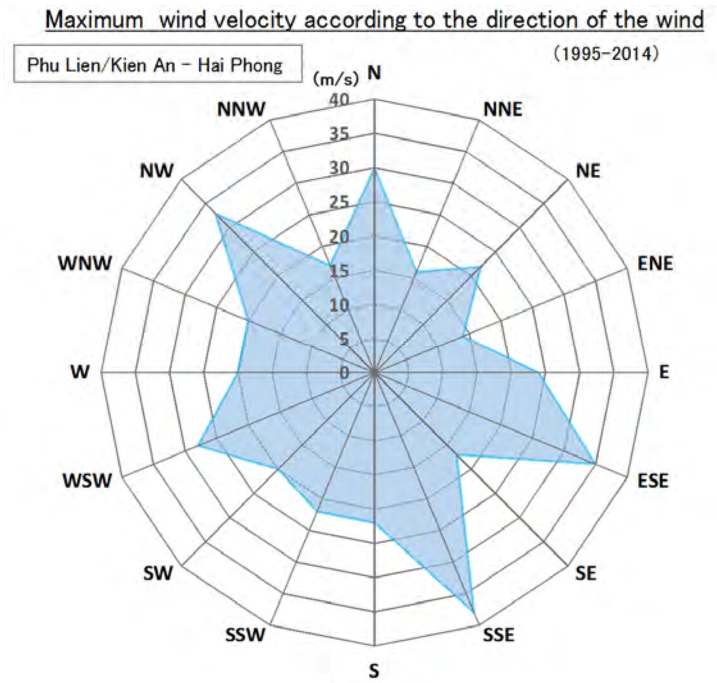


Figure 3.7-2 Maximum Wind Velocity in Each Direction

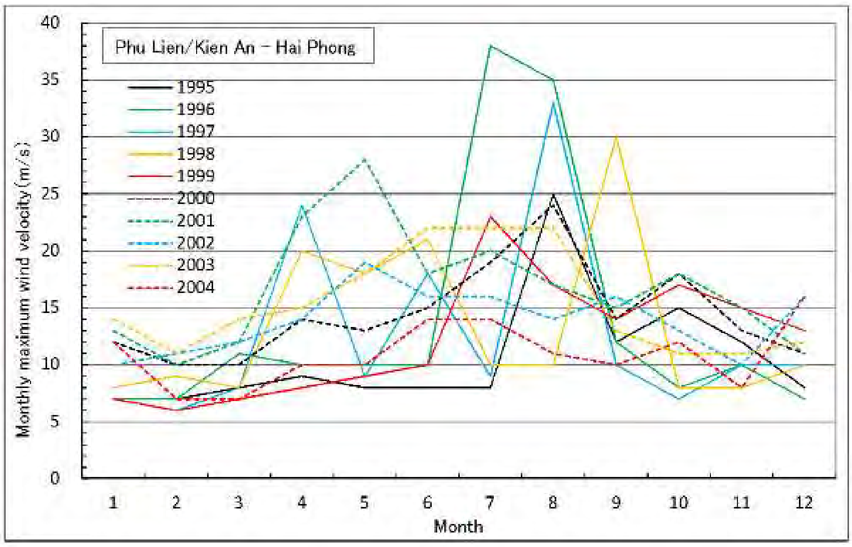
(2) Characteristics of Wind Velocity

Table 3.7-2 shows records of the monthly wind velocity from 1995 to 2014 and Figure 3.7-3 presents a summary for each year.

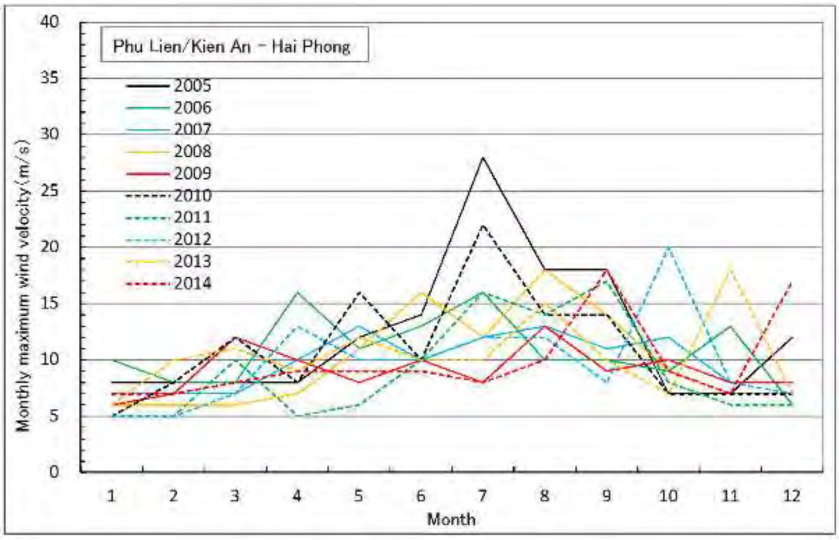
Table 3.7-2 List of Maximum Wind Velocity Phu Lien/Kien An (1995-2014)

Phu Lien/Kien An-Hai Phong — Maximum wind velocity (m/s)

Year \ Month	1	2	3	4	5	6	7	8	9	10	11	12
1995	7	7	8	9	8	8	8	**25**	12	15	12	8
1996	7	7	11	10	10	10	**38**	35	12	8	10	7
1997	7	6	8	24	9	18	9	**33**	10	7	10	10
1998	8	9	8	20	18	21	10	10	**30**	8	8	10
1999	7	6	7	8	9	10	**23**	17	14	17	15	13
2000	12	10	10	14	13	15	19	**24**	14	18	13	11
2001	13	10	12	23	**28**	18	20	17	15	18	15	11
2002	10	11	12	14	**19**	16	16	14	16	13	10	16
2003	14	11	14	15	18	**22**	**22**	**22**	13	11	11	12
2004	12	7	7	10	10	14	14	11	10	12	8	**16**
2005	8	8	8	8	12	14	**28**	18	18	7	7	12
2006	10	8	8	**16**	11	13	**16**	10	10	9	13	6
2007	7	7	7	10	**13**	10	12	**13**	11	12	8	8
2008	6	6	6	7	11	**16**	12	18	14	9	7	7
2009	6	7	12	10	8	10	8	**13**	9	10	8	8
2010	5	8	12	8	16	10	**22**	14	14	7	7	7
2011	5	5	10	5	6	10	16	14	**17**	8	6	6
2012	5	5	7	13	10	10	12	12	8	**20**	8	7
2013	6	10	11	9	12	10	10	15	10	7	**18**	7
2014	7	7	8	9	9	9	8	10	**18**	9	7	17



(a)1995-2004



(b) 2005-2014

Figure 3.7-3 Monthly Maximum Wind Velocity in Phu Lien/Kien An

(3) Probability Analysis for Wind Velocity

Table 3.7-3 summarizes the maximum wind velocity for each year at Phu Lien/ Kien An, Hai Phong, and probabilities have been calculated using these values.

Among the different probability distribution models, the following turned out to be a good fit:

1. Gumbel distribution(Gumbel)
2. Generalized Extreme Value distribution (GEV I)
3. Log Pearson type III distribution (LOGP3)
4. SQRT-exponential type maximum distribution (SQRT-ET)

In this distribution, the value of SLSC to evaluate fitness less than 0.04 are all models. Table 3.7-4 shows the results of the wind velocity probability analysis, and Figure 3.7-4 shows that 1 (Gumbel) best matches the probabilities for the wind velocity and is therefore selected.

Table 3.7-3 Maximum Wind Velocity Each Year at Phu Lien/ Kien An

Phu Lien/Kien An-Hai Phong

Year	day/Month	Maximum Velocity (m/s)	Wind direction
1995	4/August	25	NW
1996	24/July	38	SSE
1997	23/August	33	NW
1998	10/September	30	N
1999	25/July	23	NW
2000	22/August	24	E
2001	9/May	28	WSW
2002	19/May	19	NW
2003	14/June	22	NW
2004	18/December	16	NE
2005	28/July	28	ESE
2006	14/July	16	SW
2007	12/August	13	SE
2008	27/June	16	SW
2009	16/August	13	SSN
2010	17/July	22	NE
2011	30/September	17	NNW
2012	29/October	20	W
2013	11/November	18	NW
2014	17/September	18	NW

Table 3.7-4 Results of Wind Velocity Probability Analysis

Hai Phong - Wind Velocity

Conformity degree evaluation calculation list

Exceedence probability: Wind Velocity (m/s)

Item	Method	GUMBEL	GEV*I	LOGP3	SQRT-ET
Return・Period	2-Year	20.98	20.66	20.74	20.46
	3-year	24.30	23.61	23.64	23.31
	5-year	28.00	26.95	26.91	26.68
	10-year	32.65	31.24	31.07	31.22
	20-year	37.10	35.44	35.13	35.87
	30-year	39.67	37.90	37.51	38.68
	50-year	42.88	41.02	40.53	42.33
	100-year	47.20	45.30	44.71	47.49
	200-Year	51.51	49.66	49.00	52.91
	300-Year	54.03	52.25	51.58	56.21
	500-Year	57.20	55.55	54.89	60.48
SLSC		0.0264	0.0206	0.0257	0.0248
Correlation Coefficient		0.9948	0.9947	0.9950	0.9925
Estimate value		44.83	44.84	44.03	48.38
Estimate error		5.4	7.5	6.8	6.1
Candidate for adoption		◎	○	○	○

Number of sample N=20 **Maximum value=38m/s** Phu Lien/Kien An: 1995-2014

Note1 : SLSC is Standard least-squares criterion regarding 100-Year Probability.

Note2 : Estimate value and error is a value by Jackknife Method regarding 100-year.

⇒ Method for evaluating the stability of probability model.

Note3 : ○- Shall meet the SLSC≦0.04.

Note4 : ◎- Distribuntion form to adopt: Estimate Error is minimum in SLSC≦0.04.

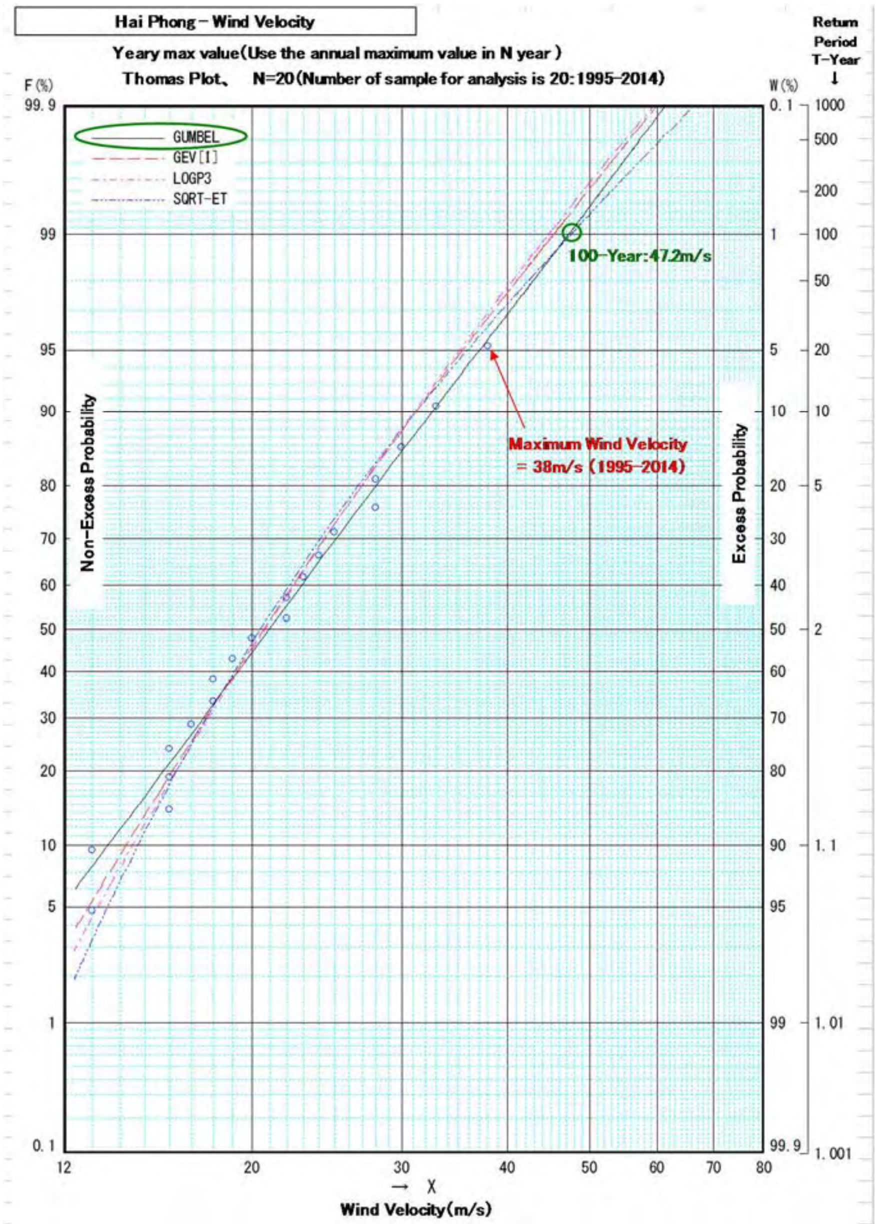


Figure 3.7-4 Probability Distribution Graph for Wind Velocity

Based on the observed data, the maximum design speed at the bridge site with a 100-year return period is 47.2m/s (2min average wind speed, H=12m from land, land height 115m), and this is thus also used as the design wind speed in Chapter 6.

3.7.2 Wind Load

(1) Design Wind Speed

The maximum wind speed obtained from the observed data and discussed in Chapter 3 is 47.2m/s (2min average wind speed, H=12m from land, land height is 115m). The observation point is located on a tree-covered hill, and the elevation and ground roughness are very different from the bridge sites. Here, the roughness category is set according to the Handbook on Wind Resistance

Design for Road Bridges as shown in Table 3.7-5, and the wind speed is estimated at the bridge locations. Although it is difficult to convert the wind speed because of the difference in altitude, the observation site is an independent peak and the conversion rate for flat ground was used for the correction.

Table 3.7-5 Wind Speed Conversion

Location	Roughness category	Modification factor E1	Height from land	Land height	Wind speed
Observation site	III	0.83	12m	115m	47.2m/s (2min)
Bridge site	II	1.00	10m	0m	37.9m/s (5min)

The average duration of wind speed is different from the 2min observation value and the 5min design value. Since past studies show this difference to be about 1.05 and it seems varied, this difference was ignored here.

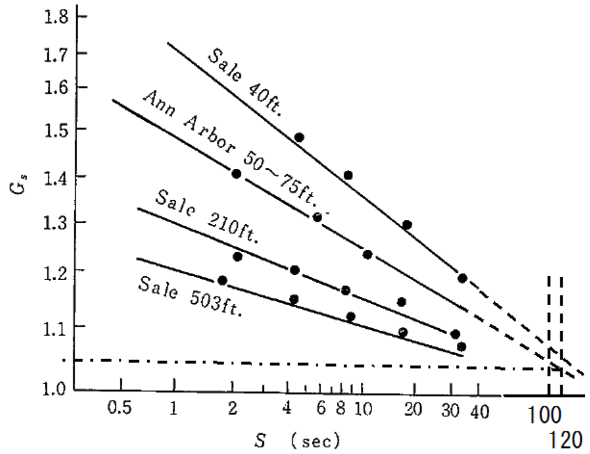


Figure 3.7-5 Example of Relation Gust Factor Gs and Evaluation Time S

Refer to KOUKYOIII

The design wind speed is estimated as follows.

$$V_{10} = V_m \times (\frac{z}{z_m})^{\alpha} = 31.4[m/s]$$

$$V_d = V_{10} \times (E_1) = 37.9[m/s]$$

V_m = observation data = 47.2[m/s] (2min average wind speed)

Z_m = observation elevation (height from land) = 127[m]

z = design elevation (height from land) = 10[m]

α = roughness factor = 0.16 (at bridge site, roughness category II)

$$E_1 = \text{modification factor} = {1.0(bridge\ site)}/{0.83(observation\ site)}$$

In addition to the above estimation, according to TCVN 2737-1995, the 3sec wind speed in Hai

Phong is 59m/sec, and the estimated 5min wind speed is about 39.3m/s - 34.7m/s with a gust factor of 1.5-1.7. This value is almost the same as the design wind speed of 37.9m/s.

Table 3.7-6 Values of V_B for Wind Zone in Vietnam

Wind zone according to TCVN 2737-1995	V_B (m/s)
I	38
II	45
III	53
IV	59

V_B : Basic 3-second gust wind speed with 100-year return period appropriate to the Wind Zone in which the bridge is located, as specified in Table 3.7-6:

The following equation is used for the design wind load for Nguyen Trai and Vu Yen Bridge.

$$p = 0.5\rho(V_d)^2 C_d G$$

Where:

p = wind pressure

ρ = mass density of air = 0.125 [kg s^2/m4]

C_d = drag coefficient

G = gust factor

V_d = design wind velocity 37.9 [m/s]

Appendix A4 TRAFFIC SURVEYS AND TRAFFIC DEMAND FORECAST

4.1 Results from the Traffic Count Survey

4.1.1 Daily Traffic Variation Calculations

For survey stations 1 to 4, traffic data was collected for 7 days while for survey stations 5 to 11, traffic data was only collected for 4 days in total, 3 weekdays and 1 weekend. In order to compare the daily traffic variation using the same baseline, the 4 day traffic data needed to be extrapolated.

For survey stations 5 to 11, traffic data was only collected for 4 days in total, 3 weekdays and 1 weekend. To get the daily traffic variation for 7 days for the 4 day survey stations, by traffic mode, first, the following equation was used to calculate the total traffic for 7 days for the 4 days survey station.

$$Total\ 7\ Days\ Traffic_{(4\ Days\ Survey\ Station)} = \underbrace{Total\ 4\ Days\ Traffic_{(4\ Days\ Survey\ Station)} \times \frac{1}{4\ Days}}_{\text{Average 1 Day Traffic (4 Days Survey Station)}} \times \underbrace{\frac{Average\ Traffic\ 7\ Days_{(7\ Days\ Survey\ Station)}}{Average\ Traffic\ 4\ Days_{(7\ Days\ Survey\ Station)}}}_{\text{Scaling Factor}} \times 7\ Days$$

Average 1 Day Traffic (4 Days Survey Station)

Scaling Factor

Once the total 7 days traffic for the 4 days survey station was calculated, the daily traffic for the missing days was calculated by mode by the following equation.

$$Traffic\ on\ Day\ x_{(4\ Days\ Survey\ Station)} = \underbrace{\frac{Average\ Day\ x\ Traffic_{(7\ Days\ Survey\ Station)}}{Total\ Average\ Traffic_{(7\ Days\ Survey\ Station)}}}_{\text{Proportion of the Average Daily Traffic by Day and by Mode (7 Day Survey Stations)}} \times Total\ 7\ Days\ Traffic_{(4\ Days\ Survey\ Station)}$$

Proportion of the Average Daily Traffic by Day and by Mode (7 Day Survey Stations)

The proportion of the average daily traffic by day and by mode for the 7 day survey stations (Stations 1-4) are shown as follows.

Table 4.1-1 Proportion of the Average Daily Traffic by Day and by Mode (7 Day Survey Stations)

Unit: vehicles

Average Daily Traffic the 7 Day Survey Stations (Stations 1-4)								
Traffic Mode	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Average for 7 Days
Bicycle	1,647	1,640	1,807	1,870	1,805	1,632	1,557	1,708
Cyclo	62	56	51	54	54	69	46	56
Motor-cycle	31,999	30,606	30,487	30,927	30,724	30,368	28,311	30,489
Car/Light Vehicles	4,577	4,520	4,674	4,688	4,518	4,785	4,408	4,595
Taxi	561	593	602	572	502	658	614	586
Minibus <=25 pax (Public/Private)	431	485	525	477	429	591	510	492
Medium and Large bus >25 pax (Public/Private)	758	650	668	653	716	750	745	706
Truck	8,443	8,939	9,009	9,435	9,214	8,035	5,515	8,370
Others	53	65	65	73	47	53	69	61
Total Vehicles	48,530	47,553	47,886	48,748	48,008	46,939	41,774	47,062

Proportion of the Average Daily Traffic by Day and by Mode for the 7 Day Survey Stations (Stations 1-4)								
Traffic Mode	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Total
Bicycle	13.77%	13.71%	15.11%	15.64%	15.10%	13.65%	13.02%	100.00%
Cyclo	15.88%	14.34%	12.93%	13.70%	13.70%	17.61%	11.84%	100.00%
Motor-cycle	14.99%	14.34%	14.28%	14.49%	14.40%	14.23%	13.27%	100.00%
Car/Light Vehicles	14.23%	14.05%	14.53%	14.57%	14.04%	14.87%	13.70%	100.00%
Taxi	13.68%	14.45%	14.68%	13.96%	12.23%	16.05%	14.96%	100.00%
Minibus <=25 pax (Public/Private)	12.51%	14.07%	15.23%	13.83%	12.43%	17.14%	14.79%	100.00%
Medium and Large bus >25 pax (Public/Private)	15.34%	13.15%	13.53%	13.23%	14.49%	15.19%	15.07%	100.00%
Truck	14.41%	15.26%	15.38%	16.10%	15.73%	13.71%	9.41%	100.00%
Others	12.54%	15.30%	15.19%	17.25%	11.12%	12.36%	16.24%	100.00%
Total Vehicles	14.73%	14.43%	14.54%	14.80%	14.57%	14.25%	12.68%	100.00%

An example for the calculation of the traffic volume for the days that were not surveyed for the 4 days survey station is shown below. In this example, at Survey Station 5 for the Truck vehicle type, Thursdays, Fridays and Saturdays were not surveyed.

Example of Estimating the Traffic Volume on the Non-Surveyed Days
Survey Station 5 (4 Days Survey Station)
Vehicle Type: Truck

Calculate the Total 4 Days Traffic (4 Days Survey Station)

Vehicle Type	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday		Sunday		Total Traffic Volume for the 4 Surveyed Days
Truck	1063	+	1048	+	836	+		+		+		+	982	=	3929

Calculate the Average 1 Day Traffic (4 Days Survey Station)

Vehicle Type	4 Day Total				Day Traffic (4 Days Survey Station)
Truck	3929	/	4	=	982

Calculate the Average Traffic for the Surveyed Days for the 4 Day Survey Station using the 7 Day Survey Station Data

Vehicle Type	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday		Sunday						Average Traffic for 4 Days (7 Days Survey Station)
Truck	8443	+	6651	+	9009	+		+		+		+	5274	=	29377	/	4	=	7344

Calculate the Scaling Factor for Estimating the 7 Day Traffic for the 4 Day Survey Station

Vehicle Type	Average Traffic 7 Days (7 Day Survey Station)		Average Traffic 4 Days (7 Days Survey Station)		Scaling Factor
Truck	7972	/	7344	=	1.085512

Calculate the Total 7 Days Traffic for the 4 Days Survey Station

Vehicle Type	Average 1 Day Trafffic (4 Days Survey Station)		Scaling Factor		7 Days		Total 7 Days Traffic (4 Days Survey Station)
Truck	982	*	1.085512	*	7	=	7464

Calculate the Traffic Volume for the Non-Surveyed Days

	Proportion of the Average Daily Traffic by Day and for the Truck Mode (7 Days Survey Station)		Total 7 Days Traffic (4 Days Survey Station)		Estimated Traffic for the Non-Surveyed Days
Thursday	16.10%	*	7464	=	1202
Friday	15.73%	*	7464	=	1174
Saturday	13.71%	*	7464	=	1024

Final Results

Vehicle Type	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Truck	1063	1048	836	1202	1174	1024	982

Figure 4.1-1 Example of Estimating the Traffic Volume on Non-Surveyed Days

4.1.2 Details for the Ratio of Daily Traffic to Daytime Traffic

The ratio of daily traffic to daytime traffic is the proportion between the 24 hour traffic volume and the 12 hour traffic volume and was calculated by the following equation by traffic mode. From the traffic survey, the car/light vehicle and taxi modes were aggregated to the car mode while minibuses and medium and large buses were aggregated to the bus mode for a more simplified analysis.

$$Ratio\ of\ Daily\ Traffic\ to\ Daytime\ Traffic = \frac{24\ Hour\ Traffic\ Volume\ by\ Mode}{12\ Hour\ Traffic\ Volume\ by\ Mode}$$

After examining the hourly traffic volume for the survey stations to see the traffic profile and morning and evening peak hours, it was determined to calculate the 12 hour traffic volume from 7:00 to 19:00.

The values for the ratio of daily traffic to daytime traffic for the 7 day and 4 day survey stations for all survey days as well as the 7 day and 4 day averages are shown in the following tables.

Table 4.1-2 Ratio of Daily Traffic to Daytime Traffic for the 7 Day Survey Stations

7 Day Survey Stations – Ratio of Daily Traffic to Daytime Traffic								
(1) QL5, Nomura Industrial Park	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**	**7 Day Average**
Motorcycles	1.37	1.41	1.40	1.41	1.39	1.35	1.31	1.38
Cars	1.37	1.34	1.31	1.34	1.41	1.38	1.39	1.37
Buses	1.27	1.28	1.32	1.33	1.29	1.31	1.42	1.32
Trucks	1.63	1.67	1.66	1.69	1.70	1.72	1.74	1.69
(2) QL10, Kien Bridge	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**	**7 Day Average**
Motorcycles	1.36	1.39	1.31	1.31	1.30	1.28	1.25	1.31
Cars	1.34	1.33	1.34	1.34	1.45	1.36	1.34	1.36
Buses	1.33	1.41	1.34	1.29	1.33	1.37	1.45	1.36
Trucks	1.49	1.47	1.51	1.49	1.55	1.64	1.65	1.54
(3) TL359, Binh Bridge	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**	**7 Day Average**
Motorcycles	1.31	1.31	1.33	1.31	1.34	1.30	1.29	1.31
Cars	1.33	1.33	1.32	1.28	1.34	1.33	1.32	1.32
Buses	1.33	1.29	1.42	1.31	1.36	1.43	1.57	1.39
Trucks	1.26	1.32	1.29	1.27	1.32	1.30	1.36	1.30
(4) AH14, Dong Hai Bridge	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**	**7 Day Average**
Motorcycles	1.27	1.27	1.29	1.29	1.28	1.27	1.34	1.29
Cars	1.26	1.29	1.29	1.29	1.31	1.29	1.39	1.30
Buses	1.23	1.34	1.35	1.25	1.32	1.30	1.61	1.35
Trucks	1.67	1.76	1.73	1.82	1.77	1.75	1.75	1.75

Note: Arithmetic mean used to calculate the average

Source: Study Team

Table 4.1-3 Ratio of Daily Traffic to Daytime Traffic for the 4 Day Survey Stations

4 Day Survey Stations – Ratio of Daily Traffic to Daytime Traffic								
(5) TL 352, Si Bridge	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**	**4 Day Average**
Motorcycles	1.46	1.44	1.40				1.31	1.40
Cars	1.32	1.27	1.35				1.22	1.29
Buses	1.47	1.37	1.11				1.71	1.41
Trucks	1.15	1.15	1.16				1.18	1.16
(6) QL10, Gia Bridge	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**	**4 Day Average**
Motorcycles			1.37	1.22	1.44	1.37		1.35
Cars			1.35	1.30	1.44	1.32		1.35
Buses			1.43	1.25	1.37	1.37		1.35
Trucks			1.56	1.52	1.55	1.56		1.55
(7) TL359, Thuy Trieu/Ngu Lao	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**	**4 Day Average**
Motorcycles			1.33	1.31	1.35	1.33		1.33
Cars			1.28	1.25	1.28	1.35		1.29
Buses			1.37	1.42	1.48	1.43		1.42
Trucks			1.35	1.39	1.37	1.38		1.37
(8) QL10, Tram Bac Bridge	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**	**4 Day Average**
Motorcycles	1.34	1.40	1.33				1.26	1.33
Cars	1.27	1.36	1.37				1.29	1.32
Buses	1.36	1.43	1.33				1.47	1.40
Trucks	1.53	1.52	1.49				1.61	1.54
(9) Phan Dang Luu St., Kien An Bridge	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**	**4 Day Average**
Motorcycles			1.32	1.32	1.32	1.30		1.32
Cars			1.31	1.32	1.37	1.29		1.32
Buses			1.38	1.43	1.37	1.62		1.45
Trucks			1.28	1.26	1.24	1.25		1.26
(10) Truong Chinh Street, Niem Bridge	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**	**4 Day Average**
Motorcycles			1.28	1.30	1.31	1.38		1.32
Cars			1.36	1.36	1.39	1.40		1.38
Buses			1.38	1.34	1.36	1.43		1.38
Trucks			1.35	1.38	1.48	1.62		1.46
(11) Pham Van Dong St.	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**	**4 Day Average**
Motorcycles	1.27	1.25	1.27				1.28	1.27
Cars	1.40	1.37	1.43				1.36	1.39
Buses	1.26	1.25	1.34				1.25	1.27
Trucks	1.16	1.16	1.20				1.23	1.19

Note: Arithmetic mean used to calculate the average

Source: Study Team

4.1.3 Details for the Peak Ratio

Peak ratio values for all days of the week as well as average values for weekdays and weekends for all survey stations are shown as follows.

Table 4.1-4 Peak Ratio for Survey Stations 1 and 2

(1) QL5, Nomura Industrial Park										
Inbound										
	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**	**7 Day Mean**	**Weekday Mean**	**Weekend Mean**
Motorcycles	0.32	0.33	0.28	0.26	0.29	0.22	0.13	0.26	0.29	0.17
Cars	0.10	0.11	0.12	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Buses	0.11	0.14	0.13	0.14	0.13	0.12	0.15	0.13	0.13	0.13
Trucks	0.12	0.12	0.11	0.12	0.13	0.13	0.12	0.12	0.12	0.12
Outbound										
	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**	**7 Day Mean**	**Weekday Mean**	**Weekend Mean**
Motorcycles	0.22	0.21	0.22	0.20	0.22	0.18	0.14	0.20	0.21	0.16
Cars	0.10	0.10	0.11	0.10	0.10	0.10	0.12	0.11	0.10	0.11
Buses	0.14	0.13	0.15	0.12	0.13	0.15	0.14	0.14	0.13	0.15
Trucks	0.10	0.11	0.11	0.12	0.12	0.12	0.11	0.11	0.11	0.11
(2) QL10, Kien Bridge										
Inbound										
	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**	**7 Day Mean**	**Weekday Mean**	**Weekend Mean**
Motorcycles	0.20	0.20	0.17	0.16	0.17	0.16	0.11	0.17	0.18	0.14
Cars	0.12	0.12	0.11	0.11	0.12	0.20	0.12	0.13	0.12	0.16
Buses	0.15	0.16	0.13	0.12	0.15	0.12	0.15	0.14	0.14	0.14
Trucks	0.12	0.12	0.12	0.12	0.11	0.12	0.11	0.12	0.12	0.12
Outbound										
	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**	**7 Day Mean**	**Weekday Mean**	**Weekend Mean**
Motorcycles	0.16	0.17	0.18	0.16	0.18	0.15	0.13	0.16	0.17	0.14
Cars	0.11	0.11	0.10	0.11	0.12	0.11	0.13	0.11	0.11	0.12
Buses	0.14	0.13	0.14	0.14	0.14	0.14	0.25	0.15	0.14	0.19
Trucks	0.11	0.12	0.11	0.11	0.11	0.10	0.11	0.11	0.11	0.11

Note: Arithmetic mean used to calculate the average

Source: Study Team

Table 4.1-5 Peak Ratio for Survey Stations 3 and 4

(3) TL359, Binh Bridge									
Inbound									
	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**	**7 Day Mean**	**Weekday Mean**	**Weekend Mean**
Motorcycles	0.18	0.16	0.15	0.18	0.17	0.15	0.12	0.16	0.17	0.14
Cars	0.13	0.12	0.12	0.11	0.13	0.11	0.13	0.12	0.12	0.12
Buses	0.16	0.18	0.21	0.18	0.15	0.13	0.16	0.17	0.17	0.14
Trucks	0.12	0.12	0.13	0.12	0.12	0.13	0.12	0.12	0.12	0.12
Outbound										
	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**	**7 Day Mean**	**Weekday Mean**	**Weekend Mean**
Motorcycles	0.14	0.14	0.14	0.14	0.15	0.13	0.12	0.14	0.14	0.13
Cars	0.11	0.11	0.11	0.12	0.11	0.12	0.12	0.11	0.11	0.12
Buses	0.16	0.17	0.16	0.15	0.16	0.16	0.24	0.17	0.16	0.20
Trucks	0.12	0.12	0.12	0.13	0.14	0.12	0.12	0.13	0.13	0.12
(4) AH14, Dong Hai Bridge										
Inbound										
	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**	**7 Day Mean**	**Weekday Mean**	**Weekend Mean**
Motorcycles	0.18	0.18	0.16	0.18	0.17	0.14	0.11	0.16	0.17	0.13
Cars	0.14	0.11	0.11	0.16	0.12	0.11	0.10	0.12	0.13	0.11
Buses	0.20	0.20	0.21	0.23	0.13	0.17	0.18	0.19	0.19	0.17
Trucks	0.11	0.11	0.12	0.14	0.13	0.12	0.10	0.12	0.12	0.11
Outbound										
	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**	**7 Day Mean**	**Weekday Mean**	**Weekend Mean**
Motorcycles	0.26	0.24	0.23	0.23	0.23	0.24	0.13	0.22	0.24	0.18
Cars	0.16	0.18	0.14	0.15	0.15	0.14	0.12	0.15	0.15	0.13
Buses	0.21	0.26	0.24	0.18	0.25	0.29	0.18	0.23	0.23	0.23
Trucks	0.11	0.11	0.12	0.11	0.11	0.11	0.10	0.11	0.11	0.11

Note: Arithmetic mean used to calculate the average

Source: Study Team

Table 4.1-6 Peak Ratio for Survey Stations 5 and 6

(5) TL 352, Si Bridge										
Inbound										
	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**	**4 Day Mean**	**Weekday Mean**	**Weekend**
Motorcycles	0.44	0.43	0.38				0.15	0.35	0.42	0.15
Cars	0.11	0.15	0.12				0.13	0.13	0.13	0.13
Buses	0.15	0.22	0.25				0.25	0.22	0.21	0.25
Trucks	0.14	0.12	0.14				0.13	0.13	0.13	0.13
Outbound										
	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**	**4 Day Mean**	**Weekday Mean**	**Weekend**
Motorcycles	0.21	0.22	0.19				0.12	0.18	0.21	0.12
Cars	0.12	0.14	0.11				0.18	0.14	0.12	0.18
Buses	0.23	0.20	0.14				0.18	0.19	0.19	0.18
Trucks	0.13	0.13	0.13				0.14	0.13	0.13	0.14
(6) QL10, Gia Bridge										
Inbound										
	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**	**4 Day Mean**	**Weekday Mean**	**Weekend**
Motorcycles			0.21	0.21	0.20	0.16		0.19	0.21	0.16
Cars			0.13	0.13	0.12	0.14		0.13	0.13	0.14
Buses			0.15	0.15	0.12	0.14		0.14	0.14	0.14
Trucks			0.11	0.11	0.11	0.11		0.11	0.11	0.11
Outbound										
	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**	**4 Day Mean**	**Weekday Mean**	**Weekend**
Motorcycles			0.17	0.17	0.17	0.14		0.16	0.17	0.14
Cars			0.13	0.13	0.10	0.12		0.12	0.12	0.12
Buses			0.14	0.14	0.11	0.17		0.14	0.13	0.17
Trucks			0.14	0.14	0.12	0.10		0.13	0.14	0.10

Note: Arithmetic mean used to calculate the average

Source: Study Team

Table 4.1-7 Peak Ratio for Survey Stations 7 and 8

(7) TL359, Thuy Trieu/Ngu Lao										
Inbound										
	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**	**4 Day Mean**	**Weekday Mean**	**Weekend**
Motorcycles			0.16	0.15	0.16	0.13		0.15	0.16	0.13
Cars			0.15	0.13	0.14	0.13		0.14	0.14	0.13
Buses			0.16	0.16	0.14	0.20		0.17	0.15	0.20
Trucks			0.11	0.13	0.11	0.13		0.12	0.12	0.13
Outbound										
	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**	**4 Day Mean**	**Weekday Mean**	**Weekend**
Motorcycles			0.15	0.14	0.16	0.13		0.14	0.15	0.13
Cars			0.12	0.11	0.13	0.12		0.12	0.12	0.12
Buses			0.23	0.24	0.28	0.13		0.22	0.25	0.13
Trucks			0.11	0.12	0.12	0.13		0.12	0.11	0.13
(8) QL10, Tram Bac Bridge										
Inbound										
	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sun day**	**4 Day Mean**	**Weekday Mean**	**Weekend**
Motorcycles	0.38	0.43	0.40				0.14	0.34	0.40	0.14
Cars	0.14	0.15	0.11				0.15	0.14	0.13	0.15
Buses	0.13	0.15	0.12				0.18	0.15	0.13	0.18
Trucks	0.13	0.13	0.12				0.11	0.12	0.13	0.11
Outbound										
	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**	**4 Day Mean**	**Weekday Mean**	**Weekend**
Motorcycles	0.27	0.26	0.26				0.14	0.24	0.27	0.14
Cars	0.11	0.14	0.12				0.15	0.13	0.12	0.15
Buses	0.13	0.15	0.12				0.18	0.15	0.13	0.18
Trucks	0.10	0.11	0.11				0.11	0.11	0.11	0.11

Note: Arithmetic mean used to calculate the average

Source: Study Team

Table 4.1-8 Peak Ratio for Survey Stations 9 and 10

(9) Phan Dang Luu St., Kien An Bridge

Inbound

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	4 Day Mean	Weekday Mean	Weekend
Motorcycles			0.19	0.19	0.20	0.18		0.19	0.19	0.18
Cars			0.10	0.11	0.11	0.12		0.11	0.11	0.12
Buses			0.28	0.13	0.18	0.13		0.18	0.20	0.13
Trucks			0.11	0.11	0.10	0.11		0.11	0.11	0.11

Outbound

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	4 Day Mean	Weekday Mean	Weekend
Motorcycles			0.21	0.21	0.22	0.20		0.21	0.21	0.20
Cars			0.11	0.12	0.11	0.11		0.11	0.11	0.11
Buses			0.16	0.18	0.19	0.23		0.19	0.18	0.23
Trucks			0.12	0.12	0.10	0.11		0.11	0.11	0.11

(10) Truong Chinh Street, Niem Bridge

Inbound

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	4 Day Mean	Weekday Mean	Weekend
Motorcycles			0.18	0.17	0.19	0.13		0.17	0.18	0.13
Cars			0.10	0.12	0.11	0.11		0.11	0.11	0.11
Buses			0.11	0.12	0.13	0.14		0.13	0.12	0.14
Trucks			0.12	0.13	0.13	0.13		0.13	0.13	0.13

Outbound

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	4 Day Mean	Weekday Mean	Weekend
Motorcycles			0.16	0.16	0.16	0.13		0.15	0.16	0.13
Cars			0.10	0.10	0.10	0.11		0.10	0.10	0.11
Buses			0.11	0.11	0.10	0.11		0.11	0.11	0.11
Trucks			0.13	0.15	0.13	0.11		0.13	0.14	0.11

Note: Arithmetic mean used to calculate the average

Source: Study Team

Table 4.1-9 Peak Ratio for Survey Station 11

(11) Pham Van Dong St.

Inbound

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	4 Day Mean	Weekday Mean	Weekend
Motorcycles	0.19	0.18	0.19				0.11	0.17	0.19	0.11
Cars	0.14	0.13	0.12				0.12	0.13	0.13	0.12
Buses	0.17	0.13	0.20				0.11	0.15	0.17	0.11
Trucks	0.12	0.13	0.11				0.11	0.12	0.12	0.11

Outbound

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	4 Day Mean	Weekday Mean	Weekend
Motorcycles	0.15	0.18	0.14				0.10	0.14	0.16	0.10
Cars	0.11	0.11	0.10				0.11	0.11	0.11	0.11
Buses	0.12	0.11	0.11				0.12	0.11	0.11	0.12
Trucks	0.13	0.11	0.12				0.12	0.12	0.12	0.12

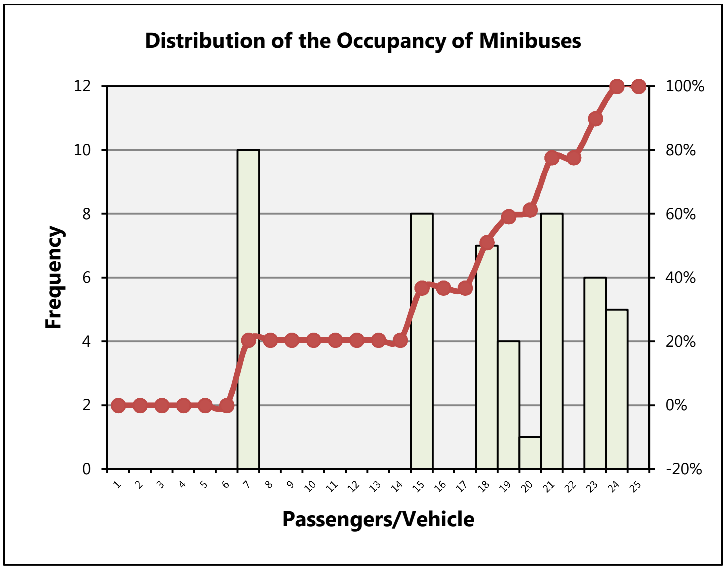
Note: Arithmetic mean used to calculate the average

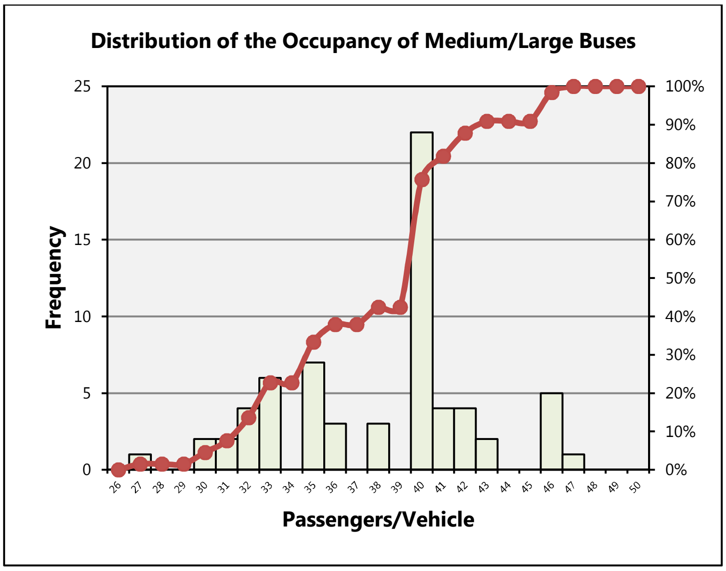
Source: Study Team

4.2 Calculations for the Analysis of the Vehicle Occupancy Survey

For the bicycle, cyclo, motorcycle, car/light vehicles and taxi modes, because the occupancies for these vehicle types generally do not vary by much, the arithmetic mean was used. For the minibus and medium and large bus modes, because the occupancies can vary, the weighted arithmetic mean was used to calculate the average for all survey stations based on the number of vehicles surveyed at each station.

The distribution and cumulative distribution of the vehicle occupancies for minibuses and medium and large buses are shown as follows.





Source: Study Team

Figure 4.2-1 Distribution for Vehicle Occupancies for Minibuses and Medium and Large Buses

4.3 Results from the Roadside Origin Destination Survey

The roadside OD interview survey was carried out at the roadside at approximately the same locations as the traffic count and vehicle occupancy surveys by the local contractor with the support of the Traffic Police.

The roadside OD interview survey was conducted at 4 locations for 2 weekdays and 1 weekend day and at 7 locations for 1 weekday and 1 weekend day.

This information is summarized as follows.

Table 4.3-1 Summary of the Roadside OD Interview Survey

Survey Station	Survey Hours	Survey Days (weekday)	Survey Days (weekend)	Total Survey Days
(1) QL5, Nomura Industrial Park	12	2	1	3
(2) QL10, Kien Bridge	12	2	1	3
(3) TL359, Binh Bridge	12	2	1	3
(4) AH14, Dong Hai Bridge	12	2	1	3
(5) TL352, Si Bridge	12	1	1	2
(6) QL10, Gia Bridge	12	1	1	2
(7) TL359, Thuy Trieu/Ngu Lao	12	1	1	2
(8) QL10, Tram Bac Bridge	12	1	1	2
(9) Phan Dang Luu St., Kien An Bridge	12	1	1	2
(10) Truong Chinh Street (at Niem Bridge)	12	1	1	2
(11) Pham Van Dong St.	12	1	1	2

Source: Study Team

(1) Private Mode Drivers

The total number of persons interviewed for drivers of private modes for all 11 survey stations were 12,195. The breakdown by travel mode by numbers is shown in the following table and the proportion is shown in the figure below. A large majority of those interviewed were motorcycle drivers at 78.5%.

The sampling rate for all vehicles by survey station as well as by vehicle type by survey station is also shown as follows.

Table 4.3-2 Number of Private Mode Drivers Interviewed by Survey Station

Survey Station	Private Drivers Interviewed					Total Traffic Count*	Sampling Rate
	Bicycle - driver	Motorcycle - driver	Car - driver	Others	Total Respondents/Survey Station		
(1) QL5, Nomura Industrial Park	29	801	225	17	1,072	66,672	1.61%
(2) QL10, Kien Bridge	0	637	133	0	770	29,693	2.59%
(3) TL359, Binh Bridge	0	922	339	2	1,263	80,086	1.58%
(4) AH14, Dong Hai Bridge	51	877	268	0	1,196	45,015	2.66%
(5) TL352, Si Bridge	22	793	154	5	974	23,612	4.12%
(6) QL10, Gia Bridge	9	705	225	0	939	31,430	2.99%
(7) TL359, Thuy Trieu/Ngu Lao	82	639	293	0	1,014	27,499	3.69%
(8) QL10, Tram Bac Bridge	2	793	193	0	988	23,021	4.29%
(9) Phan Dang Luu St., Kien An Bridge	114	841	159	0	1,114	30,584	3.64%
(10) Truong Chinh Street (at Niem Bridge)	0	1,113	280	0	1,393	142,702	0.98%
(11) Pham Van Dong St.	1	1,447	24	0	1,472	37,128	3.96%
Total	310	9,568	2,293	24	12,195	537,441	2.27%

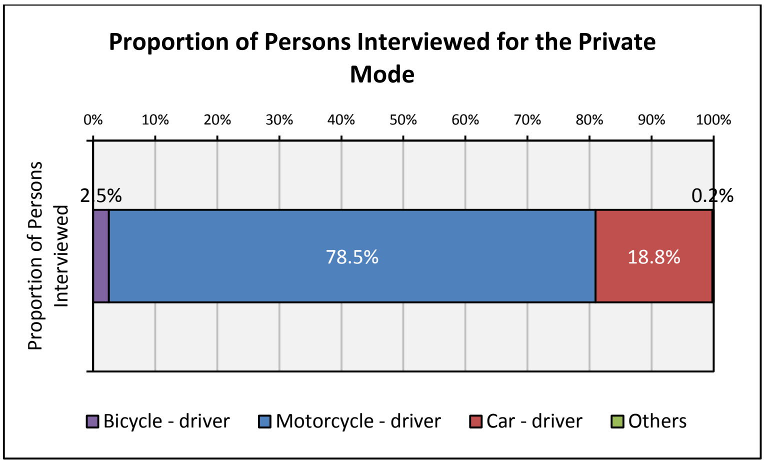
Note: *Total Traffic Count for each survey station was re-proportioned based on the number of days and hours of the OD roadside interview survey because the traffic count survey was conducted for 24 hours/7 days for survey stations 1-4 and 24 hours/4 days for survey stations 5-11 while the OD roadside interview survey was conducted for 12 hours/3 days for survey stations 1-4 and 12 hours/2 days for survey stations 5-11.

Source: Study Team

Table 4.3-3 Sampling Rate by Private Mode

Survey Station	Sampling Rate by Vehicle Type			
	Bicycle - driver	Motorcycle - driver	Car - driver	Others
(1) QL5, Nomura Industrial Park	1.03%	1.51%	2.08%	13.03%
(2) QL10, Kien Bridge	0.00%	2.55%	3.39%	0.00%
(3) TL359, Binh Bridge	0.00%	1.36%	4.47%	1.90%
(4) AH14, Dong Hai Bridge	2.54%	2.34%	4.98%	0.00%
(5) TL352, Si Bridge	0.70%	4.04%	19.43%	6.87%
(6) QL10, Gia Bridge	0.34%	2.82%	6.06%	0.00%
(7) TL359, Thuy Trieu/Ngu Lao	2.58%	2.82%	18.86%	0.00%
(8) QL10, Tram Bac Bridge	0.45%	3.96%	7.71%	0.00%
(9) Phan Dang Luu St., Kien An Bridge	4.11%	3.27%	7.91%	0.00%
(10) Truong Chinh Street (at Niem Bridge)	0.00%	0.90%	4.05%	0.00%
(11) Pham Van Dong St.	0.03%	4.97%	0.47%	0.00%
Total:	0.84%	2.13%	4.56%	3.02%

Source: Study Team



Source: Study Team

Figure 4.3-1 Proportion of Persons Interviewed for the Private Mode for All Survey Stations

1) Average Travel Time by Mode for Private Drivers

The travel mode with the longest average travel time was car drivers with an average travel time of 31.78 minutes. The average travel time for both cars and motorcycles was observed to be roughly the same. On the other hand, the mode with the shortest average travel time was bicycle riders with an average travel time of 13.48 minutes.

Table 4.3-4 Summary of the Average Travel Time by Private Mode

	Bicycle	Motorcycle	Car	Others
Average Travel Time	13.48	31.55	31.78	15.60
Sample Size	310	9,568	2,293	24
Note: Average travel time was calculated using the geometric mean				

Source: Study Team

2) Descriptive Statistics for the Average Travel Time by Mode for Private Drivers

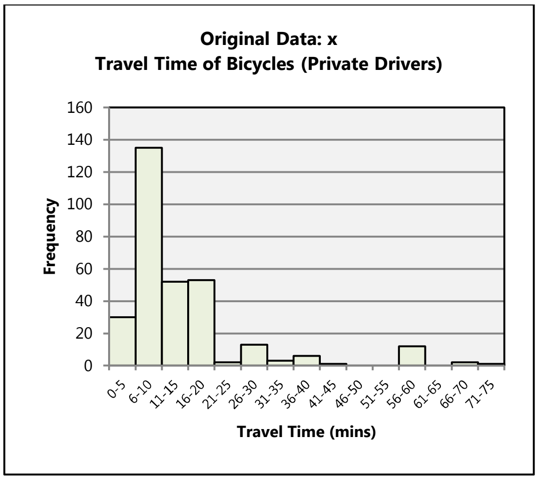
The descriptive statistics for average travel time by private mode is shown in the table as follows.

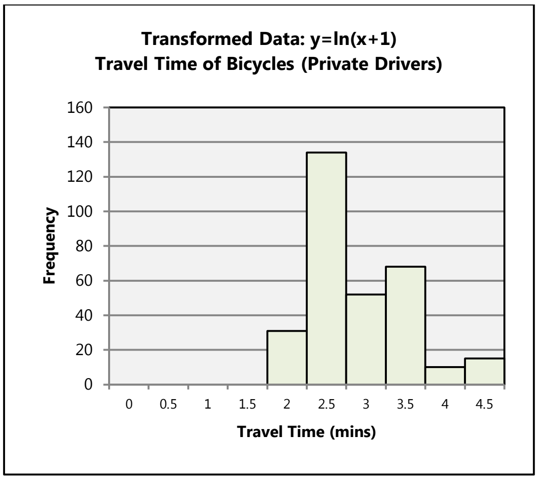
Table 4.3-5 Summary of the Descriptive Statistics of Travel Time by Private Mode

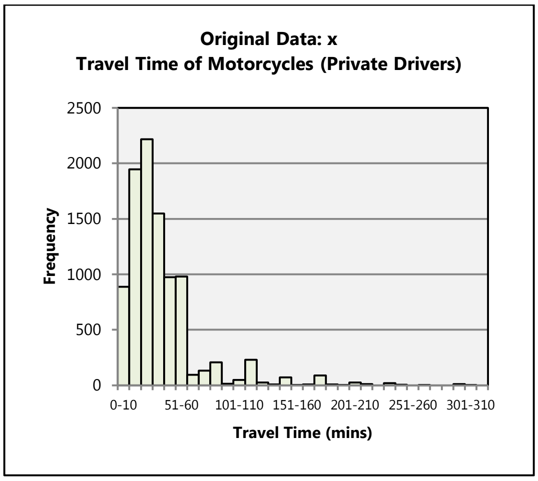
Descriptive Statistic of Travel Time	Bicycle	Motorcycle	Car	Others
Mean (mins)	13.64	31.83	32.10	15.87
Lower Confidence Interval (95%)	12.76	31.38	31.07	11.62
Upper Confidence Interval (95%)	14.57	32.28	33.15	21.54
Sample Size	310	9,568	2,293	24
Note: Data was transformed by using the following formula: Original Data = x, Transformed Data = y=ln(x+1), Reconverted Data = z=exp(y)-1				

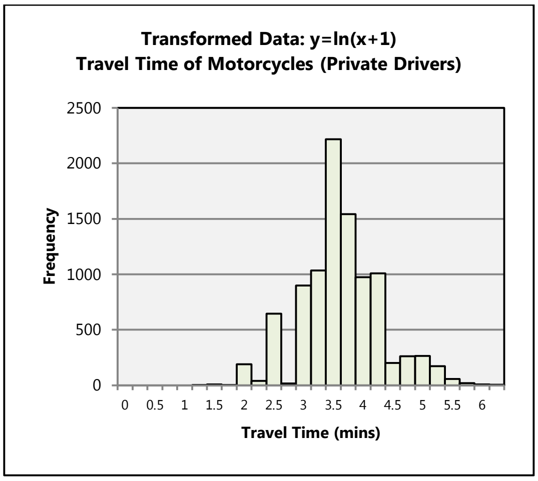
Source: Study Team

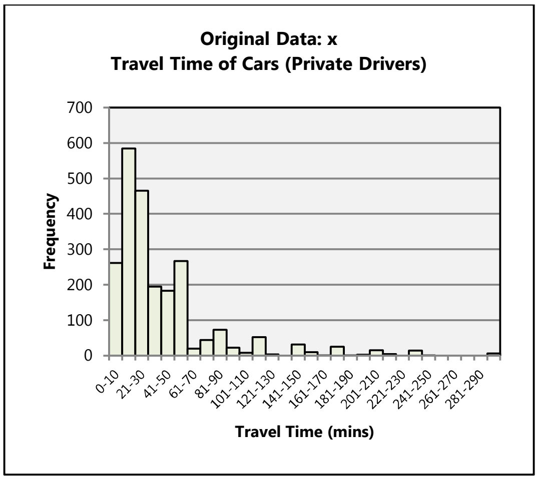
Histograms for the travel time of each mode are shown as follows and it can be seen that the distribution for the travel time for each mode are log-normal and therefore the original data was transformed by a natural logarithm function to obtain a normal distribution in the natural logarithm domain in order to calculate the arithmetic mean and confidence intervals and the data was then transformed back into the original units by taking an exponential function.

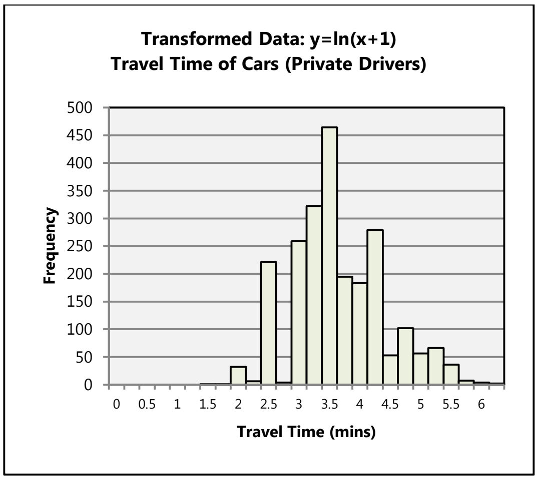

Original Data: x
Travel Time of Bicycles (Private Drivers)
Frequency
0 20 40 60 80 100 120 140 160
0-5 6-10 11-15 16-20 21-25 26-30 31-35 36-40 41-45 46-50 51-55 56-60 61-65 66-70 71-75
Travel Time (mins)


Transformed Data: y=ln(x+1)
Travel Time of Bicycles (Private Drivers)
Frequency
0 20 40 60 80 100 120 140 160
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5
Travel Time (mins)


Original Data: x
Travel Time of Motorcycles (Private Drivers)
Frequency
0 500 1000 1500 2000 2500
0-10 51-60 101-110 151-160 201-210 251-260 301-310
Travel Time (mins)


Transformed Data: y=ln(x+1)
Travel Time of Motorcycles (Private Drivers)
Frequency
0 500 1000 1500 2000 2500
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6
Travel Time (mins)


Original Data: x
Travel Time of Cars (Private Drivers)
Frequency
0 100 200 300 400 500 600 700
0-10 21-30 41-50 61-70 81-90 101-110 121-130 141-150 161-170 181-190 201-210 221-230 241-250 261-270 281-290
Travel Time (mins)


Transformed Data: y=ln(x+1)
Travel Time of Cars (Private Drivers)
Frequency
0 50 100 150 200 250 300 350 400 450 500
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6
Travel Time (mins)

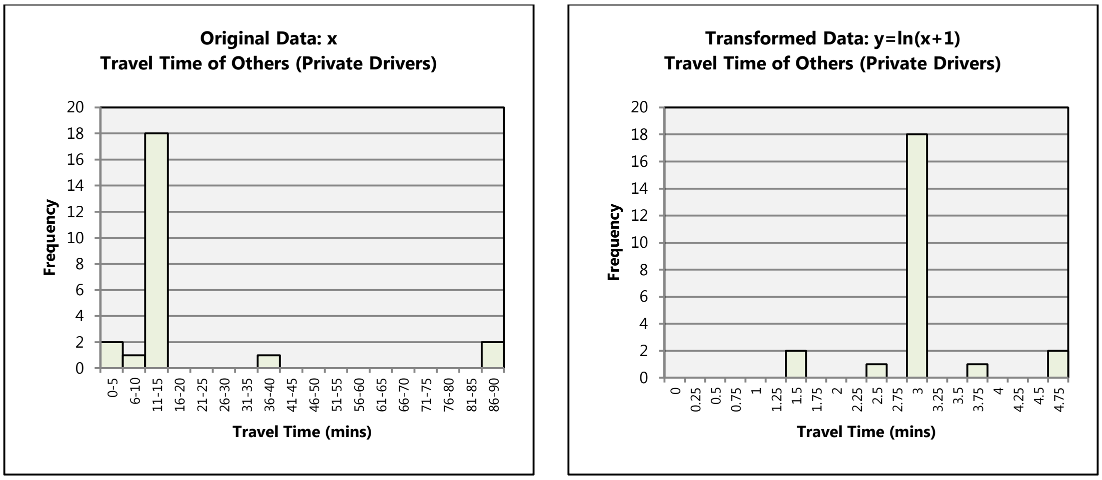
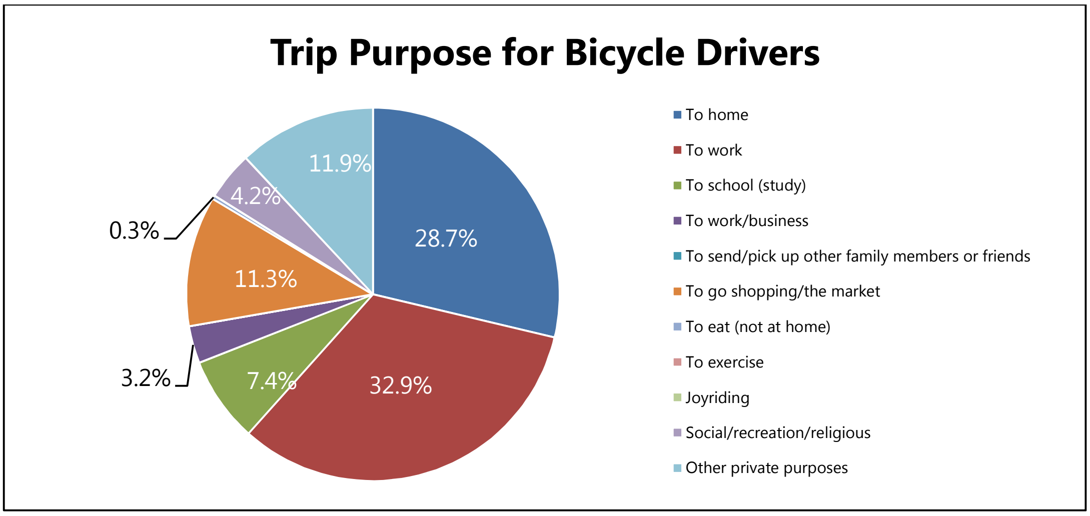
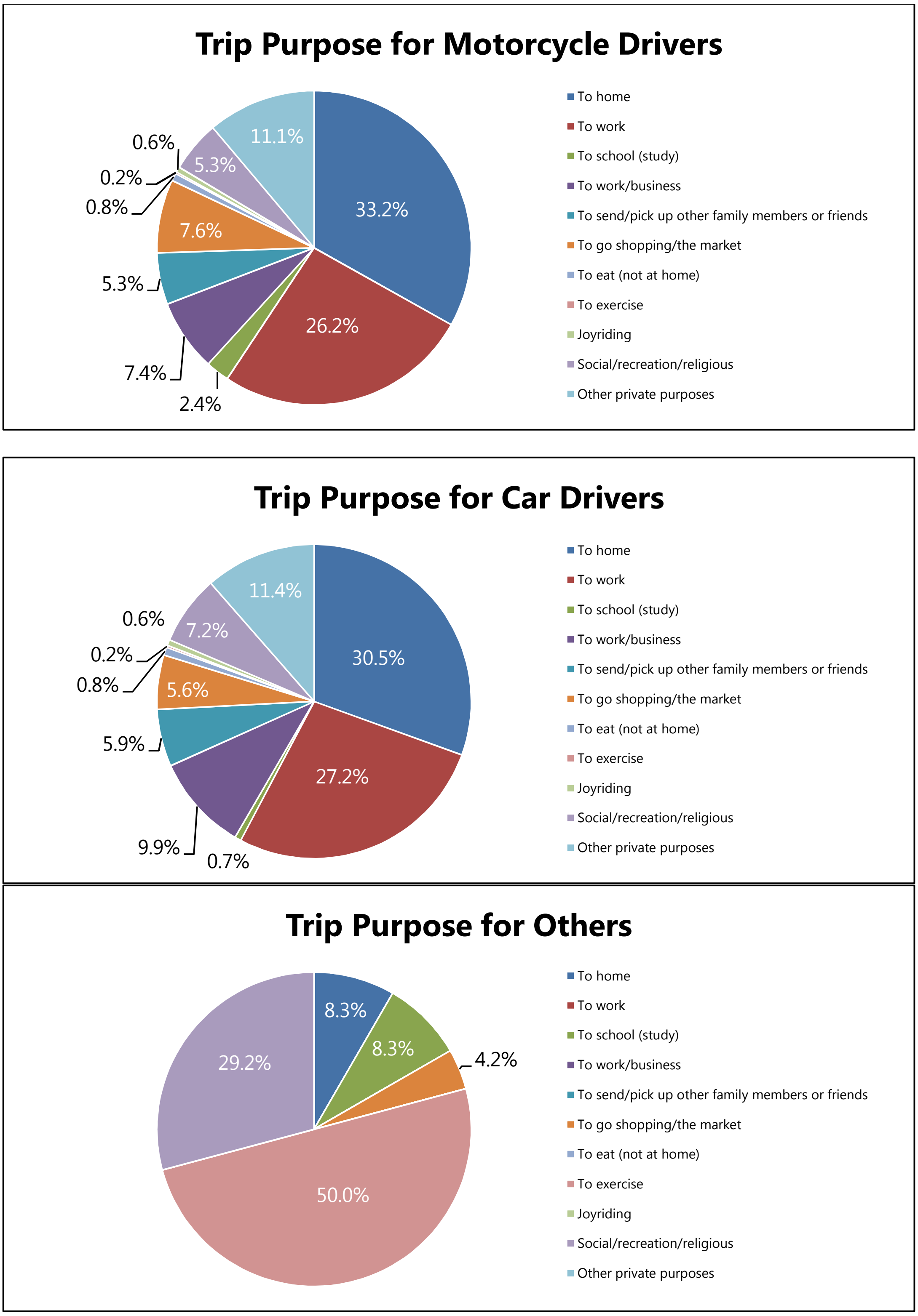


Figure 4.3-2 Histogram of the Travel Time by Private Modes

3) Trip Purpose by Travel Mode

For motorized transport, motorcycle and car, and bicycle the main trip purposes are to home and to work and the proportion is roughly the same.





Note: *Only 24 samples were observed for the Others mode and among those 24 samples, 50% of the trip purposes were for exercising.

Source: Study Team

Figure 4.3-3 Trip Purpose by Private Drivers Travel Mode

4) Willingness to Pay for Private Drivers

The following is an analysis of Willingness to Pay for Private Drivers. Willingness to Pay questions were added to the roadside OD interview survey in order to get the data needed to determine the toll fee for both the Nguyen Trai and Vu Yen Bridges if the Vietnamese authorities decide to implement a toll for using the bridges.

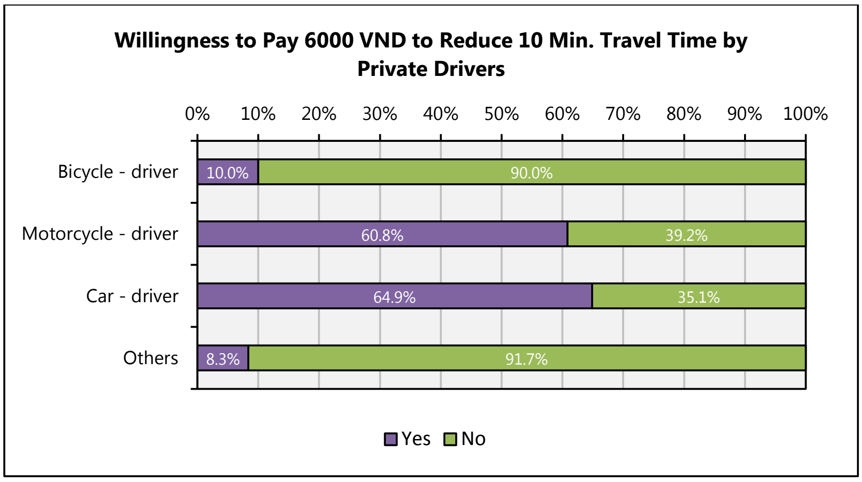
In the roadside OD interview survey for private drivers, respondents were also asked about their willingness to pay to reduce their travel time. One of the questions asked were if survey respondents were willing to pay 6,000 VND to reduce 10 minutes of travel time. The willingness to pay an amount of 6,000 VND was determined based on past experience of working on the "Preparatory Survey on Transit Oriented Development in Binh Duong Province and BRT Development Project in the Socialist Republic of Vietnam" conducted by JICA in February 2014.

Over 60% of drivers of motorized transport such as motorcycle and car were willing to pay while for non-motorized transport, bicycle and others, more than 90% of respondents were not willing to pay.

Table 4.3-6 Willingness to Pay for 6,000 VND to Reduce 10 Minutes of Travel Time by Mode (Number of Respondents)

	Travel Mode - Private Drivers			
	Bicycle - driver	Motorcycle - driver	Car - driver	Others
Yes	31	5,822	1,488	2
No	279	3,746	805	22
Total Number of Respondents:	310	9,568	2,293	24

Source: Study Team



Source: Study Team

Figure 4.3-4 Willingness to Pay to 6,000 VND to Reduce 10 Minutes of Travel Time by Mode (Proportion)

Respondents were also asked about the maximum amount they were willing to pay if they answered "Yes" to the question if they were willing to pay 6000 VND to reduce 10 minutes of travel time. Among all modes, the average maximum amount varied from between around 9,500 VND to 14,000 VND. For the Others mode, only 2 samples were collected and so the average maximum willingness to pay was not calculated for this mode as there were too few samples to make a meaningful calculation.

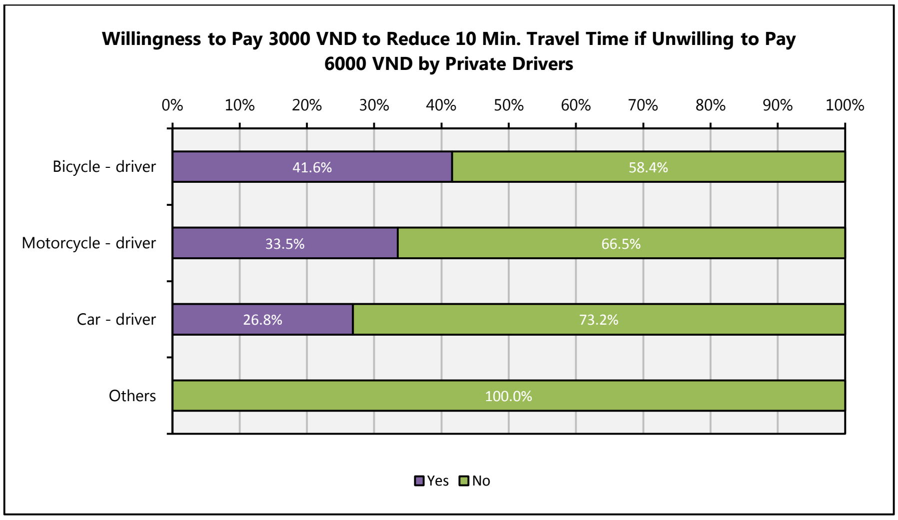
Table 4.3-7 Summary of the Average Maximum Willingness to Pay to Reduce 10 Minutes of Travel Time

	Bicycle	Motorcycle	Car	Others*
Average Max. WTP (VND)	9,903	10,128	13,591	-
Sample Size	31	5,817	1,488	2

Note: *Too few samples to calculate an average value
The average was calculated by transforming the original data into natural log units and then the arithmetic mean was calculated and the calculated values were then reconverted back into the original units using an exponential function

Source: Study Team

Last, if they answered "No" to the question if they were willing to pay 6,000 VND to reduce 10 minutes of travel time, respondents were asked if they were willing to pay 1/2 of that amount, that is, 3,000 VND. It was found that if respondents were not willing to pay 6,000 VND to reduce 10 minutes, a majority for each mode were also not willing to pay 3,000 VND to reduce 10 minutes.



Source: Study Team

Figure 4.3-5 Willingness to Pay 3,000 VND if Unwilling to Pay 6,000 VND to Reduce 10 Minutes of Travel Time

The statistics and distribution of data for the collected willingness to pay data are shown as follows.

The descriptive statistics for the average maximum willingness to pay to reduce 10 minutes of travel time are shown in the following table.

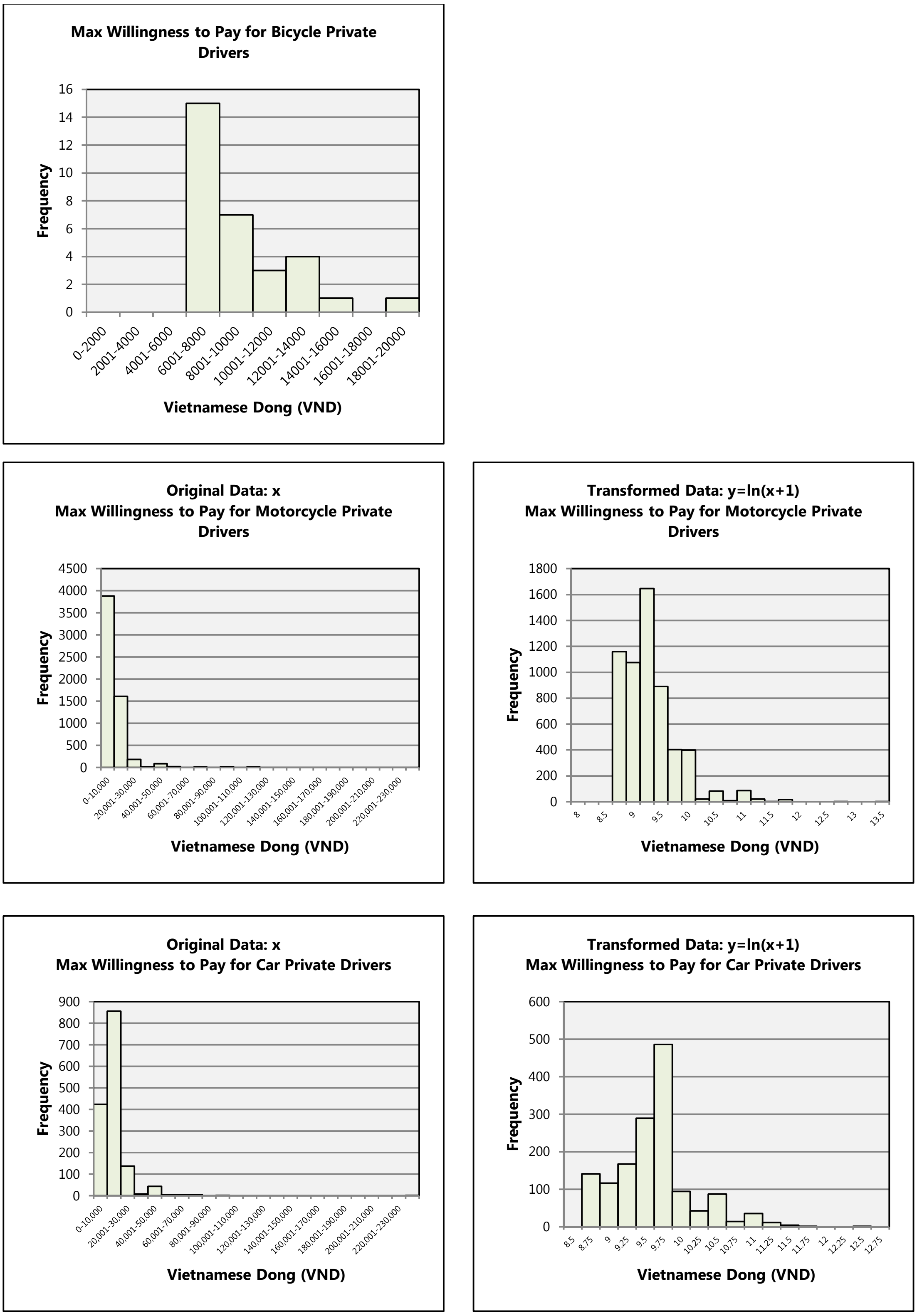
Table 4.3-8 Summary of the Average Maximum Willingness to Pay to Reduce 10 Minutes of Travel Time

Descriptive Statistic of the Max. WTP	Bicycle	Motorcycle	Car	Others*
Mean (mins)	9,903	10,128	13,591	-
Lower Confidence Interval (95%)	8,818	10,008	13,246	-
Upper Confidence Interval (95%)	10,989	10,250	13,945	-
Sample Size	31	5,817	1,488	2

Note: *Too few samples to calculate an average value
The bicycle mode's data distribution was found to be approximately normal and was not transformed. Data was transformed using the following formula:
Original Data = x, Transformed Data = y=ln(x+1), Reconverted Data = z=exp(y)-1

Source: Study Team

Histograms for the average maximum willingness to pay for each mode are shown as follows and it can be seen that the distribution for the average maximum willingness to pay for the motorcycle and car modes are log-normal and therefore the original data was transformed by a natural logarithm function to obtain a normal distribution in the natural logarithm domain in order to calculate the arithmetic mean and confidence intervals and the data was then transformed back into the original units by taking an exponential function.

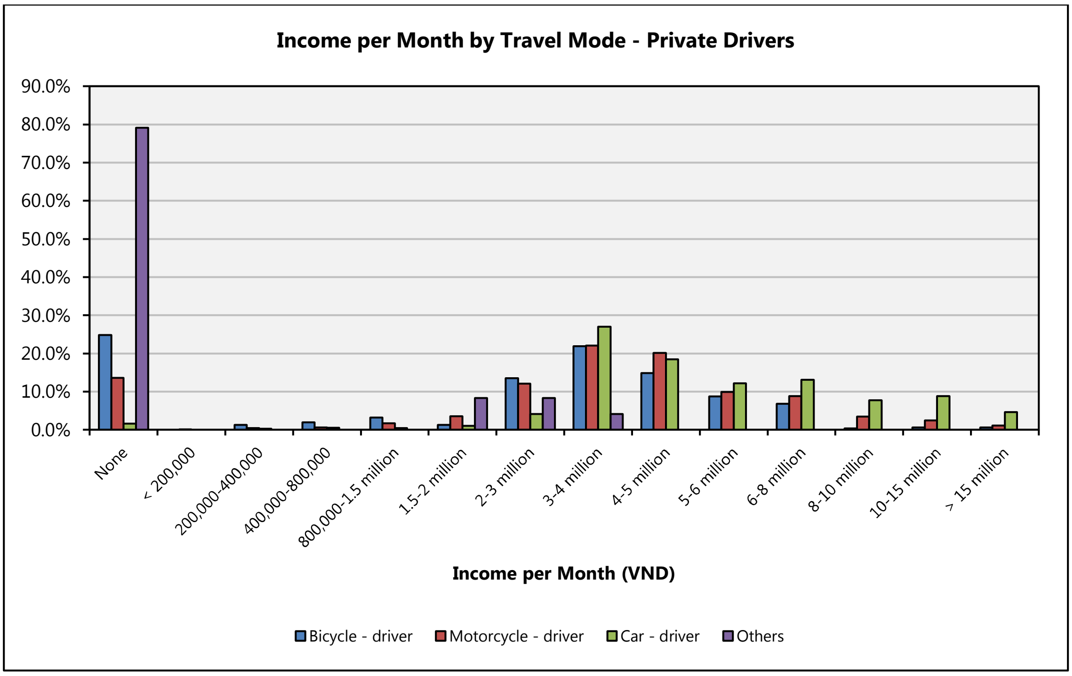


Source: Study Team

Figure 4.3-6 Histogram of the Maximum Willingness to Pay by Private Mode

5) Individual Income per Month by Travel Mode

For the walking and bicycle travel modes, a significant number of respondents said that they had no income per month which means that these are probably students. For both motorized modes of motorcycles and cars, the income range with the largest number of respondents is between 3-4 million VND per month.



Source: Study Team

Figure 4.3-7 Individual Income per Month by Travel Mode - Private Drivers

The average individual income per month by private travel mode is shown in the following table and it can be seen that for bicycles, motorcycles and cars, the average individual income per month ranges between 3 million VND to 5.3 million VND.

Table 4.3-9 Summary of the Average Individual Income per Month by Private Travel

	Bicycle	Motorcycle	Car	Others*
Average Individual Income per Month (VND)	4,003,433	4,646,322	6,092,420	-
Sample Size	233	8,266	2,256	5

Note: *Not enough samples to calculate a meaningful average value

Source: Study Team

6) Descriptive Statistics for the Individual Income per Month by Travel Mode for Private Drivers

The descriptive statistics for the average individual income per month by private travel mode is shown in the following table.

Table 4.3-10 Descriptive Statistics of the Individual Income per Month by Private Travel

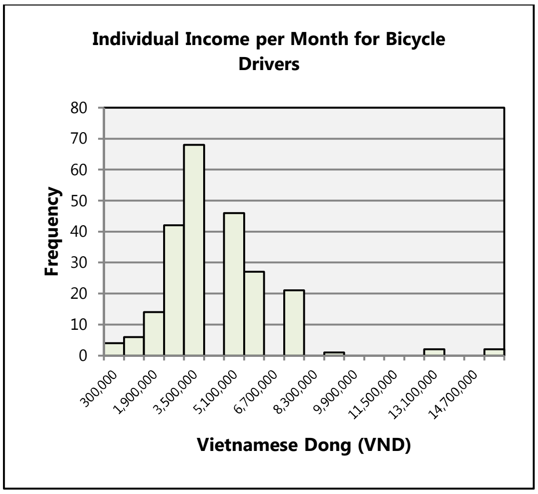
Descriptive Statistic of Individual Income per Month	Bicycle	Motorcycle	Car	Others*
Mean (VND)	4,003,433	4,646,322	6,092,420	-
Lower Confidence Interval (95%)	3,734,141	4,591,954	5,951,296	-
Higher Confidence Interval (95%)	4,272,726	4,700,691	6,233,545	-
Sample Size	233	8,266	2,256	5

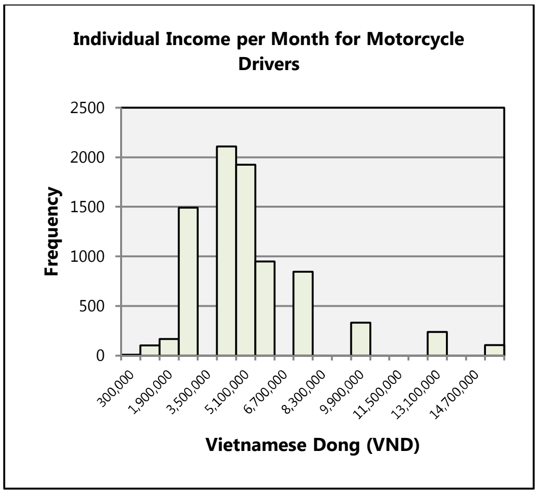
Note: *Not enough samples to calculate a meaningful average value
Arithmetic mean was used to calculate the mean.

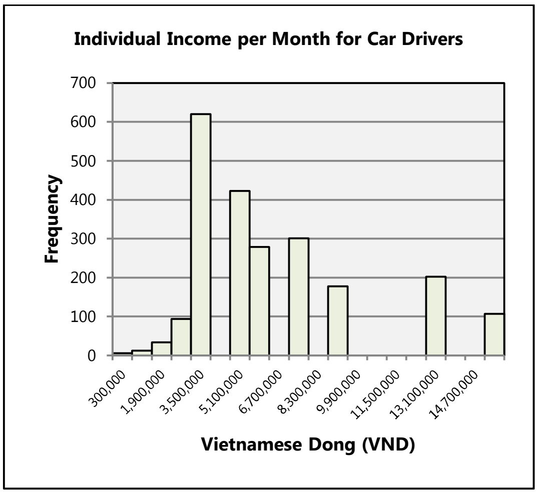
Source: Study Team

The histograms for the individual income per month for drivers of each mode are shown as follows. There is a large frequency of respondents who answered “None” with regards to individual income. This is because in Vietnam, there is a large informal economy and many of the respondents were not comfortable in disclosing their individual income per month and hence a large number of respondents answered “None”.

Excluding the responses for “None” for each mode, it seems that the distributions are approximately normal. Therefore, mean individual income per month for each private mode was calculated using the arithmetic mean.







Source: Study Team

Figure 4.3-8 Histogram of Individual Income per Month – Private Drivers

(2) Public Mode Drivers

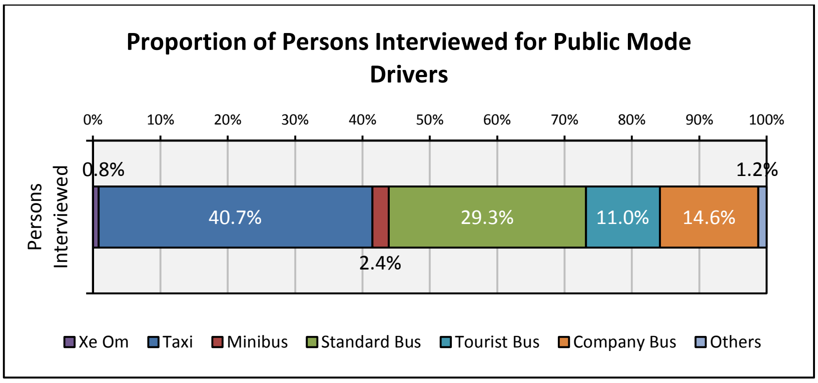
The total number of persons interviewed for drivers of public modes for all 11 survey stations were 246. The breakdown by travel mode including walking are shown in the following table by omitting modes such as cyclo, school bus and ferry of which there were no respondents. The sampling rate is also given for taxis and buses. For other modes, the sampling rate is omitted because not enough samples were collected during the interview survey.

Table 4.3-11 Number of Public Mode Drivers Interviewed by Survey Station

Survey Station	Public Drivers Interviewed								Total Traffic Count*	Sampling Rate	Sampling by Vehicle Type	
	Xe Om	Taxi	Minibus	Standard Bus	Tourist Bus	Company Bus	Others	Total Respondents/ Survey Station			Taxi Sampling Rate	Bus Sampling Rate
(1) QL5, Nomura Industrial Park	0	7	1	6	3	1	0	18	3,736	0.48%	0.75%	0.39%
(2) QL10, Kien Bridge	0	0	0	20	0	0	0	20	2,196	0.91%	0.00%	1.14%
(3) TL359, Binh Bridge	1	27	1	3	0	0	1	33	3,062	1.08%	2.13%	0.22%
(4) AH14, Dong Hai Bridge	0	1	0	1	4	5	0	11	1,766	0.62%	0.12%	1.11%
(5) TL352, Si Bridge	0	7	1	9	0	2	0	19	272	6.99%	7.82%	6.58%
(6) QL10, Gia Bridge	0	2	1	11	13	0	0	27	2,019	1.34%	0.54%	1.52%
(7) TL359, Thuy Trieu/Ngu Lao	0	15	1	3	0	11	2	32	673	4.75%	7.08%	3.25%
(8) QL10, Tram Bac Bridge	0	2	0	2	4	2	0	10	1,518	0.66%	0.70%	0.65%
(9) Phan Dang Luu St., Kien An Bridge	0	8	0	6	2	10	0	26	749	3.47%	2.23%	4.62%
(10) Truong Chinh Street (at Niem Bridge)	1	11	0	0	0	1	0	13	3,686	0.35%	0.49%	0.07%
(11) Pham Van Dong St.	0	20	1	11	1	4	0	37	1,815	2.04%	1.99%	2.11%
All Survey Stations	2	100	6	72	27	36	3	246	21,491	1.14%		

Note: Cyclo, School Bus and Ferry modes omitted as there were 0 respondents
*Total Traffic Count for each survey station was re-proportioned based on the number of days and hours of the OD roadside interview survey because the traffic count survey was conducted for 24 hours/7 days for survey stations 1-4 and 24 hours/4 days for survey stations 5-11 while the OD roadside interview survey was conducted for 12 hours/3 days for survey stations 1-4 and 12 hours/2 days for survey stations 5-11.

Source: Study Team

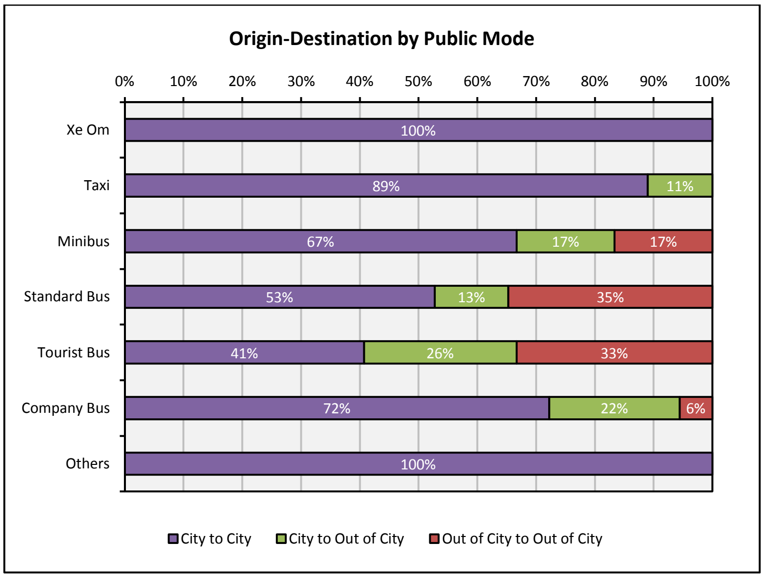


Source: Study Team

Figure 4.3-9 Proportion of Persons Interviewed for Public Mode Drivers for All Survey Stations

1) Origin-Destination by Mode

The origin and destination for city to city, city to out of city and out of city to out of city by mode were counted. Of the standard bus drivers surveyed, 53% of trips started and ended in the city while 35% of trips started and ended out of the city. A similar percentage of trips for tourist bus drivers were also observed. On the other hand for minibuses and company buses, a large majority of the trips started and ended within the city.



Source: Study Team

Figure 4.3-10 Origin-Destination by Public Modes

2) Average Travel Time by Origin-Destination and by Mode

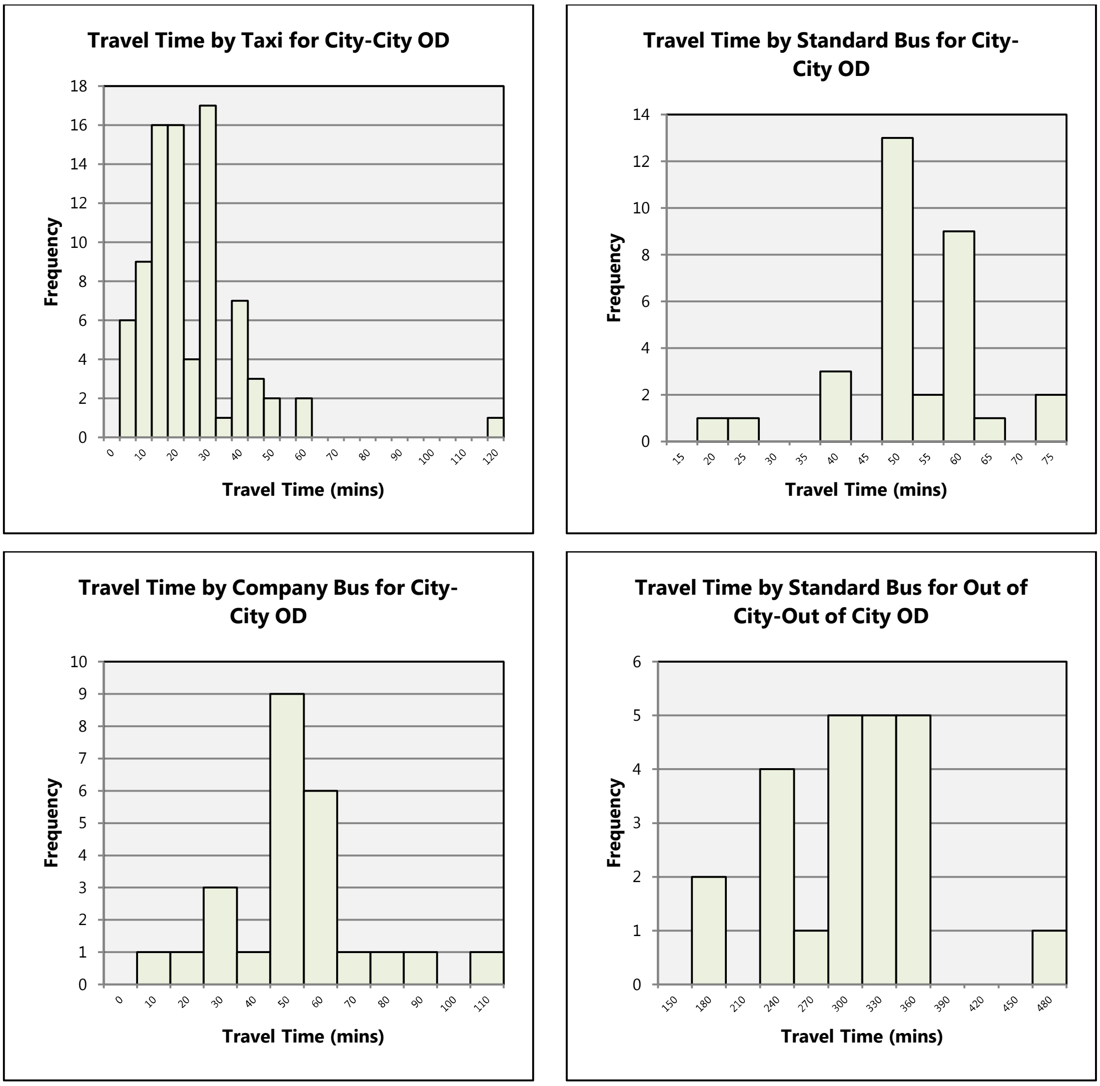
Among the xe om and taxi modes, average travel time within the city were between 19.9 and 22.5 minutes while average travel time on buses, excluding tourist buses and company buses ranged from between 52.5 minutes to 56.7 minutes.

Table 4.3-12 Travel Time by Origin-Destination and by Mode

Origin-Destination	Average Travel Time (mins)						
	Xe Om	Taxi	Minibus	Standard Bus	Tourist Bus	Company Bus	Others
City to City	22.5[a)]	19.9[1)]	56.7[a)]	52.5[2)]	55.7[a)]	51.2[3)]	32.0[a)]
City to Out of City	-	118.6[a)]	120.0[b)]	141.1[a)]	209.3[a)]	216.3[a)]	-
Out of City to Out of City	-	-	240.0[b)]	304.1[4)]	247.8[a)]	270.0[a)]	-

Note:
a) Arithmetic mean used, no histogram due to insufficient samples
b) 1 sample only
1) Geometric mean used, refer to the histogram for the distribution
2) Arithmetic mean used, refer to the histogram for the distribution
3) Arithmetic mean used, refer to the histogram for the distribution
4) Arithmetic mean used, refer to the histogram for the distribution

Source: Study Team



Source: Study Team

Figure 4.3-11 Histograms for Travel Time by Origin-Destination and by Mode

3) Average Seating Capacity by Origin-Destination and by Mode

The average seating capacity of public modes by origin-destination is tabulated as follows.

Table 4.3-13 Average Seating Capacity by Origin-Destination and by Mode

Origin-Destination	Average Seating Capacity						
	Xe Om	Taxi	Minibus	Standard Bus	Tourist Bus	Company Bus	Others
City to City	1.0	4.2	21.7	36.2	28.7	31.9	10.0
City to Out of City	-	3.6	25.0	36.7	34.1	31.4	-
Out of City to Out of City	-	-	25.0	34.1	32.0	31.5	-

Note: Arithmetic mean used

Source: Study Team

4) Average Number of Passengers on Board by Origin-Destination and by Mode

Comparing the average number of passengers on board with the average seating capacity, it can be seen that buses in general, especially within the city, are not widely used. On average, buses are only 1/3 or 1/2 full.

Table 4.3-14 Average Number of Passengers on Board by Origin-Destination and by Mode

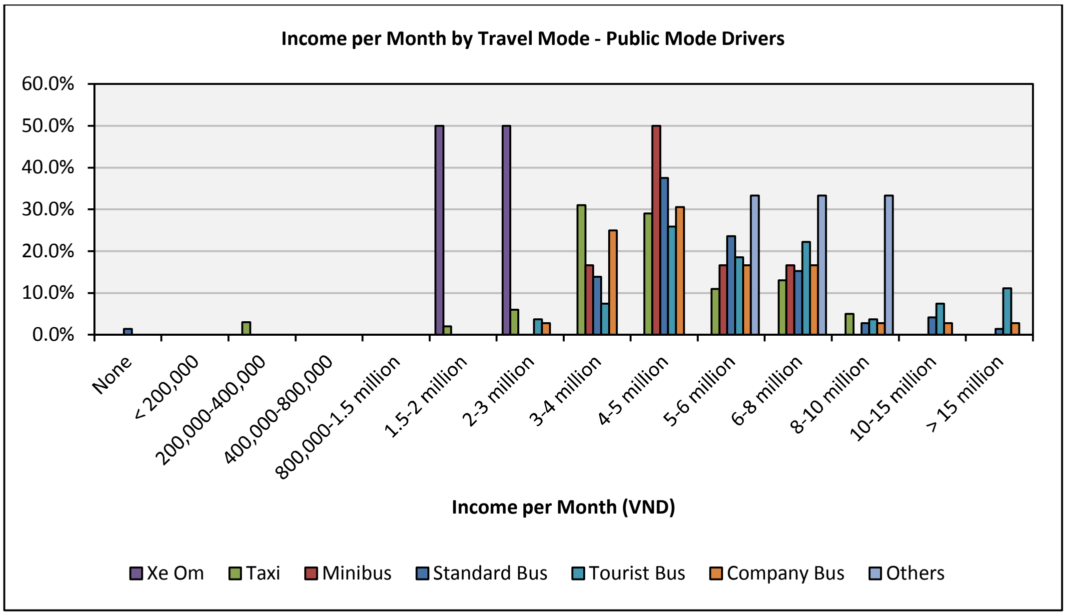
Origin-Destination	Average Number of Passengers on Board (including the Driver)						
	Xe Om	Taxi	Minibus	Standard Bus	Tourist Bus	Company Bus	Others
City to City	1.0	2.4	9.0	11.5	3.7	10.5	2.0
City to Out of City	-	2.3	8.0	13.1	13.6	10.8	-
Out of City to Out of City	-	-	25.0	20.8	14.8	17.5	-

Note: Arithmetic mean used

Source: Study Team

5) Individual Income per Month for Public Mode Drivers by Mode

Looking at the individual income per month for public mode drivers by mode, income for xe om drivers were lower than drivers of 4-wheeled vehicles. Of all the 4-wheeled vehicle drivers, a large proportion earned between 4 million and 5 million VND.



Source: Study Team

Figure 4.3-12 Income per Month by Travel Mode - Public Mode Drivers

It was calculated that the average individual income per month by public mode drivers ranged between 4.5 million VND for taxi drivers to 6.1 million VND for charter bus drivers which includes tourist and company bus drivers. Public bus drivers included standard bus and minibus drivers.

Table 4.3-15 Average Individual Income per Month by Public Mode Drivers

	Taxi Drivers	Public Bus Drivers	Charter Bus Drivers
Average Individual Income per Month (VND)	4,549,000[a]	5,265,025[b]	5,516,982[b]
Sample Size	100	78	63
Notes: a) Average for taxi drivers calculated using the arithmetic mean, b) Average for public bus drivers and charter bus drivers was calculated by transforming the original data using a natural logarithmic function, calculating the arithmetic mean in the natural log domain and then reconverting back to the original data units using an exponential function			

Source: Study Team

6) Descriptive Statistics for the Individual Income per Month for Public Drivers by Mode

The descriptive statistics for individual income per month by public mode drivers is shown in the following table.

Table 4.3-16 Descriptive Statistics of Individual Income per Month by Public Mode Drivers

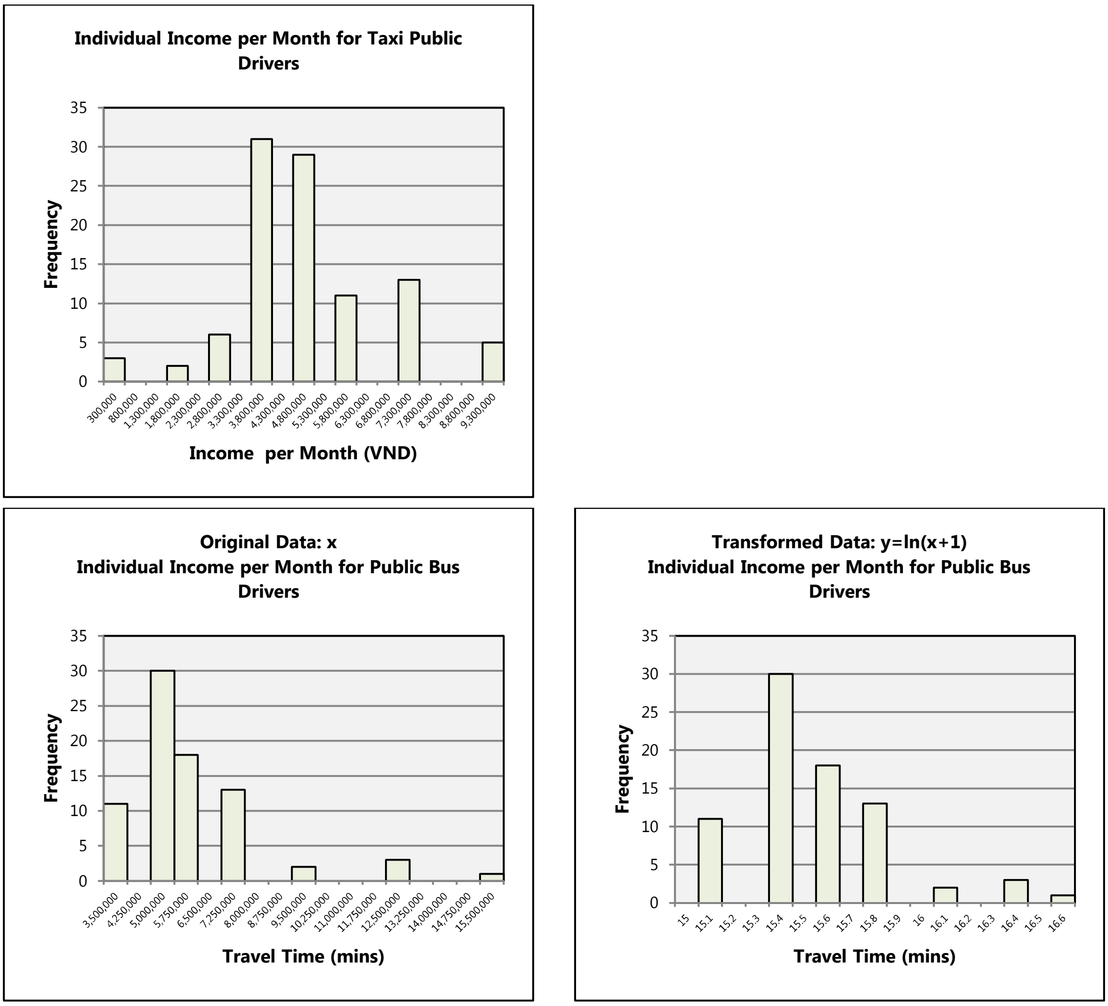
Descriptive Statistic of Individual Income per Month	Taxi Drivers	Public Bus Drivers	Charter Bus Drivers
Mean (VND)	4,549,000	5,265,025	5,516,982
Lower Confidence Interval (95%)	4,194,329	4,905,526	4,951,150
Upper Confidence Interval (95%)	4,903,670	5,650,869	6,147,479
Sample Size	100	78	63
For the public bus drivers and charter bus drivers data, the data was transformed and reconverted using the following formula: Original Data = x, Transformed Data = y=ln(x+1), Reconverted Data = z=exp(y)-1			

Source: Study Team

The samples for the standard bus, tourist bus and company bus were aggregated to the Chartered Bus category because there were not enough samples for each type of bus.

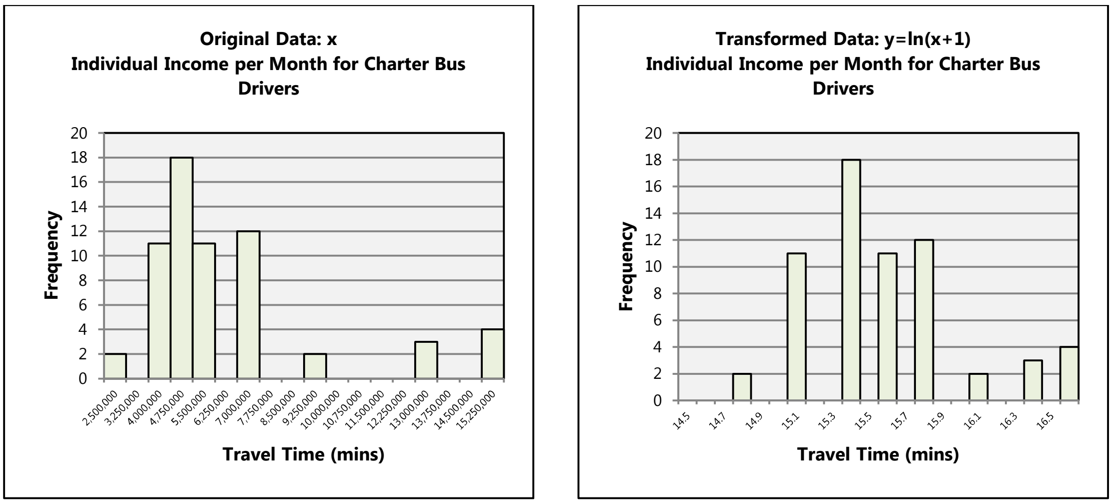
The histograms showing the distributions for taxi, public bus and chartered bus public drivers are shown as follows.

It can be seen that for individual income per month for taxi public drivers, the distribution is approximately normal. However, the distributions of public bus drivers and charter bus drivers are seen to be log-normal. As a result, the original data was transformed using a natural logarithmic function and the arithmetic mean was calculated in the natural log domain and the calculated average values were then reconverted back to the original data units using an exponential function.



Source: Study Team

Figure 4.3-13 Histogram of Individual Income per Month for Taxi and Public Bus Drivers



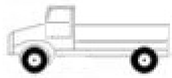
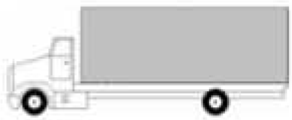
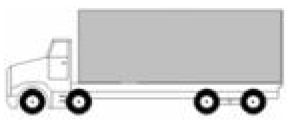
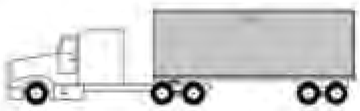
Source: Study Team

Figure 4.3-14 Histogram of Individual Income per Month for Charter Bus Drivers

(3) Freight Mode Drivers

Freight mode drivers were surveyed based on the 4 different truck types as shown below.

Table 4.3-17 Types of Trucks Surveyed

Truck Type	Truck Diagram	Example of Surveyed Vehicle
Pickup Truck		
Rigid-Chassis Truck (2 axles)		
Rigid-Chassis Truck (>=3 axles)	 	
Truck/Tractor-Trailer (separated type)	 	

Source: Study Team

The total number of persons interviewed for drivers of freight modes for all 11 survey stations were 1,335. The breakdown by vehicle type is shown in the following table and the proportion is in the table after. A majority of the freight vehicles surveyed were trucks with 2 axles (56% of all trucks surveyed, see Figure 4.3-15).

Table 4.3-18 Number of Freight Mode Drivers Interviewed by Survey Station

Survey Station	Freight Drivers Interviewed					Freight Drivers Total Traffic Count*	Freight Drivers Sampling Rate
	Pickup Truck	Rigid-Chassis Truck (2 axles)	Rigid-Chassis Truck (>= 3 axles)	Truck/Tractor-Trailer (separated type)	Total Freight Drivers /Survey Station		
(1) QL5, Nomura Industrial Park	46	57	15	15	133	20,793	0.64%
(2) QL10, Kien Bridge	44	35	20	3	102	6,761	1.51%
(3) TL359, Binh Bridge	18	76	4	4	102	2,712	3.76%
(4) AH14, Dong Hai Bridge	81	205	46	30	362	19,779	1.83%
(5) TL352, Si Bridge	34	32	0	0	66	982	6.72%
(6) QL10, Gia Bridge	20	45	12	16	93	3,907	2.38%
(7) TL359, Thuy Trieu/Ngu Lao	11	58	14	3	86	1837	4.68%
(8) QL10, Tram Bac Bridge	12	52	0	0	64	3,853	1.66%
(9) Phan Dang Luu St., Kien An Bridge	20	66	7	1	94	2,495	3.77%
(10) Truong Chinh Street (at Niem Bridge)	27	60	7	2	96	3,047	3.15%
(11) Pham Van Dong St.	54	62	6	15	137	1947	7.04%
Total	367	748	131	89	1,335	68,115	1.96%

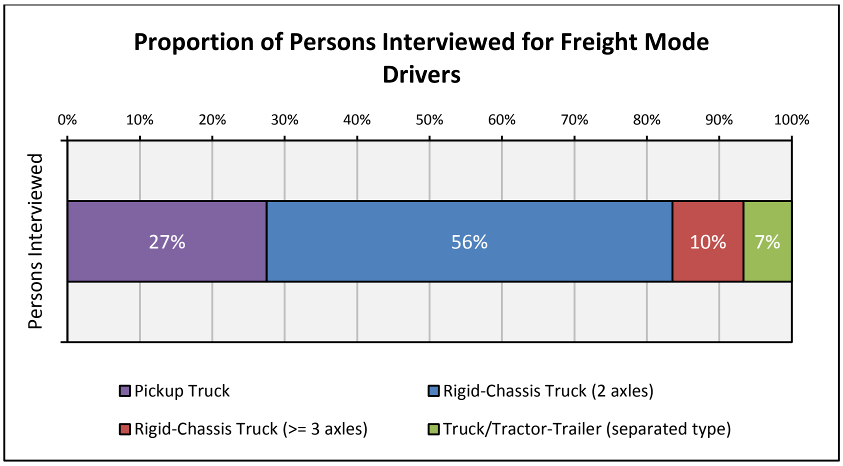
Note: *Total Traffic Count for each survey station was re-proportioned based on the number of days and hours of the OD roadside interview survey because the traffic count survey was conducted for 24 hours/7 days for survey stations 1-4 and 24 hours/4 days for survey stations 5-11 while the OD roadside interview survey was conducted for 12 hours/3days for survey stations 1-4 and 12 hours/2 days for survey stations 5-11.

Source: Study Team

Table 4.3-19 Sampling Rate by Freight Vehicle Type

Survey Station	Sampling Rate by Freight Vehicle Type			
	Pickup Truck	Rigid-Chassis Truck (2 axles)	Rigid-Chassis Truck (>= 3 axles)	Truck/Tractor-Trailer (separated type)
(1) QL5, Nomura Industrial Park	1.7%	1.8%	1.5%	0.1%
(2) QL10, Kien Bridge	20.8%	1.1%	2.4%	0.1%
(3) TL359, Binh Bridge	2.8%	5.0%	1.6%	1.3%
(4) AH14, Dong Hai Bridge	9.7%	8.9%	4.1%	0.2%
Total 4 Stations:	4.3%	3.7%	2.7%	0.1%

Source: Study Team

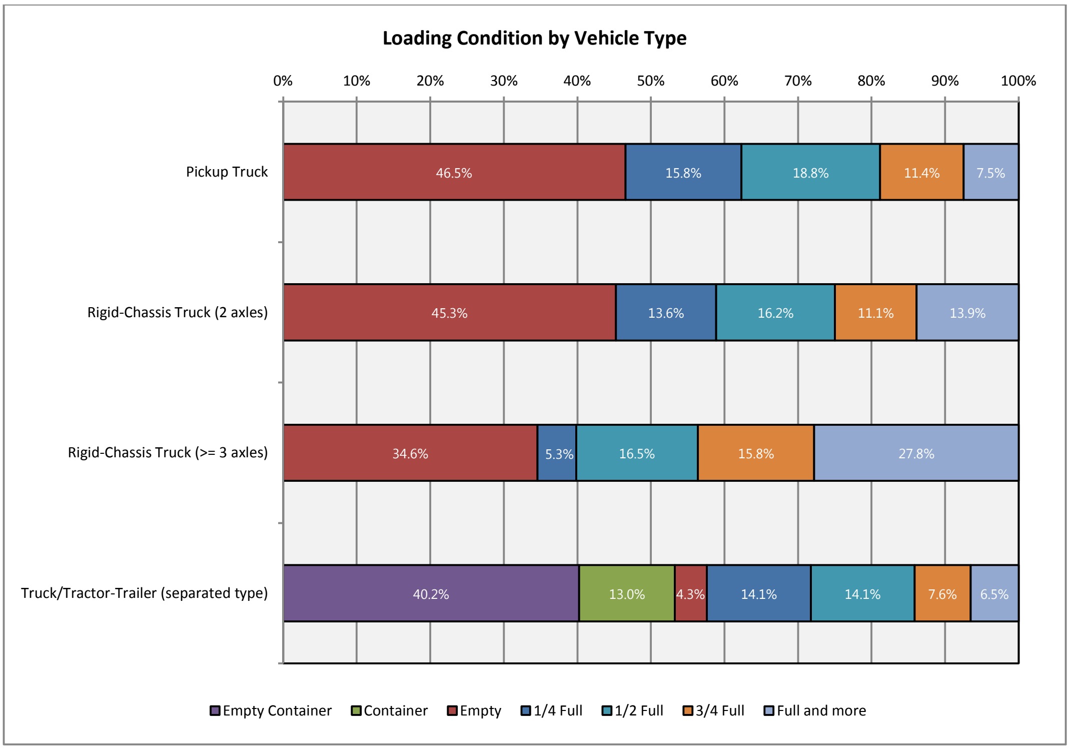


Source: Study Team

Figure 4.3-15 Proportion of the Number of Freight Mode Drivers Interviewed

1) Loading Conditions by Vehicle Type

The breakdown of the loading condition by vehicle type is shown in the following table. From the survey results, the vehicle type that is most fully loaded is the rigid-chassis truck with more than 3 axles (loading condition Full and More: 27.8%, Figure 4.3-16) while among truck-tractor trailer vehicles, only 6.5% were fully loaded. On the other hand, 40.2% of truck-tractor trailer vehicles were hauling empty containers.

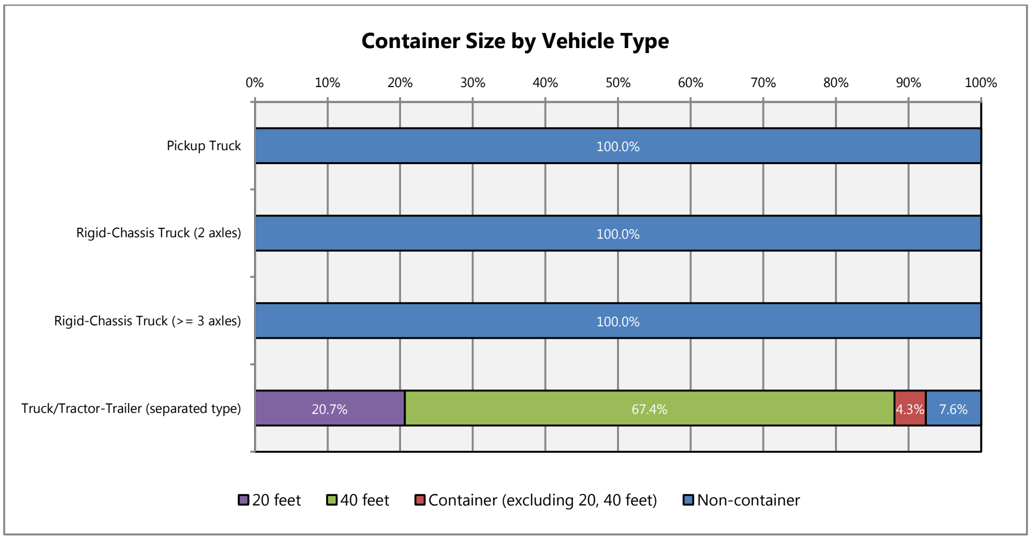


Source: Study Team

Figure 4.3-16 Loading Condition by Vehicle Type

2) Container Size by Vehicle Type

The breakdown of container sizes hauled by truck vehicles is shown in the following table. Among truck/tractor-trailers, standard 40 feet containers made up 67.4% of the containers being transported while standard 20 feet containers made up 20.7%. Containers excluding 20, 40 feet generally refer to 45 feet containers.



Source: Study Team

Figure 4.3-17 Container Size by Vehicle Type

3) Average Maximum Loading Weight by Vehicle Type

The breakdown of the average maximum loading weight by vehicle type is shown in the following table. The highest average maximum loading weight came from truck/tractor trailers (separated type) with an average of 23.78 metric tons.

Table 4.3-20 Average Maximum Loading Weight by Vehicle Type

	Pickup Trucks	Rigid-Chassis Trucks (2 axles)	Rigid-Chassis Trucks (3 axles)	Truck/Tractor Trailers (separated type)
Average Maximum Loading Weight (metric tons)	1.74	2.53	6.71	23.78
Sample Size	367	748	131	89
Note: For pickup trucks, rigid-chassis trucks (2 axles), rigid-chassis trucks (3 axles), the average was calculated by transforming the original data using a natural logarithm function and then the arithmetic mean was used in the natural log domain and then the data was reconverted back to the original units using a exponential function. The average for truck/tractor trailers was calculated using the arithmetic mean.				

Source: Study Team

4) Descriptive Statistics for the Average Maximum Loading Weight by Vehicle Type for Freight Drivers

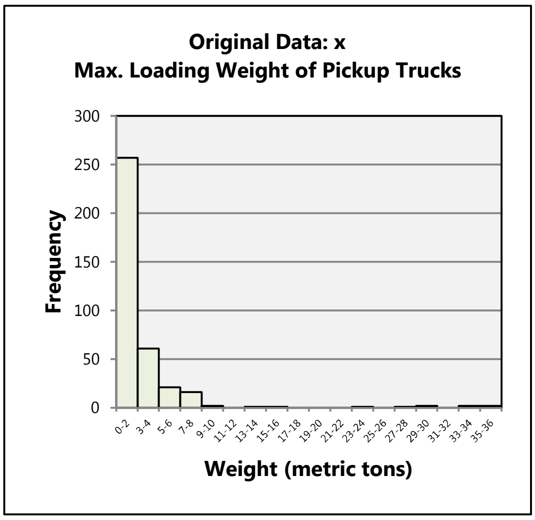
A summary of the descriptive statistics for the maximum loading weight by vehicle type is shown in the following table.

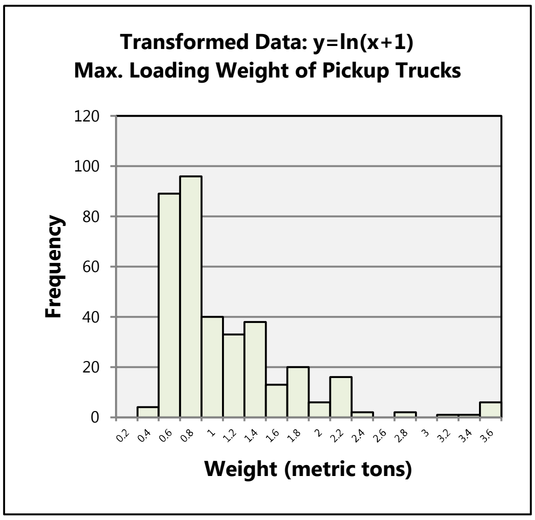
Table 4.3-21 Summary of Descriptive Statistics for the Maximum Loading Weight by Vehicle Type

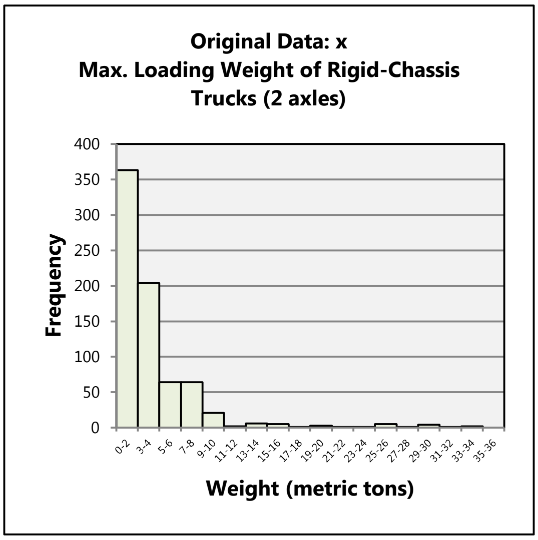
Descriptive Statistics of the Max Loading Weight	Pickup Trucks	Rigid-Chassis Trucks (2 axles)	Rigid-Chassis Trucks (3 axles)	Truck/Tractor Trailers (separated type)
Mean (metric tons)	1.74	2.53	6.71	23.78
Lower Confidence Interval (95%)	1.57	2.37	5.56	21.61
Upper Confidence Interval (95%)	1.92	2.70	8.05	25.96
Sample Size	367	748	131	89
For the pickup trucks, rigid-chassis trucks (2 axles) and rigid-chassis trucks (3 axles) the data was transformed and reconverted using the following formula: Original Data = x, Transformed Data = y=ln(x+1), Reconverted Data = z=exp(y)-1				

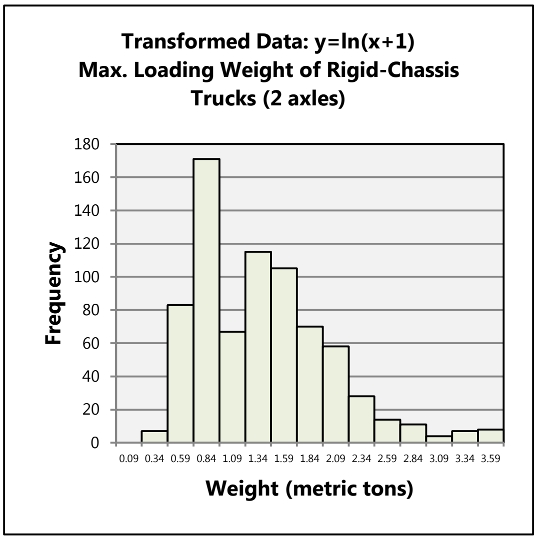
Source: Study Team

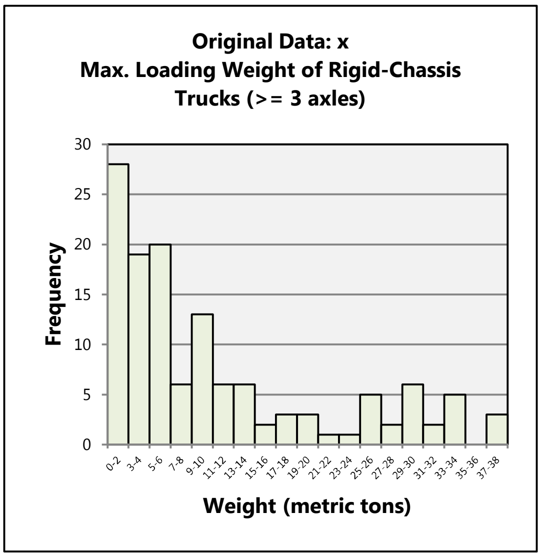
The distributions for the maximum loading weight by vehicle type are shown in the following histograms. It can be seen that except the truck/trailer vehicle type, the distributions are log-normal distributed and therefore the average weight was calculated by transforming the original data using the natural logarithm function and then the arithmetic mean was calculated in the natural log domain and the calculated data was then reconverted back to the original units using an exponential function.

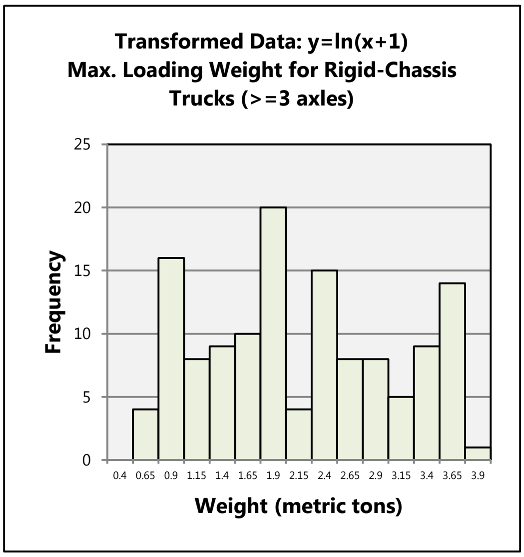

Original Data: x
Max. Loading Weight of Pickup Trucks
Frequency
Weight (metric tons)

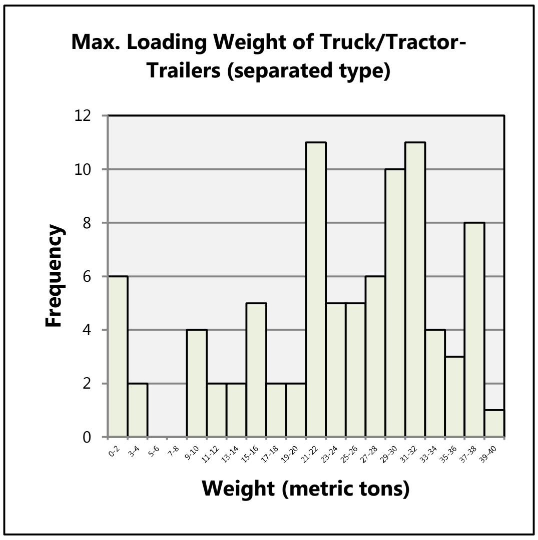

Transformed Data: y=ln(x+1)
Max. Loading Weight of Pickup Trucks
Frequency
Weight (metric tons)


Original Data: x
Max. Loading Weight of Rigid-Chassis Trucks (2 axles)
Frequency
Weight (metric tons)


Transformed Data: y=ln(x+1)
Max. Loading Weight of Rigid-Chassis Trucks (2 axles)
Frequency
Weight (metric tons)


Original Data: x
Max. Loading Weight of Rigid-Chassis Trucks (>= 3 axles)
Frequency
Weight (metric tons)


Transformed Data: y=ln(x+1)
Max. Loading Weight for Rigid-Chassis Trucks (>=3 axles)
Frequency
Weight (metric tons)

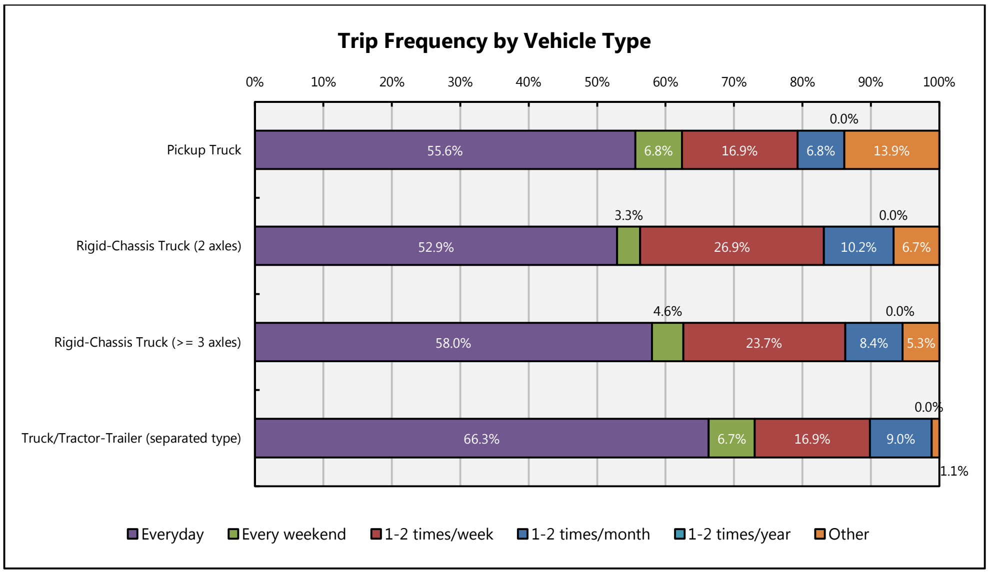


Source: Study Team

Figure 4.3-18 Histogram of Max. Loading Weight by Vehicle Type

5) Trip Frequency by Vehicle Type

The breakdown of the trip frequency by vehicle type is shown in the following table. For each vehicle type, the majority of trips occur every day and if the trips do not occur every day then trips occur at least 1-2 times per week (see Figure 4.3-19).



Source: Study Team

Figure 4.3-19 Trip Frequency by Vehicle Type

6) Average Travel Time by Vehicle Type

The breakdown of the average travel time, in minutes, by vehicle type is shown in the following table. The truck/tractor trailer followed by the rigid-chassis trucks had the highest average travel times at 114.05 minutes and 94.11 minutes respectively.

Table 4.3-22 Average Travel Time by Vehicle Type

	Pickup Trucks	Rigid-Chassis Trucks (2 axles)	Rigid-Chassis Trucks (3 axles)	Truck/Tractor Trailers (separated type)
Average Travel Time (mins)	48.49	56.51	94.11	114.05
Sample Size	367	748	131	89
Note: The average was calculated by transforming the original data into natural log units and then the arithmetic mean was calculated and the calculated values were then reconverted back into the original units using an exponential function				

Source: Study Team

7) Descriptive Statistics for the Average Travel Time by Vehicle Type for Freight Drivers

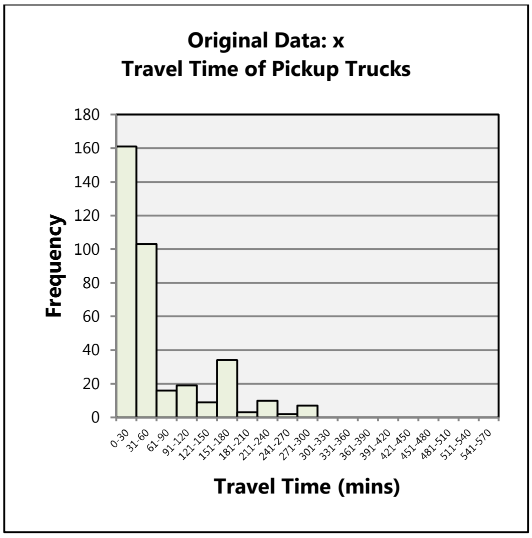
A summary of the descriptive statistics for the travel time by vehicle type for freight drivers is shown in the following table.

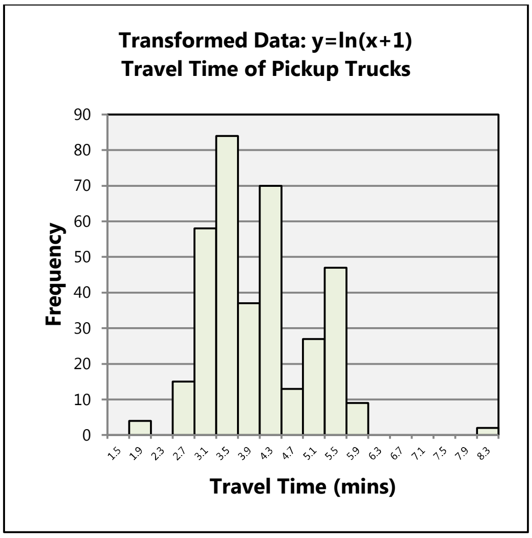
Table 4.3-23 Summary of the Descriptive Statistics of Travel Time by Vehicle Type

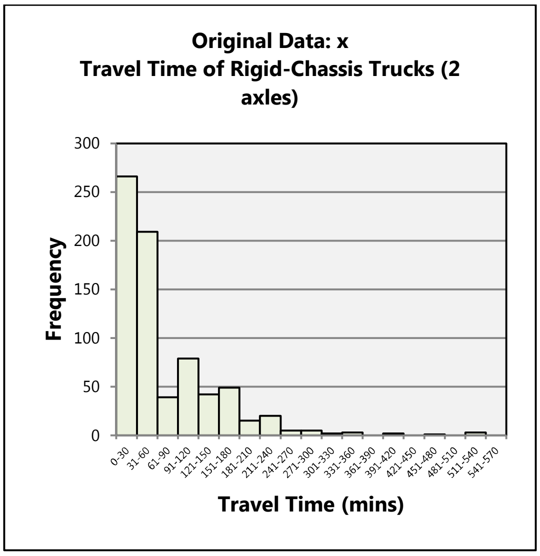
Descriptive Statistics of the Travel Time	Pickup Trucks	Rigid-Chassis Trucks (2 axles)	Rigid-Chassis Trucks (3 axles)	Truck/Tractor Trailers (separated type)
Mean (mins)	48.49	56.51	94.11	114.05
Lower Confidence Interval (95%)	43.97	52.76	77.08	92.92
Upper Confidence Interval (95%)	53.45	60.53	114.86	139.92
Sample Size	367	748	131	89
The data was transformed and reconverted using the following formula: Original Data = x, Transformed Data = y=ln(x+1), Reconverted Data = z=exp(y)-1				

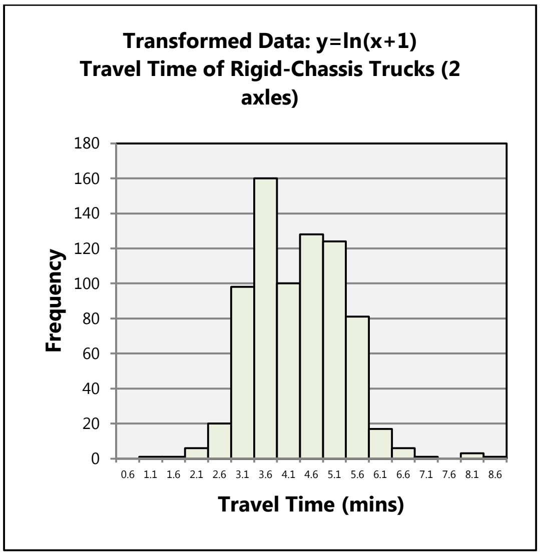
Source: Study Team

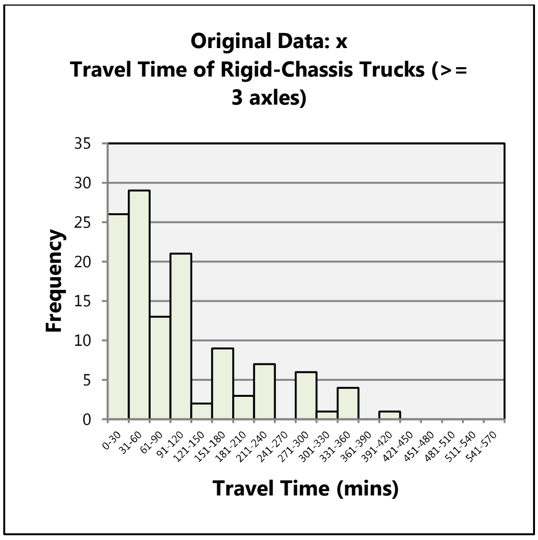
Histograms for the travel time of each mode are shown as follows and it can be seen that the distribution for the travel time for each mode are log-normal and therefore the average value was calculated by transforming the original data using a natural logarithmic function and the arithmetic mean was calculated in the natural log domain and the calculated values were then reconverted into the original data units using an exponential function.

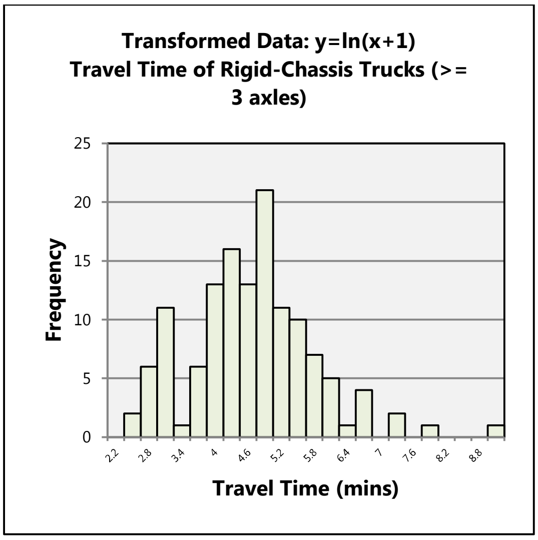

Original Data: x
Travel Time of Pickup Trucks
Frequency
Travel Time (mins)

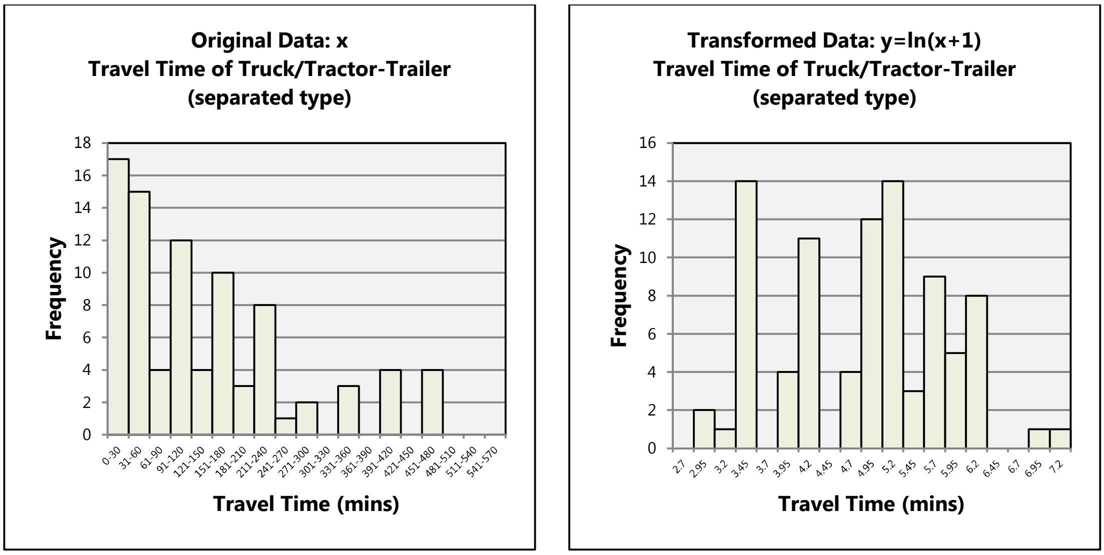

Transformed Data: y=ln(x+1)
Travel Time of Pickup Trucks
Frequency
Travel Time (mins)


Original Data: x
Travel Time of Rigid-Chassis Trucks (2 axles)
Frequency
Travel Time (mins)


Transformed Data: y=ln(x+1)
Travel Time of Rigid-Chassis Trucks (2 axles)
Frequency
Travel Time (mins)


Original Data: x
Travel Time of Rigid-Chassis Trucks (>= 3 axles)
Frequency
Travel Time (mins)


Transformed Data: y=ln(x+1)
Travel Time of Rigid-Chassis Trucks (>= 3 axles)
Frequency
Travel Time (mins)



Source: Study Team

Figure 4.3-20   Histogram of Travel Time by Vehicle Type

8) Willingness to Pay for Freight Drivers

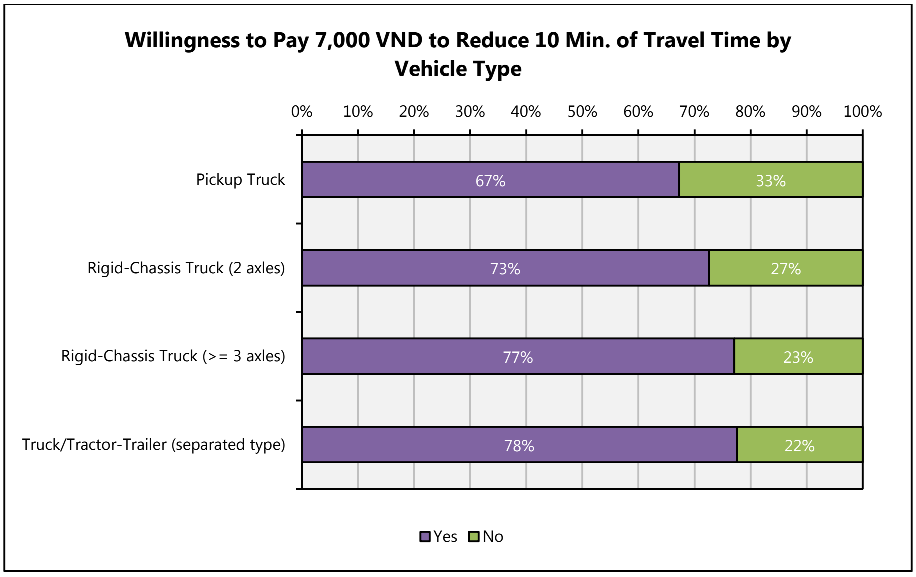
The following is an analysis of Willingness to Pay for Private Drivers. Willingness to Pay questions were added to the roadside OD interview survey in order to get the data needed to determine the toll fee for both the Nguyen Trai and Vu Yen Bridges if the Vietnamese authorities decide to implement a toll for using the bridges.

In the roadside OD interview for freight drivers, respondents were also asked about their willingness to pay to reduce their travel time. One of the questions asked were if survey respondents were willing to pay 7,000 VND to reduce 10 minutes of travel time. The willingness to pay an amount of 7,000 VND was determined based on past experience of working on the "Preparatory Survey on Transit Oriented Development in Binh Duong Province and BRT Development Project in the Socialist Republic of Vietnam" conducted by JICA in February 2014. Over 67% of freight drivers for all vehicle types were willing to pay to reduce travel time (see Figure 4.3-21).

Table 4.3-24 Willingness to Pay 7,000 VND to Reduce 10 Minutes of Travel Time by Vehicle Type (Respondents)

	Vehicle Type			
	Pick up for cargo	Truck (2 axles)	Truck (more than 3 axles)	Trailer (separated type)
Yes	247	543	101	69
No	120	205	30	20
Total Number of Respondents	367	748	131	89

Source: Study Team



Source: Study Team

Figure 4.3-21 Willingness to Pay 7,000 VND to Reduce 10 Minutes of Travel Time by Vehicle Type (Proportion)

Respondents were also asked about the maximum amount they were willing to pay if they answered "Yes" to the question if they were willing to pay 7,000 VND to reduce 10 minutes of travel time. Among all modes, the average maximum amount varied from between around 11,000 VND to less than 14,000 VND (see Table 4.3-25).

Table 4.3-25 Average Maximum Willingness to Pay for Freight Drivers

	Pickup Trucks	Rigid-Chassis Trucks (2 axles)	Rigid-Chassis Trucks (3 axles)	Truck/Tractor Trailers (separated type)
Average Maximum WTP (VND)	13,461	12,482	11,262	13,461
Sample Size	245	543	101	69
Note: The average was calculated by transforming the original data into natural log units and then the arithmetic mean was calculated and the calculated values were then reconverted back into the original units using an exponential function				

Source: Study Team

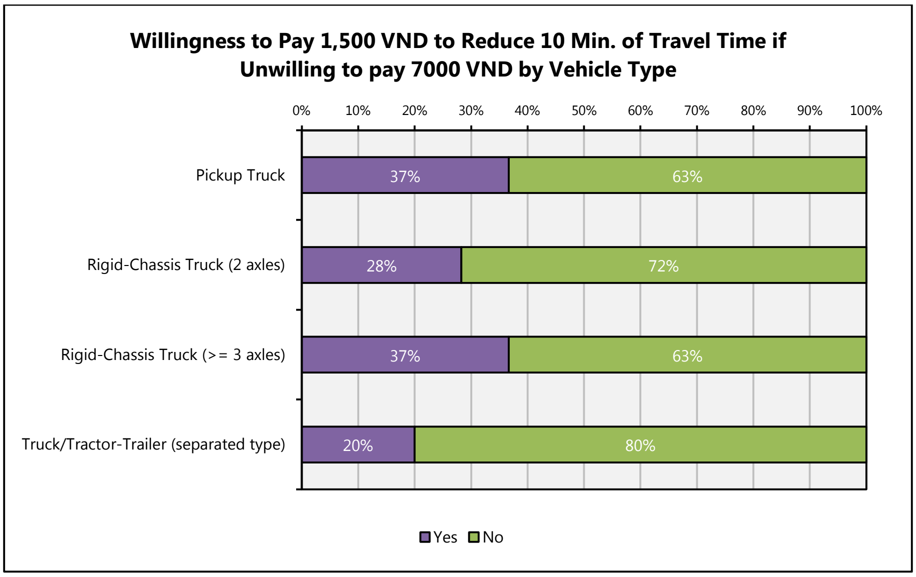
Lastly, respondents that answered "No" to the question if they were willing to pay 7,000 VND to reduce 10 minutes of travel time were asked if they were willing to pay 1,500 VND.

A majority of respondents that answered "No" to the question of whether they were willing to pay 7,000 VND to reduce 10 minutes of travel time also answered that they would not be willing to pay 1,500 VND. For each vehicle type, the proportion of "No" responses ranged from 63% to 80% (see Figure 4.3-22).

Table 4.3-26 Willingness to Pay 1,500 VND to Reduce 10 Minutes of Travel Time (Respondents)

	Vehicle Type			
	Pickup Trucks	Rigid-Chassis Trucks (2 axles)	Rigid-Chassis Trucks (>= 3 axles)	Truck/Tractor Trailer (separated type)
Yes	44	58	11	4
No	76	147	19	16
Total Number of Respondents	120	205	30	20

Source: Study Team



Source: Study Team

Figure 4.3-22 Willingness to Pay 1,500 VND to Reduce 10 Minutes of Travel Time (Proportion)

The statistics and distribution of data for the collected willingness to pay data are shown as follows.

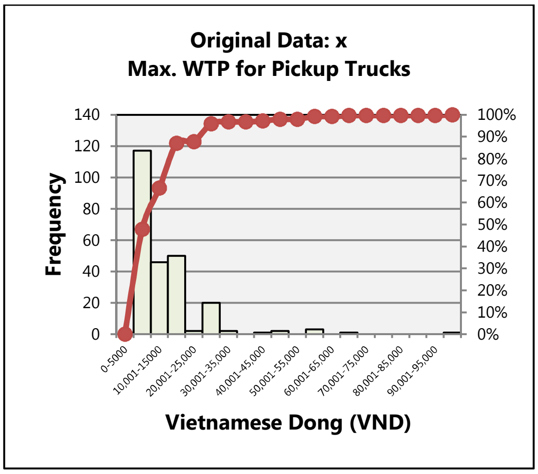
A summary of the descriptive statistics for the willingness to pay for freight drivers is shown in the following table.

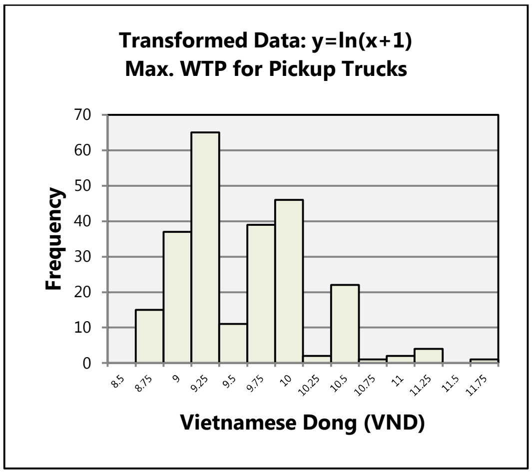
Table 4.3-27 Summary of the Descriptive Statistics for the Maximum Willingness to Pay to Reduce 10 Minutes of Travel Time by Vehicle Type

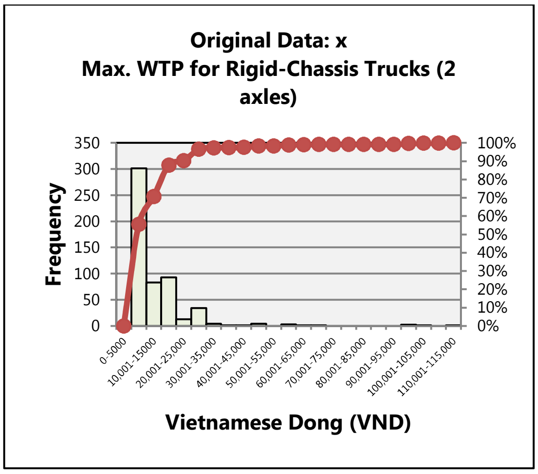
Descriptive Statistics of the Max. WTP	Pickup Trucks	Rigid-Chassis Trucks (2 axles)	Rigid-Chassis Trucks (3 axles)	Truck/Tractor Trailers (separated type)
Mean (VND)	13,461	12,482	11,262	13,461
Lower Confidence Interval (95%)	12,592	11,923	10,185	11,935
Upper Confidence Interval (95%)	14,389	13,067	12,452	15,183
Sample Size	245	543	101	69
The data was transformed and reconverted using the following formula: Original Data = x, Transformed Data = y=ln(x+1), Reconverted Data = z=exp(y)-1				

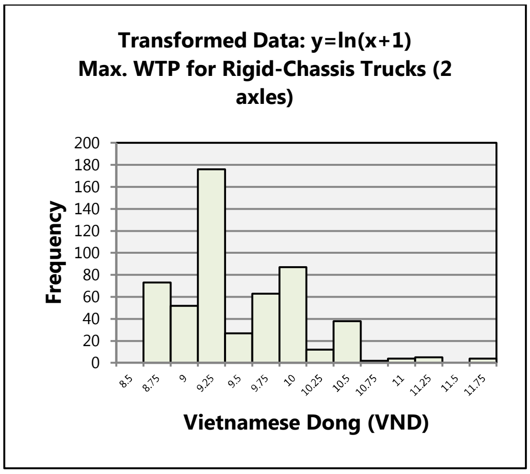
Source: Study Team

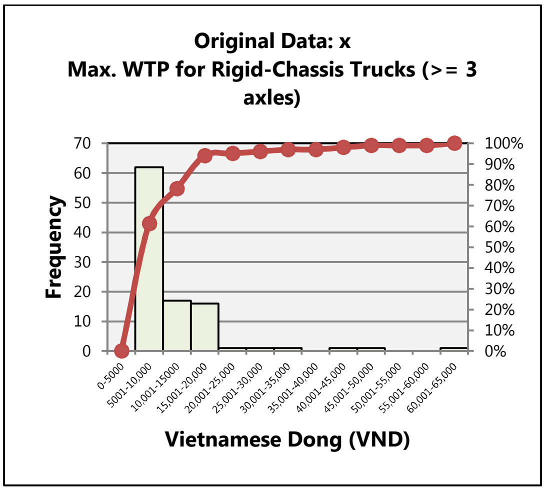
Histograms for the maximum willingness to pay for each mode are shown as follows and it can be seen that the distribution for the maximum willingness to pay for each mode are log-normal and therefore the original data was transformed using a natural logarithm function and the arithmetic mean was calculated in the natural log domain and the calculated mean was then reconverted back in the original data units using an exponential function.

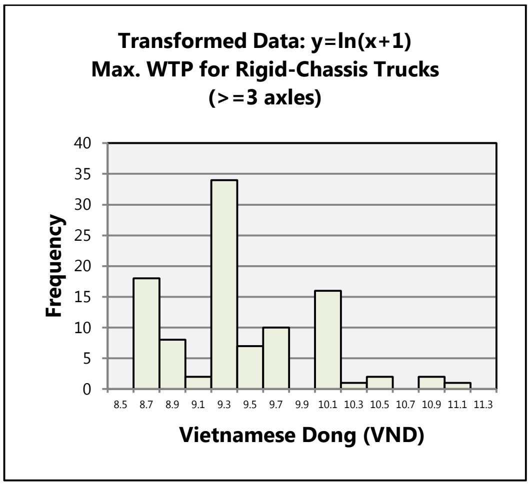

Original Data: x
Max. WTP for Pickup Trucks
Frequency
Vietnamese Dong (VND)

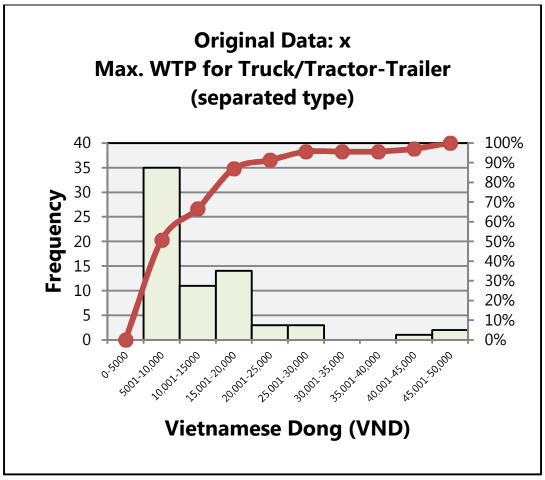

Transformed Data: y=ln(x+1)
Max. WTP for Pickup Trucks
Frequency
Vietnamese Dong (VND)

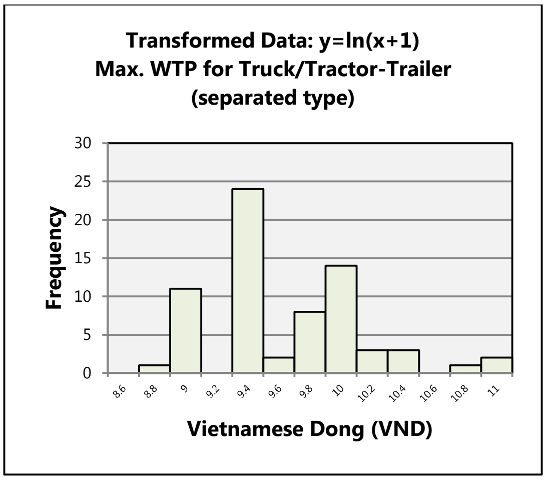

Original Data: x
Max. WTP for Rigid-Chassis Trucks (2 axles)
Frequency
Vietnamese Dong (VND)


Transformed Data: y=ln(x+1)
Max. WTP for Rigid-Chassis Trucks (2 axles)
Frequency
Vietnamese Dong (VND)


Original Data: x
Max. WTP for Rigid-Chassis Trucks (>= 3 axles)
Frequency
Vietnamese Dong (VND)


Transformed Data: y=ln(x+1)
Max. WTP for Rigid-Chassis Trucks (>=3 axles)
Frequency
Vietnamese Dong (VND)





Source: Study Team

Figure 4.3-23 Histogram of Max. Willing to Pay by Vehicle Type

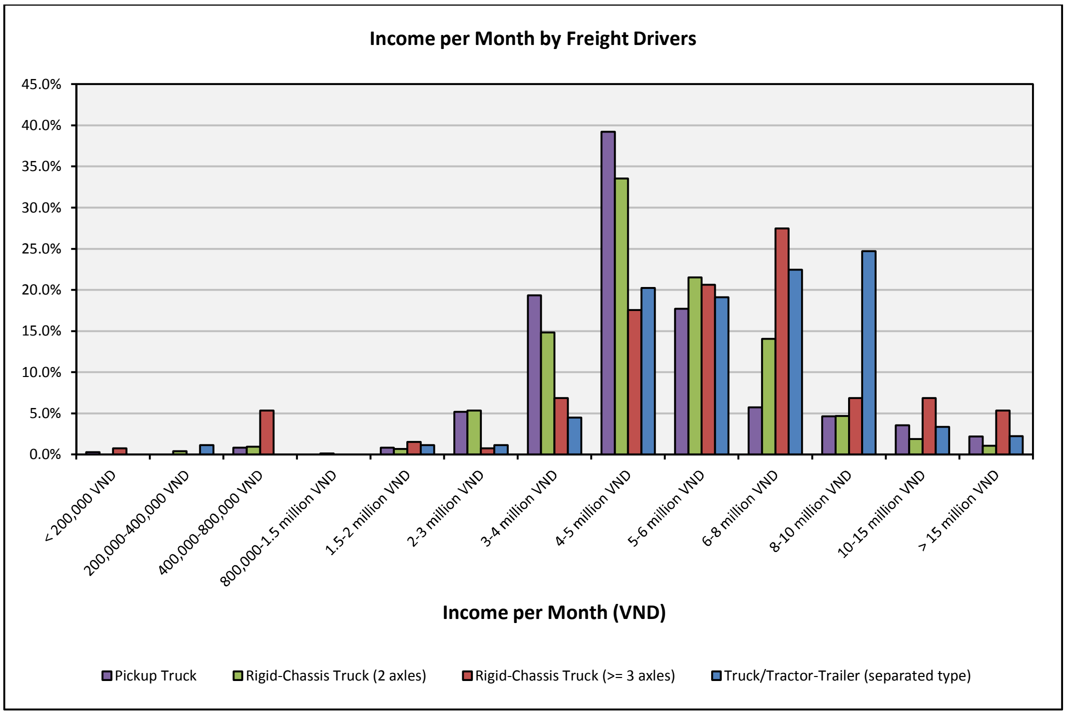
9) Individual Income per Month for Freight Mode Drivers by Mode

For pickup truck and rigid-chassis truck (2 axles) drivers, most drivers earned an individual income per month of between 4-5 million VND while for rigid-chassis truck (3 axles or more) drivers, most drivers earned an individual income per month of 6-8 million per month. For drivers of truck/tractor trailers, a large proportion of drivers for this vehicle type earned between 8-10 million VND per month (see Table 4.3-28 and Figure 4.3-24).

Table 4.3-28 Average Individual Income per Month by Vehicle Type

	Pickup Trucks	Rigid-Chassis Trucks (2 axles)	Rigid-Chassis Trucks (>= 3 axles)	Truck/Tractor Trailers (separated type)
Average Individual Income per Month by Vehicle Type (VND)	5,181,233	5,213,900	6,445,038	6,725,281
Sample Size	365	741	131	89
Note: The average was calculated using the arithmetic mean				

Source: Study Team



Source: Study Team

Figure 4.3-24 Income per Month by Freight Drivers

10) Descriptive Statistics for the Individual Income per Month for Freight Mode Drivers by Mode

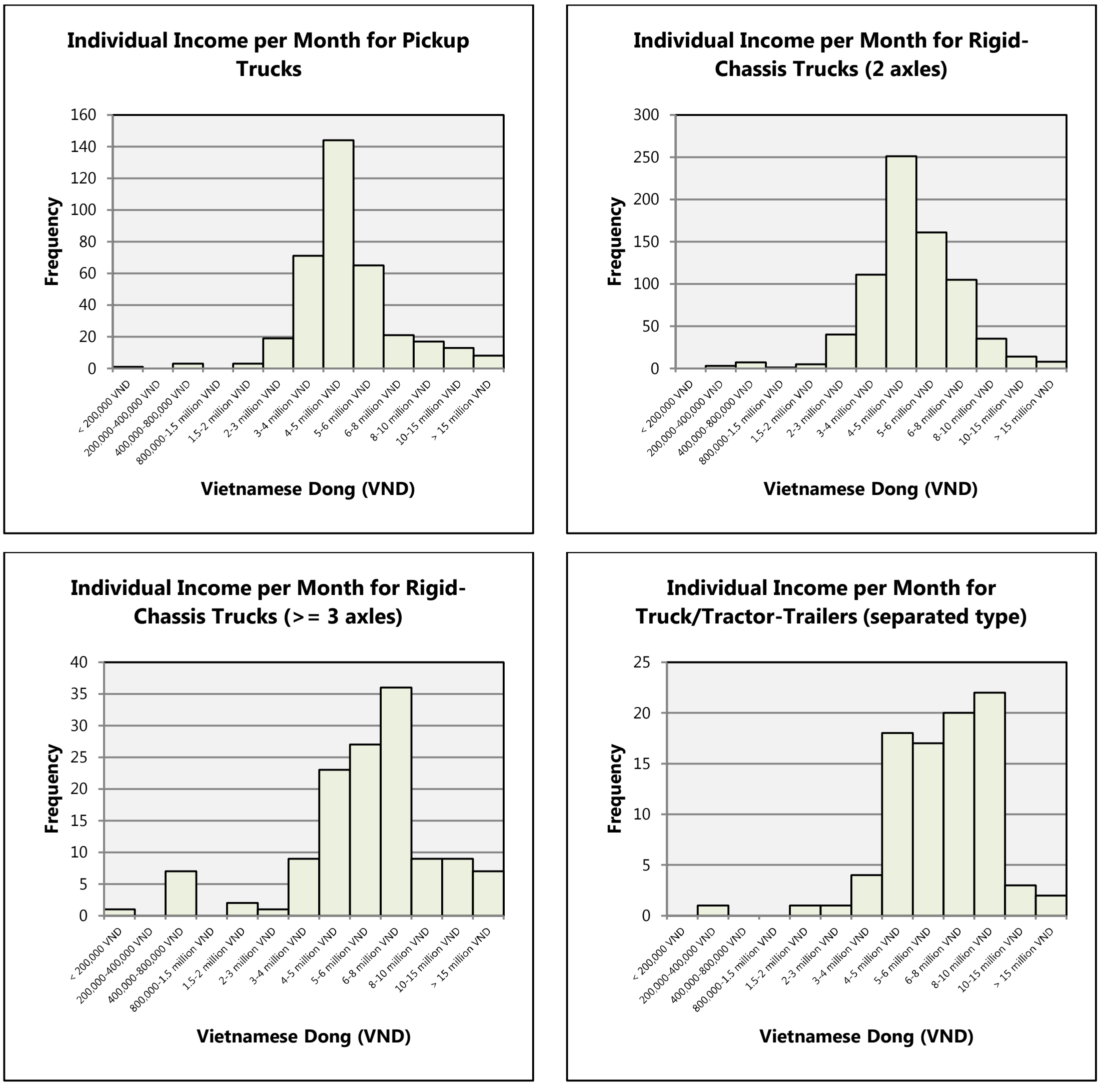
A summary of the descriptive statistics for the individual income per month for freight mode drivers by mode is shown in the following table.

Table 4.3-29 Summary of Descriptive Statistics for the Individual Income per Month by Vehicle Type

Descriptive Statistics of the Individual Income per Month	Pickup Trucks	Rigid-Chassis Trucks (2 axles)	Rigid-Chassis Trucks (>= 3 axles)	Truck/Tractor Trailers (separated type)
Arithmetic Mean (VND)	5,181,233	5,213,900	6,445,038	6,725,281
Standard Deviation	2,524,489	2,145,319	3,328,616	2,594,762
Kurtosis	5.19	5.36	1.00	1.42
Skewness	2.14	1.74	0.89	0.76
Sample Size	365	741	131	89
95% Confidence Level of the Population Mean	5,181,233 +/- 259,849 = (4,921,384, 5,441,082)	5,213,900 +/- 145,718 = (5,059,182, 5,368,618)	6,445,038 +/- 575,357 = (5,869,681, 7,020,396)	6,725,281 +/- 546,593 = (6,178,688, 7,271,874)

Source: Study Team

The distributions for individual income per month for truck types are shown in the following histograms and it can be seen that the distributions are approximately normally distributed even though the skewness for pickup trucks and rigid-chassis trucks (2 axles) exceeds the general rules of thumb of less than 1 (greater than -1) for normal distributions.



Source: Study Team

Figure 4.3-25 Histogram for the Individual Income per Month for Freight Mode Drivers

4.4 Axle Load Survey for Civil Works Design

4.4.1 Analysis Methodology for the Axle Load Survey Data

In order to assess the damage heavy commercial vehicles put on pavement, the raw measured data in metric tons for each axle needed to be processed into an average equivalency factor (EF) for each type of vehicle. The average EF for each type of vehicle represents the average damaging effect of a vehicle in each class, not the damaging effect for the average vehicle.

The EF is expressed as the number of standard (80 kN) axles that would cause the same amount of damage. The relationship between the axle load and damage is a power relationship. For example, a standard axle load of 8.16 metric tons will have an EF = 1, while doubling the axle load to 16.32 metric tons will have an EF = 22.6, in other words, a damaging effect will be 22 times bigger than that of standard 8.16 metric tons trucks, instead of just a double (2 times) damaging effect.

For each axle the EF was calculated based on the following equation[1] :

$$EF = \left(\frac{axle\ load\ (metric\ tons)}{8.16}\right)^{4.5}$$

The calculated EF for each axle that was surveyed was then summed to get the total EF for each vehicle surveyed.

<u>The overall purpose of this analysis is to calculate the average EF value for each vehicle group type.</u>

For certain types of vehicle configurations, there were too few samples to calculate a meaningful average value for the EF so the average EF was calculated based on the 4 major commercial vehicle types: rigid-chassis, truck-trailer, tractor-trailer and bus.

[1] Overseas Road Note 40, A guide to axle load surveys and traffic counts for determining traffic loading on pavements, TRL Limited/Department for International Development of the United Kingdom (2004)

Table 4.4-1 Commercial Vehicle Types for the Average EF Analysis

Commercial Vehicle Type	Axles	Axle Configuration
Rigid-Chassis	2 axles	1.1
	2 axles	1.2
	3 axles	1.11
	3 axles	1.22
	4 axles	11.22
	4 axles	12.22
Truck-Trailer	5 axles	1.2+222
Tractor-Trailer	5 axles	1.22-22
	6 axles	1.22-222
Bus		-

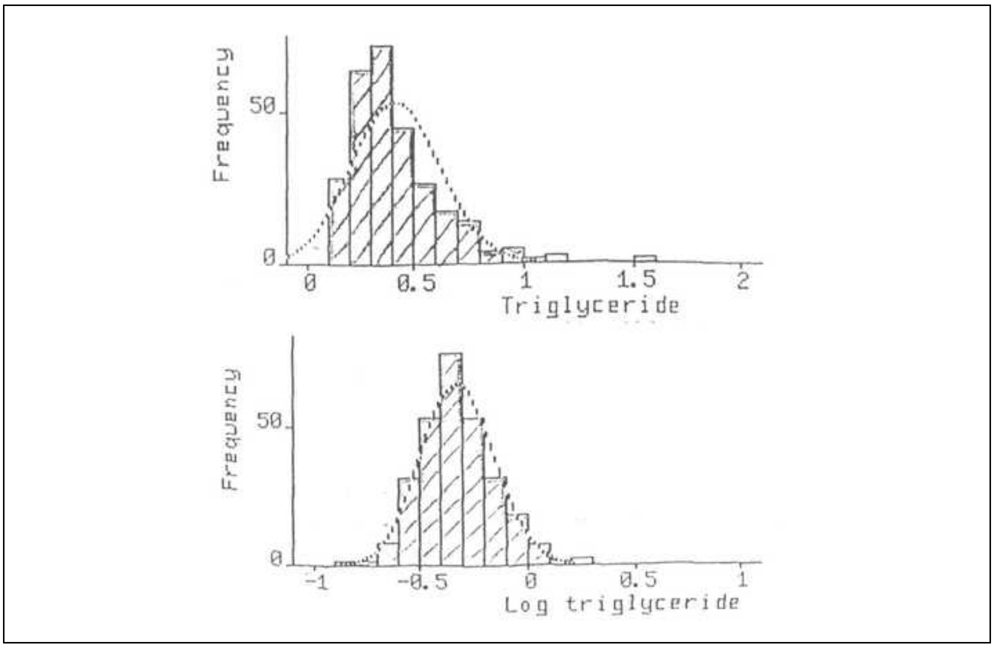
Source: Study Team

The standard way to calculate the average EF value for each commercial vehicle type would be to use the arithmetic mean, however, the arithmetic mean can only be used if the distribution of the sampled data was normally distributed.

Before any calculation of the average or mean value, histograms were constructed for each commercial vehicle type by survey station and for all of the survey stations.

After the histograms where constructed, it was found that most of the sampled data reflected a log-normal distribution. Therefore the arithmetic mean could not be used to calculate the average value. With a log-normal distribution, the geometric mean must be used to calculate the mean value. However, with a log-normal distribution, it is not a simple task to calculate the 95% confidence intervals using conventional means like in the case of a normal distribution.

One way to overcome this is to transform the data with the log-normal distribution so that it becomes a normal distribution. Taking a natural log (base e) of the sampled data will normalize the data. When the transformed data is normally distributed, the usual conventional methods could be used to calculate the mean (arithmetic mean) and the 95% confidence intervals. In the figure below, the top histogram is log-normal distributed and by using a natural log transformation of the original data, the data becomes normally distributed as shown in the histogram on the bottom.



Source: Statistics Research & Methodology, University College London (2010), https://epilab.ich.ucl.ac.uk/coursematerial/statistics/summarising_normal_dist/non_normal/transformations.html

Figure 4.4-1 Transforming Log-Normal Distributed Data to Normal Distributions

Once the mean and 95% confidence intervals are calculated, it is necessary to reconvert the data back to the original units using an inverse function.

For the axle load data, in cases where the surveyed data was found to have a log-normal distribution, the data was transformed by the following equations (for the equation to transform the data, a constant value of 1 was added to the original data before taking the natural log to ensure that the data remained positive):

$$\text{Original Data (EF = Equivalency Factor)}: x = EF$$

$$\text{Transformed Data Equation}: y = \ln(x + 1)$$

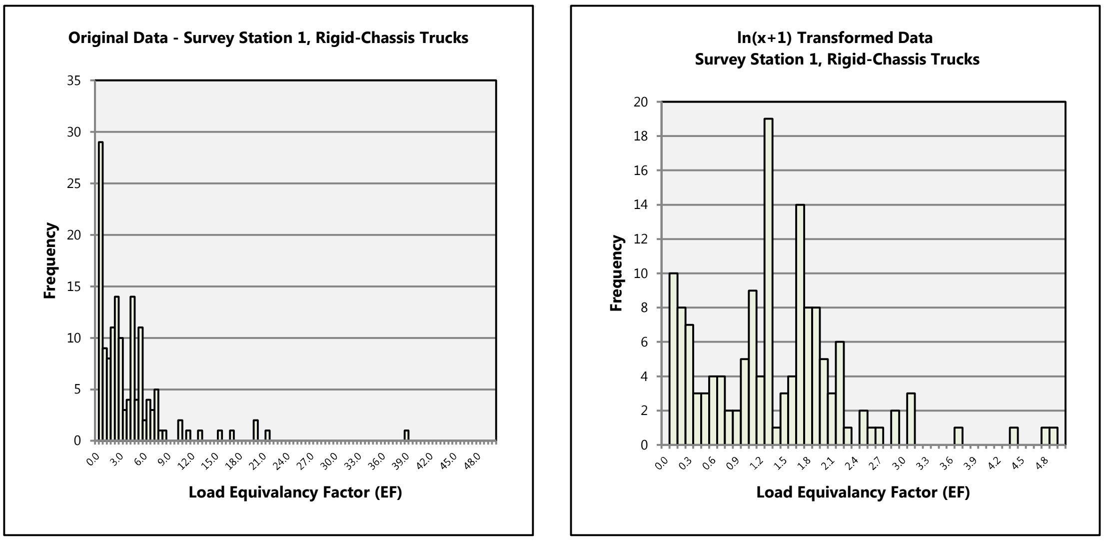
$$\text{Equation to Reconvert the Data}: z = \exp(y) - 1$$

(1) Descriptive Statistics for Survey Station 1 Axle Load Data

Histograms and descriptive statistics for rigid-chassis trucks, tractor-trailers and buses for survey station (1) are shown as follows.

1) Rigid-Chassis Trucks

The distribution of the original data and the transformed data for rigid-chassis trucks for survey station (1) are shown in the following figure. After taking a natural log transformation of the original data, the data became normally distributed.



Source: Study Team

Figure 4.4-2 Original Data (Left), Transformed Data (Right) for Rigid-Chassis Trucks, Survey Station 1

The descriptive statistics for the rigid-chassis trucks data for survey station (1) are shown in the following table. After the data transformation, the skewness value reduced from 6.37 to 1.03 which fits the general rules of thumb (between around -1 and 1) for a normal distribution. The average EF value calculated for rigid-chassis trucks for survey station (1) is 2.77 (95% confident that the mean lies between 2.25 and 3.38).

Table 4.4-2 Descriptive Statistics for Rigid-Chassis Trucks, Survey Station 1

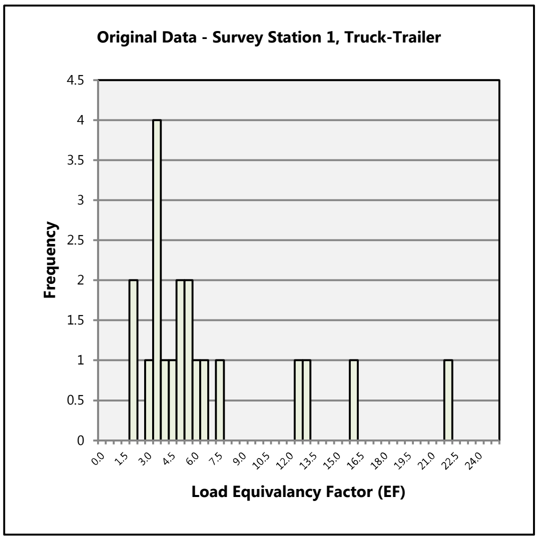
Station 1			
Rigid-Chassis			
	Original Data	**Transformed Data**	**Reconverted Data**
Unit:	**x = EF**	**y = ln(x+1)**	**z = exp(y) - 1**
Mean	5.91	1.33	2.77
Skewness	6.37	1.03	-
Lower Confidence Level (95%)	3.37	1.18	2.25
Upper Confidence Level (95%)	8.46	1.48	3.38
Sample Size	146	146	146

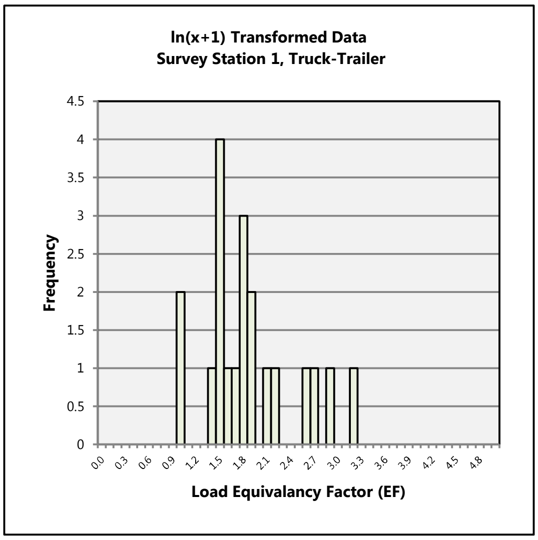
Note: EF = Equivalency Factor

Source: Study Team

2) Truck-Trailers

The distribution of the original data and the transformed data for truck-trailers for survey station (1) is shown in the following figure. After taking a natural log transformation of the original data, the data became normally distributed.





Source: Study Team

Figure 4.4-3 Original Data (Left), Transformed Data (Right) for Truck-Trailers, Survey Station 1

The descriptive statistics for the truck-trailer data for survey station (1) are shown in the following table. After the data transformation, the skewness value reduced from 1.81 to 0.71 (between around -1 and 1) which fits the general rule of thumb for a normal distribution. The average EF value calculated for truck-trailers for survey station (1) is 5.20 (95% confident that the mean lies between 3.71 and 7.15).

Table 4.4-3 Descriptive Statistics for Truck-Trailers, Survey Station 1

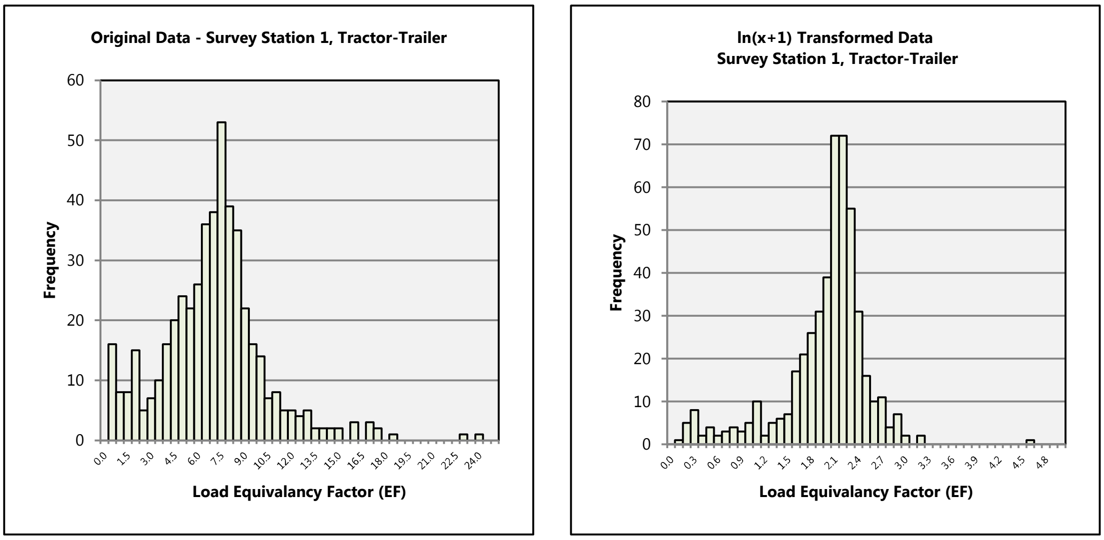
Station 1			
Truck-Trailer			
	Original Data	**Transformed Data**	**Reconverted Data**
Unit:	**x = EF**	**y = ln(x+1)**	**z = exp(y) - 1**
Mean	6.43	1.82	5.20
Skewness	1.81	0.71	-
Lower Confidence Level (95%)	3.97	1.55	3.71
Upper Confidence Level (95%)	8.88	2.10	7.15
Sample Size	20	20	20

Note: EF = Equivalency Factor

Source: Study Team

3) Tractor-Trailers

The distribution of the original data and the transformed data for tractor-trailers for survey station (1) are shown in the following figure. After taking a natural log transformation of the original data, the data became normally distributed.



Source: Study Team

Figure 4.4-4 Original Data (Left), Transformed Data (Right) for Tractor-Trailers, Survey Station 1

The descriptive statistics for the tractor-trailer data for survey station (1) are shown in the following table. After the data transformation, the skewness value reduced from 9.50 to -1.10 which fits the general rule of thumb (between around -1 and 1) for a normal distribution. The average EF value calculated for tractor-trailers for survey station (1) is 5.92 (95% confident that the mean lies between 5.58 and 6.27).

Table 4.4-4 Descriptive Statistics for Tractor-Trailers, Survey Station 1

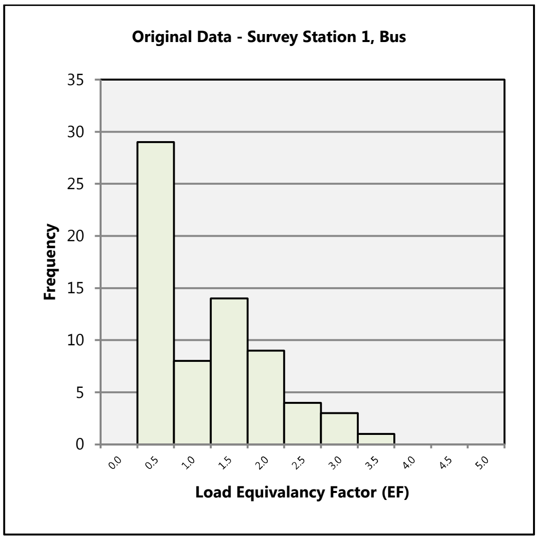
Station 1			
Tractor-Trailer			
	Original Data	**Transformed Data**	**Reconverted Data**
Unit:	**x = EF**	**y = ln(x+1)**	**z = exp(y) - 1**
Mean	6.92	1.93	5.92
Skewness	9.50	-1.10	-
Lower Confidence Level (95%)	6.46	1.88	5.58
Upper Confidence Level (95%)	7.37	1.98	6.27
Sample Size	484	484	484

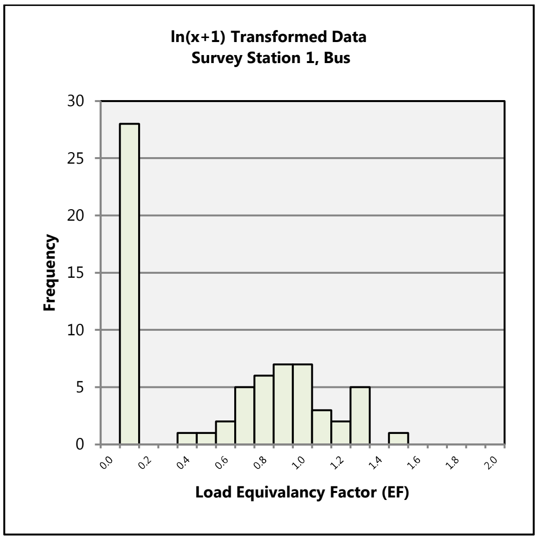
Note: EF = Equivalency Factor

Source: Study Team

4) Buses

The distribution of the original data and the transformed data for buses for survey station (1) are shown in the following figure. After taking a natural log transformation of the original data, the data became normally distributed.





Source: Study Team

Figure 4.4-5 Original Data (Left), Transformed Data (Right) for Buses, Survey Station 1

The descriptive statistics for the bus data for survey station (1) are shown in the following table. After the data transformation, the skewness value reduced from an already low value of 0.55 to 0.08 which fits the general rule of thumb (between around -1 and 1) for a normal distribution. The average EF value calculated for buses for survey station (1) is 0.71 (95% confident that the mean lies between 0.53 and 0.91).

Table 4.4-5 Descriptive Statistics for Buses, Survey Station 1

Station 1			
Bus			
	Original Data	**Transformed Data**	**Reconverted Data**
Unit:	**x = EF**	**y = ln(x+1)**	**z = exp(y) - 1**
Mean	0.90	0.54	0.71
Skewness	0.55	0.08	-
Lower Confidence Level (95%)	0.69	0.42	0.53
Upper Confidence Level (95%)	1.11	0.65	0.91
Sample Size	68	68	68

Note: EF = Equivalency Factor

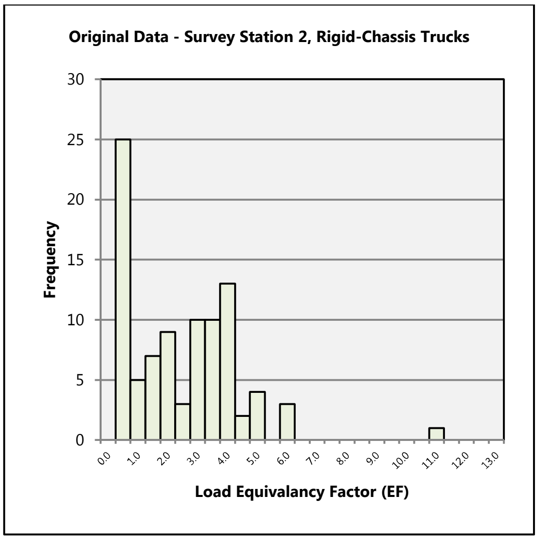
Source: Study Team

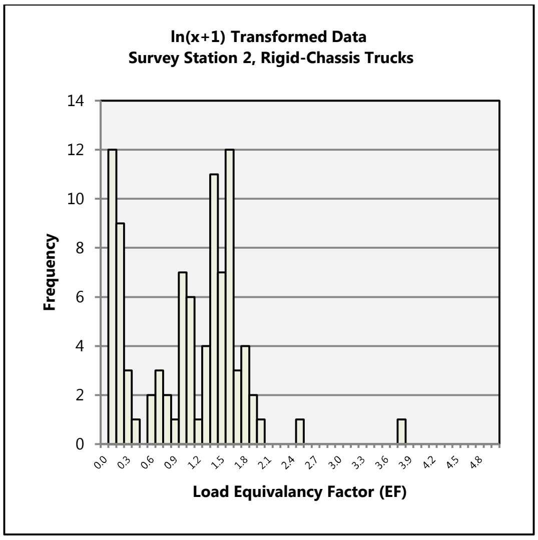
(2) Descriptive Statistics for Survey Station 2 Axle Load Data

Histograms and descriptive statistics for rigid-chassis trucks, tractor-trailers and buses for survey station (2) are shown as follows. In survey station (2), only 1 sample for truck-trailer vehicles was surveyed and as a result it was not possible to calculate an average EF value for this vehicle type at this survey station.

1) Rigid-Chassis Trucks

The distribution of the original data and the transformed data for rigid-chassis trucks for survey station (2) are shown in the following figure. After taking a natural log transformation of the original data, the data became normally distributed.





Source: Study Team

Figure 4.4-6 Original Data (Left), Transformed Data (Right) for Rigid-Chassis Trucks, Survey Station 2

The descriptive statistics for the rigid-chassis trucks data for survey station (2) are shown in the following table. After the data transformation, the skewness value reduced from 7.20 to 0.40 which fits the general rule of thumb (between around -1 and 1) for a normal distribution. The average EF value calculated for rigid-chassis trucks for survey station (2) is 1.78 (95% confident that the mean lies between 1.42 and 2.20).

Table 4.4-6 Descriptive Statistics for Rigid-Chassis Trucks, Survey Station 2

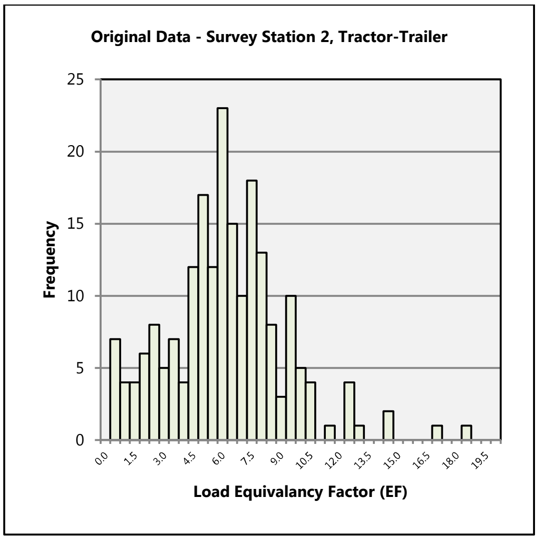
Station 2			
Rigid-Chassis			
	Original Data	**Transformed Data**	**Reconverted Data**
Unit:	**x = EF**	**y = ln(x+1)**	**z = exp(y) - 1**
Mean	2.63	1.02	1.78
Skewness	7.20	0.40	-
Lower Confidence Level (95%)	1.73	0.88	1.42
Upper Confidence Level (95%)	3.54	1.16	2.20
Sample Size	93	93	93

Note: EF = Equivalency Factor

Source: Study Team

2) Tractor-Trailers

Next, the distribution of the original data for tractor-trailers for survey station 2 is shown in the following figure. As shown, it can be seen that the original data already fits a normal distribution and therefore no transformation of the data was necessary.



Source: Study Team

Figure 4.4-7 Original Data for Tractor-Trailers, Survey Station 2

The descriptive statistics for the tractor-trailers data for survey station (2) are shown in the following table. The skewness value of the original data is 0.62 which already fits the general rule of thumb (between around -1 and 1) for a normal distribution. The average EF value calculated for rigid-chassis trucks for survey station (2) is 5.94 (95% confident that the mean lies between 5.53 and 6.36).

Table 4.4-7 Descriptive Statistics for Tractor-Trailers, Survey Station 2

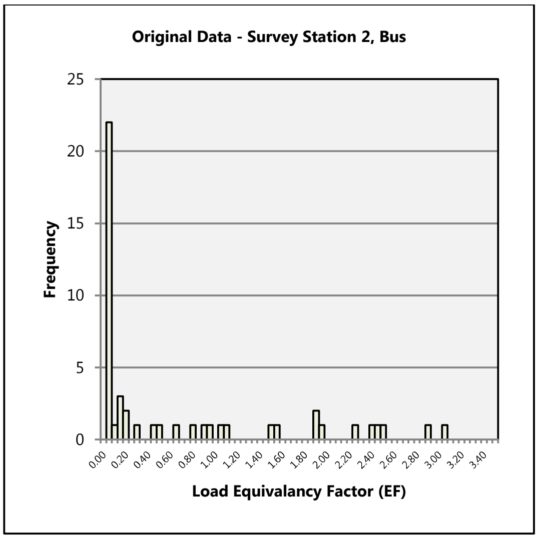
Station 2			
Tractor-Trailer			
	Original Data	**Transformed Data**	**Reconverted Data**
Unit:	**x = EF**	**y = ln(x+1)**	**z = exp(y) - 1**
Mean	5.94	-	-
Skewness	0.62	-	-
Lower Confidence Level (95%)	5.53	-	-
Upper Confidence Level (95%)	6.36	-	-
Sample Size	205	-	-

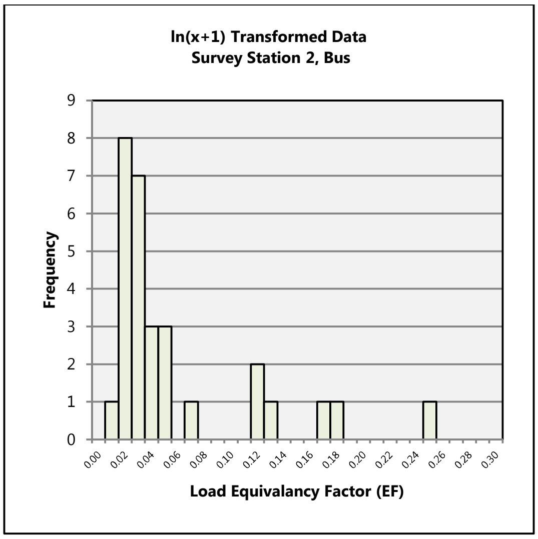
Note: EF = Equivalency Factor

Source: Study Team

3) Buses

The distribution of the original data and the transformed data for buses for survey station (2) are shown in the following figure. After taking a natural log transformation of the original data, the data became approximately normally distributed.





Source: Study Team

Figure 4.4-8 Original Data (Left), Transformed Data (Right) for Buses, Survey Station 2

The descriptive statistics for the bus data for survey station (2) are shown in the following table. After the data transformation, the skewness value reduced from an already low value of 1.28 to 0.92 which fits the general rule of thumb (between around -1 and 1) for a normal distribution. The average EF value calculated for buses for survey station (2) is 0.48 (95% confident that the mean lies between 0.29 and 0.69).

Table 4.4-8 Descriptive Statistics for Buses, Survey Station 2

Station 2			
Bus			
	Original Data	**Transformed Data**	**Reconverted Data**
Unit:	**x = EF**	**y = ln(x+1)**	**z = exp(y) - 1**
Mean	0.67	0.39	0.48
Skewness	1.28	0.92	-
Lower Confidence Level (95%)	0.40	0.25	0.29
Upper Confidence Level (95%)	0.93	0.53	0.69
Sample Size	48	48	48

Note: EF = Equivalency Factor

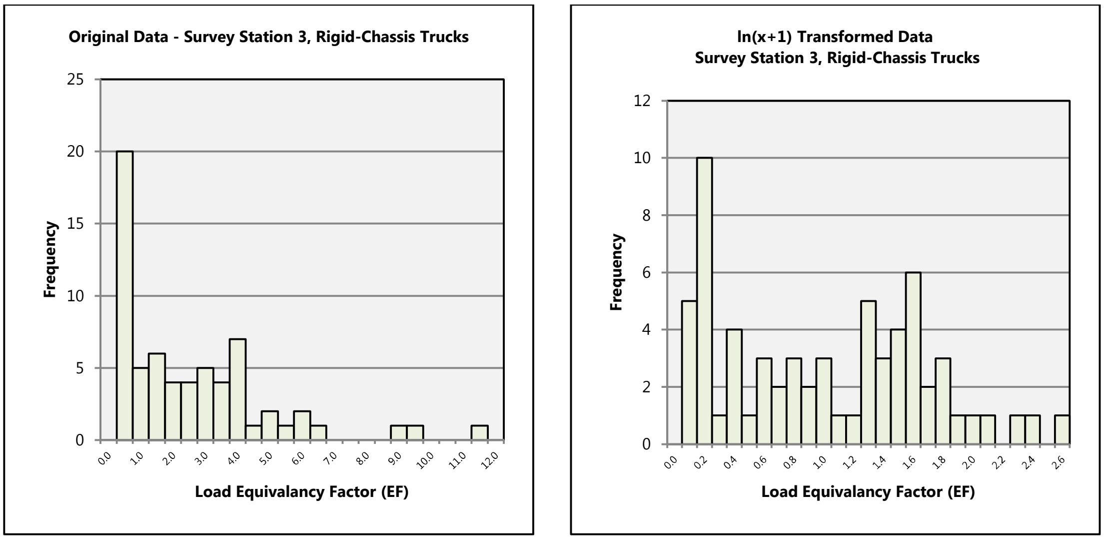
Source: Study Team

(3) Descriptive Statistics for Survey Station 3 Axle Load Data

Histograms and descriptive statistics for rigid-chassis trucks, tractor-trailers and buses for survey station (3) are as follows. No truck-trailers were surveyed at this survey station.

1) Rigid-Chassis Trucks

The distribution of the original data and the transformed data for rigid-chassis trucks for survey station (3) are shown in the following figure. After taking a natural log transformation of the original data, the data became normally distributed.



Source: Study Team

Figure 4.4-9 Original Data (Left), Transformed Data (Right) for Rigid-Chassis Trucks, Survey Station 3

The descriptive statistics for the rigid-chassis trucks data for survey station (3) are shown in the following table. After the data transformation, the skewness value reduced from 1.59 to 0.23 which fits the general rule of thumb (between around -1 and 1) for a normal distribution. The average EF value calculated for rigid-chassis trucks for survey station (3) is 1.62 (95% confident that the mean lies between 1.21 and 2.10).

Table 4.4-9 Descriptive Statistics for Rigid-Chassis Trucks, Survey Station 3

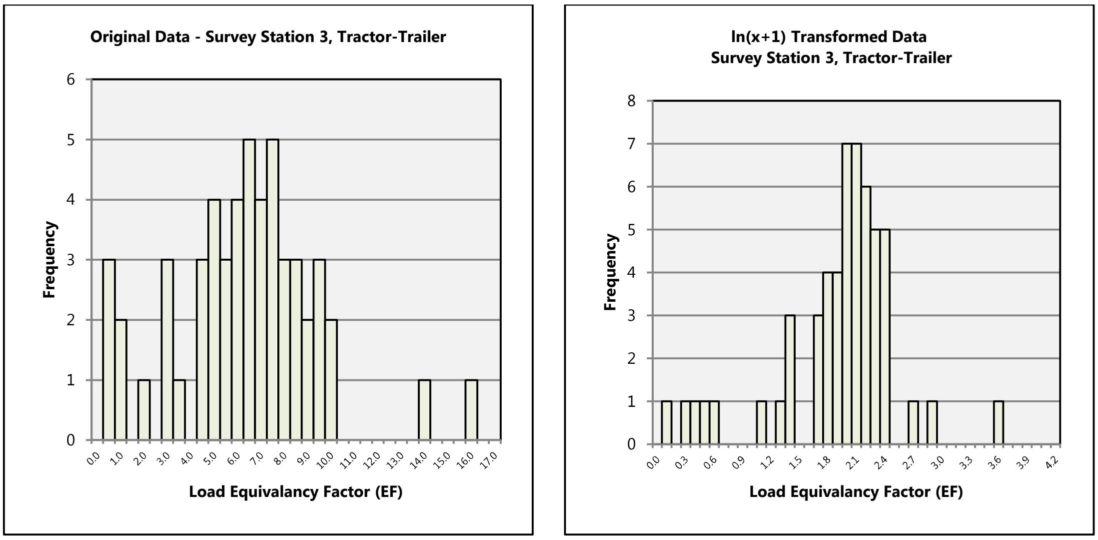
Station 3			
Rigid-Chassis			
	Original Data	**Transformed Data**	**Reconverted Data**
Unit:	**x = EF**	**y = ln(x+1)**	**z = exp(y) - 1**
Mean	2.30	0.96	1.62
Skewness	1.59	0.23	-
Lower Confidence Level (95%)	1.71	0.80	1.21
Upper Confidence Level (95%)	2.89	1.13	2.10
Sample Size	65	65	65

Note: EF = Equivalency Factor

Source: Study Team

2) Tractor-Trailers

The distribution of the original data and the transformed data for tractor-trailers for survey station (3) are shown in the following figure. After taking a natural log transformation of the original data, the data became normally distributed.



Source: Study Team

Figure 4.4-10 Original Data (Left), Transformed Data (Right) for Tractor-Trailers, Survey Station 3

The descriptive statistics for the tractor-trailer data for survey station (3) are shown in the following table. After the data transformation, the skewness value reduced from 3.62 to -0.92 which fits the general rule of thumb (between around -1 and 1) for a normal distribution. The average EF value calculated for truck-trailers for survey station (3) is 5.43 (95% confident that the mean lies between 4.41 and 6.63).

Table 4.4-10 Descriptive Statistics for Tractor-Trailers, Survey Station 3

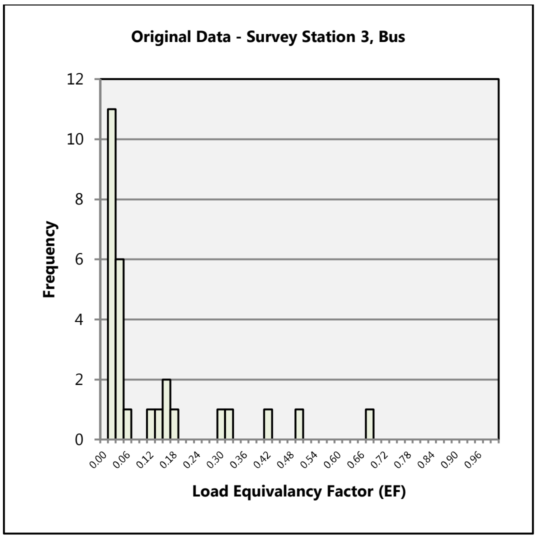
Station 3			
Tractor-Trailer			
	Original Data	**Transformed Data**	**Reconverted Data**
Unit:	**x = EF**	**y = ln(x+1)**	**z = exp(y) - 1**
Mean	6.63	1.86	5.43
Skewness	3.62	-0.92	-
Lower Confidence Level (95%)	5.26	1.69	4.41
Upper Confidence Level (95%)	8.00	2.03	6.63
Sample Size	54	54	54

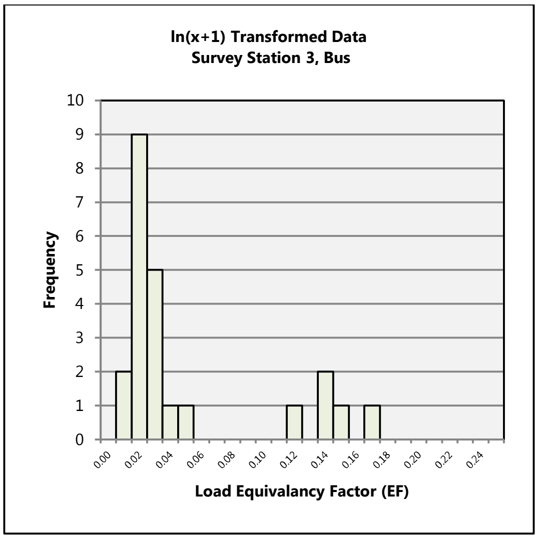
Note: EF = Equivalency Factor

Source: Study Team

3) Buses

The distribution of the original data and the transformed data for buses for survey station (3) are shown in the following figure. A number of transformations were tested but only the natural log transformation caused the data to approximately resemble a normal distribution.





Source: Study Team

Figure 4.4-11 Original Data (Left), Transformed Data (Right) for Buses, Survey Station 3

The descriptive statistics for the bus data for survey station (3) are shown in the following table. After the data transformation, the skewness value reduced from 1.50 to 1.27 which is slightly above the general rule of thumb (between around -1 and 1) for a normal distribution. The average EF value calculated for truck-trailers for survey station (3) is 0.31 (95% confident that the mean lies between 0.16 and 0.48).

Table 4.4-11 Descriptive Statistics for Buses, Survey Station 3

Station 3			
Bus			
	Original Data	**Transformed Data**	**Reconverted Data**
Unit:	**x = EF**	**y = ln(x+1)**	**z = exp(y) - 1**
Mean	0.41	0.27	0.31
Skewness	1.50	1.27	-
Lower Confidence Level (95%)	0.20	0.15	0.16
Upper Confidence Level (95%)	0.62	0.39	0.48
Sample Size	35	35	35

Note: EF = Equivalency Factor

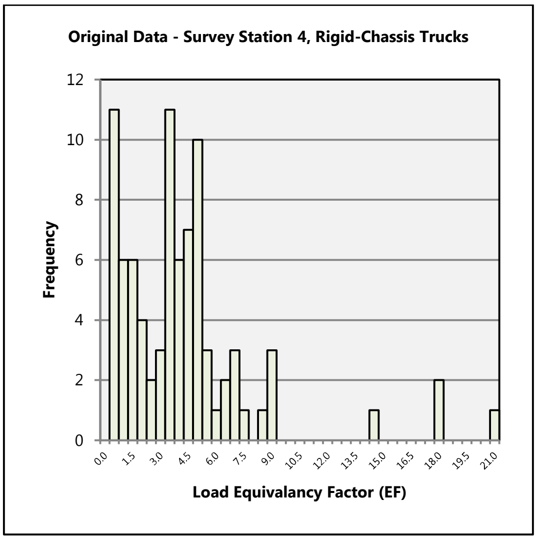
Source: Study Team

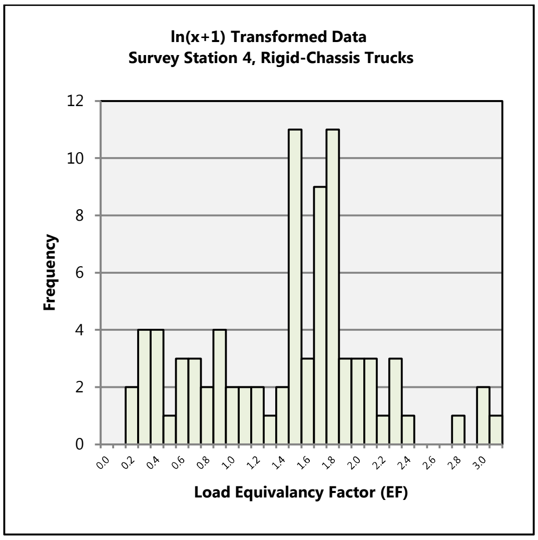
(4) Descriptive Statistics for Survey Station 4 Axle Load Data

Histograms and descriptive statistics for rigid-chassis trucks and tractor-trailers for survey station (4) are as follows. For truck-trailer vehicles only 4 were surveyed and this was not enough to calculate a meaningful average EF value. Also, no buses were surveyed at this survey station.

1) Rigid-Chassis Trucks

The distribution of the original data and the transformed data for rigid-chassis trucks for survey station (4) are shown in the following figure. After taking a natural log transformation of the original data, the data became normally distributed.





Source: Study Team

Figure 4.4-12 Original Data (Left), Transformed Data (Right) for Rigid-Chassis Trucks, Survey Station 4

The descriptive statistics for the rigid-chassis trucks data for survey station (4) are shown in the following table. After the data transformation, the skewness value reduced from 2.39 to 0.02 which fits the general rule of thumb (between around -1 and 1) for a normal distribution. The average EF value calculated for rigid-chassis trucks for survey station (4) is 3.00 (95% confident that the mean lies between 2.45 and 3.63).

Table 4.4-12 Descriptive Statistics for Rigid-Chassis Trucks, Survey Station 4

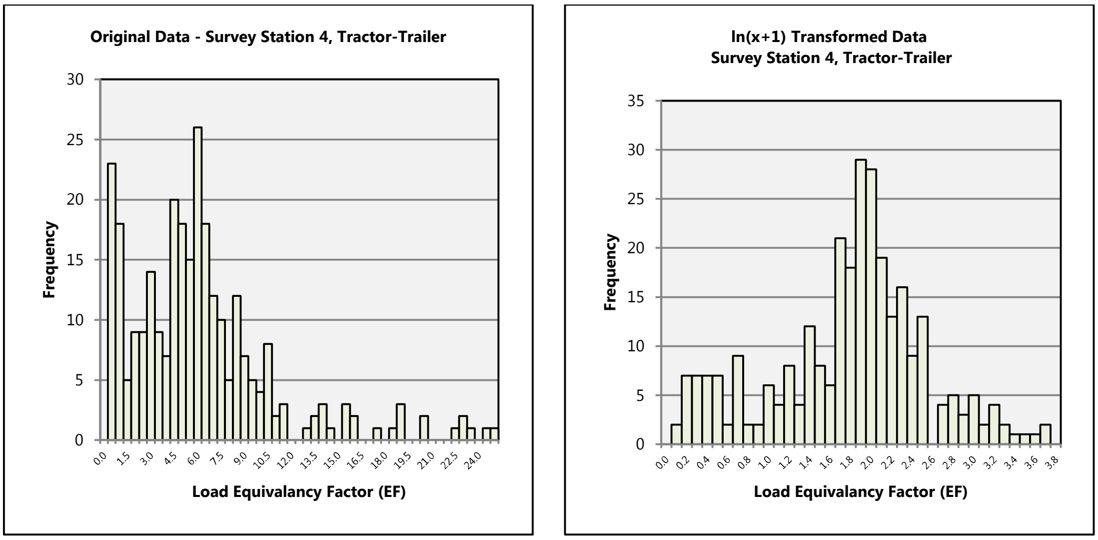
Station 4			
Rigid-Chassis			
	Original Data	**Transformed Data**	**Reconverted Data**
Unit:	**x = EF**	**y = ln(x+1)**	**z = exp(y) - 1**
Mean	4.01	1.39	3.00
Skewness	2.39	0.02	-
Lower Confidence Level (95%)	3.18	1.24	2.45
Upper Confidence Level (95%)	4.83	1.53	3.63
Sample Size	84	84	84

Note: EF = Equivalency Factor

Source: Study Team

2) Tractor-Trailers

The distribution of the original data and the transformed data for tractor-trailers for survey station (4) are shown in the following figure. After taking a natural log transformation of the original data, the data became normally distributed.



Source: Study Team

Figure 4.4-13 Original Data (Left), Transformed Data (Right) for Tractor-Trailers, Survey Station 4

The descriptive statistics for the tractor-trailer data for survey station (4) are shown in the following table. After the data transformation, the skewness value reduced from 2.34 to -0.29 which fits the general rule of thumb (between around -1 and 1) for a normal distribution. The average EF value calculated for tractor-trailers for survey station (4) is 4.67 (95% confident that the mean lies between 4.20 and 5.19).

Table 4.4-13 Descriptive Statistics for Tractor-Trailers, Survey Station 4

Station 4			
Tractor-Trailer			
	Original Data	**Transformed Data**	**Reconverted Data**
Unit:	**x = EF**	**y = ln(x+1)**	**z = exp(y) - 1**
Mean	6.40	1.74	4.67
Skewness	2.34	-0.29	-
Lower Confidence Level (95%)	5.72	1.65	4.20
Upper Confidence Level (95%)	7.08	1.82	5.19
Sample Size	289	289	289

Note: EF = Equivalency Factor

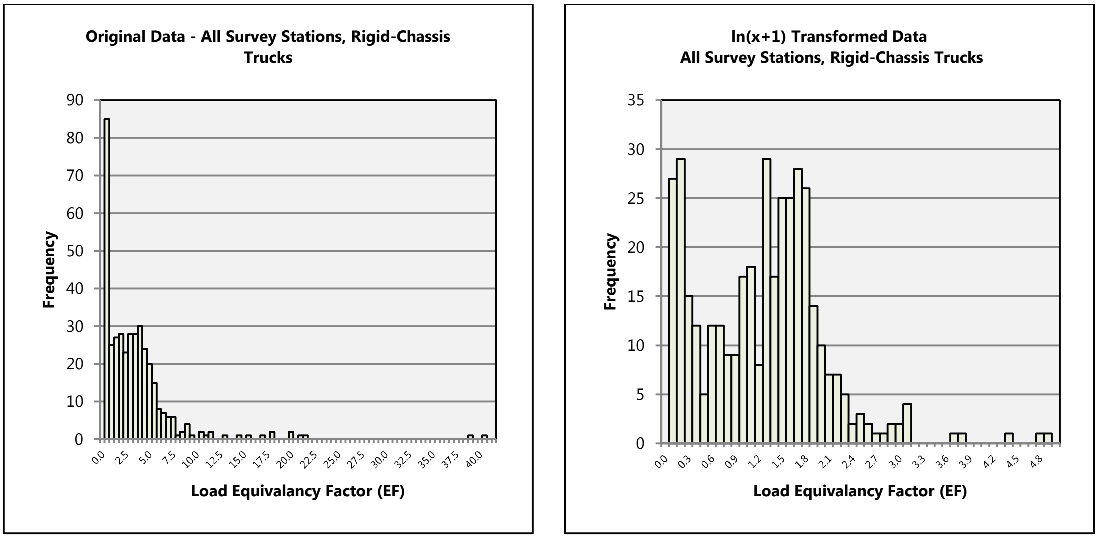
Source: Study Team

(5) Descriptive Statistics for Axle Load Data for All Survey Stations

Lastly for the axle load survey data analysis, histograms and descriptive statistics for rigid-chassis trucks, truck-trailers, tractor-trailers and buses for all 4 survey stations are shown as follows.

1) Rigid-Chassis Trucks

The distribution of the original data and the transformed data for rigid-chassis trucks for all survey stations are shown in the following figure. After taking a natural log transformation of the original data, the data became normally distributed.



Source: Study Team

Figure 4.4-14 Original Data (Left), Transformed Data (Right) for Rigid-Chassis Trucks, All Survey Stations

The descriptive statistics for the rigid-chassis truck data for all survey stations are shown in the following table. After the data transformation, the skewness value reduced from 9.33 to 0.76 which fits the general rule of thumb (between around -1 and 1) for a normal distribution. The average EF value calculated for rigid-chassis trucks for all survey stations is 2.34 (95% confident that the mean lies between 2.09 and 2.62).

Table 4.4-14 Descriptive Statistics for Rigid-Chassis Trucks, All Survey Stations

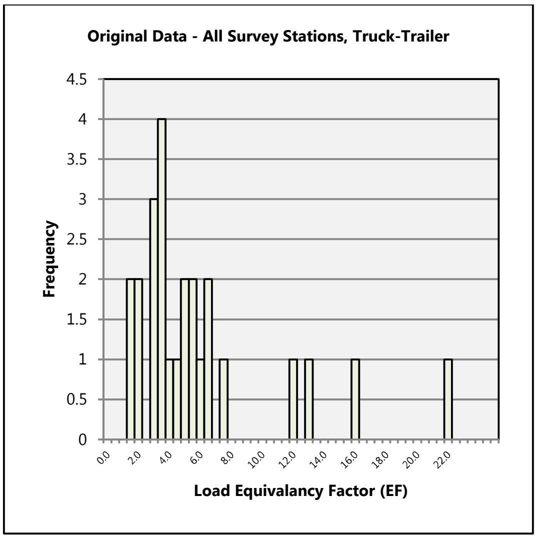
All Survey Stations			
Rigid-Chassis			
	Original Data	**Transformed Data**	**Reconverted Data**
Unit:	**x = EF**	**y = ln(x+1)**	**z = exp(y) - 1**
Mean	4.11	1.21	2.34
Skewness	9.33	0.76	-
Lower Confidence Level (95%)	3.10	1.13	2.09
Upper Confidence Level (95%)	5.12	1.29	2.62
Sample Size	388	388	388

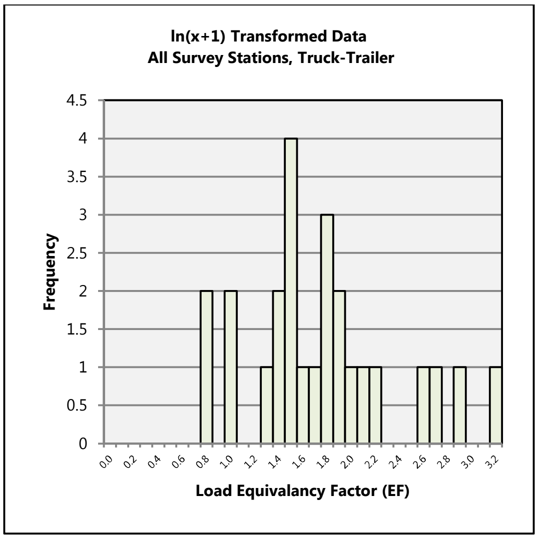
Note: EF = Equivalency Factor

Source: Study Team

2) *Truck-Trailers*

The distribution of the original data and the transformed data for truck-trailers for all survey stations are shown in the following figure. After taking a natural log transformation of the original data, the data became normally distributed.





Source: Study Team

Figure 4.4-15 Original Data (Left), Transformed Data (Right) for Truck-Trailers, All Survey Stations

The descriptive statistics for the truck-trailer data for all survey stations are shown in the following table. After the data transformation, the skewness value reduced from 1.98 to 0.58 which fits the general rule of thumb (between around -1 and 1) for a normal distribution. The average EF value calculated for truck-trailers for all survey stations is 4.50 (95% confident that the mean lies between 3.27 and 6.09).

Table 4.4-15 Descriptive Statistics for Truck-Trailers, All Survey Stations

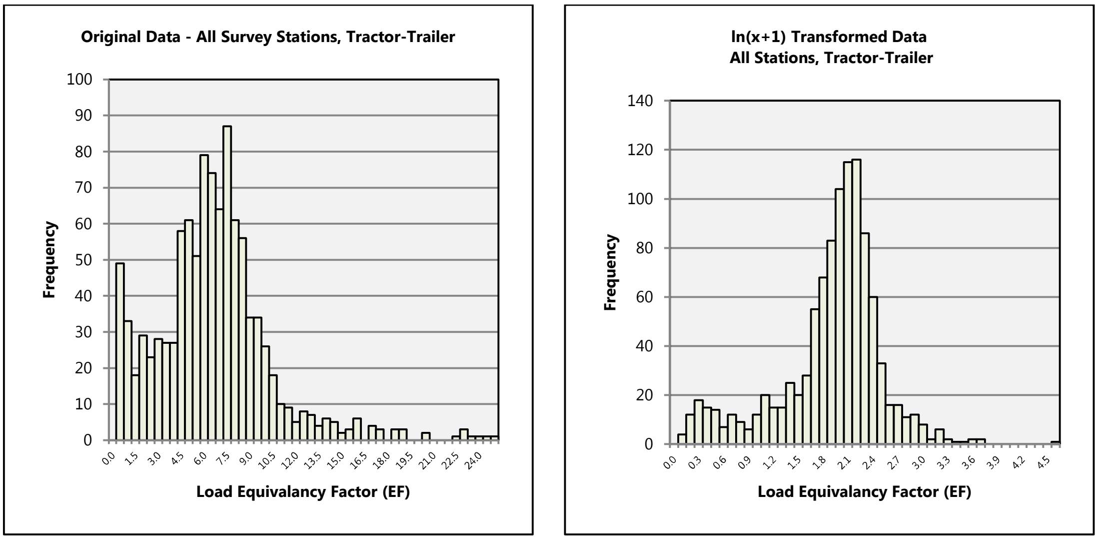
All Survey Stations			
Truck-Trailer			
	Original Data	**Transformed Data**	**Reconverted Data**
Unit:	**x = EF**	**y = ln(x+1)**	**z = exp(y) - 1**
Mean	5.71	1.71	4.50
Skewness	1.98	0.58	-
Lower Confidence Level (95%)	3.66	1.45	3.27
Upper Confidence Level (95%)	7.76	1.96	6.09
Sample Size	25	25	25

Note: EF = Equivalency Factor

Source: Study Team

3) Tractor-Trailers

The distribution of the original data and the transformed data for tractor-trailers for all survey stations are shown in the following figure. After taking a natural log transformation of the original data, the data became normally distributed.



Source: Study Team

Figure 4.4-16 Original Data (Left), Transformed Data (Right) for Tractor-Trailers, All Survey Stations

The descriptive statistics for the tractor-trailer data for all survey stations are shown in the following table. After the data transformation, the skewness value reduced from 5.97 to -0.80 which fits the general rule of thumb (between around -1 and 1) for a normal distribution. The average EF value calculated for tractor-trailers for all survey stations is 5.37 (95% confident that the mean lies between 5.14 and 5.62).

Table 4.4-16 Descriptive Statistics for Tractor-Trailers, All Survey Stations

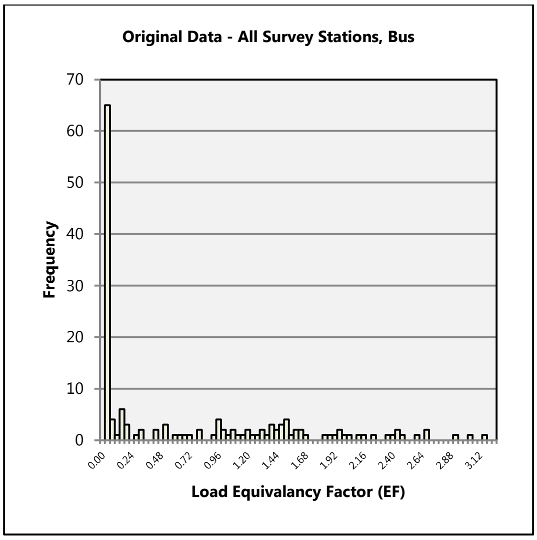
All Survey Stations			
Tractor-Trailer			
	Original Data	**Transformed Data**	**Reconverted Data**
Unit:	**x = EF**	**y = ln(x+1)**	**z = exp(y) - 1**
Mean	6.56	1.85	5.37
Skewness	5.97	-0.80	-
Lower Confidence Level (95%)	6.26	1.81	5.14
Upper Confidence Level (95%)	6.87	1.89	5.62
Sample Size	1032	1032	1032

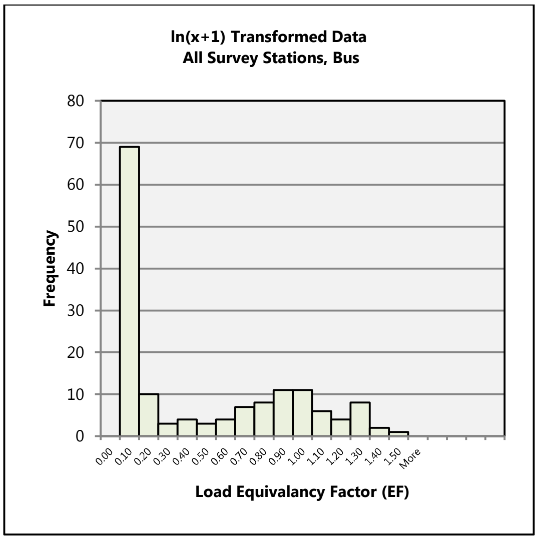
Note: EF = Equivalency Factor

Source: Study Team

4) Buses

The distribution of the original data and the transformed data for buses for all survey stations are shown in the following figure. After taking a natural log transformation of the original data, the data became normally distributed.





Source: Study Team

Figure 4.4-17 Original Data (Left), Transformed Data (Right) for Buses, All Survey Stations

The descriptive statistics for the bus data for all survey stations are shown in the following table. After the data transformation, the skewness value reduced from 0.99 to 0.58 which fits the general rule of thumb (between around -1 and 1) for a normal distribution. The average EF value calculated for buses for all survey stations is 0.53 (95% confident that the mean lies between 0.43 and 0.65).

Table 4.4-17 Descriptive Statistics for Buses, All Survey Stations

All Survey Stations			
Bus			
	Original Data	**Transformed Data**	**Reconverted Data**
Unit:	**x = EF**	**y = ln(x+1)**	**z = exp(y) - 1**
Mean	0.71	0.43	0.53
Skewness	0.99	0.58	-
Lower Confidence Level (95%)	0.57	0.35	0.43
Upper Confidence Level (95%)	0.85	0.50	0.65
Sample Size	151	151	151

Note: EF = Equivalency Factor

Source: Study Team

4.5 Survey Forms

4.5.1 Traffic Count Survey Form

Traffic Count Survey **Station:** Binh Bridge
Day-Date: Wed - 18/03/2015

Hướng: Từ: … ………..…………….. **Đến:** ………………………..
Lựa chọn 1 hướng: Về (Inbound) or Đi (Outbound)

Giờ (Hour)	Khoảng đếm/ Time Period		Bicycle/ Xe đạp	Cyclo/ Xích lô	Motor-cycle/ Xe máy	Car/Light Vehicles/ Ô tô con	Taxi	Minibus <=25 pax (Public/Private) / Xe buýt, xe khách dưới 25 chỗ	Medium and Large bus >25 pax (Public/Private) / Xe buýt, xe khách trên 25 chỗ	Truck/ Xe tải, contener các loại	Others
Ghi giờ đếm, ví dụ 0:00 - 1:00	0:00	0:05									
	0:05	0:10									
	0:10	0:15									
	0:15	0:20									
	0:20	0:25									
	0:25	0:30									
	0:30	0:35									
	0:35	0:40									
	0:40	0:45									
	0:45	0:50									
	0:50	0:55									
	0:55	1:00									

Source: Study Team

Figure 4.5-1 Sample Traffic Count Survey Form

4.5.2 Vehicle Occupancy Survey Form

Traffic Occupancy Form: **Station:** Binh Bridge
Day-Date: Wed - 18/03/2015

All Driver and Passenger in a vehicle should be counted

Survey Period

1 Morning Peak (7:00-9:00) 2 Off-Peak (12:00-14:00) 3 Evening Peak (16:00-18:00)

Surveyor:...

Hướng: Từ: … ………..…………….. **Đến:** ……………………….

Lựa chọn 1 hướng: Về (Inbound) or Đi (Outbound)

Giờ (Hour)	Khoảng đếm/ Time Period		Bicycle/ Xe đạp	Cyclo/ Xích lô	Motor-cycle/ Xe máy	Car/Light Vehicles/ Ô tô con	Taxi	Minibus <=25 pax (Public/Private) / Xe buýt, xe khách dưới 25 chỗ	Medium and Large bus >25 pax (Public/Private) / Xe buýt, xe khách trên 25 chỗ	Truck/ Xe tải, contener các loại	Others
Ghi giờ đếm, ví dụ 0:00 - 1:00	0:00	0:05									
	0:05	0:10									
	0:10	0:15									
	0:15	0:20									
	0:20	0:25									
	0:25	0:30									
	0:30	0:35									
	0:35	0:40									
	0:40	0:45									
	0:45	0:50									
	0:50	0:55									
	0:55	1:00									

Source: Study Team

Figure 4.5-2 Sample Vehicle Occupancy Survey Form

4.5.3 OD Interview Survey Form for Private Drivers

OD Interview Survey (Private Mode Drivers)

BASIC INFORMATION

Q1. Survey Number

Q2. Supervisor

Q3. Interviewer

Q4. Survey Location

Q5. Survey Direction
1 Inbound 2 Outbound

Q6. Date
Y Y Y Y M M D D

Q7. Day
1 Monday 2 Tuesday 3 Wednesday 4 Thursday 5 Friday 6 Saturday 7 Sunday

Q8. Survey Time (hh:mm, 24h)
h h : m m

INTERVIEW DATA

Q9. Traffic Mode
1 Walking 2 Bicycle - driver 3 Motorcycle - driver
4 Car - driver 5 Others

Q10. Origin (No., Street, (Phuong/Xa), District, City/Province)
If it is a special zone (Port, Industrial park), Pls write the name in specific)

Q11. Destination (No., Street (Phong/Xa), District, City/Province)
If it is a special zone (Port, Industrial park), Pls write the name in specific)

Q12. Trip Purpose
1 To Home 2 To Work 3 To School (study) 4 At work/Business
5 To send/To pick up other family mei 6 To go shopping/market 7 To eat (not at home) 8 To have an exercise
9 Joy riding 10 Social/Recreation/Religious 11 Other private purposes

Q13. Travel Time (minutes)

Q14. Are you willing to pay an additional 6000 VND if your trip in Q13 is reduced by 10 minutes?
1 Yes 2 No

Q15. If "Yes" was answered for Q14, what is the maximum amount you are willing to pay?

Q16. If "No" was answered for Q14 are you willing to pay 3000 VND?
1 Yes 2 No

Q17. What is your occupation?
1 Leader of branches, administration levels and units
2 Professional 3 Technical and associate professional
4 Clerical worker 5 Service workers and shop/market sales worke
6 Skilled agriculture, forestry and fishery worker
7 Craft and related trades worker 8 Plant and machine operator and assembler
9 Elementary occupation 10 Student (elementary)
11 Student (high school & university) 12 Housewife
13 Jobless/Retired/Too young 14 Small vendors
15 Military people/police 16 Businessperson
17 Others

Q18. What is your individual income per month?
1 None 2 < 200,000 VND 3 200,000-400,000 VND
4 400,000-800,000 VND 5 800,000-1.5 million VND 6 1.5-2 million VND
7 2-3 million VND 8 3-4 million VND 9 4-5 million VND
10 5-6 million VND 11 6-8 million VND 12 8-10 million VND
13 10-15 million VND 14 > 15 million VND

Source: Study Team

Figure 4.5-3 Sample OD Interview Survey Form for Private Drivers - English

Phỏng vấn OD (người lái phương tiện cá nhân)

THÔNG TIN CƠ BẢN

Q1. Mã số khảo sát | **Q2. Người giám sát** | **Q3. Nhân viên phỏng vấn**

Q4. Địa điểm phỏng vấn | **Q5. Hướng khảo sát** 1 Vào nội thành 2 Ra ngoại thành | **Q6. Ngày**

Q7. Thứ
1 Thứ hai 2 Thứ ba 3 Thứ tư 4 Thứ năm 5 Thứ sáu 6 Thứ bảy 7 Chủ nhật

Q8. Thời gian (hh:mm, 24h) :

THÔNG TIN PHỎNG VẤN

Q9. Loại phương tiện
1 Đi bộ 2 Người đi xe đạp 3 Người lái xe máy
4 Người lái xe ô tô con 5 Khác

Q10. Nơi xuất phát (Số nhà, Đường, Phường/ xã, Quận/ huyện, Tỉnh/ thành phố)
Nếu đây là một khu vực đặc biệt (cảng , khu công nghiệp), hãy viết tên cụ thể

Q11. Điểm đến (Số nhà, Đường, Phường/ xã, Quận/ huyện, Tỉnh/ thành phố)
Nếu đây là một khu vực đặc biệt (cảng , khu công nghiệp), hãy viết tên cụ thể

Q12. Mục đích chuyến đi
1 Đi về nhà 2 Đi làm 3 Đi học 4 Mục đích công việc/ kinh doanh
5 Đưa/ đón người thân hoặc bạn bè 6 Đi mua sắm/ đi chợ 7 Đi ăn uống (không phải ăn ở nhà) 8 Thể dục thể thao
9 Lái xe để thư giãn (phi thể thao) 10 Mục đích xã hội/ giải trí/ tôn giáo 11 Các mục đích cá nhân khác

Q13. Thời gian đi lại (phút)

Q14. Bạn có sẵn sàng trả thêm một khoảng 6000 VND nếu thời gian chuyến đi của bạn ở câu Q13 giảm đi 10 phút?
1 Có 2 Không

Q15. Nếu trả lời "Có" ở câu 14, bạn sẵn sàng trả thêm tối đa bao nhiêu tiền để giảm thời gian đi lại?

Q16. Nếu trả lời "Không" ở câu 14, bạn có sẵn sàng trả 3000 VND?
1 Có 2 Không

Q17. Nghề nghiệp
1 Lãnh đạo cơ quan/ đơn vị
2 Chuyên gia 3 Kỹ thuật viên
4 Nhân viên văn phòng 5 Nhân viên phục vụ/ bán hàng ở cửa hàng/ ch
6 Nông, lâm, ngư nghiệp
7 Nghề thủ công & thương nghiệp 8 Lắp ráp, vận hành máy móc thiết bị
9 Lao động sơ cấp 10 Học sinh tiểu học
11 Học sinh trung học/ Sinh viên 12 Nội trợ
13 Thất nghiệp/ Nghỉ hưu/ Quá nhỏ 14 Buôn bán nhỏ
15 Bộ đội/ Công an 16 Thương nhân
17 Khác

Q18. Thu nhập cá nhân hàng tháng
1 Không có 2 < 200,000 VND 3 200,000-400,000 VND
4 400,000-800,000 VND 5 800,000-1.5 triệu VND 6 1.5-2 triệu VND
7 2-3 triệu VND 8 3-4 triệu VND 9 4-5 triệu VND
10 5-6 triệu VND 11 6-8 triệu VND 12 8-10 triệu VND
13 10-15 triệu VND 14 > 15 triệu VND

Source: Study Team

Figure 4.5-4 Sample OD Interview Survey Form for Private Drivers - Vietnamese

4.5.4 OD Interview Survey Form for Public Drivers

OD Interview Survey (Public Mode Drivers)

BASIC INFORMATION

- Q1. Survey Number
- Q2. Supervisor
- Q3. Interviewer
- Q4. Survey Location
- Q5. Survey Direction: 1 Inbound, 2 Outbound
- Q6. Date
- Q7. Day: 1 Monday, 2 Tuesday, 3 Wednesday, 4 Thursday, 5 Friday, 6 Saturday, 7 Sunday
- Q8. Survey Time (hh:mm, 24h)

INTERVIEW DATA

- Q9. Plate Number
- Q10. If bus, route?
- Q11. Traffic Mode: 1 Xe Om, 2 Cyclo, 3 Taxi, 4 Minibus (<=25 pax), 5 Standard Bus (>25 pax), 6 Tourist Bus, 7 Company Bus, 8 School Bus, 9 Ferry, 10 Others
- Q12. Origin (No., Street (Phong/Xa), District, City/Province)
  If it is a special zone (Port, Industrial park), Pls write the name in specific)
- Q13. Destination (No., Street (Phong/Xa), District, City/Province)
  If it is a special zone (Port, Industrial park), Pls write the name in specific)
- Q14. Number of Passengers on Board (Including Driver)
- Q15. Seating Capacity
- Q16. Travel Time (minutes)
- Q17. What is your individual income per month?
  1 None, 2 < 200,000 VND, 3 200,000-400,000 VND, 4 400,000-800,000 VND, 5 800,000-1.5 million VND, 6 1.5-2 million VND, 7 2-3 million VND, 8 3-4 million VND, 9 4-5 million VND, 10 5-6 million VND, 11 6-8 million VND, 12 8-10 million VND, 13 10-15 million VND, 14 > 15 million VND

Source: Study Team

Figure 4.5-5 Sample OD Interview Survey Form for Public Mode Drivers - English

Phỏng vấn OD (người lái phương tiện công cộng)

THÔNG TIN CƠ BẢN

Q1. Mã số khảo sát

Q2. Người giám sát

Q3. Nhân viên phỏng vấn

Q4. Địa điểm phỏng vấn

Q5. Hướng khảo sát
1 Vào nội thành 2 Ra ngoại thành

Q6. Ngày
Y Y Y Y M M D D

Q7. Thứ
1 Thứ hai 2 Thứ ba 3 Thứ tư 4 Thứ năm 5 Thứ sáu 6 Thứ bảy 7 Chủ nhật

Q8. Thời gian (hh:mm, 24h)
h h : m m

THÔNG TIN PHỎNG VẤN

Q9. Biển số xe

Q10. Nếu là xe buýt thì là tuyến số mấy?

Q11. Loại phương tiện

1	Xe Om	2	Xich lô	3	Taxi	4	Xe buýt nhỏ (<=25 chỗ)
5	Xe buýt tiêu chuẩn (>25 chỗ)	6	Xe khách du lịch	7	Xe khách đưa đón nhân viên công ty	8	Xe đưa đón học sinh
9	Phà	10	Khác				

Q12. Nơi xuất phát (Số nhà, Đường, Phường/ xã, Quận/ huyện, Tỉnh/ thành phố)
Nếu đây là một khu vực đặc biệt (cảng , khu công nghiệp), hãy viết tên cụ thể

Q13. Điểm đến (Số nhà, Đường, Phường/ xã, Quận/ huyện, Tỉnh/ thành phố)
Nếu đây là một khu vực đặc biệt (cảng , khu công nghiệp), hãy viết tên cụ thể

Q14. Số lượng hành khách trên phương tiện (kể cả lái xe)

Q15. Số lượng ghế ngồi trên phương tiện

Q16. Thời gian đi lại (phút)

Q17. Thu nhập cá nhân hàng tháng

1	Không có	2	< 200,000 VND	3	200,000-400,000 VND
4	400,000-800,000 VND	5	800,000-1.5 triệu VND	6	1.5-2 triệu VND
7	2-3 triệu VND	8	3-4 triệu VND	9	4-5 triệu VND
10	5-6 triệu VND	11	6-8 triệu VND	12	8-10 triệu VND
13	10-15 triệu VND	14	> 15 triệu VND		

Source: Study Team

Figure 4.5-6 Sample OD Interview Survey Form for Public Mode Drivers - Vietnamese

4.5.5 OD Interview Survey Form for Freight Drivers

OD Interview Survey (Freight Drivers)

BASIC INFORMATION

Q1. Survey Number

Q2. Supervisor

Q3. Interviewer

Q4. Survey Location

Q5. Survey Direction
1 Inbound 2 Outbound

Q6. Date

Q7. Day
1 Monday 2 Tuesday 3 Wednesday 4 Thursday 5 Friday 6 Saturday 7 Sunday

Q8. Survey Time (hh:mm, 24h)

INTERVIEW DATA

Q9. Vehicle Type
1 Pick up for cargo 2 Truck (2 axles) 3 Truck (more than 3 axles)
4 Trailer (separated type)

Q10. Loading Condition
1 Empty Container 2 Container 3 Empty
4 1/4 Full 5 1/2 Full 6 3/4 Full
7 Full and more

Q11. Container Size
1 20 feet 2 40 feet 3 Container (exclude 20, 40 feet)
4 Non-container

Q12. What is the maximum loading weight (ton)?

Q13. What is the trip frequency?
1 Everyday 2 Every weekenc 3 1-2 times/week 4 1-2 times/month 5 1-2 times/year 6 Other

Q14. Origin (No., Street (Phong/Xa), District, City/Province)
If it is a special zone (Port, Industrial park), Pls write the name in specific)

Q15. Destination (No., Street (Phong/Xa), District, City/Province)
If it is a special zone (Port, Industrial park), Pls write the name in specific)

Q16 Travel Time (minutes)

Q17. Are you willing to pay an additional 6000 VND if your trip in Q16 is reduced by 10 minutes?
1 Yes 2 No

Q18. If "Yes" was answered for Q17, what is the maximum amount you are willing to pay?

Q19. If "No" was answered for Q18, are you willing to pay 3000 VND?
1 Yes 2 No

Q20. What is your individual income per month?
1 None 2 < 200,000 VND 3 200,000-400,000 VND
4 400,000-800,000 VND 5 800,000-1.5 million VND 6 1.5-2 million VND
7 2-3 million VND 8 3-4 million VND 9 4-5 million VND
10 5-6 million VND 11 6-8 million VND 12 8-10 million VND
13 10-15 million VND 14 > 15 million VND

Source: Study Team

Figure 4.5-7 Sample OD Interview Survey Form for Freight Drivers - English

Phỏng vấn OD (người lái phương tiện vận tải hàng hóa)

THÔNG TIN CƠ BẢN

Q1. Mã số khảo sát

Q2. Người giám sát

Q3. Nhân viên phỏng vấn

Q4. Địa điểm phỏng vấn

Q5. Hướng khảo sát
1 Vào nội thành 2 Ra ngoại thành

Q6. Ngày
Y Y Y Y M M D D

Q7. Thứ
1 Thứ hai 2 Thứ ba 3 Thứ tư 4 Thứ năm 5 Thứ sáu 6 Thứ bảy 7 Chủ nhật

Q8. Thời gian (hh:mm, 24h)
h h : m m

THÔNG TIN PHỎNG VẤN

Q9. Loại phương tiện
1 Xe gom hàng hóa 2 Xe tải (2 trục) 3 Xe tải (nhiều hơn 3 trục)
4 Xe mooc (loại tách rời)

Q10. Tình trạng chất tải
1 Container trống 2 Container có hàng 3 Không có container
4 1/4 tải trọng 5 1/2 tải trọng 6 3/4 tải trọng
7 Đầy tải và nhiều hơn

Q11. Kích thước Container
1 20 feet 2 40 feet 3 Container khác (không phải loại 20, 40 feet)
4 Không phải container

Q12. Xe chở tối đa được bao nhiêu tấn?

Q13. Tần suất chuyến đi
1 Hàng ngày 2 Mọi cuối tuần 3 1-2 lần/ tuần 4 1-2 lần/ tháng 5 1-2 lần/ năm 6 Khác

Q14. Nơi xuất phát (Số nhà, Đường, Phường/ xã, Quận/ huyện, Tỉnh/ thành phố)
Nếu đây là một khu vực đặc biệt (cảng , khu công nghiệp), hãy viết tên cụ thể

Q15. Điểm đến (Số nhà, Đường, Phường/ xã, Quận/ huyện, Tỉnh/ thành phố)
Nếu đây là một khu vực đặc biệt (cảng , khu công nghiệp), hãy viết tên cụ thể

Q16 Thời gian đi lại (phút)

Q17. Bạn có sẵn sàng trả thêm một khoản 6000 VND nếu thời gian chuyến đi của bạn ở câu Q16 giảm đi 10 phút?
1 Có 2 Không

Q18. Nếu trả lời "Có" ở câu Q17, bạn sẵn sàng trả thêm tối đa bao nhiêu tiền để giảm thời gian đi lại?

Q19. Nếu trả lời "Không" ở câu Q17, bạn có sẵn sàng trả thêm 3000 VND?
1 Có 2 Không

Q20. Thu nhập cá nhân hàng háng của anh/chị là bao nhiêu?
1 Không có 2 < 200,000 VND 3 200,000-400,000 VND
4 400,000-800,000 VND 5 800,000-1.5 triệu VND 6 1.5-2 triệu VND
7 2-3 triệu VND 8 3-4 triệu VND 9 4-5 triệu VND
10 5-6 triệu VND 11 6-8 triệu VND 12 8-10 triệu VND
13 10-15 triệu VND 14 > 15 triệu VND

Source: Study Team

Figure 4.5-8 Sample OD Interview Survey Form for Freight Drivers - Vietnamese

4.5.6 Axle Load Survey Form

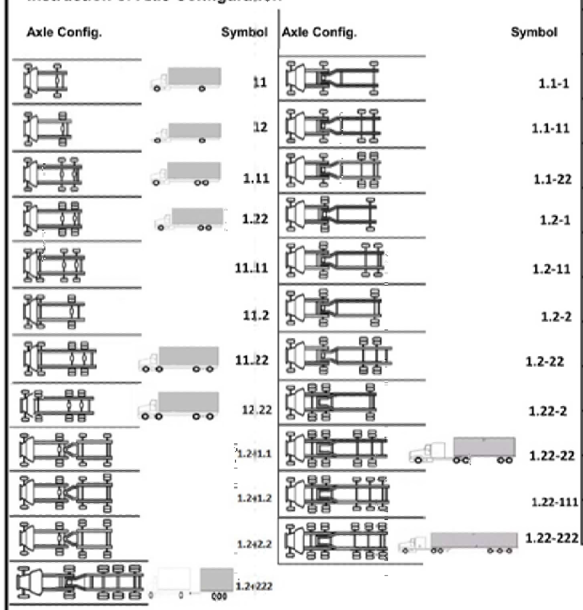
AXLE LOAD SURVEY FORM

BASIC INFORMATION

Q1. Survey Number	Q2. Supervisor	Q3. Interviewer
Q4. Survey Location		Q5. Survey Direction: 1 Inbound 2 Outbound
Q6. Date: Y Y Y Y M M D D	Q7. Day: 1 Monday 2 Tuesday 3 Wednesday 4 Thursday 5 Friday 6 Saturday 7 Sunday	

AXLE LOAD DATA

Instruction of Axle Configuration



						Axle Load (Ton)					
No.	Time (hh:mm)	O - Đi	D - Đến	BUS	Axle Config.	Axle 1	Axle 2	Axle 3	Axle 4	Axle 5	Axle 6
1	6:30	O An Tiến, An Lão	D Đằng Hải, Hải An		1.11	2.5	5.0	5.0			
2	6:35	O An Tiến, An Lão	D Đằng Hải, Hải An	Bus		2.5	2.75				
		O	D								
		O	D								
		O	D								
		O	D								
		O	D								
		O	D								
		O	D								
		O	D								
		O	D								
		O	D								

Source: Study Team

Figure 4.5-9 Axle Load Survey Form

4.6 Details from the Traffic Demand Forecast

4.6.1 Summary of the Traffic Demand Forecasts

2020 Unit: Traffic Volume (pcu/day)	Case 1	Case 2	Case 3	Case 4	Case 5	2015 Current Estimate	METI Study Estimation (2020) Case 1-0	Case 1-1	Case 1-2	Case 1-3
Kien Bridge	49,200	49,800	42,100	50,300	49,600	31,400	43,200	40,900	37,900	38,500
Binh Bridge	84,900	45,600	56,000	59,400	40,100	38,800	103,800	46,300	62,900	42,800
Nguyen Trai Bridge		20,800	42,400		26,800			59,700		32,100
Vu Yen Bridge		28,700		35,200	28,300				46,200	33,600
Subtotal	134,100	144,900	140,500	144,900	144,800	70,200	147,000	146,900	147,000	147,000
Haiphong-Quang Ninh Expressway(up to the eastern border with Quang Ninh Province)	17,500	17,500	18,100	17,400	17,400					
Hanoi-Haiphong Expressway (up to the western border of Haiphong)	58,800	57,900	59,600	57,900	57,800					
QL5 (up to the western border of Haiphong)	45,400	46,300	44,600	46,300	46,400	56,900				
Ring Road 3 (northeast section)	9,600	21,800	4,600	22,900	21,600					
Ring Road 3 (northern section)	8,100	10,200	6,400	10,600	10,000					

Case 1: Do Nothing
Case 2: Construction of the Nguyen Trai Bridge and Vu Yen Bridge
Case 3: Construction of Nguyen Trai Bridge only
Case 4: Construction of Vu Yen Bridge only
Case 5: Construction of Nguyen Trai Bridge without roundabout access (1 lane access road via Le Thanh Tong St.) and Vu Yen Bridge
METI Study: Study on the Highway Bridge in the New Urban Area of Hai Phong, the Socialist Republic of Vietnam, February 2014, Study on Economic Partnership Projects in Developing Countries in FY2013, Ministry of Economy, Trade and Industry, Japan

Source: Study Team

Table 4.6-1 Comparisons in the Traffic Volume Crossing the Cam River for the Different Cases for 2020

Table 4.6-2 Comparisons in the Traffic Volume Crossing the Cam River for the Different Cases for 2030

2030 Unit: Traffic Volume (pcu/day)	Case 1	Case 2	Case 3	Case 4	Case 5	2015 Current Estimate	METI Study Estimation (2030) Case 2-0	Case 2-1	Case 2-2	Case 2-3
Kien Bridge	68,600	50,200	50,000	51,800	46,700	31,400	78,300	69,000	70,400	64,600
Binh Bridge	164,600	72,000	89,800	107,500	66,200	38,800	190,200	89,600	119,300	82,200
Nguyen Trai Bridge		81,300	108,400		87,500			110,400		81,300
Vu Yen Bridge		55,100		96,300	59,600				78,800	41,200
Subtotal	233,200	258,600	248,200	255,600	260,000	70,200	268,500	269,000	268,500	269,300
Haiphong-Quang Ninh Expressway(up to the eastern border with Quang Ninh Province)	34,300	35,600	35,400	35,800	36,800					
Hanoi-Haiphong Expressway (up to the western border of Haiphong)	75,900	74,800	74,600	77,700	76,800					
QL5 (up to the western border of Haiphong)	44,900	46,000	46,300	43,200	44,100	56,900				
Ring Road 3 (northeast section)	9,200	29,400	7,700	32,000	30,000					
Ring Road 3 (northern section)	14,200	17,800	8,600	26,600	21,300					

Case 1: Do Nothing
Case 2: Construction of the Nguyen Trai Bridge and Vu Yen Bridge
Case 3: Construction of Nguyen Trai Bridge only
Case 4: Construction of Vu Yen Bridge only
Case 5: Construction of Nguyen Trai Bridge without roundabout access (1 lane access road via Le Thanh Tong St.) and Vu Yen Bridge
METI Study: Study on the Highway Bridge in the New Urban Area of Hai Phong, the Socialist Republic of Vietnam, February 2014, Study on Economic Partnership Projects in Developing Countries in FY2013, Ministry of Economy, Trade and Industry, Japan

Source: Study Team

4.6.2 Methodology for Determining the Traffic Capacity

The traffic capacity was calculated changing the Vietnamese urban road design specifications (TCXDVN104-2007) using the following formula.

$$C_{hour} = n_{xl} \cdot Z \cdot Ptt$$

$$C_{h24} = C_{hour} \cdot 5000/(D \cdot K) \cdot DN$$

Where:

Ptt: possible traffic volume per hour (PCU/hour/lane)

Z: weighting coefficient (affected by the slope)

n_{xl}: number of lanes

C_{hour}: capacity per hour

D : peak hour directional factor (%)

K: 30^{th} largest traffic volume in a year/average annual daily traffic volume (%) (this time, the daytime 12 hour peak ratio was used instead)

DN: ratio of daily traffic to daytime traffic

C_{h24}: daily traffic volume (PCU/day)

Using the formula as shown above, the capacity of Nguyen Trai Bridge and Vu Yen Bridge were calculated and are shown on the next page.

Table 4.6-3 Determination of the Traffic Capacity of Vu Yen Bridge and Nguyen Trai Bridge

	Vu Yen Bridge	**Nguyen Trai Bridge**	**Nguyen Trai Bridge access road to Le Thanh Tong St.**
Traffic survey station data that was used as a base for calculations	Kien Bridge	Binh Bridge	Binh Bridge
Ptt possible traffic volume per hour (pcu/hour/lane)	1800	1800	1800
Z: weighting coefficient (affected by the slope)	0.932[2]	1.000	1.000
n_{xl}: number of lanes	4	4	1
C_{hour}: capacity per hour	6,710	7,200	1,800
D: peak hour directional factor (%)	52.6	54.2	54.2
K: daytime 12 hour peak ratio (peak h/12h)	13.2	14.5	14.5
DN: ratio of daily traffic to daytime traffic (24h/12h)	1.442	1.321	1.321
C_{h24}: daily traffic volume (pcu/day)	70,000	61,000	16,000

Source: Study Team

[2] According to the Highway Capacity Manual, the traffic volume is different based on the slope and proportion of large sized vehicles.If the proportion of large sized vehicles is 15%, the large sized vehicle pcu should be set as 2.75. At 0%, the pcu for large sized vehicles should be set at 1.5. As a result, the traffic capacity is set at 70,000 pcu as this is 93.2% of the normal traffic capacity: (1 pcu/2.75 pcu)/(1 pcu/1.5 pcu) * 15% + 1 pcu * 85%.

4.6.3 Analysis on the Necessity of a Grade-Separated Roundabout

For the examination of the effect on the roundabout located at the south end of Nguyen Trai Bridge, the results of the congestion at the roundabout was shown, but whether or not an improved roundabout would require grade separation or a signalized at-grade intersection, it is necessary to make a judgement in advance. Therefore, a simplified analysis was done to determine if the traffic volume would be manageable if the roundabout was changed to a signalized intersection in 2020 when Nguyen Trai Bridge is built.

For the analysis methodology, the number of signal phases was defined and at the various inputs to the intersection, the congestion rate was used to calculate the intersection demand rate. Furthermore, the effect from oncoming traffic traveling straight at the intersection was ignored, as it was estimated that this value was trivial.

The formula for the simplified traffic intersection demand rate is given by:

$$\rho = \frac{\sum_{n=1.N}(Q_n/C_n)}{N/\varphi}$$

Where:

ρ: Simplified traffic intersection demand rate

Q_n: Traffic volume at various inputs to the intersection

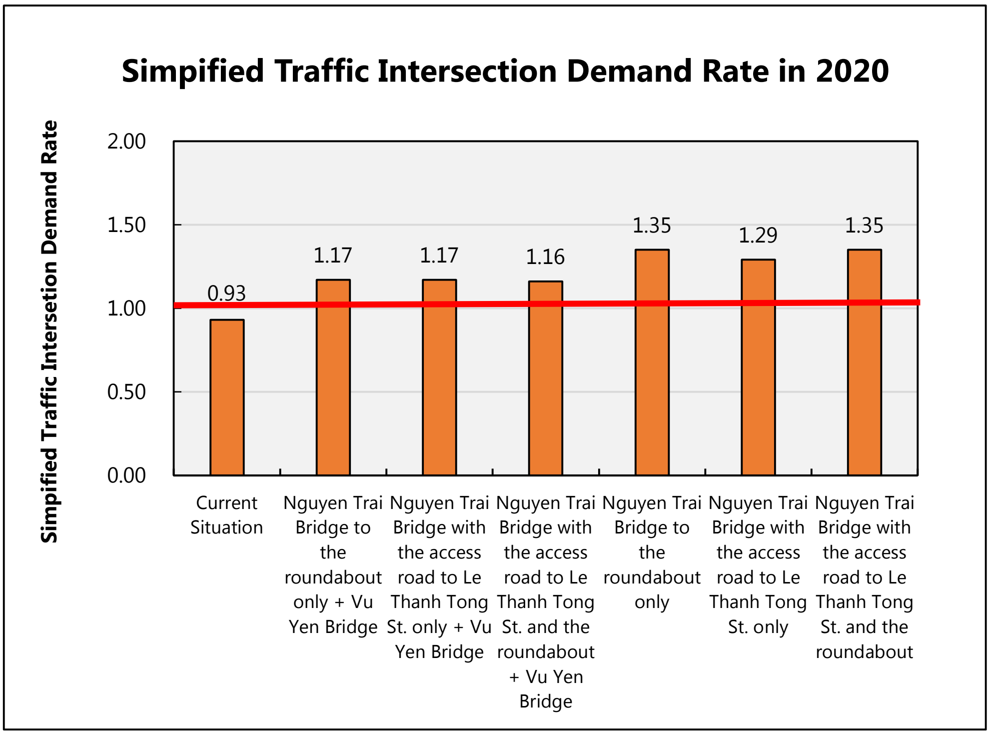
C_n: Traffic capacity at various inputs to the intersection (= 1,100 pcu/hour × number of lanes)

N: Number of input points to the intersection

φ: Number of signal phases (assumed as 2)

As a result, for all cases, the simplified traffic intersection demand rate exceeded 1.0 and as a result it was confirmed that a signalized intersection would not be able to manage the traffic volume and a drastic measure such as grade separation need to be considered.

Furthermore, because this is a simplified analysis, there is room for a more detailed analysis.



Source: Study Team

Figure 4.6-1 Simplified Traffic Intersection Demand Rate for the Various Cases

4.7 Impact of Existing Development Plans on the Bridges in this Study

This section describes the impacts of existing development plans in Hai Phong on the two bridges in this study (Nguyen Trai Bridge and Vu Yen Bridge). There are two main existing development plans that the study team judged to have a significant impact on the bridges in this study. They are the construction of the Hoang Van Thu Bridge and the development of the new administrative centre north of the Cam River.

4.7.1 Impact of the Hoang Van Thu Bridge on the Bridges in this Study

(1) Background and Current Situation of Hoang Van Thu Bridge

Hoang Van Thu Bridge was originally listed as one of the bridges to be constructed by 2030 in the Hai Phong Road Transportation Master Plan up to 2020 and Vision to 2030.

However, on 10 November 2015, the Hai Phong People's Committee announced in a press conference that construction of the Integrated Political Administration Centre to be located on the northern bank of the Cam River in Thuy Nguyen District was approved. The project will contain two major components, the development of the new urban area and the construction of Hoang Van Thu Bridge over the Cam River to connect the new urban area with the existing city centre of Hai Phong.

The project will require a total investment of around 10 trillion VND, of which 7 trillion VND is needed for the construction of Hoang Van Thu Bridge and embankment for the Cam River. The Hai Phong People's Committee suggested that the Vietnamese central government in Hanoi should earmark 7 trillion VND for the construction of the bridge.

Duong Ngoc Tran, Head of the Municipal Department of Planning and Investment of Hai Phong said that the plan to request the earmarked 7 trillion VND from the central government was appropriate because of Hai Phong's position as one of leading contributors of revenue to the central government, ranking third behind Hanoi and Ho Chi Minh City in the first six months of 2015.

For the remaining 3 trillion VND of the project, the Hai Phong People's Committee said that the funds would be mobilized from different sources, such as selling project land and organizing auctions of the land lots.

Previously, plans for the construction of Hoang Van Thu Bridge had been mentioned in the following decisions.

1. Decision No. 1841/QD-UBND dated 15th November 2011 by Hai Phong People's Committee on approving the Detailed Plan (scale 1/5000) on Bac Song Cam new urban area in District of Thuy Nguyen
2. Decision No. 2666/QD-UBND dated 1st December 2014 by Hai Phong People's Committee on approving the Detailed Plan (scale 1/2000) on the new administrative center in Bac Song Cam new urban area.

Currently, the detailed design for Hoang Van Thu Bridge has not yet been conducted and hence there is no information regarding the length of the bridge, width, type of structure and etc.

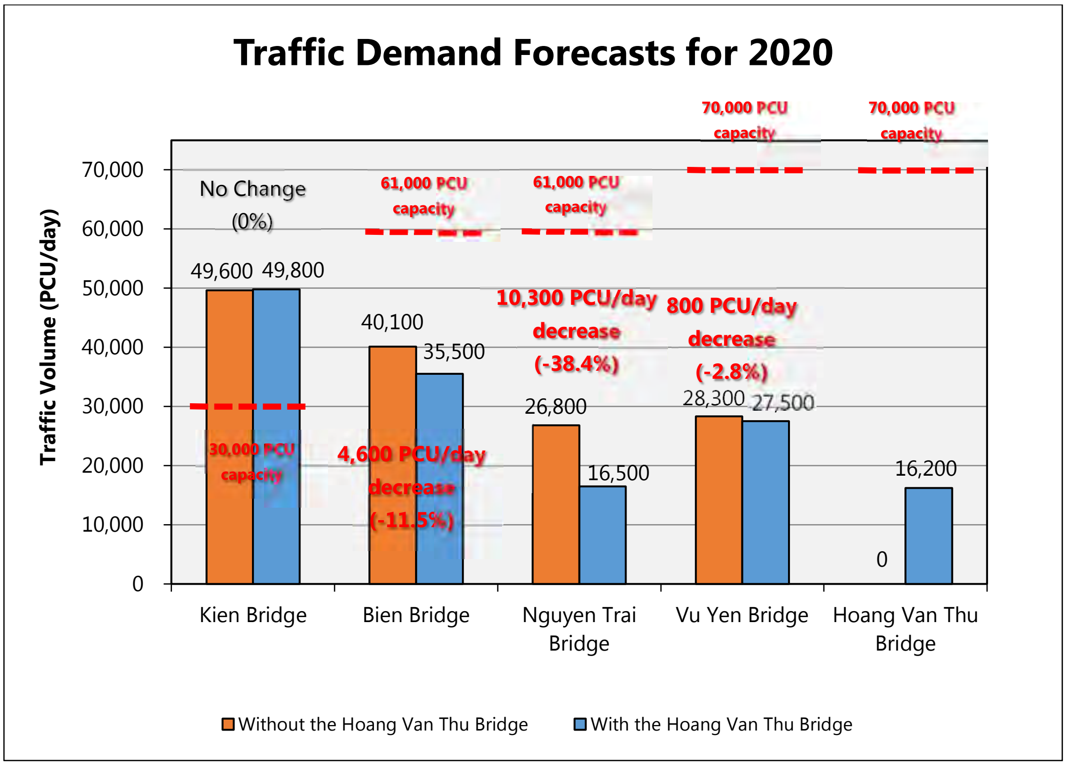
The Vietnamese central government's Ministry of Planning and Investment has not issued any official documents although it said it approved the plan that the Hai Phong People's Committee had submitted. The Ministry of Planning and Investment's Deputy Minister Dao Quang Thu said that the central government had not reached any decision on the matter as the central government is facing a budget deficit and an increase in public debt.

However, by mid-November 2015, the Vietnamese central government ordered a suspension[3] to the construction of new administrative centres due to the large cost and this presumably also halts the Hai Phong People's Committee's plans to construct Hoang Van Thu Bridge in advance of the Nguyen Trai and Vu Yen Bridges.

(2) Impact of Hoang Van Thu Bridge on Traffic Estimates

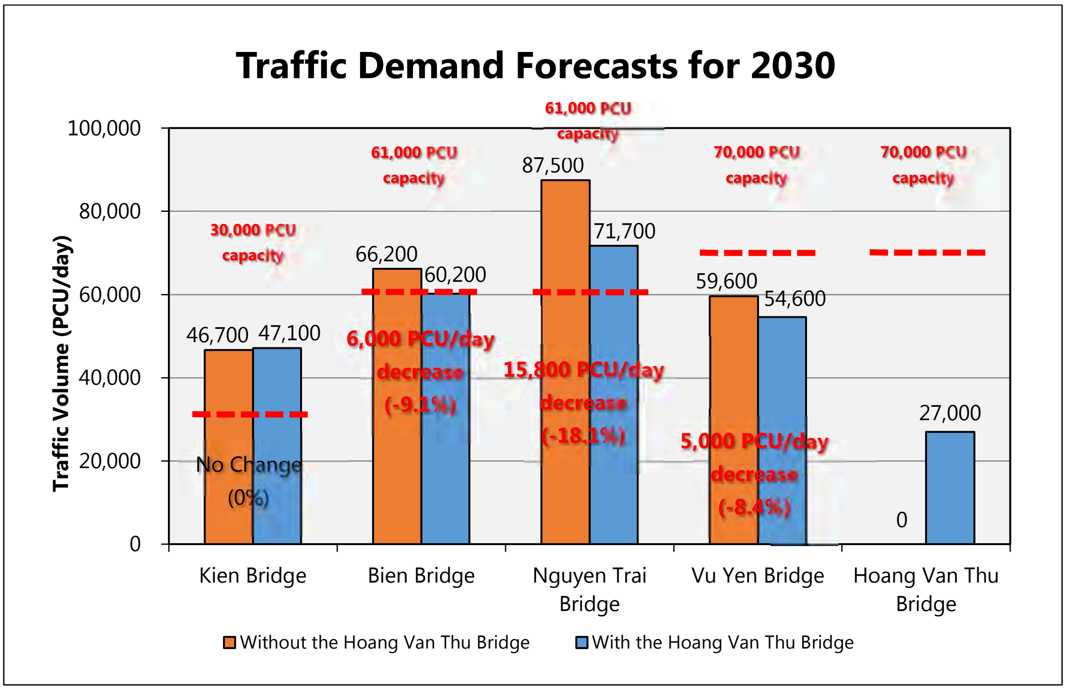
The results from the future traffic demand for 2020 and 2030 for 2 cases: with the construction of Hoang Van Thu Bridge and without the construction of Hoang Van Thu Bridge is shown below. Overall, if Hoang Van Thu Bridge is built, the forecasted traffic demand on Bien Bridge, Nguyen Trai Bridge and Vu Yen Bridge will decrease compared to the situation if Hoang Van Thu Bridge is not built.

[3] Gov't asks provinces to halt construction of costly administrative centres. Vietnamnet. http://english.vietnamnet.vn/fms/society/146544/gov-t-asks-provinces-to-halt-construction-of-costly-administrative-centers.html



Source: Study Team

Figure 4.7-1 Traffic Demand Forecasts for 2020. With and Without the Hoang Van Thu Bridge



Source: Study Team

Figure 4.7-2 Traffic Demand Forecast for 2030, With and Without the Hoang Van Thu Bridge

1) Impact on Traffic Demand Estimates for Kien Bridge

The impact on traffic demand estimates from the construction of Hoang Van Thu Bridge will be minimal as shown in the above figure.

2) Impact on the Traffic Demand Estimates for Bien Bridge

If Hoang Van Thu Bridge is built, the traffic demand estimates for Bien Bridge for 2020 will decrease by 4,600 PCU/day and for 2030 will decrease by 6,000 PCU/day compared to the case where Hoang Van Thu Bridge is not built. This represents an 11.5% and 9.1% decrease in the estimated traffic demand for Bien Bridge in 2020 and 2030, respectively.

3) Impact on the Traffic Demand Estimates for Nguyen Trai Bridge

If Hoang Van Thu Bridge is built, the traffic demand estimates for Nguyen Trai Bridge for 2020 will decrease by 10,300 PCU/day and for 2030 will decrease by 15,800 PCU/day. Building Hoang Van Thu Bridge will have a large impact on the traffic demand estimates for Nguyen Trai Bridge because the decrease of 10,300 PCU/day in 2020 represents a 38.4% decrease in the estimated traffic demand.

In 2030, the estimated traffic demand of Nguyen Trai Bridge without the construction of Hoang Van Thu Bridge is 87,500 PCU/day and the bridge will be congested as it exceeds the capacity of 70,000 PCU/day. With the construction of Hoang Van Thu Bridge, the estimated traffic demand on Nguyen Trai Bridge in 2030 will decrease to 71,700 PCU/day and the forecasted congestion on Nguyen Trai Bridge can be distributed to other bridges.

4) Impact on the Traffic Demand Estimates for Vu Yen Bridge

If Hoang Van Thu Bridge is built, the traffic demand estimates for Vu Yen Bridge for 2020 and 2030 will decrease by 800 PCU/day and 5,000 PCU/day respectively and this represents a decrease of 2.8% and 8.4%, respectively. Therefore the construction of Hoang Van Thu Bridge will have a large impact on the estimated traffic demand for Vu Yen Bridge.

By 2030, due to the progress of urban development of the Vietnam-Singapore Industrial Park Haiphong (VSIP Haiphong), it is estimated that there will be a large increase in the number of trips generated on the north bank of the Cam River. As a result, in case Hoang Van Thu Bridge is not built, the trips across the Cam River will be distributed to Vu Yen Bridge due to congestion at Bien Bridge and Nguyen Trai Bridge.

On the other hand, in case Hoang Van Thu Bridge is built, congestion on Bien Bridge and Nguyen Trai Bridge will be mitigated and the necessity of crossing the Cam River via Vu Yen Bridge will be decreased. As a result, the estimated traffic demand for Vu Yen Bridge is decreased in case Hoang Van Thu Bridge is built.

5) The Need for Hoang Van Thu Bridge in the Future

From the viewpoint of transport planning, it can be said that Hoang Van Thu Bridge is necessary to meet the future increase in traffic demand across the Cam River. Especially in

2030, due to urban development on the north bank of the Cam River, the traffic demand will increase and it is expected that the 4 bridges (Bien, Kien, Nguyen Trai, Vu Yen) will not be able to meet the traffic demand. From the construction of Hoang Van Thu Bridge, the traffic demand for crossing the Cam River will be distributed among the various bridges and it is expected that Hoang Van Thu Bridge could be completed by 2030.

6) Estimated Year at Which Hoang Van Thu Bridge will be Necessary

In case Hoang Van Thu Bridge is constructed first before Nguyen Trai Bridge, based on the traffic demand forecast from this study, the impact on the two bridges that are the focus of this study (Nguyen Trai Bridge and Vu Yen Bridge) are summarized as follows.

Looking at Table 4.4-8 – Forecast of When the Traffic Volume will Exceed Capacity in Chapter 4 of this study, if Nguyen Trai Bridge is first constructed, then by 2024, it is estimated that the traffic volume will exceed the capacity of Nguyen Trai Bridge so by 2024, it would be necessary for Nguyen Trai Bridge and Hoang Van Thu Bridge to be constructed. It can also be said that the same situation would arise if Hoang Van Thu Bridge is constructed first instead of Nguyen Trai Bridge. By 2024, at the very least, if the two new bridges are not built, then the existing bridges will not be able to handle the traffic demand caused by the planned new development on the north side of the Cam River.

In the case where both Nguyen Trai and Vu Yen Bridges are built first, then it was estimated that Nguyen Trai Bridge reaches maximum capacity in 2027 and at this time, construction of Hoang Van Thu Bridge will be necessary.

(3) Influence of Hoang Van Thu Bridge on the Economic Evaluation of the Projects in this Study

The schedule for the construction of Hoang Van Thu Bridge is a critical factor for the proposed projects, particularly for the Nguyen Trai Bridge construction project, because Nguyen Trai Bridge and Hoang Van Thu Bridge both cross the Cam River in parallel and have competing characteristics with each other.

Although the base case assumes that Hoang Van Thu Bridge is constructed by 2030 (i.e., after 2020), this schedule may be advanced to a considerable extent according to Vietnamese officials. Therefore, traffic assignment was conducted assuming that both Nguyen Trai Bridge and Hoang Van Thu Bridge exist in 2020, and the difference of economic benefit was estimated.

The results have revealed that the construction of Hoang Van Thu Bridge will not affect the Nguyen Trai Bridge project adversely. Actually the calculated EIRR showed only a negligible difference. This is due to the fact that the stream of economic benefits differs slightly only in several years between 2023 and 2029.

4.7.2 Impact of the Construction of the New Administrative Area on the Bridges in this Study

The construction of the new administrative area is not expected to have a large impact on the traffic demand across the Cam River. This is due to the fact that compared to the planned employment population of the industrial park, the planned employment population of the new administrative area is quite small (by 2020 the employment population of the new administrative area is forecasted to be 5,000 persons while by 2040, at the maximum build-out of the new administrative area, the employment population is forecasted to increase by 3,000 to 8,000 persons. Refer to the table below.

Table 4.7-1 Assumptions about the VSIP Hai Phong Development

Thuy Nguyen District	2011	2015	2020	2040
District Population (persons)	308,000	401,000	456,000	533,000
New Urban Area Population (persons)	16,000	109,000	150,000	175,000
Industrial Park Employment Population	0	33,000	50,000	50,000
New Administrative Area, Employment Population (persons)	0	2,000	5,000	8,000

Source: Pre-Feasibility Study for the Nguyen Trai Bridge Project at Thuy Nguyen District in Hai Phong, Vietnam, Final Report, AECOM

As a result, the new administrative area is not expected to be a large trip attractor and will not have much of an impact on the traffic demand of Nguyen Trai Bridge or Hoang Van Thu Bridge.

Appendix A5 EXAMINATION OF SUITABLE CROSSING ALTERNATIVES FOR THE CAM RIVER

5.1 Preliminary Design for Tunnel Crossing

The following two types of tunnels are examined as alternatives for a tunnel crossing under the Cam River:

- Case 1: Immersed tube tunnel
- Case 2: Shield tunnel

The advantages and disadvantages of both tunnel types are examined and a priority tunnel plan for crossing the Cam River is selected.

A preliminary design for the selected tunnel type will be carried out to compare the cost, construction period, advantages and disadvantages with bridge structures.

5.1.1 Outline of Tunnel Types

Either an immersed tube tunnel or a shield tunnel is considered to be utilized for crossing the Cam River. Cut and cover tunnels can be utilized in areas where construction is possible by directly excavating the ground surface and can be therefore be applied as approach tunnels. An outline of these three tunnel construction methods is included below.

(1) Immersed Tube Tunnels

Immersed tube tunnels are utilized principally for underwater crossings. They have a more than 100-year history and the method is commonly used for road and railway tunnels for the crossing of rivers, estuaries and sea channels especially in harbors.

There are many examples of immersed tube tunnels in the world. In Vietnam, the Saigon River Tunnel at Saigon Port in Ho Chi Minh City was constructed using the immersed tube tunnel method and was the first such road tunnel in Southeast Asia when it opened in November 2011.

Immersed tube tunnels consist of several segments with hollow box sections. The segments are designed so that they can float with their own buoyancy by closing both ends of the segment with bulkheads.

The segments are prefabricated in a dry dock near the construction site which is equipped with necessary facilities for towing and sinking of the segments. Once segment fabrication is complete, the dry dock is sank and the tunnel elements will float with their own buoyancy. Tug boats are then used to tow the segments one by one to the site where they are immersed into a trench which has been dredged in the riverbed or harbor bed in advance to ensure enough depth for the tunnel. Each segment is then connected with the previously immersed segment and water pressure is used to fix the segments one after another.

The trench is then backfilled with suitable material and a protection layer for the immersed tunnel structure is installed on top of the segment. Once the segment has been immersed and the surrounding backfill completed, the riverbed is then restored to its original or designed level.

The immersed tube tunnel method will only be applied in areas directly under the river. Both ends of the immersed tube tunnel are connected with the approach tunnels (cut and cover tunnels) constructed from the ground surface level. The tunnel can then be connected to the ground surface and the road network in the city.

(2) Shield Tunnels

The shield tunnel method uses one or two shield machines that consist of large metal mechanical cylinders which are used to bore through soft ground. A rotating wheel equipped with cutting teeth is located at the front end of the shield machine, and a chamber with a set of hydraulic jacks is installed behind the cutting wheel. The hydraulic jacks are supported by the finished part of the tunnel lining and are used to push the shield machine forward.

There are two major shield machine types as described below.

a) Earth pressure balanced shield machine

The excavated soil is mixed with slurry in the chamber. This turns the excavated soil into mud pressure and holds it under soil pressure to stabilize the cutting face.

b) Slurry type shield machine

The excavated soil is left in the chamber and external pressurized slurry is used to stabilize the cutting face, which is similar to the construction method used for bored piles or diaphragm walls where the trench wall is filled with bentonite slurry. The slurry is circulated to transport the excavated soil by fluid conveyance. Slurry type shield machines are always equipped with slurry feeders and discharge equipment to circulate and pressurize the slurry, as well as slurry processing equipment on the ground to adjust the slurry properties.

Selection of the shield machine type depends on ground conditions, surface conditions, dimensions of the tunnel section, boring distance, tunnel alignment, construction period, etc. Both above types are closed-face shield machines as the head part of the machine is "closed" and separated from the rear part of the machine.

Systems for the removal of soil (or soil mixed with slurry) are also equipped.

The head has a working chamber filled with soil or slurry between the cutting face and the bulkhead to stabilize the cutting face under soil pressure.

Once a certain distance has been excavated (about 1.0-2.0m), a new tunnel lining is built between the end of the shield machine and the previously installed lining using an erector installed behind the shield machine. The erector is a rotating mechanical system that picks up precast concrete segments and places them in the desired position to form the tunnel lining.

The tunnel lining forms the continuous wall of the tunnel and usually consists of several precast concrete segments which form one section of the tunnel lining.

Behind the shield, inside the finished part of the tunnel, several support mechanisms can be installed that are part of the shield machine. These include systems for dirt removal, slurry pipelines if applicable, control rooms, rails for transport of precast segments, etc.

(3) Cut and Cover Tunnels

Cut and cover tunnels are the most common and economical way to construct tunnels and always been applied for the approach tunnels of immersed tube tunnels or shield tunnels.
The tunnel is excavated or cut in accordance with the design alignment employing a cofferdam and strong supporting beam system to prevent any risk of the tunnel collapsing.
The tunnel structure will then be formed by constructing the foundation, walls, and roof etc. inside the excavated area, and then backfilling or covering the completed tunnel.
There are two main construction methods as shown below.

1) Bottom-up Method:

First, cofferdam walls such as steel pipe piles, sheet piles or diaphragm walls, will be installed down to the existing supporting layer. Once the walls are in place, the soil between the walls is excavated to a depth below the tunnel floor. The tunnel structure is then constructed from the bottom up, starting with the floor slab, continuing with the sidewalls, and ending with the roof slab. After the tunnel structure is complete, the excavated trench is backfilled and the roadway or ground on top of the tunnel is restored.

2) Top-down Method:

The tunnel structure is constructed in reverse order compared to the bottom-up method.
A diaphragm wall is first constructed and the soil within the diaphragm wall is then excavated up to the bottom of the roof slab. The roof slab is then constructed between the diaphragm walls. Once the roof slab concrete has cured and reached the required concrete strength, the soil under the roof slab is excavated from the tunnel entrance or temporarily opening the roof slab up to the bottom of the floor slab. The tunnel floor slab is the last part of construction to be completed. The diaphragm walls are used as the external tunnel walls and form part of the permanent structure.

5.1.2 Criteria for the Preliminary Design of Tunnel Planning

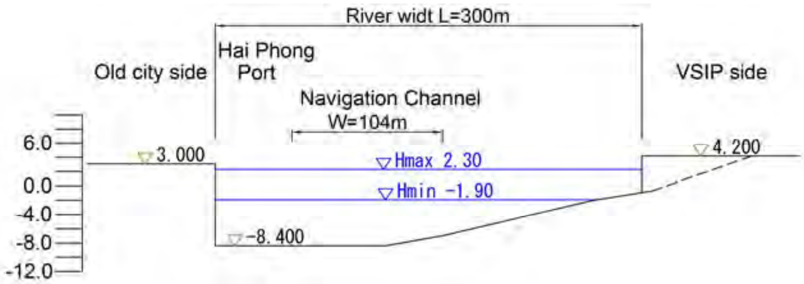
In order to select the tunnel type, the conditions at the construction site, such as the geological and hydrological conditions and the navigational conditions of the channel, are first summarized in this section.

(1) Geological and Hydrological Conditions

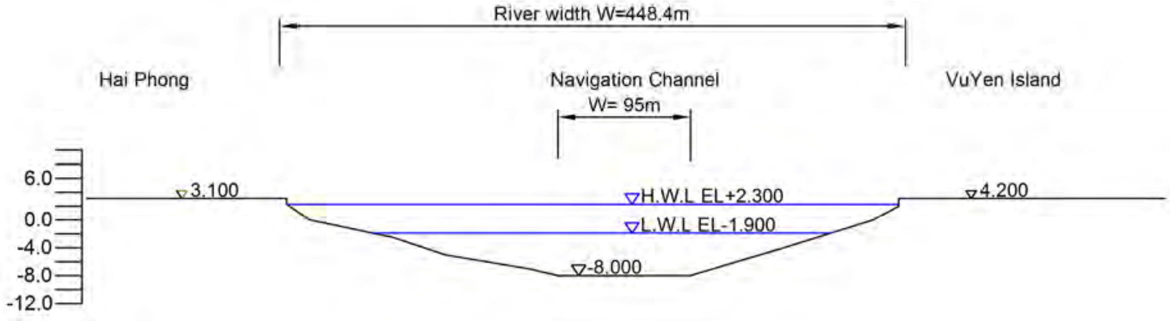
1) River Width and Depth

The width and depth of the river at the planned tunnel crossing are estimated based on the results of the sounding of the Cam River carried by Vietnam Maritime Safety North in 2011. The depth of Hai Phong Port is EL-8.4m according to hearings conducted with Hai Phong Port.

The cross sections for both Nguyen Trai and Vu Yen are shown in Figure 5.1-1.



a) Nguyen Trai Tunnel



b) Vu Yen Tunnel

Figure 5.1-1 Cross Section of the Cam River at the Tunnel Crossing

2) Water Level of the Cam River

Since the Cam River is a tidal river and the project area is located close to the river mouth, the water level of the Cam River in the project area is almost the same as the sea water level. Based on our studies, the water level is estimated as follows.

HWL: EL+2.300m

LWL: EL -1.900m

3) Geological Conditions

According to the soil investigation results, the subsoil consists of soft alluvial layers and marine clay deposit layers with a thickness of about 30m in both the Nguyen Trai and Vu Yen area. Some of the upper layers where the proposed tunnel is planned to be located consist of softer ground with an SPT value of less than 5 and the total thickness of the softer clay layer is about 20m. The SPT value of the clay layer below the upper softer layers increases gradually up to about EL-30m. Medium dense to dense sand layers exits below EL-30m.

(2) Navigational Conditions

According to information from Maritime Safety North, the conditions of the navigation channel are as follows.

- Navigation channel: One way navigation for vessels accessing the port of Hai Phong and Vat Cach. The navigation channel of the Cam River has a design width of 80m.
- Tonnage allowed on channel: Song Cam channel is designed for vessels up to 20,000GWT entering Chua Ve Port and 10,000GWT entering Hai Phong Port. However, 50,000GWT vessels of suitable draft, in other words 50,000GWT vessels which are not fully loaded, can enter Hai Phong Port.

The number of vessels that have entered Hoang Dieu Harbor in Hai Phong Port is summarized in Table 5.1-1 for each weight category. The table shows that the total number of vessels navigating in the project area of the Cam River is 1,000 to 1,300 vessels per year and averages 80 to 100 vessels a month (around 3 vessels a day). Among these, vessels less than 15,000GWT account for more than 90% of the total. Larger than 15,000GWT vessels have accessed the harbor 4 to 6 times per month and the number has not changed although the total number of vessels navigating the Cam River tends to be decreasing.

Table 5.1-1 Number of Vessels Entering Hoang Dieu Harbor in Hai Phong Port

Year	Less than 5,000 GWT	5,000 GWT ~ 7,000 GWT	7,000 GWT ~ 15,000 GWT	15,000 GWT ~ 40,000 GWT	Total	Average per month
2010	544	232	459	48	1,283	107
2011	467	205	465	64	1,201	100
2012	370	149	415	58	992	83
2013 1)	267	109	351	62	789	79

Note 1): As of October 2013.

Source: Final Report of "Study on the Highway Bridge in the New Urban Area of Hai Phong, the Socialist Republic of Vietnam (February 2014)"

(3) Ground Level

The present ground level is around EL+3.0m on the old city side (south side) of Nguyen Trai Tunnel and the VSIP area (north side) will be filled up to EL+4.2m to prevent flooding according to development plans.

The embankment height on Vu Yen Island on the north side of Vu Yen Tunnel is expected to be EL+3.1m. The height of the connecting roads of both Nguyen Trai Tunnel and Vu Yen Tunnel are therefore set as follows.

Nguyen Trai Tunnel: South side EL+3.0m, North side EL+4.2m

Vu Yen Tunnel : South side EL+3.1m, North side EL +3.1m

(4) Limit Conditions of Ground Surface Disturbance

Although there is a port facility, railway yard and houses on the old city side of Nguyen Trai Tunnel, these will be relocated in the near future according to HPPC. In other areas such as in the VSIP area where Nguyen Trai Tunnel will be connected and around both approaches of the Vu Yen Tunnel, no ground surface disturbance is anticipated.

5.1.3 Selection of Tunnel Type for Cam River Crossing

The selection of the tunnel type is dictated by the length, width (cross section), construction period, cost, and construction experience in Vietnam related to the tunnel.

(1) Alignment, Profile and Traffic Lanes

1) Alignment

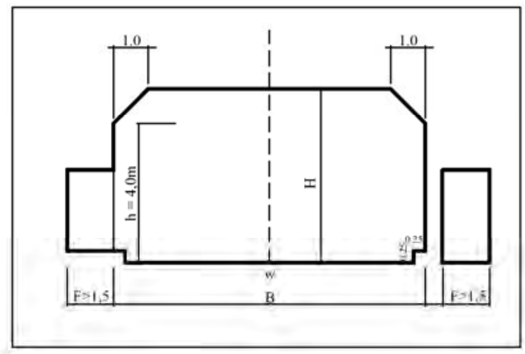
Although both immersed tube tunnels and shield tunnels can used for curved alignments, the alignment of the planned road has not yet been fixed and both tunnel alignments are therefore assumed to be straight.

2) Profile

The maximum gradient of the tunnel profile is 4% in consideration of the ventilation of the tunnel, and a R=3,000m vertical transition curve is applied in consideration of the sight distance in both convex and trough vertical curve.

3) Clearance and Traffic Lane Width

The vertical clearance of the tunnel is 4.75m according to TCVN4054:2005 (see Figure 5.1-2) and the traffic lane width is 2x3.75m=7.5m, with another 3.0m reserved for walkways and bikeways. The cross section for both Nguyen Trai Tunnel and Vu Yen Tunnel is shown in Figure 5.1-3.



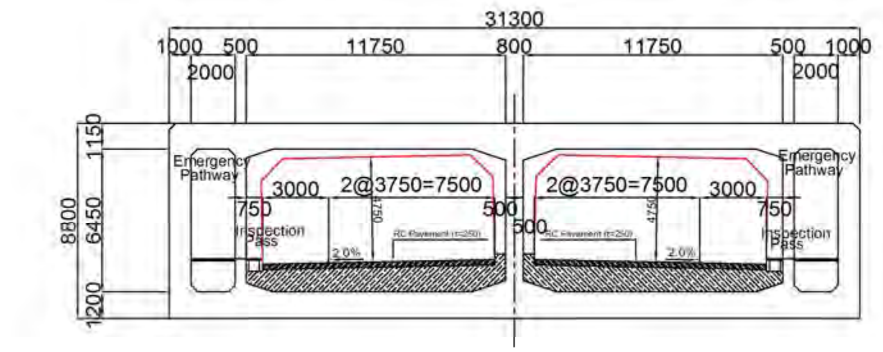
Notes:
1) The left part is used when the walkway and bikeway are located close to the traffic lanes, and the right part is used when they are separated.
2) F - Width for bikeway and walkway; B - Width reserved for highway facilities

Figure 5.1-2 Tunnel Clearances

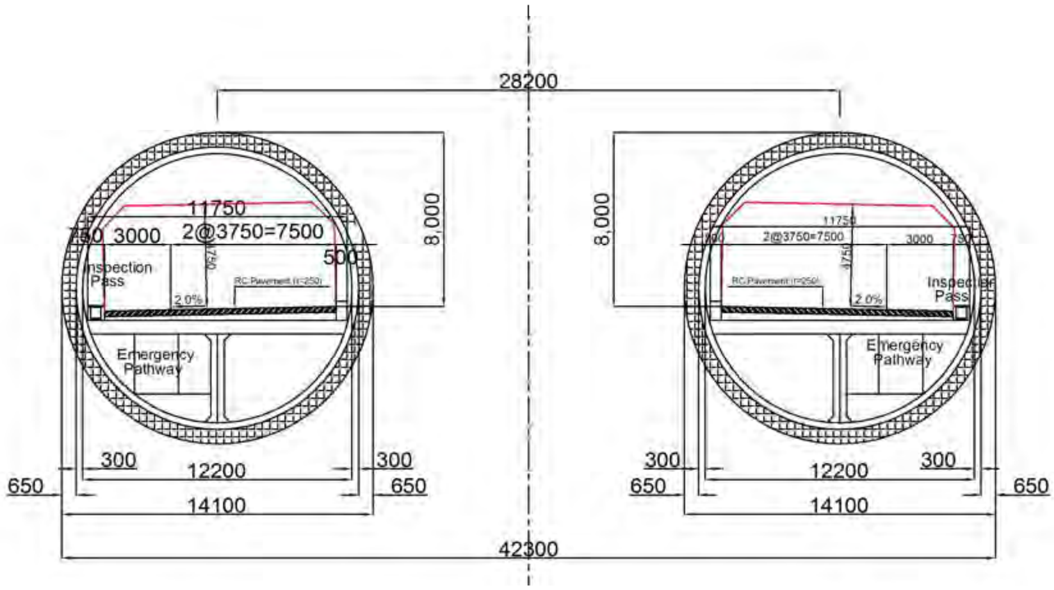
(2) Cross Section

The tunnel should have evacuation passages which are separated from the driveway. Inspection passages (w=750mm) should also be provided for tunnel maintenance beside the traffic lanes. The evacuation passages are usually set in corridors provided on both sides of the driveway in the immersed tube tunnel, while they are set under the driveway in the case of shield tunnels. The minimum requirement of the evacuation passage is to have a 2.0m width and a height of more than 2.1m. The remaining space of the corridor is used for common ducts and the installation/arrangement of cables and electrical boards for the tunnel E&M system.

Although the width of the space between the traffic lanes and the middle wall is specified as 0.25m in TCVN4054, it should be kept as 0.5m in consideration of the space required for cladding panels and emergency facilities. The cross section of both the immersed tube tunnel and the shield tunnel is shown in Figure 5.1-3.



a) Immersed Tube Tunnel



b) Shield Tunnel

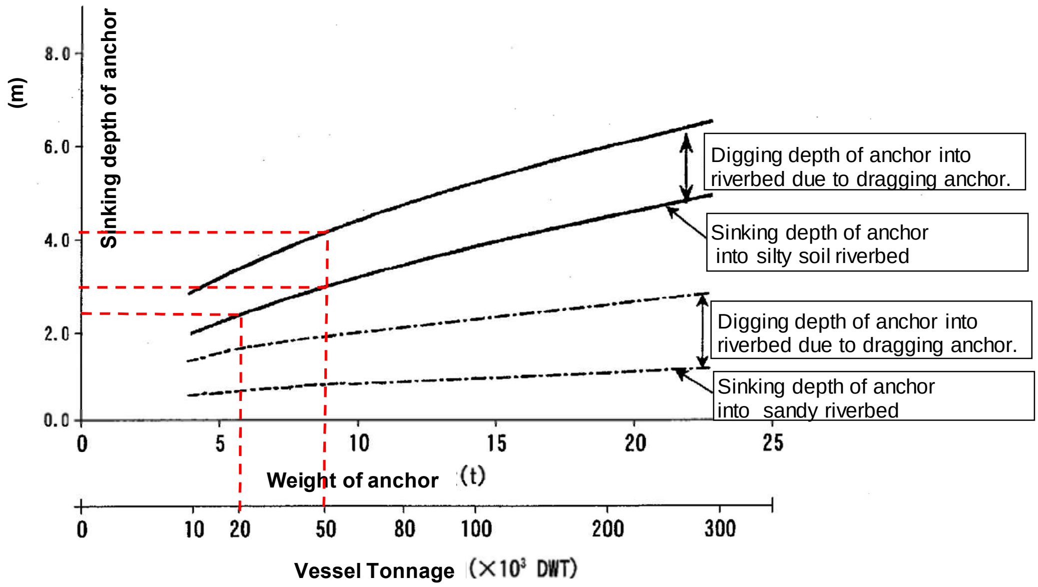
Figure 5.1-3 Tunnel Cross Sections

(3) Tunnel Earth Cover

The tunnel requires an earth cover for the protection of the tunnel structure in case of immersed tube tunnels, and for safe construction in the case of shield tunnels.

1) Immersed Tube Tunnel

The earth cover is usually determined from the thickness of the protection layer of the immersed tube tunnel. The protection layer is designed according to the estimated sinking depth of a ship anchor based on the protection layer thickness of immersed tube tunnels in Japan (see Figure 5.1-4).



(Source: Design and Construction Manual for Immersed Tunnels" published the Coastal Development Institute of Technology)

Figure 5.1-4 Thickness of Protection Layer in Japan

In case of silty soil riverbeds, the anchor sinking depth of a 50,000DWT vessel is around 3.0m and the anchor digging depth is around 1.0m more, making the total depth 4.0m as shown in Figure 5.5-4.

a) Nguyen Trai Tunnel

Large vessels such as 50,000GWT ships will not sail upstream of Hoan Dieu Harbor in Hai Phong Port because Binh Bridge which is located upstream of the port only has a 25m clearance. However, 50,000GWT vessels are expected to enter Hoan Dieu Harbor in Hai Phong Port to be moored. The thickness of the earth cover over the proposed tunnel should therefore be kept at 3.0m for the Nguyen Trai Tunnel.

b) Vu Yen Tunnel

Since Vu Yen Tunnel is planned to be located near the river mouth of the Cam River, 50,000GWT vessels are expected to enter the port which is upstream of the Vu Yen Tunnel. The earth cover over the proposed tunnel should therefore be kept 4.0m thick in consideration of the anchor digging depth.

2) Shield Tunnel

A minimum earth cover thicker than the external tunnel diameter is usually used for shield tunnels. The earth cover of the shield tunnel shall therefore be 1.5 times the external tunnel diameter under the Cam River, while the earth cover shall be kept the same as the external tunnel diameter on land areas.

3) Cut and Cover Tunnels

The earth cover of cut and cover tunnel sections shall be kept at more than 2.5m in consideration of public utilities installed underground. Cut and cover tunnels shall therefore be constructed 2.5m below the ground surface. U-shaped walls, T-shaped retaining walls and gravity walls shall be used where it is difficult to secure a 2.5m thick earth cover.

The top 2.5m part of the diaphragm wall should also be removed once the backfill has been completed.

(4) Selection of Tunneling Method

Table 5.1-2 and Figure 5.1-5 show a comparison between the immersed tube tunneling method and the shield tunneling method.

Table 5.1-2 Comparison of Immersed Tube Tunneling and Shield Tunneling Methods

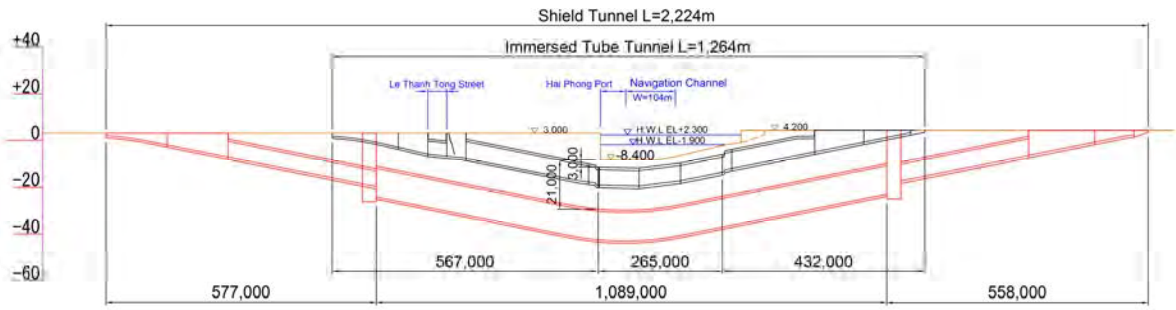
Item		Immersed Tube Tunneling	Comparison	Shield Tunneling
Width	Under river	31.3m	= 1)	42.3m
	On land	31.7m		42.3m
Length	Nguyen Trai	**1,262m**	> 2)	2,224m
	Vu Yen	**1,256m**	>	2,176m
Impact on Navigation		Some works impact navigation but can be controlled	< 3)	**No impact**
Social impact		**small**	>	Large (Because the length of tunnelis lomger)

Impact on natural environment	Necessary countermeasure	<	**No large-scale excavation inside the river**
Construction Period	**Shorter (50 to 55 month)**	>	60 to 65 months
Construction Cost	**Cheaper**	>	Around 1.5 times of immersed tube tunnel
Experience in Vietnam	**Saigon River Tunnel (opened in Nov. 2011)**	>	No experience in Vietnam
Construction Yard	Dry dock for fabrication of tunnel elements is required as an additional yard.	<	**Not required**
Maintenance	**Cheaper**	>	Tunnel length is longer

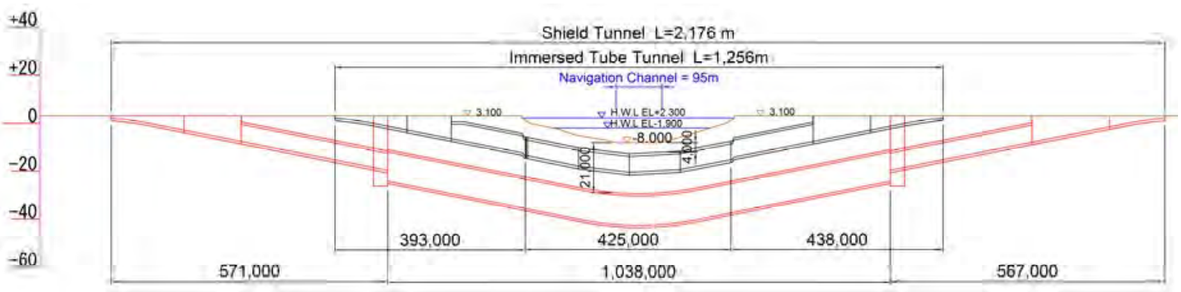
Notes: 1) = Both methods equal or equivalent.

2) > Immersed tube tunneling method is superior to shield tunneling method.

3) < Immersed tube tunneling method is inferior to shield tunneling method.



a) Nguyen Trai Tunnel



b) Vu Yen Tunnel

Figure 5.1-5 Comparison of Immersed Tube Tunnel and Shield Tunnel

Based on Table 5.7-2, the immersed tube tunneling method is in this case considered inferior to the shield tunneling method because of the impact on navigation and the requirement of a construction yard.

However, the number of the vessels arriving at Hoang Dieu Harbor in Hai Phong Port averages 80 to 100 a month (around 3 vessels a day), and these include only 2 or 3 a month which are larger than 15,000DWT. This is a considerably smaller number compared with Saigon Port (20,000DWT vessels 16 times/month, including 40,000-75,000DWT vessels 2 times/month) during the construction of the Saigon River Tunnel. It can therefore be considered that navigational control is not difficult and the impact of construction of both Nguyen Trai Tunnel and Vu Yen Tunnel will be very small.

As for the additional yard for the immersed tube tunnel construction, it is necessary to allocate an 8,400m^2 dry dock for Nguyen Trai Tunnel and a 12,000 m^2 dry dock for Vu Yen Tunnel separated from but as close as possible to the tunnel construction site for the fabrication of the tunnel elements. The dry dock yards are temporary facilities and their required period of use is estimated to be around 3 years. Based on our site investigations, there is space for a dry dock yard on Vu Yen Island where there are currently many fish ponds and the VIN Group plans to develop a new urban area in the future. The allocation of the dry dock can therefore be considered not to affect the project.

According to our analysis, the immersed tube tunneling method is superior to the shield tunneling method in regard to construction cost and construction period. It is also advantageous as there is past experience in Vietnam of using the method for the Saigon River Tunnel in Ho Chi Minh City which was opened to traffic in 2011.

In contrast, Vietnam has no experience of applying the shield tunneling method for road tunnel construction. A 14.1m diameter shield tunnel is one of the largest tunnel sizes available and very few have so far been constructed anywhere in the world.

Moreover, since an immersed tunnel would be much shorter than a shield tunnel (around half the shield tunnel length), the maintenance cost of an immersed tube tunnel would be cheaper than that of a shield tunnel. Land acquisition for the tunnel construction yard would also be much simpler in case of an immersed tunnel.

Based on the reasons mentioned above, the immersed tube tunneling method should be selected for further comprehensive evaluation as the tunnel plan for crossing the Cam River.

5.1.4 Preliminary Design for Immersed Tunnel

(1) Structure Planning

The structural type, material and dimensions of the elements including the length shall be evaluated in consideration of structural safety, water tightness, construction cost, construction method, and other restrictions.

1) Immersed Tube Tunnel

The 3 structural types shown below can be applied for both Nguyen Trai Tunnel and Vu Yen Tunnel.

a) Reinforced concrete structure

b) Open sandwich structure (steel-concrete composite structure)

c) Full sandwich structure (steel-concrete composite structure)

However, the construction cost of steel-concrete composite structures is 10 to 20% higher than that of reinforced concrete structures. As Vietnam has experience of constructing an immersed tube tunnel from reinforced concrete in the form of the Saigon River Tunnel, a reinforced concrete structure will be applied for the tunnel structure type of both Nguyen Trai Tunnel and Vu Yen Tunnel.

2) Approach Tunnel

An immersed tube tunnel will be used only for the part under the Cam River. Other parts where the tunnel can be constructed from the ground surface level will apply the cut and cover tunneling method for which there are two methods, the top-down method and the bottom-up method (refer to Section 5.1.1). The top-down method is usually superior to the bottom-up method in regard to construction cost and schedule, and is also an effective construction method for soft soil ground conditions.

However, the structural characteristics of tunnels constructed with the top-down method are dissimilar to immersed tube tunnels, while tunnels constructed with the bottom-up method can be similar to immersed tube tunnels as the cross section of the tunnel in such cases can be made similar in shape as for immersed tube tunnels.

The bottom-up method is usually applied to the interface tunnel between the immersed tube tunnel and the cut and cover tunnel constructed by the top-down method (the end section). The tunnels connected with both ends of the immersed tunnel shall therefore be constructed by the bottom-up method for sections between 20m and 30m in length.

In case the earth cover is less than 2.5m thick, the approach road connected with the cut and cover tunnel will be an open section in the form of a U-shape wall and gravity wall.

(2) Tunnel Structure

The overall tunnel structure therefore consists of the following parts:

a) Immersed tube tunnel

b) End section constructed with the bottom-up method which connects the immersed tunnel and the cut and cover tunnel constructed with the top-down method

c) Cut and cover tunnel constructed with the top-down method

d) U-shaped structure with diaphragm wall

e) U-shaped retaining wall

In the case of the Nguyen Trai Tunnel, Le Thanh Tong Street is running along the port at a distance of around 330m on the old city side. If the tunnel is to be connected with Le Thanh Tong Street, the gradient of the tunnel is more than 6%. Therefore the approach road of the tunnel shall pass Le Thanh Tong Street in an underpass tunnel and be connected with Nguyen Trai Street.

Figure 5.1-6 to Figure 5.1-9 and Table 5.1-3 show a summary of the preliminary design of the tunnel structure for both Nguyen Trai Tunnel and Vu Yen Tunnel.

1) Nguyen Trai Tunnel

Table 5.1-3 Outline of Preliminary Design for Nguyen Trai Tunnel

Item	Structure Type, Dimensions and Length
Immersed tunnel	- To pass under the Cam River and Port - RC structure - Cross section: 8.8m(H)x31.3m(W) - Length L=87+89+89=265m (3 elements)
End Section	- Between the immersed tube tunnel and the cut and cover tunnel - Constructed with the bottom-up method with steel pipe pile cofferdams - Each length L=20mx2=40m
Cut and Cover Tunnel	- Old city side L=262m, VSIP side L=177m (total L=460m) - RC diaphragm wall: t=1.2m, L=40m - Top-down method
U-shaped Structure with Diaphragm Wall	- Old city side L=41m, VSIP side L=105m (total L=125m) - RC diaphragm wall: t=1.0m, L=40m - Top-down method
Box Culvert	- To pass under Le Thanh Tong Street - RC box culvert (L=40m)
U-shaped Retaining Wall	- Old city side L=162m, VSIP side L=100m (total L=282m) - Nguyen Trai Street in VSIP area

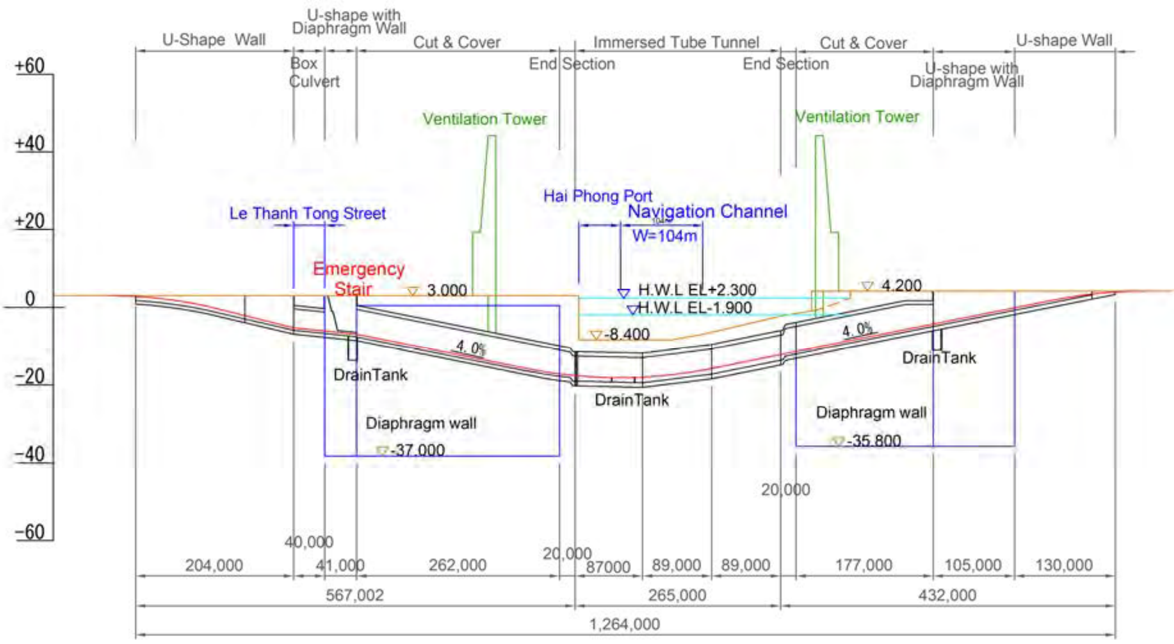
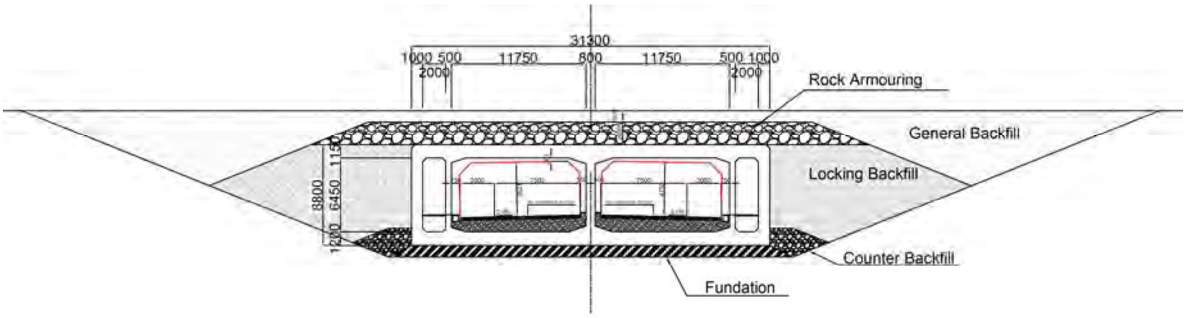
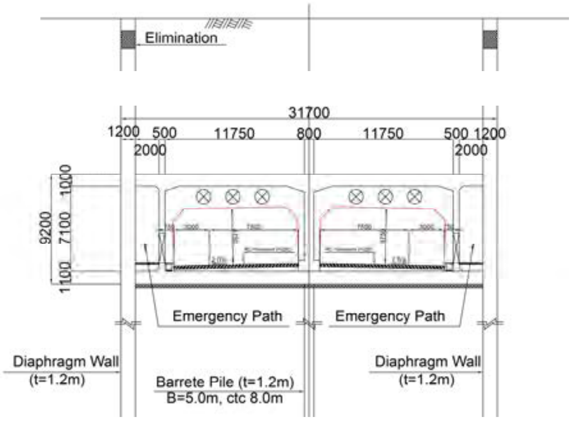


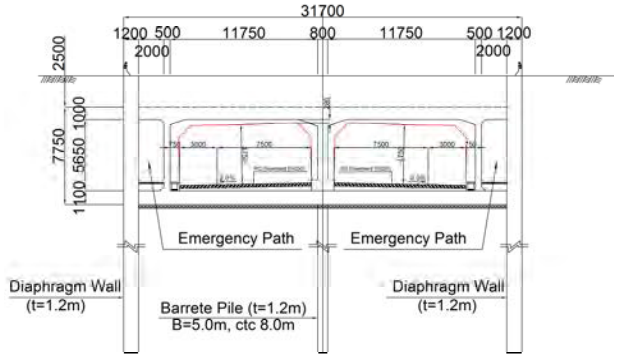
Figure 5.1-6 Profile of Nguyen Trai Tunnel



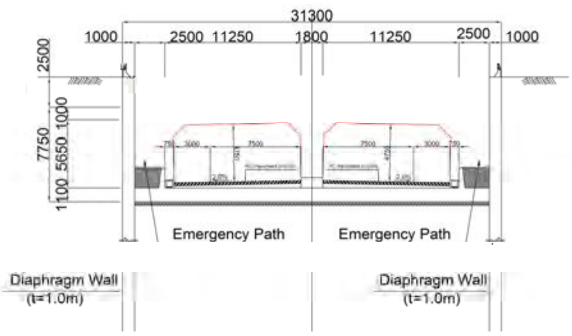
(a) Immersed Tube Tunnel



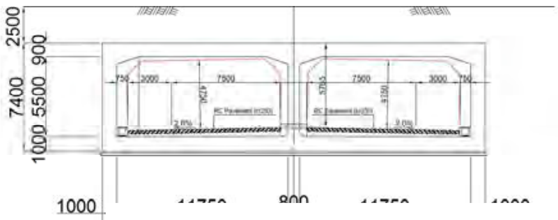
(b) Cut and Cover Tunnel



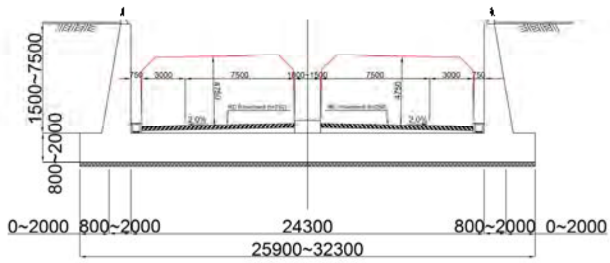
(c) Tunnel Entrance (VSIP side)



(d) U-shaped Structure with Diaphragm Wall



(e) Underpass at Le Thanh Tong Street



(f) U-shaped Wall (Nguyen Trai Street)

Figure 5.1-7 Cross Section of Nguyen Trai Tunnel

2) Vu Yen Tunnel

Table 5.1-4 Outline of Preliminary Design for Vu Yen Tunnel

Item	Structure Type, Dimensions and Length
Immersed tunnel	- To pass under the Cam River - RC structure - Cross section: 8.9m(H)x31.3m(W) - Length L=110+105x3=425m (4 elements)
End Section	- Between the immersed tube tunnel and the cut and cover tunnel. - Constructed with the bottom-up method with steel pipe pile cofferdams - Each length L=30mx2=60m
Cut and Cover Tunnel	- Hai Phong side L=123m, VY Island side L=140m (total L=263m) - RC diaphragm wall: t=1.2m, L=40m - Top-down method
U-shaped Structure with Diaphragm Wall	- Hai Phong side L=91m, VY Island side L=118m (total L=209m) - RC diaphragm wall: t=1.0m, L=40m - Top-down method
U-shaped Retaining Wall	- Hai Phong side L=149m, VY Island side L=110m (total L=220m) - Nguyen Trai Street in VSIP area

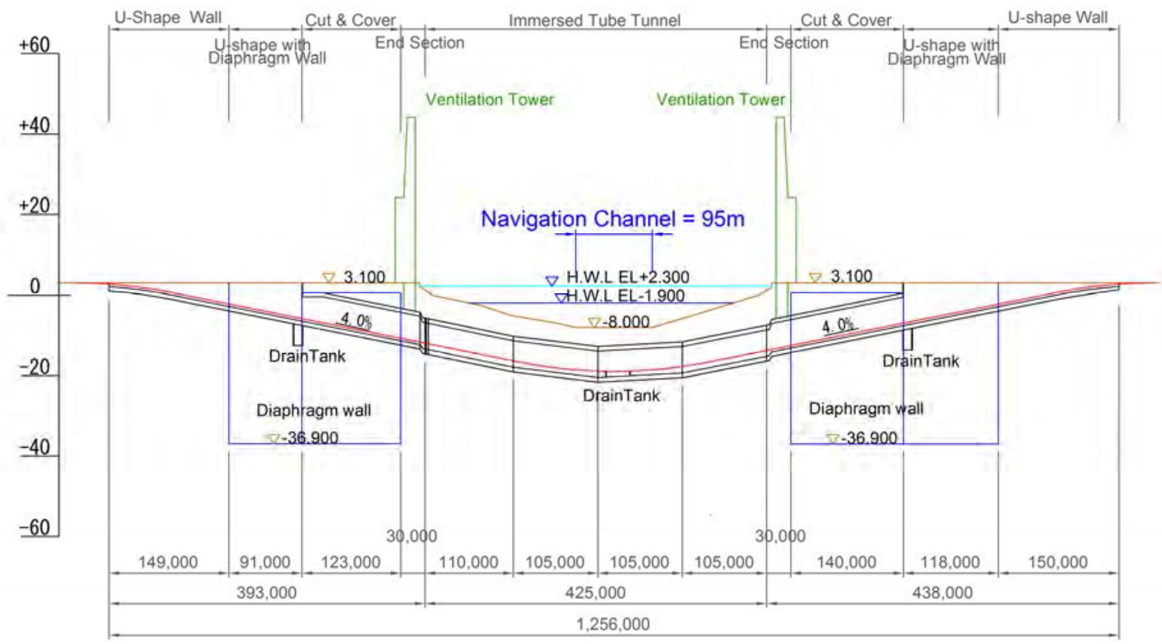
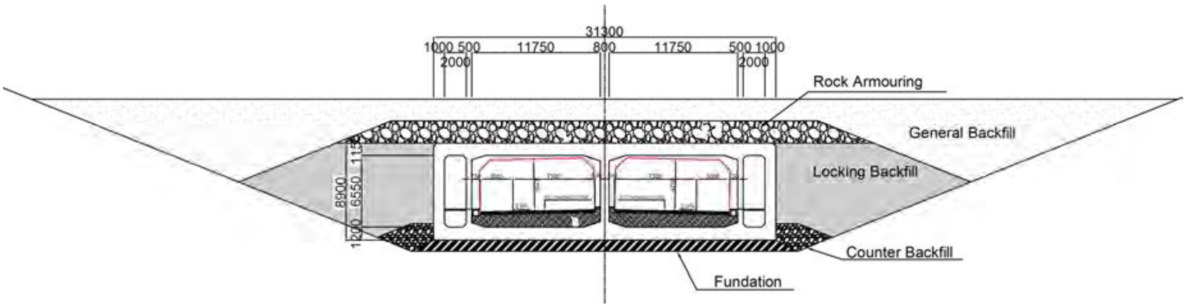
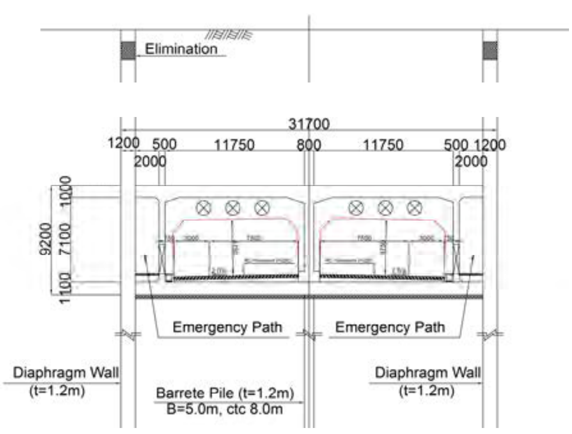


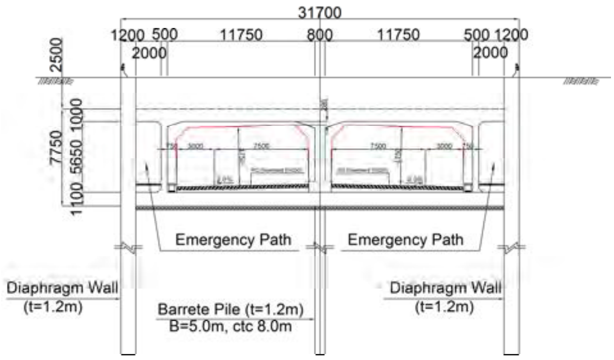
Figure 5.1-8 Profile of Vu Yen Tunnel



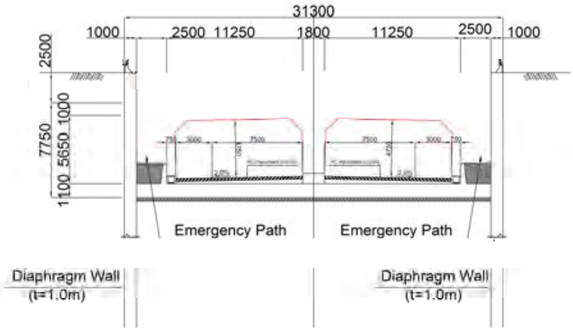
(a) Immersed Tube Tunnel



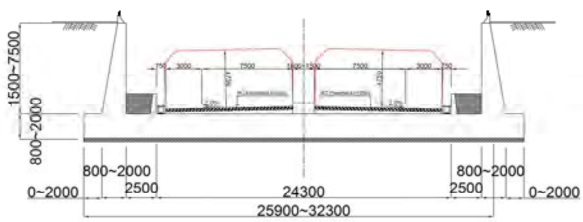
(b) Cut and Cover Tunnel



(c) Tunnel Entrance (Hai Phong side)



(d) U-shaped Structure with Diaphragm Wall



(e) U-shaped Wall

Figure 5.1-9 Cross Section of Vu Yen Tunnel

(3) Electrical & Mechanical (E&M) System for Tunnel

The electrical & mechanical (E&M) system required for the tunnel is as shown below. The image of the tunnel E&M facilities is shown in Figure 5.1-10.

a) Ventilation system

b) Lighting system

c) Drainage system

d) Emergency system

e) Tunnel control system and power supply system, etc.

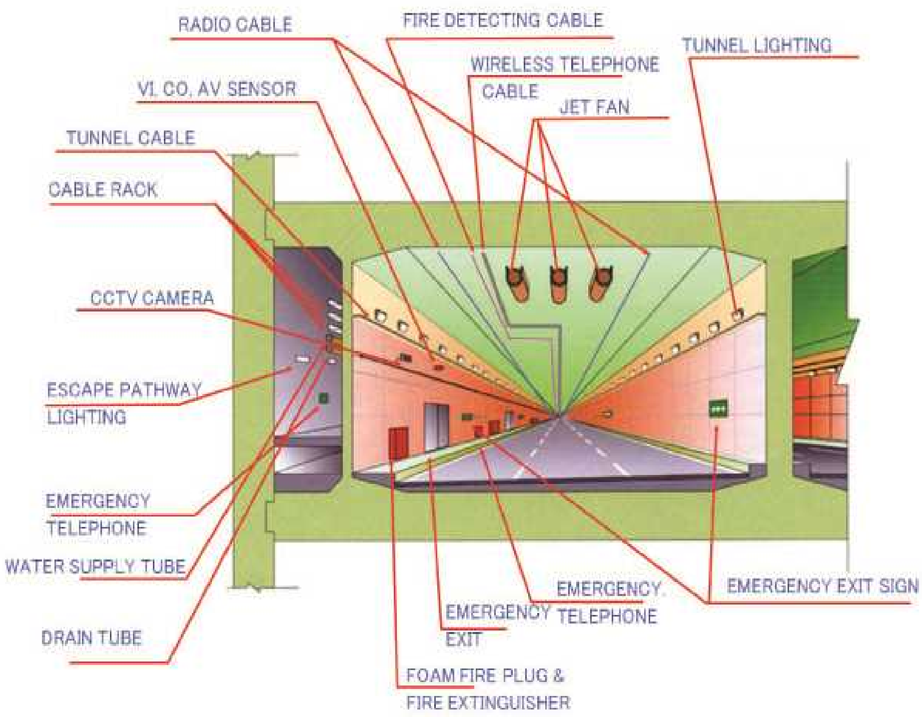


Figure 5.1-10 Example Layout of Tunnel E&M Facilities

1) Ventilation System

Road tunnels create a confined space where emissions from vehicles can sometime build up to unacceptable levels without dilution by the provision of fresh air or removal of exhaust air from the tunnel by natural or forced ventilation. The basic concept of the ventilation system is to ensure safe and smooth driving conditions, and to offer environmental protection for both tunnel users and the areas around the tunnel entrances.

The ventilation system is generally determined in consideration of tunnel length, traffic volume through the tunnel, potential traffic jams caused by accidents and fires inside the tunnel, and the environment around the tunnel entrances.

Both Nguyen Trai Tunnel and Vu Yen Tunnel are relatively short as the length of each tunnel is less than 800m. However, the traffic volume in 2020 is expected to be more than 4,000 PCUs/hour according to the final report of "Study on the Highway Bridge in the New Urban Area of Hai Phong, the Socialist Republic of Vietnam (February 2014)".

A 3m wide bikeway or walkway is also planned and it is expected that many motorbike users will use the tunnels.

A forced ventilation system is therefore applied for both tunnels due to the reasons shown below.

- Expected busy traffic with more than 4,000PCUs/h
- Necessity of environmental protection for motorbike users
- Necessity of ventilation during traffic jams caused by accidents
- Necessity of ventilation in case of fires

There are several types of forced ventilation systems such as longitudinal ventilation systems, semi-transverse ventilation systems, transverse ventilation systems and a combination of these types. Among them, since both tunnels have two separate tunnel sections with one-directional traffic on each driveway, the longitudinal ventilation system will be the most economical and widespread system. In particular, the use of jet fans is effective in terms of low running cost, to provide ventilation even if vehicles are lined up in the tunnel due to accidents etc., and to remove smoke in the event of fires.

In addition to the above, since the north side entrance of Nguyen Trai Tunnel will be planned in old city and the surrounding condition in future around the south side entrance of Nguyen Trai Tunnel and the both side entrance of Vu Yen Tunnel will be urban area, zero fume emissions at the tunnel entrance should be considered. All emissions from the vehicles must be expelled by the concentrated exhaust from an elevated ventilation outlet in a ventilation tower with the execution of natural air from the entrance of the tunnel to meet the zero-entrance-emissions condition. The ventilation tower with concentrated ventilation system therefore, shall be employed to secure the acceptable environmental conditions at the tunnel entrances (see Figure 5.1-7 and Figure 5.1-9).

2) Lighting system

It is important that the lighting system in the tunnel can recreate the same conditions of safety, confidence and comfort that motorists experience on the road connected to the tunnel whatever the time of day or night in order to ensure safe passage inside the tunnel for motorists. The tunnel lighting should illuminate the presence and movement of other tunnel users or objects, as well as the tunnel geometry to guide drivers quickly through the tunnel without any disturbances or problems.

The significant contrast in lighting between daylight and tunnel luminance causes a slowdown of vehicles when motorists approach the tunnel entrance. This phenomenon, known as the "black hole" effect, can be minimized by providing an entrance lighting system at the threshold zone to allow time for eye adaptation. Since the opposite phenomenon occurs at night, some lights are required at the open section on the approach road outside the tunnel.

The types of lighting installed inside the tunnel and on the open sections of the approach roads leading to the tunnel are as follows.

a) Base illumination lights
b) Entrance lighting
c) Lights at tunnel exits
d) Outside lights on approach roads leading to tunnel entrances

Illumination control devices which control the outside lights on the approach roads leading to the tunnel entrances, the lights at the tunnel exits, and the entrance lighting of the tunnels shall be provided so that motorists can visually recognize the inside of the tunnel and approach road and drive safely.

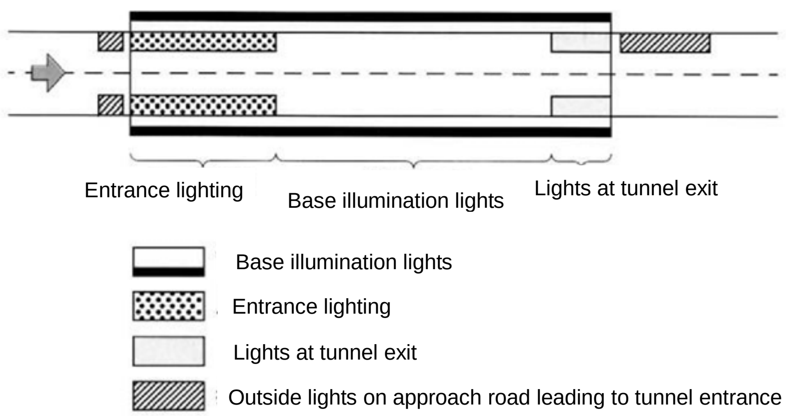


Figure 5.1-11 Lighting Layout

3) Drainage system

Road surface drainage systems are composed of drain tanks, drain pumps, pipes and an operation system to remove rainwater, fire fighting water, washing water or condensation water, and permissible water intake from the tunnel structures. It is difficult to install the main drainage system entirely at the lowest point of the tunnel because it is very difficult to make the drain tank deep enough due to restrictions in the tunnel structure. Therefore, minimum drainage and drain pumps are installed at the lowest point of the tunnel to remove rainwater brought by vehicles from outside the tunnel, fire fighting water and washing water.

On the other hand, rainwater falling on the open sections on both sides of the tunnel approaches shall be collected at the tunnel entrances using drainage sumps and drain pumps in order for the rainwater not to flow into the tunnel (see Figure 5.1-7 and Figure 5.1-9).

4) Tunnel Control and Emergency System

The scale of the emergency system is determined by the tunnel class, and the tunnel class is in turn determined by the relationship between the tunnel length and the traffic volume through the tunnel according to the “Standard for Installation of Emergency Systems for Road Tunnels” published the Japan Road Association (see Figure 5.1-11).

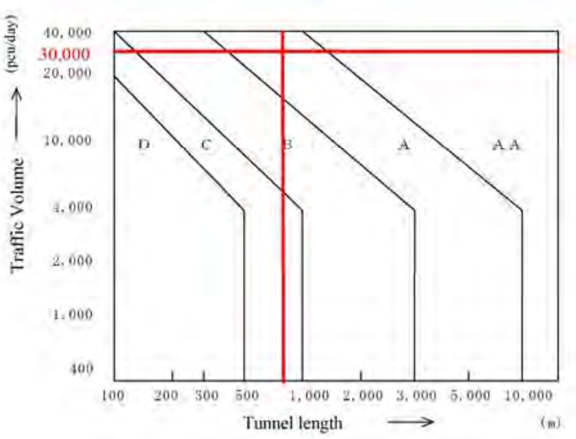


Figure 5.1-12 Tunnel Classes Used to Determine Scale of Emergency

The length Nguyen Trai Tunnel is 744m and that of Vu Yen Tunnel is 748m. The traffic volume in 2020 is expected to be 32,100 PCUs/day in Nguyen Trai Tunnel and 33,600 PCUs/day in Vu Yen Tunnel.

Based on Figure 5.5-12, both tunnels are classified as Class A, and the emergency facilities shown in Table 5.5-5 shall therefore be installed.

Table 5.1-5 Emergencies Facilities

<table>
<tr><th>Safety System</th><th>Contents</th><th>Remarks</th></tr>
<tr><td rowspan="4">Information and Warning Apparatus</td><td>Emergency telephone</td><td>Provided in case of fires, accidents or vehicle breakdowns in the tunnel.
The telephone units are installed on the side walls and in the evacuation passages.</td></tr>
<tr><td>Push-button alarm system</td><td>To send an alarm signal to the control center in case of fires or accidents in the tunnel.</td></tr>
<tr><td>Automatic fire detection system with optical fire detector</td><td>To detect the outbreak of fires based on the presence of heat, smoke, or light.</td></tr>
<tr><td>Tunnel information boards as warning system</td><td>Installed on approach roads leading to the tunnel entrances.</td></tr>
<tr><td rowspan="2">Fire Fighting Apparatus</td><td>Fire extinguishers</td><td rowspan="2">For primary fire-fighting by tunnel users.</td></tr>
<tr><td>Foam hydrants</td></tr>
<tr><td rowspan="3">Evacuation Guide Facility</td><td>Illuminated exit guide boards</td><td>To show evacuation doors and distance to tunnel exits.</td></tr>
<tr><td>Smoke exhaust systems</td><td>Jet fans installed over the driveway.</td></tr>
<tr><td colspan="2">Emergency pathway with ventilation equipment that maintains a slight positive pressure in the emergency pathway to reduce smoke ingress in the event of a fire.</td></tr>
<tr><td rowspan="5">Other Emergency Facilities</td><td>Hydrant at portal</td><td>For fire fighting by the fire services.</td></tr>
<tr><td>Wireless radio / telephone system</td><td>To enable radio communication between the fire services and people inside the tunnel.</td></tr>
<tr><td>Radio rebroadcast system</td><td>To enable users to catch radio waves inside the tunnels.</td></tr>
<tr><td>Loud speaker system</td><td>To enable users to receive notices or instructions during emergencies.</td></tr>
<tr><td>Monitoring system</td><td>Closed-Circuit Television Systems (CCTV).</td></tr>
</table>

(4) Countermeasure for social and natural environment

1) Social Impact

Areas around the tunnel openings require land acquisition including some aquaculture facilities and agricultural land.

However, in case of Nguyen Trai Tunnel, the function of port can be kept as same as present condition. And also Vu yen Tunnel will not affect the oil storage base near construction site.

2) Impact on natural environment

The U-shape section, about250m will obstruct the surface currents and groundwater flow, which negatively affects the wetlands and mangrove forests on Vu Yen Island.

3) Impact on living environment

Since the ventilation tower with concentrated ventilation system will be employed, therefore it will be unlikely happen the high concentrations of emissions in the areas near the tunnel openings.

Regarding noise around the tunnel opening, it should be kept to satisfy the regulation on noise in Vietnam by a noise absorption system.

5.1.5 Construction of the Immersed Tube Tunnel

(1) Construction Sequence

The sequence of the immersed tube tunnel construction and the cut and cover tunnel construction is shown in Figure 5.1-13 and Figure 5.1-14, respectively.

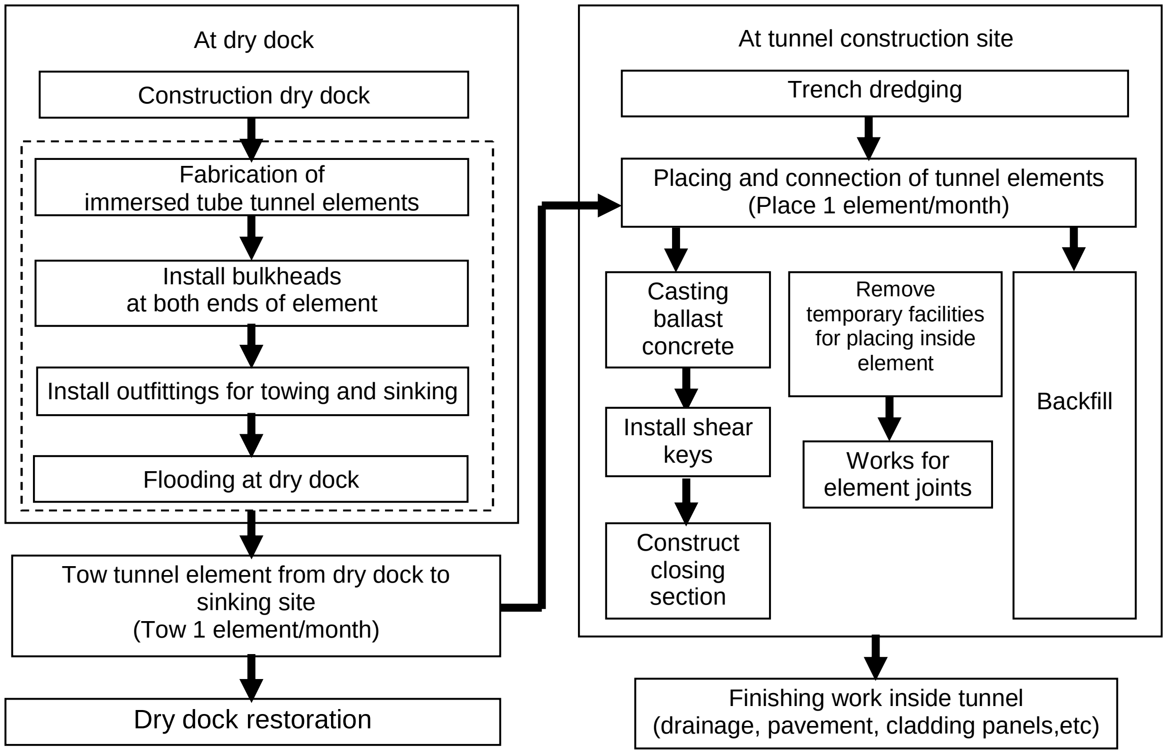


Figure 5.1-13 Sequence of Immersed Tube Tunnel Construction

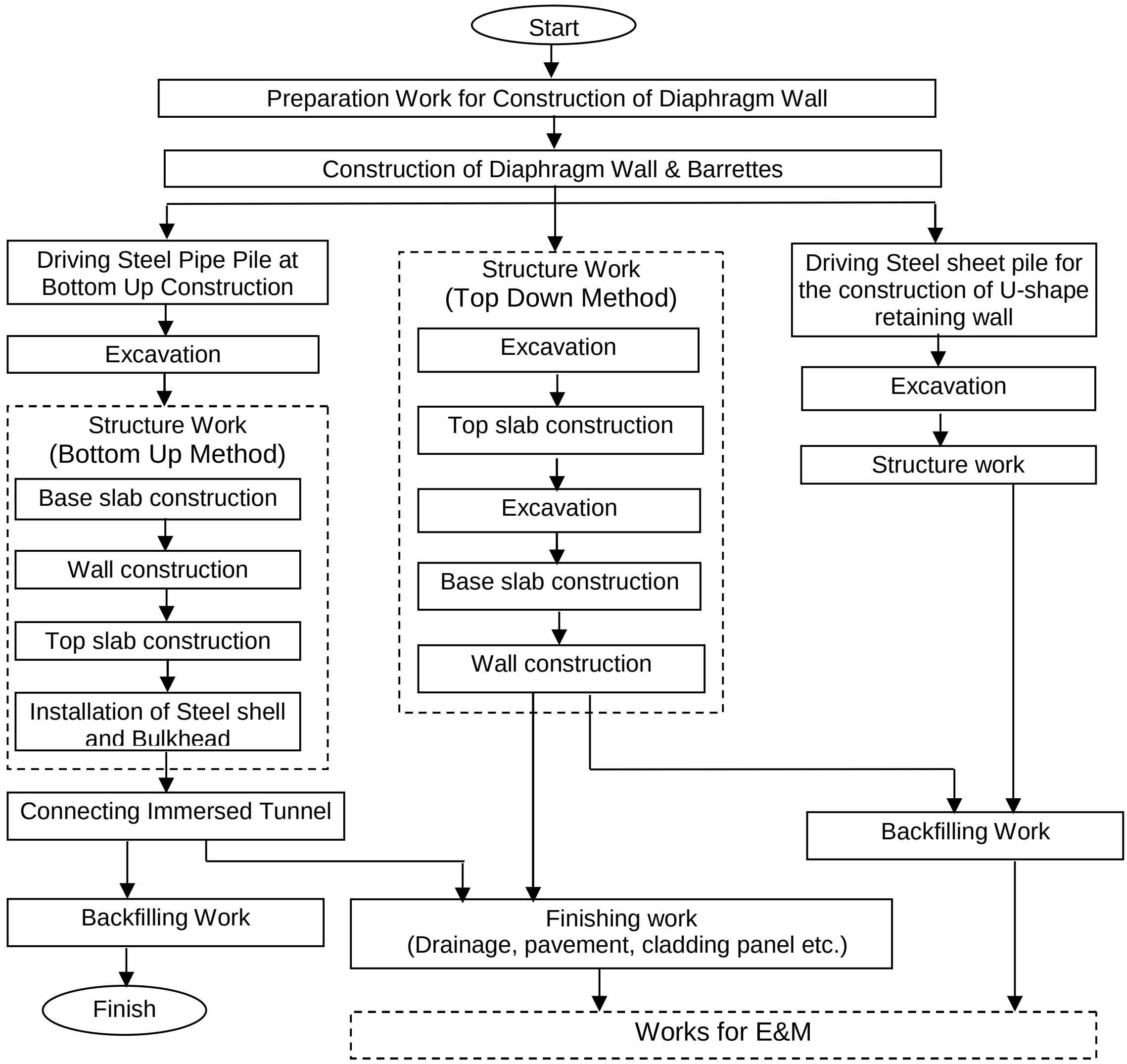


Figure 5.1-14 Sequence of Cut and Cover Tunnel Construction

(2) Navigation Control Plan

Table 5.1-6 shows the plan for the navigation control during the immersed tube tunnel construction.

Table 5.1-6 Navigation Control during Construction

Work item	Assumed navigation control	Period
Dredging of reverbed	Navigation channel may be diverted or reduced to till half of present wide temporally.	6month
Preparation works for towing and immersion	Navigation shall be controlled partially.	About 2 weeks 2 month before towing
Tunnel elements towing	Navigation shall be closed	0.5 day per towing
Placing the element into the riverbed	Navigation shall be closed	One (1) day per immersion works
Backfilling works carried out in succession of the tunnel element immersion	Navigation channel may be diverted or reduced to till half of present wide.	6month

(3) Countermeasure for natural environment

Since large-scale excavation inside the river is required during the construction period, the countermeasure for the Water pollution of the river, such as silt-curtain etc. to minimize the negative impact on the natural environment.

(4) Construction Schedule

Total construction period will be as follow.

Nguyen Trai Tunnel : 53 month

Vu Yen Tunnel : 51 month

Construction schedule for both Nguyen Trai Tunnel and Vu yen Tunnel is shown Figure 5.1-16.

(5) Construction Cost

The Construction cost is estimated as shown Table 5.5-7 and 8.

Table 5.1-7 Cost for Construction of Nguyen Trai Tunnel (1 JPY=202.84VND)

Item	Description/Quantity	Equivalent JPY	Equivalent VND (Million VND)
General	7% of Total	1,030,000,000	208,925
Immersed tunnel (RC structure)	8.8m(H)x31.3(W)x3 units L=87+89+89=265m	5,468,000,000	1,109,129
Approach Tunnel	Old city side L=567m VSIP side L=432m	6,459,000,000	1,310,144
Finishing work	L=1,234m	236,000,000	47,870
E&M	L=744m	2,552,000,000	517,648
Total		**15,745,000,000**	**3,193,716**

Table 5.1-8 Cost for Construction of Vu Yen Tunnel (1 JPY=202.84VND)

Item	Description/Quantity	Equivalent JPY	Equivalent VND (Million VND)
General	7% of Total	1,182,000,000	239,757
Immersed tunnel (RC structure)	8.9m(H)x31.3(W)x4units L=110+105x3=425m	7,933,000,000	1,609,130
Approach Tunnel	HP side L=393m VY island side L=438m	6,171,000,000	1,251,726
Finishing work	L=1,256m	244,000,000	49,493
E&M	L=748m (Tunnel Section)	2,536,000,000	514,402
Highway	W=35.5m, L=924m	492,000,000	99,797
Total	Total length L=2,180m	**18,558,000,000**	**3,764,305**

5.1.6 Operation and Maintenance of the Tunnel

The tunnel must be designed and operated as an integral part of the city network and not as a potential bottleneck within the network. Also a key role of the tunnel management is the efficient and safe operation of the tunnel.

The tunnel management can be divided into 2 parts, the first part is the tunnel operation and the second part is the cleaning and the maintenance of the tunnel structure and E&M facility.

An example of organization of tunnel management team is shown Figure 5.1-15.

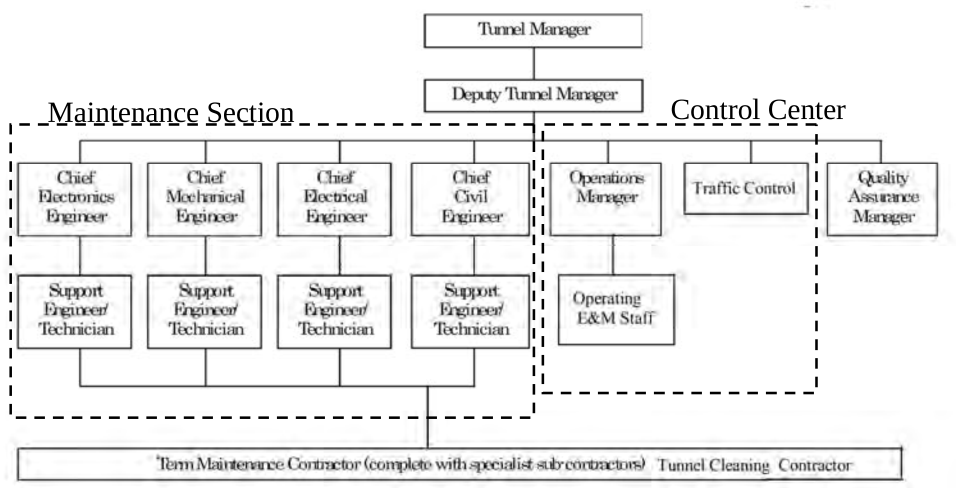


Figure 5.1-15 Example of Organization of Tunnel Management

1) Tunnel Operation

There will be 2 tunnel operations, one is normal conditions (Free flow traffic) and other is Emergency Condition as shown below

- Incidents such as a vehicle breakdown or accident happen inside the Tunnel.
- Fire and explosion inside the Tunnel as the result of the Incident.
- Sedimentation in river bed and scouring of riverbed
- Ship sinking on the Tunnel
- Earthquake

In normal condition, the ventilation fans and the lighting system are automatically controlled by a sensor and operated by the tunnel control system and monitored by the control center.

On the other hand, when an emergency event mentioned above happen inside the tunnel and can be detected by the CCTV monitors or the emergency roadside telephones, the control center will be responsible for:

- The immediate information to the necessary emergency services about event occurring inside the Tunnel and the tunnel users to prevent the risk of further incidents ;
- Alerting the E&M operating team to provide necessary control of lighting, ventilation and

pumping as required, and the traffic clearance measures inside the Tunnel.

- The immediate provision of the traffic information to minimize the effects of approach road congestion, in particular for dealing with the emergency.

2) Maintenance of the Tunnel

The purpose of the maintenance of the tunnel is as follow

- Sustaining the Tunnel in a safe and useable condition;
- Ensuring safety to the Tunnel users and staff;
- Minimizing disruption to the traffic of the Tunnel and environmental impacts on the Tunnel through the operation and maintenance carefully planned;

(a) Cleaning

Table 5.1-8 shows the example of items and frequency of tunnel cleaning.

Table 5.1-8 Frequency of the Cleaning Tunnel

Part of Tunnel	Frequency of cleaning
Tunnel Wall include cladding Panel	Motorbike lane side: **4time/year** Centre side : **2time/year**
Soffit of the Tunnel	Basically **every 5 years** Or when an excessive accumulation or build-up of deposit is observed.
Drive Way	**Every day** by dry cleaning. Washing using a water jet and brushes should be done on **2times/year**.
Drainage	On **annual basis**. It should be carried out before rainy season.
Drain Tanks	Collect rubbish floating on drain tanks on **daily basis**. Remove accumulated soil, deposited debris in the inside of drain tanks and debris attached to the pump on **monthly basis.**
Signs	**4times/year**
Emergency Path	**Once a year**

(b) Maintenance of Tunnel

General procedure of the maintenance work for the Tunnel structure is shown in Figure 5.1-16.

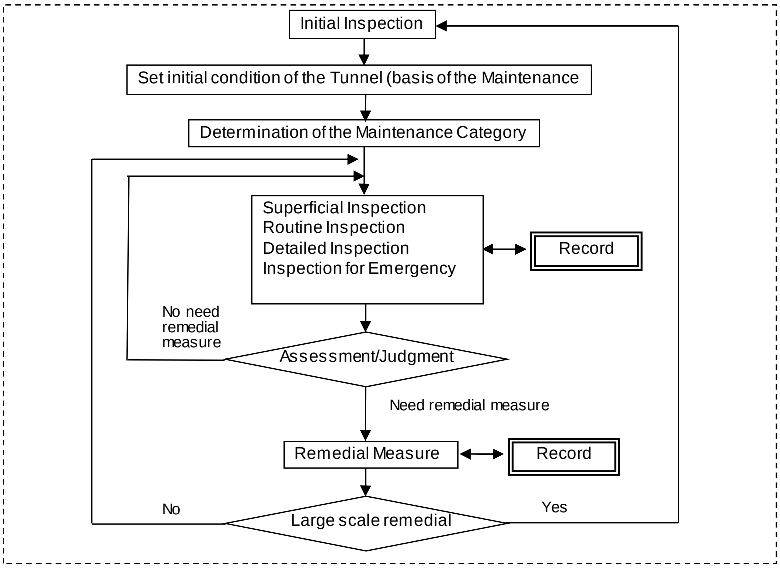


Figure 5.1-16 General maintenance Process

The items of inspection and its frequency is shown in Table 5.5-9.

Table 5.1-9 Inspection Item and Frequency

Inspection	Purpose	Frequency
Initial Inspection	To record the initial condition that will be the basis of the evaluation of the tunnel maintenance in future.	Just before open the Tunnel or after executed large scale repairing.
Daily Patrol	-To find obvious event (damage/deterioration/changes) -To monitor the temperature/humidity	Once a day
Yearly Inspection	-To understand/confirm the condition of event (damage/deterioration/changes).	Basically once a year.
Periodic Inspection	- To understand the progress/situation/ characteristic of event (damage/deterioration/changes)	Less than 6 years.
Emergency Inspection	This inspection should be carried out in the Emergency	After occur emergency
Detailed Inspection	- Close visual inspection with special access - Detail examination using some special testing - Structural analysis This may be necessary to employ specialist firms.	Any time when required

3) Cost for Operation and Maintenance of Tunnel

The cost for the operation and maintenance of tunnel is estimated in Table 5.5-10.

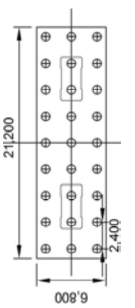
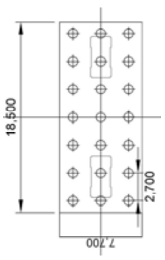
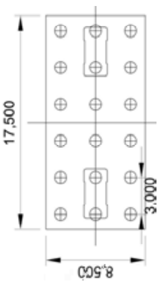
Table 5.1-10 Cost for Tunnel Operation and Maintenance

Item	Cost (million VND)	Equivalent JPY (1 JPY=202.84VND)
Operation include electricity cost	10,750	53,000,000
Cost for replacement of E&M facility or its parts	11,562	57,000,000 *1)
Maintenance of Tunnel include cleaning	8,114	40,000,000
Total	30,426	150,000,000

Note 1): Cost for replacement of E&M facility or its parts depending on the condition of the tunnel, such as traffic volume, temperature, humidity, operation of facility etc. and the total annual cost is different every year. Therefore the cost indicated in this table is the annual average of expenditure for the replacement of E&M facility or its parts.

5.2 Comparison Study Results of Foundation Type for Approach Bridges

Table 5.2 1 Comparison of the Foundation Type for Approach Bridge of High Pier Group

	Alternative-1					Alternative-2					Alternative-3				
Foundation Type	Steel Pipe Pile (φ=0.8m)					Steel Pipe Pile (φ=0.9m)					Steel Pipe Pile (φ=1.0m)				
Plan of Pile Cap	 Pile Length = 37.5 m Pile number = 27 nos.					 Pile Length = 37.5 m Pile number = 21 nos.					 Pile Length = 38 m Pile number = 18 nos.				
Pile Reaction	Pn(max) = 2,715 kN < Ra = 2,986 kN (0.909) (Load Combinations Type : Strengh II Limit State)					Pn(max) = 3,412 kN < Ra = 3,518 kN (0.970) (Load Combinations Type : Strengh II Limit State)					Pn(max) = 3,934 kN < Ra = 4,139 kN (0.951) (Load Combinations Type : Strengh II Limit State)				
Construction Cost (for Fandation)	Item		Quantity	Unit Cost (VND)	Total (1,000 VND)	Item		Quantity	Unit Cost (VND)	Total (1,000 VND)	Item		Quantity	Unit Cost (VND)	Total (1,000 VND)
	Pile Cap Concrete	m3	288	4,216,398	1,215,672	Pile Cap Concrete	m3	285	4,216,398	1,201,252	Pile Cap Concrete	m3	298	4,216,398	1,254,378
	Reinforcing steel	ton	29	0	0	Reinforcing steel	ton	28	0	0	Reinforcing steel	ton	30	0	0
	Pile	m	1,013	9,494,847	9,613,533	Pile	m	788	9,994,576	7,870,729	Pile	m	684	13,092,895	8,955,540
	Lean Concrete	m3	15	1,741,595	26,089	Lean Concrete	m3	15	1,741,595	25,729	Lean Concrete	m3	15	1,741,595	26,819
	Blinding stone	m3	30	737,139	22,085	Blinding stone	m3	30	737,139	21,780	Blinding stone	m3	31	737,139	22,702
	Excavation	m3	860	318,747	274,173	Excavation	m3	831	318,747	264,965	Excavation	m3	848	318,747	270,148
	Cofferdam	ton	110	24,798,638	2,737,770	Cofferdam	ton	105	24,798,638	2,603,857	Cofferdam	ton	104	24,798,638	2,588,978
				Total	13,889,322				Total	11,988,312				Total	13,118,565
				Ratio	**1.16**				Ratio	**1.00**				Ratio	**1.09**
Evaluation						Most Recommended									

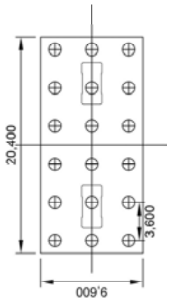
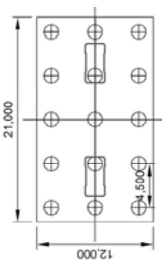
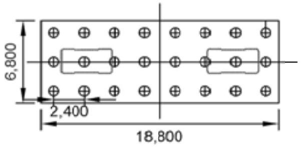
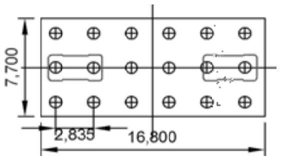
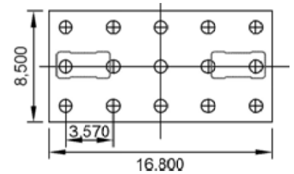
	Alternative-4					Alternative-5				
Foundation Type	Cast-in-Place Pile (φ=1.2m)					Cast-in-Place Pile (φ=1.5m)				
Plan of Pile Cap	 Pile Length = 38 m Pile number = 18 nos.					 Pile Length = 38 m Pile number = 15 nos.				
Pile Reaction	Pn(max) = 4,841 kN < Ra = 5,217 kN (0.928) (Load Combinations Type : Strengh II Limit State)					Pn(max) = 6,956 kN < Ra = 7,486 kN (0.929) (Load Combinations Type : Strengh II Limit State)				
Construction Cost (for Fandation)	Item		Quantity	Unit Cost (VND)	Total (1,000 VND)	Item		Quantity	Unit Cost (VND)	Total (1,000 VND)
	Pile Cap Concrete	m3	392	4,216,398	1,651,479	Pile Cap Concrete	m3	504	4,216,398	2,125,065
	Reinforcing steel	ton	39	0	0	Reinforcing steel	ton	50	0	0
	Pile	m	684	11,464,320	7,841,595	Pile	m	570	22,000,000	12,540,000
	Lean Concrete	m3	20	1,741,595	35,159	Lean Concrete	m3	26	1,741,595	45,045
	Blinding stone	m3	40	737,139	29,763	Blinding stone	m3	52	737,139	38,131
	Excavation	m3	1,042	318,747	332,007	Excavation	m3	1,250	318,747	398,332
	Cofferdam	ton	116	24,798,638	2,886,561	Cofferdam	ton	125	24,798,638	3,109,749
				Total	12,776,564				Total	18,256,322
				Ratio	**1.07**				Ratio	**1.52**
Evaluation										

Table 5.2-2 Comparison of the Foundation Type for Approach Bridge of Middle Pier Group

Foundation Type	Alternative-1 Steel Pipe Pile (φ=0.8m)	Alternative-2 Steel Pipe Pile (φ=0.9m)	Alternative-3 Steel Pipe Pile (φ=1.0m)
Plan of Pile Cap	 Pile Length = 37.5 m Pile number = 24 nos.	 Pile Length = 37.5 m Pile number = 18 nos.	 Pile Length = 37.5 m Pile number = 15 nos.
Pile Reaction	Pn(max) = 2,712 kN < Ra = 2,986 kN (0.908) (Load Combinations Type : Strength II Limit State)	Pn(max) = 3,512 kN < Ra = 3,552 kN (0.989) (Load Combinations Type : Strength II Limit State)	Pn(max) = 4,079 kN < Ra = 4,212 kN (0.969) (Load Combinations Type : Strength II Limit State)
Evaluation		Most Recommended	

Construction Cost (for Fandation) – Alternative-1

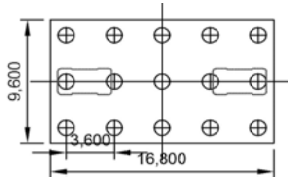
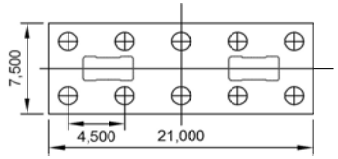
Item		Quantity	Unit Cost (VND)	Total (1,000 VND)
Pile Cap Concrete	m3	256	4,216,398	1,078,049
Reinforcing steel	ton	26	0	0
Pile	m	900	9,494,847	8,545,362
Lean Concrete	m3	13	1,741,595	23,163
Blinding stone	m3	27	737,139	19,608
Excavation	m3	780	318,747	248,470
Cofferdam	ton	103	24,798,638	2,559,219
			Total	12,473,871
			Ratio	**1.18**

Construction Cost (for Fandation) – Alternative-2

Item		Quantity	Unit Cost (VND)	Total (1,000 VND)
Pile Cap Concrete	m3	259	4,216,398	1,090,866
Reinforcing steel	ton	26	0	0
Pile	m	675	9,994,576	6,746,339
Lean Concrete	m3	13	1,741,595	23,390
Blinding stone	m3	27	737,139	19,800
Excavation	m3	770	318,747	245,295
Cofferdam	ton	100	24,798,638	2,477,384
			Total	10,603,074
			Ratio	**1.00**

Construction Cost (for Fandation) – Alternative-3

Item		Quantity	Unit Cost (VND)	Total (1,000 VND)
Pile Cap Concrete	m3	286	4,216,398	1,204,203
Reinforcing steel	ton	29	0	0
Pile	m	563	13,092,895	7,364,753
Lean Concrete	m3	15	1,741,595	25,758
Blinding stone	m3	30	737,139	21,805
Excavation	m3	820	318,747	261,513
Cofferdam	ton	102	24,798,638	2,536,901
			Total	11,414,933
			Ratio	**1.08**

Foundation Type	Alternative-4 Cast-in-Place Pile (φ=1.2m)	Alternative-5 Cast-in-Place Pile (φ=1.5m)
Plan of Pile Cap	 Pile Length = 38 m Pile number = 15 nos.	 Pile Length = 38 m Pile number = 10 nos.
Pile Reaction	Pn(max) = 5,103 kN < Ra = 5,217 kN (0.978) (Load Combinations Type : Strength II Limit State)	Pn(max) = 7,393 kN < Ra = 7,486 kN (0.998) (Load Combinations Type : Strength II Limit State)
Evaluation		

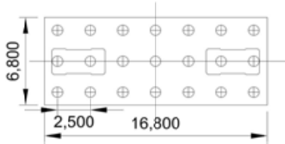
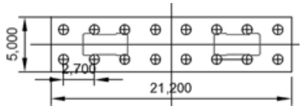
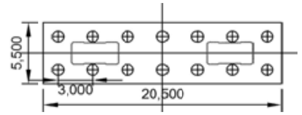
Construction Cost (for Fandation) – Alternative-4

Item		Quantity	Unit Cost (VND)	Total (1,000 VND)
Pile Cap Concrete	m3	323	4,216,398	1,360,041
Reinforcing steel	ton	32	0	0
Pile	m	570	11,464,320	6,534,662
Lean Concrete	m3	17	1,741,595	29,015
Blinding stone	m3	33	737,139	24,561
Excavation	m3	890	318,747	283,812
Cofferdam	ton	106	24,798,638	2,618,736
			Total	10,850,827
			Ratio	**1.02**

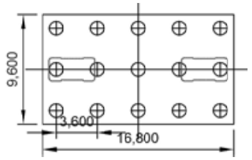
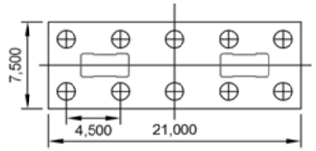
Construction Cost (for Fandation) – Alternative-5

Item		Quantity	Unit Cost (VND)	Total (1,000 VND)
Pile Cap Concrete	m3	315	4,216,398	1,328,165
Reinforcing steel	ton	32	0	0
Pile	m	380	22,000,000	8,360,000
Lean Concrete	m3	16	1,741,595	28,430
Blinding stone	m3	33	737,139	24,066
Excavation	m3	907	318,747	289,033
Cofferdam	ton	112	24,798,638	2,774,968
			Total	12,804,662
			Ratio	**1.21**

Table 5.2-3 Comparison of the Foundation type for Approach Bridge of the Low Pier Group

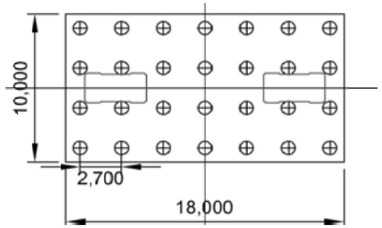
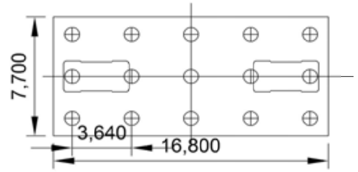
	Alternative-1	Alternative-2	Alternative-3
Foundation Type	Steel Pipe Pile (φ=0.8m)	Steel Pipe Pile (φ=0.9m)	Steel Pipe Pile (φ=1.0m)
Plan of Pile Cap	 Pile Length = 37.5 m Pile number = 21 nos.	 Pile Length = 37.5 m Pile number = 16 nos.	 Pile Length = 37.5 m Pile number = 14 nos.
Pile Reaction	Pn(max) = 2,699 kN < Ra = 2,986 kN (0.936) (Load Combinations Type : Strengh II Limit State)	Pn(max) = 3,225 kN < Ra = 3,518 kN (0.917) (Load Combinations Type : Strengh II Limit State)	Pn(max) = 3,720 kN < Ra = 4,139 kN (0.899) (Load Combinations Type : Strengh II Limit State)

Construction Cost (for Fandation)	Item		Quantity	Unit Cost (VND)	Total (1,000 VND)	Item		Quantity	Unit Cost (VND)	Total (1,000 VND)	Item		Quantity	Unit Cost (VND)	Total (1,000 VND)
	Pile Cap Concrete	m3	228	4,216,398	963,363	Pile Cap Concrete	m3	212	4,216,398	893,876	Pile Cap Concrete	m3	226	4,216,398	950,798
	Reinforcing steel	ton	23	0	0	Reinforcing steel	ton	21	0	0	Reinforcing steel	ton	23	0	0
	Pile	m	788	9,494,847	7,477,192	Pile	m	600	9,994,576	5,996,746	Pile	m	525	13,092,895	6,873,770
	Lean Concrete	m3	12	1,741,595	20,725	Lean Concrete	m3	11	1,741,595	19,380	Lean Concrete	m3	12	1,741,595	20,549
	Blinding stone	m3	24	737,139	17,544	Blinding stone	m3	22	737,139	16,406	Blinding stone	m3	24	737,139	17,395
	Excavation	m3	712	318,747	227,050	Excavation	m3	722	318,747	230,110	Excavation	m3	740	318,747	235,723
	Cofferdam	ton	97	24,798,638	2,410,428	Cofferdam	ton	105	24,798,638	2,603,857	Cofferdam	ton	104	24,798,638	2,588,978
				Total	11,116,302				Total	9,760,375				Total	10,687,213
				Ratio	**1.14**				Ratio	**1.00**				Ratio	**1.09**
Evaluation						Most Recommended									

	Alternative-4	Alternative-5
Foundation Type	Cast-in-Place Pile (φ=1.2m)	Cast-in-Place Pile (φ=1.5m)
Plan of Pile Cap	 Pile Length = 38 m Pile number = 15 nos.	 Pile Length = 38 m Pile number = 10 nos.
Pile Reaction	Pn(max) = 4,794 kN < Ra = 5,217 kN (0.906) (Load Combinations Type : Strengh II Limit State)	Pn(max) = 7,067 kN < Ra = 7,486 kN (0.954) (Load Combinations Type : Strengh II Limit State)

Construction Cost (for Fandation)	Item		Quantity	Unit Cost (VND)	Total (1,000 VND)	Item		Quantity	Unit Cost (VND)	Total (1,000 VND)
	Pile Cap Concrete	m3	323	4,216,398	1,360,041	Pile Cap Concrete	m3	315	4,216,398	1,328,165
	Reinforcing steel	ton	32	0	0	Reinforcing steel	ton	32	0	0
	Pile	m	570	11,464,320	6,534,662	Pile	m	380	22,000,000	8,360,000
	Lean Concrete	m3	17	1,741,595	29,015	Lean Concrete	m3	16	1,741,595	28,430
	Blinding stone	m3	33	737,139	24,561	Blinding stone	m3	33	737,139	24,066
	Excavation	m3	890	318,747	283,812	Excavation	m3	907	318,747	289,033
	Cofferdam	ton	106	24,798,638	2,618,736	Cofferdam	ton	112	24,798,638	2,774,968
				Total	10,850,827				Total	12,804,662
				Ratio	**1.11**				Ratio	**1.31**
Evaluation										

Table 5.2-4 Comparison of the Foundation Type for Approach Bridge of Steel Pipe Pile with Slip Layer

	Alternative-1					Alternative-2				
Foundation Type	Steel Pipe Pile (φ=0.9m)					SL Steel Pipe Pile (φ=0.9m)				
Plan of Pile Cap	 Pile Length = 37.5 m Pile number = 28 nos.					 Pile Length = 37.5 m Pile number = 15 nos.				
Pile Reaction	Pn(max) = 1,801 kN < Ra = 1,830 kN (0.984) (Load Combinations Type : Strengh II Limit State)					Pn(max) = 3,041 kN < Ra = 3,056 kN (0.995) (Load Combinations Type : Strengh II Limit State)				
Construction Cost (for Fandation)	Item		Quantity	Unit Cost (VND)	Total (1,000 VND)	Item		Quantity	Unit Cost (VND)	Total (1,000 VND)
	Pile Cap Concrete	m3	360	4,216,398	1,517,903	Pile Cap Concrete	m3	259	4,216,398	1,090,866
	Reinforcing steel	ton	36	0	0	Reinforcing steel	ton	26	0	0
	Pile	m	1,050	9,994,576	10,494,305	Pile	m	563	18,536,089	10,426,550
	Lean Concrete	m3	19	1,741,595	32,331	Lean Concrete	m3	13	1,741,595	23,390
	Blinding stone	m3	37	737,139	27,368	Blinding stone	m3	27	737,139	19,800
	Excavation	m3	968	318,747	308,445	Excavation	m3	770	318,747	245,295
	Cofferdam	ton	110	24,798,638	2,737,770	Cofferdam	ton	100	24,798,638	2,477,384
				Total	15,118,122				Total	14,283,285
				Ratio	**1.06**				Ratio	**1.00**
Evaluation						Most Recommended				