

Appendix 3.6

In-tunnel Air Quality Assessment

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Calculation of In-tunnel Air Quality at full enclosure (NO₂) - Year 2029
Internal Road near Fung Kong RDID 53, 54 (Peak Traffic Condition)

Tunnel Parameter

Length (L):	126 m
Height (H):	6.0 m
Width (W):	8.3 m
Equivalent Diameter (dt):	7.963 m
Cross-section area = H * W, (At):	49.80 m ²
Perimeter = (4*At/π) ^{0.5} , (P):	28.60 m
Equivalent length of tunnel = L + 2*3*dt, (Le):	173.777 m

Emission Data

Traffic flow (Q) - peak traffic flow: 373 veh/hr

Traffic Breakdown	PC	TAXI	LGV3	LGV4	LGV6	HGV7	HGV8	PLB	PV4	PV5	NFB6	NFB7	NFB8	FBSD	FBDD	MC	Total
No. of Vehicles (RDID 53)	76	48	0	9	5	2	9	3	0	0	0	0	0	0	4	7	163
No. of Vehicles (RDID 54)	87	55	0	20	11	5	17	3	0	0	0	0	0	0	4	8	210
Total No. of Vehicles	163	103	0	29	16	7	26	6	0	0	0	0	0	0	8	15	373
% vehicle	43.70%	27.61%	0.00%	7.77%	4.29%	1.88%	6.97%	1.61%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.14%	4.02%	100%

NO_x emission factor (g/km/veh):

50 km/hr (road design speed)	0.0104	0.2633	0.3462	0.3132	0.4316	0.547	0.9873	0.5028	0.0264	0.3096	0.2811	0.5231	0.7958	1.4052	1.5602	0.2755
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Weighted NO_x emission Factor: 0.252 g/km/veh

Total NO₂ emission factor (g/m/s) (w): 3.262E-06 g/m/s

Note: NO₂ conversion factor is 12.5% (including tailpipe NO₂ emission taken as 7.5% of Nox and 5% of NO₂/NO_x for tunnel air)

Vehicle Data

Nominal dimensions of vehicles	W (m)	H (m)	L (m)	% veh	%veh x L
PC	1.7	1.5	4.6	0.592	2.723
TAXI	1.7	1.5	4.6	0.206	0.946
LGV3	2.1	1.6	5.2	0.000	0.000
LGV4	2.1	1.6	5.2	0.028	0.146
LGV6	2.1	1.6	5.2	0.017	0.089
HGV7	2.5	4.6	16	0.012	0.199
HGV8	2.5	4.6	16	0.036	0.573
PLB	2	3	6.5	0.022	0.142
PV4	2	3	6.5	0.000	0.000
PV5	2	3	6.5	0.000	0.000
NFB6	2.5	3.5	12	0.003	0.037
NFB7	2.5	3.5	12	0.000	0.000
NFB8	2.5	3.5	12	0.000	0.000
FBSD	2.5	3.5	12	0.002	0.019
FBDD	2.5	4.6	12	0.026	0.318
MC	1.7	1.5	4.6	0.056	0.258

Note: No dimensions for motor cycles and non-franchised buses are provided. Fro the purpose of this study, the dimension of motor cycles and taxi are assumed to be the same as private car and the dimension of non-franchised buses are assumed to be the same as single deck franchised buses.

Nominal cross-section Area Ac:	3.687 m ²
Equivalent length of each vehicle	5.450 m

Calculation of In-tunnel Air Quality at full enclosure (NO₂) - Year 2029
Internal Road near Fung Kong RDID 53, 54 (Peak Traffic Condition)

No. of lane per direction, nl:	1	
Equivalent cross-sectional A for each direction, Av	3.687 m ²	
Equivalent diameter (m) dv	2.167 m	
Traffic density, N	0.104 veh/s	
Vehicle speed, v:	13.889 m/s	= 50.000 km/hr
Head to head distance on a lane, l = 2 * nl * v / N =	268.097 m	(rejected, as the tunnel length is 126m)
	126 m	

Diffusion Parameters

Reynolds number = (v/dv)/σ, Re	1929007	(where σ = 15.6*10 ⁽⁻⁶⁾)
	Since l/dt = 15.823	
	D/(N * dt ² * Re ^{0.13}) = 0.40	(according to Figure 16, Phhashi & Koso, 1985)
Diffusion coefficient, D:	17.246	

In-tunnel maximum NO₂ concentration (without background): **14.3** µg/m3

Background Concentration

One assessment point is chosen in the middle of the tunnel outlet. Cumulative air pollution concentration is calculated at different levels by Caline4 and ISCST3. ☒

	x	y	Height above Ground (m)	NO ₂ (µg/m ³)
	827823.3	840520.8	0	65.70
Outlet of Castle Peak Road (EB) depressway	827823.3	840520.8	3	63.63
	827823.3	840520.8	6	60.29
	827609.8	840565.0	0	69.53
Outlet of Castle Peak Road (WB) depressway	827609.8	840565.0	3	71.13
	827609.8	840565.0	6	72.00

The highest concentration is assumed to be the background concentration to assess inside tunnel air quality: **72.0** µg/m³

Total Maximum NO₂ Concentration inside the depressway at Castle Peak Road near Pak Shek Au - Year 2029

In-tunnel maximum NO ₂ concentration	=	14.3	+	72.0
	=	86.3	µg/m ³	(Comply with the criters stipulated in the "Practice Note on Control of Air Pollution in Vehicle Tunnels")

Calculation of In-tunnel Air Quality at full enclosure (NO₂) - Year 2029
Fanling Highway near Europa Garden Phase 1, RDID 7, 26 (Normal Condition)

Tunnel Parameter

Length (L):	126 m
Height (H):	6.0 m
Width (W):	42.3 m
Equivalent Diameter (dt):	17.976 m
Cross-section area = H * W, (At):	253.80 m ²
Perimeter = (4*At/π) ^{0.5} , (P):	96.60 m
Equivalent length of tunnel = L + 2*3*dt, (Le):	233.858 m

Emission Data

Traffic flow (Q) - peak traffic flow: 7530 veh/hr

Traffic Breakdown	PC	TAXI	LGV3	LGV4	LGV6	HGV7	HGV8	PLB	PV4	PV5	NFB6	NFB7	NFB8	FBSD	FBDD	MC	Total
No. of Vehicles (RDID 7)	2131	231	7	288	171	130	470	66	5	3	6	4	4	6	81	200	3803
No. of Vehicles (RDID 26)	2028	249	6	239	141	158	571	53	5	3	6	4	4	5	65	190	3727
Total No. of Vehicles	4159	480	13	527	312	288	1041	119	10	6	12	8	8	11	146	390	7530
% vehicle	55.23%	6.37%	0.17%	7.00%	4.14%	3.82%	13.82%	1.58%	0.13%	0.08%	0.16%	0.11%	0.11%	0.15%	1.94%	5.18%	100%

NO_x emission factor (g/km/veh):

100 km/hr (road design speed)	0.0104	0.2515	0.6125	0.5512	0.3648	-	-	-	0.0343	0.3527	-	-	-	-	-	-	0.2961
80 km/hr (cap. Speed for PLB)	-	-	-	-	-	-	-	0.5639	-	-	-	-	-	-	-	-	-
70 km/hr (cap. Speed for HGV7, HGV8, NFB6, NFB7, NFB8, FBSD, FBDD)	-	-	-	-	-	0.4663	0.8463	-	-	-	0.2344	0.4361	0.6634	1.171	1.3003	-	-

Weighted NO_x emission Factor: 0.264 g/km/veh

Total NO₂ emission factor (g/m/s) (w): 6.913E-05 g/m/s

Note: NO₂ conversion factor is 12.5% (including tailpipe NO₂ emission taken as 7.5% of Nox and 5% of NO₂/NO_x for tunnel air)

Vehicle Data

Nominal dimensions of vehicles	W (m)	H (m)	L (m)	% veh	%veh x L
PC	1.7	1.5	4.6	0.592	2.723
TAXI	1.7	1.5	4.6	0.206	0.946
LGV3	2.1	1.6	5.2	0.000	0.000
LGV4	2.1	1.6	5.2	0.028	0.146
LGV6	2.1	1.6	5.2	0.017	0.089
HGV7	2.5	4.6	16	0.012	0.199
HGV8	2.5	4.6	16	0.036	0.573
PLB	2	3	6.5	0.022	0.142
PV4	2	3	6.5	0.000	0.000
PV5	2	3	6.5	0.000	0.000
NFB6	2.5	3.5	12	0.003	0.037
NFB7	2.5	3.5	12	0.000	0.000
NFB8	2.5	3.5	12	0.000	0.000
FBSD	2.5	3.5	12	0.002	0.019
FBDD	2.5	4.6	12	0.026	0.318
MC	1.7	1.5	4.6	0.056	0.258

Note: No dimensions for motor cycles and non-franchised buses are provided. Fro the purpose of this study, the dimension of motor cycles and taxi are assumed to be the same as private car and the dimension of non-franchised buses are assumed to be the same as single deck franchised buses.

Nominal cross-section Area A _c :	4.489 m ²
Equivalent length of each vehicle	5.450 m

Calculation of In-tunnel Air Quality at full enclosure (NO₂) - Year 2029
Fanling Highway near Europa Garden Phase 1, RDID 7, 26 (Normal Condition)

No. of lane per direction, nl:	4	
Equivalent cross-sectional A for each direction, Av	17.955 m ²	
Equivalent diameter (m) dv	4.781 m	
Traffic density, N	2.092 veh/s	
Weighted averaged vehicle speed, v:	26.014 m/s	= 93.652 km/hr
Head to head distance on a lane, l = 2 * nl * v / N	99.498 m	

Diffusion Parameters

Reynolds number = (v/dv)/σ, Re	7973304	(where σ = 15.6*10 ^{^(-6)})
	Since l/dt = 5.535	
	D/(N * dt ^{^2} * Re ^{0.13}) = 0.36	(according to Figure 16, Phhashi & Koso, 1985)
Diffusion coefficient, D:	1920.475	

In-tunnel maximum NO₂ concentration (without background): **1.0** µg/m3

Background Concentration

One assessment point is chosen in the middle of the tunnel outlet. Cumulative air pollution concentration is calculated at different levels by Caline4 and ISCST3. 2

	x	y	Height above Ground (m)	NO ₂ (µg/m ³)
	827823.3	840520.8	0	107.22
Outlet of Castle Peak Road (EB) depressway	827823.3	840520.8	3	114.43
	827823.3	840520.8	6	116.07
	827609.8	840565.0	0	120.46
Outlet of Castle Peak Road (WB) depressway	827609.8	840565.0	3	128.18
	827609.8	840565.0	6	140.26

The highest concentration is assumed to be the background concentration to assess inside tunnel air quality: **140.3** µg/m³

Total Maximum NO₂ Concentration inside the depressway at Castle Peak Road near Pak Shek Au - Year 2029

In-tunnel maximum NO ₂ concentration	=	1.0	+	140.3
	=	141.2	µg/m ³	(Comply with the criters stipulated in the "Practice Note on Control of Air Pollution in Vehicle Tunnels")

Calculation of In-tunnel Air Quality at full enclosure (NO₂) - Year 2029
Internal Road near Tong Kok RDID 55, 56 (Normal Condition)

Tunnel Parameter

Length (L):	131 m
Height (H):	6.0 m
Width (W):	18.9 m
Equivalent Diameter (dt):	12.016 m
Cross-section area = H * W, (At):	113.40 m ²
Perimeter = (4*At/π) ^{0.5} , (P):	49.80 m
Equivalent length of tunnel = L + 2*3*dt, (Le):	203.096 m

Emission Data

Traffic flow (Q) - peak traffic flow: 1117 veh/hr

Traffic Breakdown	PC	TAXI	LGV3	LGV4	LGV6	HGV7	HGV8	PLB	PV4	PV5	NFB6	NFB7	NFB8	FBSD	FBDD	MC	Total
No. of Vehicles (RDID 55)	188	118	1	25	15	6	17	41	0	0	1	0	0	4	50	18	484
No. of Vehicles (RDID 56)	266	168	0	14	8	3	10	59	0	0	1	1	1	5	72	25	633
Total No. of Vehicles	454	286	1	39	23	9	27	100	0	0	2	1	1	9	122	43	1117
% vehicle	40.64%	25.60%	0.09%	3.49%	2.06%	0.81%	2.42%	8.95%	0.00%	0.00%	0.18%	0.09%	0.09%	0.81%	10.92%	3.85%	100%

NO_x emission factor (g/km/veh):

50 km/hr (road design speed)	0.0104	0.2633	0.3462	0.3132	0.4316	0.547	0.9873	0.5028	0.0264	0.3096	0.2811	0.5231	0.7958	1.4052	1.5602	0.2755
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Weighted NO_x emission Factor:

0.359 g/km/veh

Total NO₂ emission factor (g/m/s) (w):

1.393E-05 g/m/s

Note: NO₂ conversion factor is 12.5% (including tailpipe NO₂ emission taken as 7.5% of Nox and 5% of NO₂/NO_x for tunnel air)

Vehicle Data

Nominal dimensions of vehicles	W (m)	H (m)	L (m)	% veh	%veh x L
PC	1.7	1.5	4.6	0.592	2.723
TAXI	1.7	1.5	4.6	0.206	0.946
LGV3	2.1	1.6	5.2	0.000	0.000
LGV4	2.1	1.6	5.2	0.028	0.146
LGV6	2.1	1.6	5.2	0.017	0.089
HGV7	2.5	4.6	16	0.012	0.199
HGV8	2.5	4.6	16	0.036	0.573
PLB	2	3	6.5	0.022	0.142
PV4	2	3	6.5	0.000	0.000
PV5	2	3	6.5	0.000	0.000
NFB6	2.5	3.5	12	0.003	0.037
NFB7	2.5	3.5	12	0.000	0.000
NFB8	2.5	3.5	12	0.000	0.000
FBSD	2.5	3.5	12	0.002	0.019
FBDD	2.5	4.6	12	0.026	0.318
MC	1.7	1.5	4.6	0.056	0.258

Note: No dimensions for motor cycles and non-franchised buses are provided. Fro the purpose of this study, the dimension of motor cycles and taxi are assumed to be the same as private car and the dimension of non-franchised buses are assumed to be the same as single deck franchised buses.

Nominal cross-section Area Ac:

4.243 m²

Equivalent length of each vehicle

5.450 m

Calculation of In-tunnel Air Quality at full enclosure (NO₂) - Year 2029
Internal Road near Tong Kok RDID 55, 56 (Normal Condition)

No. of lane per direction, nl:	2	
Equivalent cross-sectional A for each direction, Av	8.485 m ²	
Equivalent diameter (m) dv	3.287 m	
Traffic density, N	0.310 veh/s	
Vehicle speed, v:	13.889 m/s	= 50.000 km/hr
Head to head distance on a lane, l = 2 * nl * v / N	179.051 m	(rejected, as the tunnel length is 131m)
	131.000 m	

Diffusion Parameters

Reynolds number = (v/dv)/σ, Re	2926395	(where σ = 15.6*10 ^{^(-6)})
	Since l/dt = 10.902	
	D/(N * dt ^{^2} * Re ^{0.13}) = 0.40	(according to Figure 16, Phhashi & Koso, 1985)
Diffusion coefficient, D:	124.153	
In-tunnel maximum NO ₂ concentration (without background):	5.1	µg/m3

Background Concentration

One assessment point is chosen in the middle of the tunnel outlet. Cumulative air pollution concentration is calculated at different levels by Caline4 and ISCST3. ☐

	x	y	Height above Ground (m)	NO ₂ (µg/m ³)
	827823.3	840520.8	0	72.83
Outlet of Castle Peak Road (EB) depressway	827823.3	840520.8	3	75.72
	827823.3	840520.8	6	81.28
	827609.8	840565.0	0	65.05
Outlet of Castle Peak Road (WB) depressway	827609.8	840565.0	3	64.52
	827609.8	840565.0	6	62.96

The highest concentration is assumed to be the background concentration to assess inside tunnel air quality: 81.3 µg/m³

Total Maximum NO₂ Concentration inside the depressway at Castle Peak Road near Pak Shek Au - Year 2029

In-tunnel maximum NO ₂ concentration	=	5.1	+	81.3
	=	86.4	µg/m ³	(Comply with the criters stipulated in the "Practice Note on Control of Air Pollution in Vehicle Tunnels")

Calculation of In-tunnel Air Quality at full enclosure (NO₂) - Year 2029
Internal Road near Ho Sheung Heung Road RDID 55, 56 (Normal Condition)

Tunnel Parameter

Length (L):	105 m
Height (H):	6.0 m
Width (W):	18.9 m
Equivalent Diameter (dt):	12.016 m
Cross-section area = H * W, (At):	113.40 m ²
Perimeter = (4*At/π) ^{0.5} , (P):	49.80 m
Equivalent length of tunnel = L + 2*3*dt, (Le):	177.096 m

Emission Data

Traffic flow (Q) - peak traffic flow: 1117 veh/hr

Traffic Breakdown	PC	TAXI	LGV3	LGV4	LGV6	HGV7	HGV8	PLB	PV4	PV5	NFB6	NFB7	NFB8	FBSD	FBDD	MC	Total
No. of Vehicles (RDID 55)	188	118	1	25	15	6	17	41	0	0	1	0	0	4	50	18	484
No. of Vehicles (RDID 56)	266	168	0	14	8	3	10	59	0	0	1	1	1	5	72	25	633
Total No. of Vehicles	454	286	1	39	23	9	27	100	0	0	2	1	1	9	122	43	1117
% vehicle	40.64%	25.60%	0.09%	3.49%	2.06%	0.81%	2.42%	8.95%	0.00%	0.00%	0.18%	0.09%	0.09%	0.81%	10.92%	3.85%	100%

NO_x emission factor (g/km/veh):

50 km/hr (road design speed)	0.0104	0.2633	0.3462	0.3132	0.4316	0.547	0.9873	0.5028	0.0264	0.3096	0.2811	0.5231	0.7958	1.4052	1.5602	0.2755
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Weighted NO_x emission Factor:

0.359 g/km/veh

Total NO₂ emission factor (g/m/s) (w):

1.393E-05 g/m/s

Note: NO₂ conversion factor is 12.5% (including tailpipe NO₂ emission taken as 7.5% of Nox and 5% of NO₂/NO_x for tunnel air)

Vehicle Data

Nominal dimensions of vehicles	W (m)	H (m)	L (m)	% veh	%veh x L
PC	1.7	1.5	4.6	0.592	2.723
TAXI	1.7	1.5	4.6	0.206	0.946
LGV3	2.1	1.6	5.2	0.000	0.000
LGV4	2.1	1.6	5.2	0.028	0.146
LGV6	2.1	1.6	5.2	0.017	0.089
HGV7	2.5	4.6	16	0.012	0.199
HGV8	2.5	4.6	16	0.036	0.573
PLB	2	3	6.5	0.022	0.142
PV4	2	3	6.5	0.000	0.000
PV5	2	3	6.5	0.000	0.000
NFB6	2.5	3.5	12	0.003	0.037
NFB7	2.5	3.5	12	0.000	0.000
NFB8	2.5	3.5	12	0.000	0.000
FBSD	2.5	3.5	12	0.002	0.019
FBDD	2.5	4.6	12	0.026	0.318
MC	1.7	1.5	4.6	0.056	0.258

Note: No dimensions for motor cycles and non-franchised buses are provided. Fro the purpose of this study, the dimension of motor cycles and taxi are assumed to be the same as private car and the dimension of non-franchised buses are assumed to be the same as single deck franchised buses.

Nominal cross-section Area Ac:

4.243 m²

Equivalent length of each vehicle

5.450 m

Calculation of In-tunnel Air Quality at full enclosure (NO₂) - Year 2029
Internal Road near Ho Sheung Heung Road RDID 55, 56 (Normal Condition)

No. of lane per direction, nl:	2	
Equivalent cross-sectional A for each direction, Av	8.485 m ²	
Equivalent diameter (m) dv	3.287 m	
Traffic density, N	0.310 veh/s	
Vehicle speed, v:	13.889 m/s	= 50.000 km/hr
Head to head distance on a lane, l = 2 * nl * v / N	179.051 m	(rejected, as the tunnel length is 105m)
	105.000 m	

Diffusion Parameters

Reynolds number = (v/dv)/σ, Re	22123543	(where σ = 15.6*10 ⁽⁻⁶⁾)
	Since l/dt = 8.738	
	D/(N * dt ² * Re ^{0.13}) = 0.400	(according to Figure 16, Phhashi & Koso, 1985)
Diffusion coefficient, D:	161.497	
In-tunnel maximum NO ₂ concentration (without background):	3.0	μg/m3

Background Concentration

One assessment point is chosen in the middle of the tunnel outlet. Cumulative air pollution concentration is calculated at different levels by Caline4 and ISCST3. ☐

	x	y	Height above Ground (m)	NO ₂ (μg/m ³)	
	827823.3	840520.8	0	95.86	95.86006
Outlet of Castle Peak Road (EB) depressway	827823.3	840520.8	3	89.26	89.2581
	827823.3	840520.8	6	75.09	75.09122
	827609.8	840565.0	0	78.80	78.79948
Outlet of Castle Peak Road (WB) depressway	827609.8	840565.0	3	82.01	82.0089
	827609.8	840565.0	6	88.04	88.03928

The highest concentration is assumed to be the background concentration to assess inside tunnel air quality: 95.9 μg/m³

Total Maximum NO₂ Concentration inside the depressway at Castle Peak Road near Pak Shek Au - Year 2029

In-tunnel maximum NO ₂ concentration	=	3.0	+	95.9	
	=	98.8	μg/m ³		(Comply with the criters stipulated in the "Practice Note on Control of Air Pollution in Vehicle Tunnels")

Calculation of In-tunnel Air Quality at Depressway of Castle Peak Road near Pak Shek Au (NO₂) - Year 2021
Castle Peak Road RDID 75, 76, 77, 78 (Normal Condition)

Tunnel Parameter

Length (L):	200 m
Height (H):	6.0 m
Width (W):	9.9 m
Equivalent Diameter (dt):	8.697 m
Cross-section area = H * W, (At):	59.40 m ²
Perimeter = (4*At/π) ^{0.5} , (P):	31.80 m
Equivalent length of tunnel = L + 2*3*dt, (Le):	252.179 m

Emission Data

Traffic flow (Q) - peak traffic flow: 701 veh/hr

Traffic Breakdown	PC	TAXI	LGV3	LGV4	LGV6	HGV7	HGV8	PLB	PV4	PV5	NFB6	NFB7	NFB8	FBSD	FBDD	MC	Total
No. of Vehicles (RDID 75, RDID77)	208	87	0	8	5	4	10	8	0	0	1	0	0	1	10	19	361
No. of Vehicles (RDID 76, RDID78)	198	83	0	8	5	4	10	6	0	0	1	0	0	0	7	18	340
Total No. of Vehicles	406	170	0	16	10	8	20	14	0	0	2	0	0	1	17	37	701
% vehicle	57.92%	24.25%	0.00%	2.28%	1.43%	1.14%	2.85%	2.00%	0.00%	0.00%	0.29%	0.00%	0.00%	0.14%	2.43%	5.28%	100%

NO_x emission factor (g/km/veh):

50 km/hr (road design speed)	0.014	0.334	0.779	0.607	1.158	1.476	2.742	0.844	0.059	0.609	0.900	1.796	2.852	3.127	3.551	0.298
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Weighted NO_x emission Factor: 0.340 g/km/veh

Total NO₂ emission factor (g/m/s) (w): 8.283E-06 g/m/s

Note: NO₂ conversion factor is 12.5% (including tailpipe NO₂ emission taken as 7.5% of No_x and 5% of NO₂/NO_x for tunnel air)

Vehicle Data

Nominal dimensions of vehicles	W (m)	H (m)	L (m)	% veh	%veh x L
PC	1.7	1.5	4.6	0.609	2.800
TAXI	1.7	1.5	4.6	0.210	0.968
LGV3	2.1	1.6	5.2	0.000	0.000
LGV4	2.1	1.6	5.2	0.022	0.117
LGV6	2.1	1.6	5.2	0.014	0.073
HGV7	2.5	4.6	16	0.011	0.180
HGV8	2.5	4.6	16	0.028	0.449
PLB	2	3	6.5	0.020	0.128
PV4	2	3	6.5	0.000	0.000
PV5	2	3	6.5	0.000	0.000
NFB6	2.5	3.5	12	0.003	0.034
NFB7	2.5	3.5	12	0.000	0.000
NFB8	2.5	3.5	12	0.000	0.000
FBSD	2.5	3.5	12	0.001	0.017
FBDD	2.5	4.6	12	0.024	0.286
MC	1.7	1.5	4.6	0.058	0.265

Note: No dimensions for motor cycles and non-franchised buses are provided. Fro the purpose of this study, the dimension of motor cycles and taxi are assumed to be the same as private car and the dimension of non-franchised buses are assumed to be the same as single deck franchised buses.

Nominal cross-section Area Ac:	3.250 m ²
Equivalent length of each vehicle	5.314 m

Calculation of In-tunnel Air Quality at Depressway of Castle Peak Road near Pak Shek Au (NO₂) - Year 2021
Castle Peak Road RDID 75, 76, 77, 78 (Normal Condition)

No. of lane per direction, nl:	1	
Equivalent cross-sectional A for each direction, Av	3.250 m ²	
Equivalent diameter (m) dv	2.034 m	
Traffic density, N	0.195 veh/s	
Vehicle speed, v:	13.889 m/s	= 50.000 km/hr
Head to head distance on a lane, l = 2 * nl * v / N	142.653 m	

Diffusion Parameters

Reynolds number = (v/dv)/σ, Re	437669	(where σ = 15.6*10 ^{^(-6)})
Since l/dt =	16.403	
D/(N * dt ^{^2} * Re ^{0.13}) =	0.400	(according to Figure 16, Phhashi & Koso, 1985)
Diffusion coefficient, D:	31.880	
In-tunnel maximum NO ₂ concentration (without background):	34.8	μg/m3

Background Concentration

One assessment point is chosen in the middle of the tunnel outlet. Cumulative air pollution concentration is calculated at different levels by Caline4 and ISCST3. ☒

	x	y	Height above Ground (m)	NO ₂ (μg/m ³)
	827823.3	840520.8	0	147.43
Outlet of Castle Peak Road (EB) depressway	827823.3	840520.8	3	139.66
	827823.3	840520.8	6	128.65
	827609.8	840565.0	0	121.77
Outlet of Castle Peak Road (WB) depressway	827609.8	840565.0	3	117.89
	827609.8	840565.0	6	113.17

The highest concentration is assumed to be the background concentration to assess inside tunnel air quality: 147.4 μg/m³

Total Maximum NO₂ Concentration inside the depressway at Castle Peak Road near Pak Shek Au - Year 2021

In-tunnel maximum NO ₂ concentration	=	34.8	+	147.4
	=	182.2	μg/m ³	(Comply with the criters stipulated in the "Practice Note on Control of Air Pollution in Vehicle Tunnels")

Calculation of In-tunnel Air Quality at Depressway of Castle Peak Road near Pak Shek Au (NO₂) - Year 2029
Castle Peak Road RDID 75, 76, 77, 78 (Normal Condition)

Tunnel Parameter

Length (L):	200 m
Height (H):	6.0 m
Width (W):	9.9 m
Equivalent Diameter (dt):	8.697 m
Cross-section area = H * W, (At):	59.40 m ²
Perimeter = (4*At/π) ^{0.5} , (P):	31.80 m
Equivalent length of tunnel = L + 2*3*dt, (Le):	252.179 m

Emission Data

Traffic flow (Q) - peak traffic flow: 659 veh/hr

Traffic Breakdown	PC	TAXI	LGV3	LGV4	LGV6	HGV7	HGV8	PLB	PV4	PV5	NFB6	NFB7	NFB8	FBSD	FBDD	MC	Total
No. of Vehicles (RDID 75, RDID77)	200	84	0	13	8	6	16	8	0	0	1	0	0	1	10	19	366
No. of Vehicles (RDID 76, RDID78)	166	70	0	8	5	4	10	6	0	0	1	0	0	0	7	16	293
Total No. of Vehicles	366	154	0	21	13	10	26	14	0	0	2	0	0	1	17	35	659
% vehicle	55.54%	23.37%	0.00%	3.19%	1.97%	1.52%	3.95%	2.12%	0.00%	0.00%	0.30%	0.00%	0.00%	0.15%	2.58%	5.31%	100%

NO_x emission factor (g/km/veh):

50 km/hr (road design speed)	0.0104	0.2633	0.3462	0.3132	0.4316	0.547	0.9873	0.5028	0.0264	0.3096	0.2811	0.5231	0.7958	1.4052	1.5602	0.2755
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Weighted NO_x emission Factor:

0.202 g/km/veh

Total NO₂ emission factor (g/m/s) (w):

4.613E-06 g/m/s

Note: NO₂ conversion factor is 12.5% (including tailpipe NO₂ emission taken as 7.5% of No_x and 5% of NO₂/NO_x for tunnel air)

Vehicle Data

Nominal dimensions of vehicles	W (m)	H (m)	L (m)	% veh	%veh x L
PC	1.7	1.5	4.6	0.592	2.723
TAXI	1.7	1.5	4.6	0.206	0.946
LGV3	2.1	1.6	5.2	0.000	0.000
LGV4	2.1	1.6	5.2	0.028	0.146
LGV6	2.1	1.6	5.2	0.017	0.089
HGV7	2.5	4.6	16	0.012	0.199
HGV8	2.5	4.6	16	0.036	0.573
PLB	2	3	6.5	0.022	0.142
PV4	2	3	6.5	0.000	0.000
PV5	2	3	6.5	0.000	0.000
NFB6	2.5	3.5	12	0.003	0.037
NFB7	2.5	3.5	12	0.000	0.000
NFB8	2.5	3.5	12	0.000	0.000
FBSD	2.5	3.5	12	0.002	0.019
FBDD	2.5	4.6	12	0.026	0.318
MC	1.7	1.5	4.6	0.056	0.258

Note: No dimensions for motor cycles and non-franchised buses are provided. Fro the purpose of this study, the dimension of motor cycles and taxi are assumed to be the same as private car and the dimension of non-franchised buses are assumed to be the same as single deck franchised buses.

Nominal cross-section Area Ac:

3.413 m²

Equivalent length of each vehicle

5.450 m

Calculation of In-tunnel Air Quality at Depressway of Castle Peak Road near Pak Shek Au (NO₂) - Year 2029
Castle Peak Road RDID 75, 76, 77, 78 (Normal Condition)

No. of lane per direction, nl:	1	
Equivalent cross-sectional A for each direction, Av	3.413 m ²	
Equivalent diameter (m) dv	2.085 m	
Traffic density, N	0.183 veh/s	
Vehicle speed, v:	13.889 m/s	= 50.000 km/hr
Head to head distance on a lane, l = 2 * nl * v / N	151.745 m	

Diffusion Parameters

Reynolds number = (v/dv)/σ, Re	427084	(where σ = 15.6*10 ^{^(-6)})
Since l/dt =	17.449	
D/(N * dt ^{^2} * Re ^{0.13}) =	0.400	(according to Figure 16, Phhashi & Koso, 1985)
Diffusion coefficient, D:	29.875	
In-tunnel maximum NO ₂ concentration (without background):	20.7	µg/m3

Background Concentration

One assessment point is chosen in the middle of the tunnel outlet. Cumulative air pollution concentration is calculated at different levels by Caline4 and ISCST3. ☒

	x	y	Height above Ground (m)	NO ₂ (µg/m ³)
	827823.3	840520.8	0	91.10
Outlet of Castle Peak Road (EB) depressway	827823.3	840520.8	3	86.85
	827823.3	840520.8	6	80.78
	827609.8	840565.0	0	79.58
Outlet of Castle Peak Road (WB) depressway	827609.8	840565.0	3	76.30
	827609.8	840565.0	6	74.07

The highest concentration is assumed to be the background concentration to assess inside tunnel air quality: 91.1 µg/m³

Total Maximum NO₂ Concentration inside the depressway at Castle Peak Road near Pak Shek Au - Year 2029

In-tunnel maximum NO ₂ concentration	=	20.7	+	91.1
	=	111.8	µg/m ³	(Comply with the criters stipulated in the "Practice Note on Control of Air Pollution in Vehicle Tunnels")

Calculation of In-tunnel Air Quality at Full-enclosure at Po Shek Wu Road (NO₂) - Year 2029
Po Shek Wu Road RDID 95 & 96 (Normal Condition)

Tunnel Parameter

Length (L):	125 m
Height (H):	6.0 m
Width (W):	24.3 m
Equivalent Diameter (dt):	13.625 m
Cross-section area = H * W, (At):	145.80 m ²
Perimeter = (4*At/π) ^{0.5} , (P):	60.60 m
Equivalent length of tunnel = L + 2*3*dt, (Le):	206.749 m

Emission Data

Traffic flow (Q) - peak traffic flow:		2799 veh/hr																
Traffic Breakdown		PC	TAXI	LGV3	LGV4	LGV6	HGV7	HGV8	PLB	PV4	PV5	NFB6	NFB7	NFB8	FBSD	FBDD	MC	Total
No. of Vehicles (RDID 95)		634	401	4	149	89	36	117	50	1	1	2	1	1	4	62	59	1611
No. of Vehicles (RDID 96)		407	258	4	138	82	33	108	50	1	0	1	1	1	4	62	38	1188
Total No. of Vehicles		1041	659	8	287	171	69	225	100	2	1	3	2	2	8	124	97	2799
% vehicle		37.19%	23.54%	0.29%	10.25%	6.11%	2.47%	8.04%	3.57%	0.07%	0.04%	0.11%	0.07%	0.07%	0.29%	4.43%	3.47%	100.00%
NO _x emission factor (g/km/veh):																		
50 km/hr (road design speed)		0.0104	0.2633	0.3462	0.3132	0.4316	0.547	0.9873	0.5028	0.0264	0.3096	0.2811	0.5231	0.7958	1.4052	1.5602	0.2755	
Weighted NO _x emission Factor:		0.320 g/km/veh																
Total NO ₂ emission factor (g/m/s) (w):		3.112E-05 g/m/s																
Note: NO ₂ conversion factor is 12.5% (including tailpipe NO ₂ emission taken as 7.5% of Nox and 5% of NO ₂ /NO _x for tunnel air)																		

Vehicle Data

Nominal dimensions of vehicles	W (m)	H (m)	L (m)	% veh	%veh x L
PC	1.7	1.5	4.6	0.592	2.723
TAXI	1.7	1.5	4.6	0.206	0.946
LGV3	2.1	1.6	5.2	0.000	0.000
LGV4	2.1	1.6	5.2	0.028	0.146
LGV6	2.1	1.6	5.2	0.017	0.089
HGV7	2.5	4.6	16	0.012	0.199
HGV8	2.5	4.6	16	0.036	0.573
PLB	2	3	6.5	0.022	0.142
PV4	2	3	6.5	0.000	0.000
PV5	2	3	6.5	0.000	0.000
NFB6	2.5	3.5	12	0.003	0.037
NFB7	2.5	3.5	12	0.000	0.000
NFB8	2.5	3.5	12	0.000	0.000
FBSD	2.5	3.5	12	0.002	0.019
FBDD	2.5	4.6	12	0.026	0.318
MC	1.7	1.5	4.6	0.056	0.258

Note: No dimensions for motor cycles and non-franchised buses are provided. Fro the purpose of this study, the dimension of motor cycles and taxi are assumed to be the same as private car and the dimension of non-franchised buses are assumed to be the same as single deck franchised buses.

Nominal cross-section Area Ac:	4.182 m ²
Equivalent length of each vehicle	5.450 m

Calculation of In-tunnel Air Quality at Full-enclosure at Po Shek Wu Road (NO₂) - Year 2029
Po Shek Wu Road RDID 95 & 96 (Normal Condition)

Avg. no. of lane at the northbound, nl:	2.5		
Equivalent cross-sectional A for each direction, Av	10.454 m ²		
Equivalent diameter (m) dv	3.648 m		
Traffic density, N	0.778 veh/s		
Vehicle speed, v:	13.889 m/s	=	50.000 km/hr
Head to head distance on a lane, l = 2 * nl * v / N	89.318 m		

Diffusion Parameters

Reynolds number = (v/dv)/σ, Re	244032	(where σ = 15.6*10 ⁽⁻⁶⁾)
Since l/dt=	6.555	
D/(N * dt ² * Re ^{0.13}) =	3.900	(according to Figure 16, Phhashi & Koso, 1985)
Diffusion coefficient, D:	2823.577	
In-tunnel maximum NO ₂ concentration (without background):	0.4	µg/m ³

Background Concentration

One assessment point is chosen in the middle of the tunnel outlet. Cumulative air pollution concentration is calculated at different levels by Caline4 and ISCST3. ☒

	x	y	Height above Ground (m)	NO ₂ (µg/m ³)
Outlet of Full-enclosure at Po Shek Wu Road (NB)	830778.4	840225.9	0	81.40
	830778.4	840225.9	3	81.36
	830778.4	840225.9	6	78.83
Outlet of Full-enclosure at Po Shek Wu Road (SB)	830814.5	840103.2	0	97.27
	830814.5	840103.2	3	88.28
	830814.5	840103.2	6	74.61

The highest concentration is assumed to be the background concentration to assess inside tunnel air quality: 97.3 µg/m³

Total Maximum NO₂ Concentration inside the Full-enclosure of Fanling Highway near Golf Parkview in Year 2029

In-tunnel maximum NO ₂ concentration	=	0.4	+	97.3
	=	97.7	µg/m ³	(Comply with the criters stipulated in the "Practice Note on Control of Air Pollution in Vehicle Tunnels")

Calculation of In-tunnel Air Quality at Full-enclosure at Fanling Highway near Golf Parkview (NO₂) - Year 2029
Fanling Highway RDID 11 & 22 (Normal Condition)

Tunnel Parameter

Length (L):	160 m
Height (H):	6.0 m
Width (W):	44.4 m
Equivalent Diameter (dt):	18.417 m
Cross-section area = H * W, (At):	266.40 m ²
Perimeter = (4*At/π) ^{0.5} , (P):	100.80 m
Equivalent length of tunnel = L + 2*3*dt, (Le):	270.503 m

Emission Data

Traffic flow (Q) - peak traffic flow: 8690 veh/hr

Traffic Breakdown	PC	TAXI	LGV3	LGV4	LGV6	HGV7	HGV8	PLB	PV4	PV5	NFB6	NFB7	NFB8	FBSD	FBDD	MC	Total
No. of Vehicles (RDID 11)	2630	285	8	295	176	134	483	66	6	5	7	5	5	6	81	246	4438
No. of Vehicles (RDID 22)	2406	296	7	251	149	166	602	53	5	5	7	5	5	5	65	225	4252
Total No. of Vehicles	5036	581	15	546	325	300	1085	119	11	10	14	10	10	11	146	471	8690
% vehicle	57.95%	6.69%	0.17%	6.28%	3.74%	3.45%	12.49%	1.37%	0.13%	0.12%	0.16%	0.12%	0.12%	0.13%	1.68%	5.42%	100%
NO _x emission factor (g/km/veh):																	
100 km/hr (road design speed)	0.010	0.252	1	0.551	0.365	-	-	-	0	0	-	-	-	-	-	-	0.296
80 km/hr (cap. Speed for PLB)	-	-	-	-	-	-	-	0.564	-	-	-	-	-	-	-	-	-
ap. Speed for HGV7, HGV8, NFB6, NFB7, NFB8, FBSD, FBDD)	-	-	-	-	-	0.466	0.846	-	-	-	0.234	0	1	1.171	1.300	-	-

Weighted NO_x emission Factor: 0.243 g/km/veh

Total NO₂ emission factor (g/m/s) (w): 7.336E-05 g/m/s

Note: NO₂ conversion factor is 12.5% (including tailpipe NO₂ emission taken as 7.5% of Nox and 5% of NO₂/NO_x for tunnel air)

Vehicle Data

Nominal dimensions of vehicles	W (m)	H (m)	L (m)	% veh	%veh x L
PC	1.7	1.5	4.6	0.592	2.723
TAXI	1.7	1.5	4.6	0.206	0.946
LGV3	2.1	1.6	5.2	0.000	0.000
LGV4	2.1	1.6	5.2	0.028	0.146
LGV6	2.1	1.6	5.2	0.017	0.089
HGV7	2.5	4.6	16	0.012	0.199
HGV8	2.5	4.6	16	0.036	0.573
PLB	2	3	6.5	0.022	0.144
PV4	2	3	6.5	0.000	0.000
PV5	2	3	6.5	0.000	0.000
NFB6	2.5	3.5	12	0.003	0.037
NFB7	2.5	3.5	12	0.000	0.000
NFB8	2.5	3.5	12	0.000	0.000
FBSD	2.5	3.5	12	0.002	0.019
FBDD	2.5	4.6	12	0.026	0.318
MC	1.7	1.5	4.6	0.056	0.258

Note: No dimensions for motor cycles and non-franchised buses are provided. Fro the purpose of this study, the dimension of motor cycles and taxi are assumed to be the same as private car and the dimension of non-franchised buses are assumed to be the same as single deck franchised buses.

Nominal cross-section Area Ac:	4.297 m ²
Equivalent length of each vehicle	5.452 m

Calculation of In-tunnel Air Quality at Full-enclosure at Fanling Highway near Golf Parkview (NO₂) - Year 2029
Fanling Highway RDID 11 & 22 (Normal Condition)

No. of lane per direction, nl:	5	
Equivalent cross-sectional A for each direction, Av	21.485 m ²	
Equivalent diameter (m) dv	5.230 m	
Traffic density, N	2.414 veh/s	
Weighted averaged vehicle speed, v:	26.190 m/s	= 94.285 km/hr
Head to head distance on a lane, l = 2 * nl * v / N	108.499 m	

Diffusion Parameters

Reynolds number = (v/dv)/σ, Re	695505	(where σ = 15.6*10 ^{^(-6)})
Since l/dt =	5.891	
D/(N * dt ^{^2} * Re ^{0.13}) =	0.380	(according to Figure 16, Phhashi & Koso, 1985)
Diffusion coefficient, D:	1788.312	
In-tunnel maximum NO ₂ concentration (without background):	1.4	µg/m3

Background Concentration

One assessment point is chosen in the middle of the tunnel outlet. Cumulative air pollution concentration is calculated at different levels by Caline4 and ISCST3. ☒

	x	y	Height above Ground (m)	NO ₂ (µg/m ³)
Outlet of Full-enclosure at Fanling Highway (EB) near Golf Parkview	830217.0	840317.3	0	109.92
	830217.0	840317.3	3	122.15
	830217.0	840317.3	6	120.77
Outlet of Full-enclosure at Fanling Highway (WB) near Golf Parkview	830058.6	840280.3	0	99.35
	830058.6	840280.3	3	109.17
	830058.6	840280.3	6	111.79

The highest concentration is assumed to be the background concentration to assess inside tunnel air quality: 122.2 µg/m³

Total Maximum NO₂ Concentration inside the Full-enclosure of Fanling Highway near Golf Parkview in Year 2029

In-tunnel maximum NO ₂ concentration	=	1.4	+	122.2
	=	123.6	µg/m ³	(Comply with the criters stipulated in the "Practice Note on Control of Air Pollution in Vehicle Tunnels")

Calculation of In-tunnel Air Quality at Depressway of Fanling Bypass at Lung Yeuk Tau Interchange (NO₂) - Year 2029
Fanling Bypass (SB) - RDID 488 (Normal Traffic Condition)

Tunnel Parameter

Length (L):	200 m
Height (H):	5.1 m
Width (W):	11.3 m
Cross-section area = H * W, (A _t):	57.630 m ²
Perimeter = (4*At/π) ^{0.5} , (P):	32.800 m

Emission Data

Traffic flow (Q) - peak traffic flow: 275 veh/hr

Traffic Breakdown	PC	TAXI	LGV3	LGV4	LGV6	HGV7	HGV8	PLB	PV4	PV5	NFB6	NFB7	NFB8	FBSD	FBDD	MC	Total
No. of Vehicles	120	76	1	26	15	6	20	0	0	0	0	0	0	0	0	11	275
% vehicle	43.64%	27.64%	0.36%	9.45%	5.45%	2.18%	7.27%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	4.00%	100.00%
NO _x emission factor (g/km/veh):																	
80 km/hr (road design speed)	0.0095	0.2379	0.414	0.373	0.3541	-	-	0.5639	0.0271	0.3281	-	-	-	-	-	0.25	
70 km/hr (cap. Speed for HGV7, HGV8, NFB6, NFB7, NFB8, FBSD, FBDD)	-	-	-	-	-	0.4663	0.8463	-	-	-	0.2344	0.4361	0.6634	1.171	1.3003	-	

Weighted NO_x emission Factor: 0.208 g/km/veh

Total NO₂ emission factor (g/s): 3.97E-04 g/s

Note: NO₂ conversion factor is 12.5% (including tailpipe NO₂ emission taken as 7.5% of Nox and 5% of NO₂/NOx for tunnel air), from EIA 141/2007 Wanchan Bypass

Vehicle Data

Nominal dimensions of vehicles	W (m)	H (m)	L (m)	% veh	%veh x L
PC	1.7	1.5	4.6	0.474	2.182
TAXI	1.7	1.5	4.6	0.246	1.132
LGV3	2.1	1.6	5.2	0.003	0.013
LGV4	2.1	1.6	5.2	0.085	0.440
LGV6	2.1	1.6	5.2	0.051	0.267
HGV7	2.5	4.6	16	0.021	0.328
HGV8	2.5	4.6	16	0.067	1.067
PLB	2	3	6.5	0.003	0.017
PV4	2	3	6.5	0.000	0.000
PV5	2	3	6.5	0.000	0.000
NFB6	2.5	3.5	12	0.003	0.031
NFB7	2.5	3.5	12	0.000	0.000
NFB8	2.5	3.5	12	0.000	0.000
FBSD	2.5	3.5	12	0.000	0.000
FBDD	2.5	4.6	12	0.005	0.062
MC	1.7	1.5	4.6	0.044	0.201

Note: Above information from EIA 141/2007, which is suppose to be from Transport Planning and Design Manual, Vol.2

Nominal cross-section Area A _c :	3.520 m ²
Equivalent length of each vehicle:	5.739 m

Tunnel Airflow

For Uni-directional traffic:

$$F_c = \frac{1}{2} \rho (V_c - V_T)^2 C_d A_c N$$

Push force by vehicles:

$$F_t = \frac{1}{2} \rho V_t^2 (K_{int} + K_{out} + \frac{fL}{D}) A_t$$

External wind at the entrance and exit portals:

$$F_w = \frac{1}{2} \rho (V_w \cos \theta)^2 C_w A_t$$

Air density (ρ):	1.2 kg/m ³
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Calculation of In-tunnel Air Quality at Depressway of Fanling Bypass at Lung Yeuk Tau Interchange (NO₂) - Year 2029
Fanling Bypass (SB) - RDID 488 (Normal Traffic Condition)

Vehicle speed (V _c) - road design speed:	22.2 m/s	=	80 km/hr
Velocity of air flow in tunnel (V _t):			
Vehicle drag coefficient (C _d):	0.645		
Vehicle frontal area (A _c):	3.520 m ²		
Number of vehicles in tunnel (N) = QL/V _c :	0.688		
Inlet loss coefficient (K _{in}):	0.5		
Outlet loss coefficient (K _{out}):	1.0		
Tunnel friction factor (f):	0.0155		
Length of tunnel (L):	200 m		
Hydraulic diameter of tunnel = 4 A _t /P, (D):	7.028 m		
Cross-section area of tunnel (A _t):	57.630 m ²		
External wind coefficient (C _w):	0.3		
Velocity of wind at source (V _w):	1.974 m/s		
Angle of the wind velocity component parallel to the roadway (θ)			
Notes: only external wind at the exit parallel is considered; annual-averaged measured wind speed at Ta Kwu Ling Station in 2011			

Inside Tunnel Concentration (Normal Traffic Condition)

Force balance:	F _c - F _t - F _w = 0
By solving the above equation,	aV _t ² + bV _t + c = 0

Since aV _t ² + bV _t + c = 0,	
a = C _d A _c N - (K _{in} + K _{out} + fL/D) A _t	-110.304
b = -2 C _d A _c N V _c	-69.371
c = C _d A _c N V _c ² - C _w V _w ² A _t	703.448

Tunnel air flow velocity:		
V _t (1)	2.230 m/s	
V _t (2)	-2.859 m/s	(rejected)

Inside tunnel concentration = emission rate / (tunnel air flow x underpass cross-section area):	
In-tunnel maximum NO ₂ concentration (without background):	3.1 µg/m ³

Background Concentration

One assessment point is chosen in the middle of the tunnel outlet. Cumulative air pollution concentration is calculated at different levels by Caline4 and ISCST3. ☐

	x	y	Height above Ground (m)	NO ₂ (µg/m ³)
Outlet of Fanling Bypass (SB) depressway	833298.2	840204.5	0	68.04
	833298.2	840204.5	2.55	66.91
	833298.2	840204.5	5.1	64.77

The highest concentration is assumed to be the background concentration to assess inside tunnel air quality:	68.0 µg/m ³
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Total Maximum NO₂ Concentration inside the depressway at Fanling Bypass (SB) at Lung Yeuk Tau Interchange - Year 2029

In-tunnel maximum NO ₂ concentration	=	3.1	+	68.0
	=	71.1	µg/m ³	(Comply with the criters stipulated in the "Practice Note on Control of Air Pollution in Vehicle Tunnels")

Calculation of In-tunnel Air Quality at Depressway of Fanling Bypass at Lung Yeuk Tau Interchange (NO₂) - Year 2029
Fanling Bypass (NB) - RDID 487 (Peak Traffic Condition)

Tunnel Parameter

Length (L):	200 m
Height (H):	5.1 m
Width (W):	11.3 m
Cross-section area = H * W, (A _c):	57.630 m ²
Perimeter = (4*At/π) ^{0.5} , (P):	32.800 m

Emission Data

Traffic flow (Q) - peak traffic flow: 606 veh/hr

Traffic Breakdown	PC	TAXI	LGV3	LGV4	LGV6	HGV7	HGV8	PLB	PV4	PV5	NFB6	NFB7	NFB8	FBSD	FBDD	MC	Total
No. of Vehicles	239	152	2	72	43	17	56	0	0	0	1	1	1	0	0	22	606
% vehicle	39.44%	25.08%	0.33%	11.88%	7.10%	2.81%	9.24%	0.00%	0.00%	0.00%	0.17%	0.17%	0.17%	0.00%	0.00%	3.63%	100.00%
NO _x emission factor (g/km/veh):																	
80 km/hr (road design speed)	0.0095	0.2379	0.414	0.373	0.3541	-	-	0.5639	0.0271	0.3281	-	-	-	-	-	0.25	
70 km/hr (cap. Speed for HGV7, HGV8, NFB6, NFB7, NFB8, FBSD, FBDD)	-	-	-	-	-	0.4663	0.8463	-	-	-	0.2344	0.4361	0.6634	1.171	1.3003	-	

Weighted NO_x emission Factor: 0.237 g/km/veh

Total NO₂ emission factor (g/s): 9.96E-04 g/s

Note: NO₂ conversion factor is 12.5% (including tailpipe NO₂ emission taken as 7.5% of Nox and 5% of NO₂/NOx for tunnel air), from EIA 141/2007 Wanchan Bypass

Vehicle Data

Nominal dimensions of vehicles	W (m)	H (m)	L (m)	% veh	%veh x L
PC	1.7	1.5	4.6	0.474	2.182
TAXI	1.7	1.5	4.6	0.246	1.132
LGV3	2.1	1.6	5.2	0.003	0.013
LGV4	2.1	1.6	5.2	0.085	0.440
LGV6	2.1	1.6	5.2	0.051	0.267
HGV7	2.5	4.6	16	0.021	0.328
HGV8	2.5	4.6	16	0.067	1.067
PLB	2	3	6.5	0.003	0.017
PV4	2	3	6.5	0.000	0.000
PV5	2	3	6.5	0.000	0.000
NFB6	2.5	3.5	12	0.003	0.031
NFB7	2.5	3.5	12	0.000	0.000
NFB8	2.5	3.5	12	0.000	0.000
FBSD	2.5	3.5	12	0.000	0.000
FBDD	2.5	4.6	12	0.005	0.062
MC	1.7	1.5	4.6	0.044	0.201

Note: Above information from EIA 141/2007, which is suppose to be from Transport Planning and Design Manual, Vol.2

Nominal cross-section Area A _c :	3.815 m ²
Equivalent length of each vehicle:	5.739 m

Tunnel Airflow

For Uni-directional traffic:

$$F_c = \frac{1}{2} \rho (V_c - V_T)^2 C_d A_c N$$

Push force by vehicles:

$$F_t = \frac{1}{2} \rho V_t^2 (K_{int} + K_{out} + \frac{fL}{D}) A_t$$

External wind at the entrance and exit portals:

$$F_w = \frac{1}{2} \rho (V_w \cos \theta)^2 C_w A_t$$

Calculation of In-tunnel Air Quality at Depressway of Fanling Bypass at Lung Yeuk Tau Interchange (NO₂) - Year 2029
Fanling Bypass (NB) - RDID 487 (Peak Traffic Condition)

Air density (ρ):	1.2 kg/m ³		
Vehicle speed (V _c) - road design speed:	22.2 m/s	=	80 km/hr
Velocity of air flow in tunnel (V _t):			
Vehicle drag coefficient (C _d):	0.645		
Vehicle frontal area (A _c):	3.815 m ²		
Number of vehicles in tunnel (N) = QL/V _c :	1.515		
Inlet loss coefficient (K _{in}):	0.5		
Outlet loss coefficient (K _{out}):	1.0		
Tunnel friction factor (f):	0.0155		
Length of tunnel (L):	200 m		
Hydraulic diameter of tunnel = 4 A _d /P, (D):	7.028 m		
Cross-section area of tunnel (A _t):	57.630 m ²		
External wind coefficient (C _w):	0.3		
Velocity of wind at source (V _w):	1.974 m/s		

Angle of the wind velocity component parallel to the roadway (θ)

Notes: only external wind at the exit parallel is considered; annual-averaged measured wind speed at Ta Kwu Ling Station in 2011

Inside Tunnel Concentration (Normal Traffic Condition)

Force balance:	F _c - F _t - F _w = 0
By solving the above equation,	aV _t ² + bV _t + c = 0

Since aV_t² + bV_t + c = 0,

a = C _d A _c N - (K _{in} + K _{out} + fL/D) A _t	-108.137
b = -2 C _d A _c N V _c	-165.695
c = C _d A _c N V _c ² - C _w V _w ² A _t	1773.710

Tunnel air flow velocity:

V _t (1)	3.356 m/s	
V _t (2)	-4.888 m/s	(rejected)

Inside tunnel concentration = emission rate / (tunnel air flow x underpass cross-section area):

In-tunnel maximum NO ₂ concentration (without background):	5.2 µg/m ³
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Background Concentration

One assessment point is chosen in the middle of the tunnel outlet. Cumulative air pollution concentration is calculated at different levels by Caline4 and ISCST3. ☒

	x	y	Height above Ground (m)	NO ₂ (µg/m ³)
Outlet of Fanling Bypass (SB) depressway	833298.2	840204.5	0	68.04
	833298.2	840204.5	2.55	66.91
	833298.2	840204.5	5.1	64.77

The highest concentration is assumed to be the background concentration to assess inside tunnel air quality:

68.0 µg/m³

Total Maximum NO₂ Concentration inside the depressway at Fanling Bypass (NB) at Lung Yeuk Tau Interchange - Year 2029

In-tunnel maximum NO ₂ concentration	=	5.2	+	68.0
	=	73.2	µg/m ³	(Comply with the criters stipulated in the "Practice Note on Control of Air Pollution in Vehicle Tunnels")