PORT WORKS DESIGN MANUAL

CORRIGENDUM No. 1/2018

This corrigendum contains amendments to the Port Works Design Manual, 2002 Edition, and shall be read in conjunction with Corrigenda 1/2006 and 1/2014.

(A) <u>Effect on Climate Change</u>

PART 1 – General Design Considerations for Marine Works

(a) CONTENTS

Add the following sections:
Section 2.2.5 Rise in Sea Levels due to Climate Change

Section 2.4.4 Change in Wind Speeds due to Climate Change

(b) Section 2.1 – General

Amend the 1st sentence of the 2nd paragraph to read as follows:
The five-day normals of the meteorological elements for Hong Kong from 1981 to 2010 are given in Table 1.

Delete the last sentence of the 2nd paragraph

(c) Section 2.2.4 – Extreme Water Levels

Amend the 1st paragraph to read as follows:
Updated extreme sea level frequency analysis have been carried out for Ko Lau Wan, Quarry Bay/North Point, Tai O, Tai Po Kau, Tsim Bei Tsui and Waglan Island. Extreme sea levels for return periods of 2, 5, 10, 20, 50, 100 and 200 years for these six locations are given in Tables 3 to 9A. The period of records used in each case is given in these tables. At each location, the assessment was carried out on the basis of historic tidal measurement data. Generalised Extreme Values (GEV) distribution is generally used to estimate the return values of extreme sea level and method of linear moments is used to estimate the distribution parameters. If the fitted GEV distribution is found upper bounded, Gumbel distribution is used instead. The extreme sea levels given in these tables are statistical results of the tides happening in the past. They do not necessarily represent the highest possible sea water levels that may happen at respective locations. The designers shall be responsible for making due allowance in their design for additional sea level rise having regard to the following factors:

(1) Sensitivity to sea level changes;
(2) Local topography;
(3) Possibility of being hit by tropical cyclones, in particular super typhoon class, and the effect of concurrent occurrence of astronomical high tides; and
(4) Climate change effect.

Amend the 3rd paragraph to read as follows:
Probable minimum sea levels at Quarry Bay/North Point are shown in Table 11. The values have been estimated by using GEV distribution and method of linear moments is used to estimate the distribution parameters.

(d) Section 2.2 – Tide and Water Levels

Add the following section:

2.2.5 Rise in Mean Sea Levels due to Climate Change

Recent climate research predicts that global mean sea level will continue to rise at current or accelerated rates. Mean sea level in Hong Kong is expected to rise as given in Table 42.

To obtain estimates of future extreme water levels for use in design, the sea level rise projections should be added to the extreme water levels given in Tables 3 to 9A.

The implications of rising sea levels should be considered for design of all marine works in Hong Kong. Water levels at the end of the design life should be considered.

(e) Section 2.4.2 – Extreme Wind Speeds

Amend the 3rd sentence of the 1st paragraph to read as follows:

The assessment was carried out by using GEV or Gumbel distribution, whichever gives greater values, to the annual maximum mean wind speeds for each duration and direction.

(f) Section 2.4 – Wind

Add the following section:

2.4.4 Change in Wind Speeds due to Climate Change

Storm frequency and intensity are expected to change as a result of climate change. Extreme wind speeds are expected to increase as given in Table 43.

To obtain estimates of future extreme wind speeds for use in design, the increased wind speed projections from an assumed baseline year of 2010 should be added to the extreme wind speeds given in Tables 12 to 30.

The implications of increasing wind speeds on wave generation (height and period) should be considered for design of all marine works in Hong Kong. Changing wave parameters throughout the design life of a structure should be considered to ensure the worst loading cases are identified.

(g) Section 2.5.5 – Wave Data and Data Sources

Amend the 1st sentence of the 4th paragraph to read as follows:

A summary of the wave measurement between 1994 and 2016 is given in Tables 32 and 33, and wave roses on annual basis are shown in Figure 7.

(h) Section 5.2.1 – Normal Loading Conditions

Add a bullet point after the last bullet point of the 1st paragraph:

- Variation in loads throughout design life as a result of climate change.

Add the following paragraph after the last paragraph:

Variations in hydrostatic loads and normal wind and waves environmental loads may be expected over the design life of the structure and structural performance as well as overtopping should be checked at the beginning and end of the design life of the structures.

(i) Section 5.2.2 – Extreme Loading Conditions

Add a bullet point after the last bullet point of the 1st paragraph:

- Variation in loads throughout design life as a result of climate change.

(j)	Section 5.2.3 – Temporary Loading Conditions	**Add the following sentence after the last sentence of the 1st paragraph:** The effects of climate change on Temporary Loading Conditions need not to be considered in design if this is not appropriate.
(k)	Section 5.2.4 – Accidental Loading Conditions	**Add the following sentence after the last sentence of the last paragraph:** Variation in water level at the beginning and end of design life of the structure as a result of climate change should be assessed when considering Accidental Loading Conditions.
(l)	Section 5.6 – Tides and Water Level Variations	**Add the following sentence after the last sentence of the 2nd paragraph:** Variations in tides, mean and extreme ranges of water levels may be expected over the design life of the structure and performance in relation to the four bullet points listed above should be checked at the beginning and end of the design life of the structures.
(m)	Section 5.7 – Hydrostatic Loads	**Amend the last sentence of the 1st paragraph to read as follows:** The determination of hydrostatic loads should take into account water level variations and ground water profiles mentioned in Section 2.2.5, Section 5.6 and Section 5.8 respectively. **Add the following sentence after the last sentence of the 1st paragraph:** Buoyancy forces due to variation in water level at the beginning and end of design life of the structure as a result of climate change should be considered.
(n)	Section 5.8 – Soil Pressure and Ground Water Profiles	**Add the following sentence after the last sentence of the 1st paragraph:** Variations in scour in front of the structure should be assessed due to changes in water levels and wave conditions expected due to climate change over the design life of the structure. **Add the following sentence after the last sentence of the 3rd paragraph:** Variations in tides, mean and extreme ranges of water levels may be expected over the design life of the structure and these should be included in the design for the beginning and end of the design life of the structures.
(o)	Section 5.10.2 – Wave Conditions	**Amend the 3rd sentence of the 3rd paragraph to read as follows:** For the assessment of wave heights under present day normal and accident loading conditions, a mean hourly wind speed of 17 m/s, or the equivalent wind speed adjusted for duration, may generally be used. To obtain future wind speeds including the effects of climate change, this figure may be increased by the values provided in Table 43 from an assumed baseline year of 2010. **Amend the last sentence of the last paragraph to read as follows:** The full range of water levels including the effects of climate change and in addition to the water levels mentioned in the above paragraphs should be investigated by the designer.
(p)	Section 5.14 – Temperature Variation	**Amend the 3rd sentence of the 2nd paragraph to read as follows:** Where no specific information is available concerning the temperatures of the structure at the time of construction, and the extremes expected during the design life of the structure, for design purposes an effective maximum temperature drop of 25°C and an effective maximum temperature rise of 20°C can be assumed for

relatively simple concrete deck structures under extreme environmental conditions.

(q) TABLES **Tables 1 – 30, 32 – 33 are updated as follows:**

Table 1 Five-day Normals of the Meteorological Elements for Hong Kong 1981 – 2010

		M.S.L. Pressure	Air Temperature			Wet-Bulb Temperature	Dew Point	Relative Humidity	Rainfall (Mean Daily)	Amount of Cloud	Sunshine (Mean Daily)	Wind	
			Mean Daily Maximum	Mean	Mean Daily Minimum							Prevailing Direction	Mean Speed
		(hPa)	(°C)	(°C)	(°C)	(°C)	(°C)	(%)	(mm)	(%)	(hr)	(deg.)	(m/s)
Jan	1 - 5	1020.3	19.3	17.1	15.3	14.3	11.8	72	0.8	51	5.4	70	24.8
	6 - 10	1020.5	19.0	16.8	14.9	14.0	11.4	72	0.5	54	5.5	70	24.1
	11 - 15	1020.1	18.7	16.4	14.4	13.7	11.1	72	0.8	60	4.7	70	25.6
	16 - 20	1019.9	18.6	16.4	14.5	14.0	11.8	75	0.7	63	4.6	60	25.2
	21 - 25	1019.8	18.1	15.8	14.0	13.5	11.4	75	1.1	72	3.5	60	26.3
	26 - 30	1020.8	17.7	15.5	13.7	13.0	10.6	74	1.0	66	3.9	10	24.5
	31 - 4	1020.2	18.3	16.0	14.2	13.7	11.5	76	0.8	67	4.0	70	25.2
Feb	5 - 9	1019.2	18.5	16.3	14.5	14.1	12.2	78	2.6	68	4.1	70	24.5
	10 - 14	1018.2	19.3	17.1	15.4	14.9	13.2	79	1.9	68	4.0	70	23.0
	15 - 19	1017.3	19.3	17.2	15.5	15.4	14.0	82	2.4	79	2.6	60	24.1
	20 - 24	1018.1	19.2	17.0	15.3	15.1	13.6	81	1.7	76	3.2	60	23.8
	25 - 1	1018.4	18.8	16.8	15.1	14.9	13.4	81	2.2	82	2.5	70	26.3
Mar	2 - 6	1017.9	20.1	17.6	15.6	15.1	13.0	76	2.7	69	4.0	60	23.8
	7 - 11	1017.8	20.3	18.0	16.2	15.9	14.2	80	0.7	74	3.6	60	24.1
	12 - 16	1015.6	21.9	19.4	17.5	17.8	16.6	84	1.6	82	2.6	50	20.9
	17 - 21	1014.9	22.0	19.6	17.7	17.8	16.6	84	2.6	83	2.5	60	22.0
	22 - 26	1014.7	22.2	19.9	18.2	18.2	17.0	84	4.5	86	2.0	70	24.1
	27 - 31	1014.7	22.7	20.3	18.6	18.5	17.4	84	3.8	81	2.9	70	22.0
Apr	1 - 5	1014.2	23.0	20.8	19.0	19.0	17.8	84	5.3	84	2.6	70	22.7
	6 - 10	1013.3	23.7	21.5	19.9	19.8	18.7	85	7.6	85	2.2	70	21.6
	11 - 15	1013.5	24.4	22.0	20.2	20.0	18.8	82	5.2	82	2.8	70	21.6
	16 - 20	1012.3	25.6	23.0	21.2	21.0	19.8	83	5.2	78	4.2	70	19.8
	21 - 25	1012.0	26.5	23.9	22.1	21.8	20.6	83	6.2	77	4.3	70	19.8
	26 - 30	1012.1	26.8	24.1	22.3	22.0	21.0	83	5.6	79	4.2	80	20.2
May	1 - 5	1010.7	27.4	24.8	22.9	22.8	21.8	84	9.8	79	4.0	80	19.1
	6 - 10	1010.2	28.1	25.4	23.6	23.2	22.1	82	10.8	74	5.1	80	16.9
	11 - 15	1010.1	28.7	26.1	24.3	23.8	22.7	82	6.0	73	5.3	80	19.1
	16 - 20	1009.1	28.6	26.1	24.2	23.7	22.5	82	10.1	74	4.6	80	21.6
	21 - 25	1008.2	28.5	26.2	24.5	24.0	23.0	83	8.9	78	4.0	80	21.2
	26 - 30	1007.8	29.0	26.7	25.0	24.5	23.5	83	12.3	78	4.1	80	19.8
	31 - 4	1007.0	29.6	27.3	25.5	24.9	23.9	83	11.3	76	4.7	90	21.2
Jun	5 - 9	1006.6	29.4	27.2	25.5	24.9	23.9	83	19.4	78	4.0	90	23.0
	10 - 14	1006.7	29.9	27.6	25.9	25.3	24.3	83	15.8	79	4.4	220	20.5
	15 - 19	1005.7	30.2	28.1	26.5	25.7	24.7	82	15.7	80	4.4	220	23.4
	20 - 24	1005.1	31.0	28.6	26.7	26.2	25.2	82	13.8	76	5.6	220	22.3
	25 - 29	1005.7	30.8	28.5	26.7	26.1	25.1	82	15.9	75	5.8	200	24.1
	30 - 4	1006.4	31.2	28.7	26.9	26.2	25.1	81	11.9	72	6.4	220	21.2
Observed at		The Observatory									King's Park	Waglan Island	

Table 1 Five-day Normals of the Meteorological Elements for Hong Kong (Continued) 1981 - 2010

		M.S.L. Pressure	Air Temperature			Wet-Bulb Temperature	Dew Point	Relative Humidity	Rainfall (Mean Daily)	Amount of Cloud	Sunshine (Mean Daily)	Wind	
			Mean Daily Maximum	Mean	Mean Daily Minimum							Prevailing Direction	Mean Speed
		(hPa)	(°C)	(°C)	(°C)	(°C)	(°C)	(%)	(mm)	(%)	(hr)	(deg.)	(m/s)
Jul	5 - 9	1005.9	31.3	28.8	26.8	26.0	24.9	80	9.6	70	6.6	230	21.6
	10 - 14	1005.9	31.6	29.0	26.8	26.2	25.0	80	11.0	67	7.6	230	19.4
	15 - 19	1005.7	31.4	28.8	26.8	26.1	25.1	80	16.1	69	6.9	230	22.3
	20 - 24	1006.3	31.3	28.8	26.7	26.2	25.1	81	14.3	69	7.2	230	22.0
	25 - 29	1004.8	31.3	28.7	26.7	26.1	25.0	81	11.6	68	6.4	230	20.2
	30 - 3	1004.7	31.3	28.8	26.8	26.2	25.1	81	13.0	69	6.3	230	20.5
Aug	4 - 8	1004.5	31.2	28.7	26.7	26.2	25.2	82	10.8	68	6.5	240	19.4
	9 - 13	1004.8	31.0	28.6	26.6	26.2	25.2	83	15.5	71	5.9	230	20.2
	14 - 18	1005.5	31.0	28.4	26.4	25.9	24.9	82	15.0	72	5.8	230	16.9
	19 - 23	1005.3	31.1	28.5	26.5	25.9	24.8	81	17.0	69	6.0	230	22.0
	24 - 28	1006.2	30.9	28.4	26.5	25.8	24.8	81	13.0	69	5.9	230	17.6
	29 - 2	1005.9	31.3	28.8	26.8	25.9	24.7	79	10.2	66	6.4	240	17.3
Sep	3 - 7	1007.0	30.5	28.2	26.3	25.6	24.5	81	11.6	70	5.6	90	20.9
	8 - 12	1008.1	30.5	28.0	26.1	25.2	23.9	79	10.4	65	6.0	80	20.2
	13 - 17	1008.7	30.2	27.8	25.9	24.8	23.4	78	18.2	64	5.7	90	21.6
	18 - 22	1009.6	30.0	27.6	25.7	24.5	23.0	77	8.5	66	5.7	90	23.0
	23 - 27	1010.7	29.4	27.1	25.3	24.0	22.5	77	8.0	65	5.7	80	27.4
	28 - 2	1011.8	29.2	26.8	25.1	23.8	22.3	77	5.6	64	5.6	80	26.6
Oct	3 - 7	1012.5	28.9	26.6	24.8	23.2	21.4	74	5.8	60	6.2	80	24.1
	8 - 12	1013.5	28.5	26.2	24.5	22.8	20.9	74	2.6	57	6.4	80	26.6
	13 - 17	1013.8	28.1	25.9	24.2	22.7	21.0	76	4.9	61	6.0	80	27.7
	18 - 22	1014.6	27.3	25.1	23.4	21.7	19.7	73	2.8	55	6.4	80	28.8
	23 - 27	1015.3	26.8	24.4	22.7	20.9	18.8	72	1.4	57	6.4	80	28.4
	28 - 1	1016.4	26.1	23.7	21.9	20.2	17.9	71	1.4	52	6.5	80	27.4
Nov	2 - 6	1017.0	25.4	23.2	21.3	19.7	17.4	71	2.1	53	6.2	80	28.1
	7 - 11	1016.6	25.1	22.7	20.8	19.3	17.0	71	0.9	54	6.3	80	26.6
	12 - 16	1017.2	24.5	22.2	20.2	19.0	16.9	73	1.7	61	5.3	70	25.9
	17 - 21	1018.6	23.2	20.8	18.9	17.5	15.0	70	1.2	53	6.2	80	28.4
	22 - 26	1018.2	23.3	21.1	19.1	17.8	15.3	71	0.7	53	6.2	80	25.6
	27 - 1	1019.4	22.1	19.7	17.7	16.3	13.4	69	0.9	51	5.8	70	27.0
Dec	2 - 6	1020.3	21.4	19.1	17.2	15.8	12.9	68	0.4	49	6.1	70	26.6
	7 - 11	1020.1	21.1	18.8	16.8	15.4	12.5	68	0.9	53	5.8	70	25.9
	12 - 16	1020.6	20.0	17.9	16.1	14.9	12.2	71	1.1	57	4.7	70	27.0
	17 - 21	1021.1	19.8	17.5	15.5	14.3	11.3	68	0.5	52	5.5	10	25.9
	22 - 26	1020.6	19.4	17.1	15.0	13.9	10.7	68	0.8	47	6.1	10	24.8
	27 - 31	1020.2	19.1	16.8	14.8	14.0	11.4	72	1.5	54	4.9	70	25.2
Observed at		The Observatory									King's Park	Waglan Island	

Table 2 Mean Sea Levels, Mean Higher High Water Levels and Mean Lower Low Water Levels

Location	Period of Data	Mean Sea Level (mPD)	Mean Higher High Water Level (mPD)	Mean Lower Low Water Level (mPD)
Ko Lau Wan[1]	1983-1995, 2001-Oct 2017	1.3	2.0	0.5
Quarry Bay/North Point	1954-Oct 2017	1.2	1.9	0.5
Tai O	1985-Oct 2017	1.2	2.1	0.2
Tai Po Kau	1963-Oct 2017	1.3	2.0	0.5
Tsim Bei Tsui	1974-Oct 2017	1.3	2.3	0.3
Waglan Island	1976-Oct 2017	1.4	2.0	0.7

Note 1 Ko Lau Wan Station temporarily closed between 1996 and 2000. The station is now operated by the Marine Department.

Table 3 Extreme Sea Levels at Ko Lau Wan (1983-1995, 2001-Oct 2017)

Return Periods (years)	Sea Level (mPD)
2	2.8
5	3.0
10	3.1
20	3.2
50	3.4
100	3.5
200	3.6

Table 4 Extreme Sea Levels at Quarry Bay/North Point (1954-Oct 2017)

Return Periods (years)	Sea Level (mPD)
2	2.7
5	2.9
10	3.1
20	3.2
50	3.5
100	3.6
200	3.8

Table 5 Extreme Sea Levels at Tai Po Kau (1962-Oct 2017)

Return Periods (years)	Sea Level (mPD)
2	2.9
5	3.2
10	3.5
20	3.7
50	4.2
100	4.6
200	5.1

Table 6 Extreme Sea Levels at Tsim Bei Tsui (1974-Oct 2017)

Return Periods (years)	Sea Level (mPD)
2	3.1
5	3.3
10	3.5
20	3.7
50	4.1
100	4.4
200	4.8

Table 7 Extreme Sea Levels at Waglan Island (1976-Oct 2017)

Return Periods (years)	Sea Level (mPD)
2	2.8
5	2.9
10	3.1
20	3.2
50	3.3
100	3.4
200	3.5

Note 2 The extreme sea levels at Waglan Island Station are estimated by extreme frequency analysis based on limited available data.

Table 8 Extreme Sea Levels at Chi Ma Wan (1963-1997)

[Not in use due to decommission of tide station in 1997]

Table 9 Extreme Sea Levels at Lok On Pai (1981-1999)

[Not in use due to decommission of tide station in 1999]

Add Table 9A as follows:

Table 9A Extreme Sea Levels at Tai O (1985-Oct 2017)

Return Periods (years)	Sea Level (mPD)
2	2.9
5	3.2
10	3.4
20	3.6
50	3.8
100	4.1
200	4.3

Table 10 Observed Minimum Sea Levels

Location	Period of Data	Minimum Sea Levels (mPD)
Ko Lau Wan	1974-1995, 2001-Oct 2017	-0.30
Quarry Bay	1954-Oct 2017	-0.30
Tai O	1985-Oct 2017	-0.67
Tai Po Kau	1963-Oct 2017	-0.48
Tsim Bei Tsui	1974-Oct 2017	-0.36
Waglan Island	1976-Oct 2017	-0.32

Note 2 The above tabulated sea levels are minimum hourly average sea levels.

Table 11 Probable Minimum Sea Levels at Quarry Bay/North Point (1954-Oct 2017)

Return Period (years)	Sea Level (mPD)
2	-0.16
5	-0.26
10	-0.32
20	-0.37
50	-0.42
100	-0.45
200	-0.48

Table 12 Mean Hourly Wind Speeds (m/s) – Kai Tak Airport Southeast Station (1968-Oct 2017)

Return Period (Years)	N	NE	E	SE	S	SW	W	NW
5	14	14	18	15	13	14	14	13
10	16	16	21	17	16	16	17	15
20	18	18	24	19	18	18	19	16
50	20	21	28	22	20	20	23	18
100	22	23	32	23	23	22	26	20
200	24	25	35	25	25	24	29	21

Table 13 Mean Hourly Wind Speeds (m/s) – Cheung Chau Station (1968-Oct 2017)

Return Period (Years)	N	NE	E	SE	S	SW	W	NW
5	20	20	26	26	21	20	18	19
10	22	23	30	30	25	24	21	22
20	24	26	33	34	29	27	23	25
50	27	30	37	40	34	32	27	28
100	30	34	41	45	38	35	29	31
200	33	37	44	49	43	39	32	34

Table 14 Mean Hourly Wind Speeds (m/s) – Waglan Island Station (1975-Oct 2017)

Return Period (Years)	N	NE	E	SE	S	SW	W	NW
5	22	26	27	24	22	24	20	16
10	24	29	30	28	25	28	23	18
20	26	33	33	32	29	31	26	20
50	29	38	38	38	34	35	30	23
100	31	42	41	43	38	39	33	25
200	33	46	45	48	42	42	37	27

Table 15 Mean Wind Speeds East Direction (m/s) – Kai Tak Southeast Station (1968-Oct 017)

Return Period (Years)	Duration (hr)					
	1	2	3	4	6	10
5	18	17	17	16	16	15
10	21	20	20	19	18	17
20	24	23	22	22	20	19
50	28	27	27	26	24	21
100	32	31	30	29	27	24
200	35	35	34	33	30	26

Table 16 Mean Wind Speeds Southeast Direction (m/s) – Kai Tak Southeast Station (1968-Oct 2017)

Return Period (Years)	Duration (hr)					
	1	2	3	4	6	10
5	15	15	14	13	13	12
10	17	16	16	15	14	13
20	19	18	17	17	16	15
50	22	21	20	19	18	17
100	23	22	21	21	20	18
200	25	24	23	22	21	19

Table 17 Mean Wind Speeds West Direction (m/s) – Kai Tak Southeast Station (1968-Oct 2017)

Return Period (Years)	Duration (hr)					
	1	2	3	4	6	10
5	14	13	13	13	12	11
10	17	15	15	14	14	12
20	19	18	17	16	15	14
50	23	21	20	19	17	16
100	26	23	22	21	19	17
200	29	26	24	23	21	18

Table 18 Mean Wind Speeds North Direction (m/s) – Cheung Chau Station (1968-Oct 2017)

Return Period (Years)	Duration (hr)					
	1	2	3	4	6	10
5	20	19	18	18	17	17
10	22	20	20	20	19	18
20	24	22	22	21	21	20
50	27	25	25	24	23	22
100	30	28	27	26	25	24
200	33	30	29	29	27	26

Table 19 Mean Wind Speeds Northeast Direction (m/s) – Cheung Chau Station (1968-Oct 2017)

Return Period (Years)	Duration (hr)					
	1	2	3	4	6	10
5	20	19	18	17	16	15
10	23	22	20	20	19	17
20	26	25	23	22	21	19
50	30	29	27	26	24	22
100	34	32	30	28	26	24
200	37	35	32	31	28	25

Table 20 Mean Wind Speeds East Direction (m/s) – Cheung Chau Station (1968-Oct 2017)

Return Period (Years)	Duration (hr)					
	1	2	3	4	6	10
5	26	24	24	23	22	21
10	30	28	27	26	25	23
20	33	31	30	29	27	25
50	37	35	33	32	31	29
100	41	38	36	35	33	31
200	44	41	39	38	36	33

Table 21 Mean Wind Speeds Southeast Direction (m/s) – Cheung Chau Station (1968-Oct 2017)

Return Period (Years)	Duration (hr)					
	1	2	3	4	6	10
5	26	24	24	23	22	21
10	30	29	28	27	26	24
20	34	33	32	31	30	27
50	40	38	37	36	34	31
100	45	43	41	40	38	34
200	49	47	45	43	41	37

Table 22 Mean Wind Speeds South Direction (m/s) – Cheung Chau Station (1968-Oct 2017)

Return Period (Years)	Duration (hr)					
	1	2	3	4	6	10
5	21	20	19	18	17	16
10	25	24	23	22	21	19
20	29	28	26	25	24	21
50	34	33	31	30	28	24
100	38	37	35	33	31	27
200	43	41	39	37	34	29

Table 23 Mean Wind Speeds Southwest Direction (m/s) – Cheung Chau Station (1968-Oct 2017)

Return Period (Years)	Duration (hr)					
	1	2	3	4	6	10
5	20	19	18	17	16	14
10	24	22	21	20	18	17
20	27	25	24	23	21	19
50	32	29	28	26	25	21
100	35	33	31	30	28	23
200	39	36	34	33	31	26

Table 24 Mean Wind Speeds North Direction (m/s) - Waglan Island Station (1975-Oct 2017)

Return Period (Years)	Duration (hr)					
	1	2	3	4	6	10
5	22	22	21	21	20	19
10	24	24	23	23	22	21
20	26	26	25	25	24	22
50	29	29	28	27	26	24
100	31	31	30	29	28	26
200	33	33	32	31	30	28

Table 25 Mean Wind Speeds Northeast Direction (m/s) - Waglan Island Station (1975-Oct 2017)

Return Period (Years)	Duration (hr)					
	1	2	3	4	6	10
5	26	25	24	24	23	21
10	29	28	27	26	25	23
20	33	32	30	29	28	26
50	38	36	34	33	31	29
100	42	39	37	35	33	31
200	46	43	40	38	36	33

Table 26 Mean Wind Speeds East Direction (m/s) - Waglan Island Station (1975-Oct 2017)

Return Period (Years)	Duration (hr)					
	1	2	3	4	6	10
5	27	27	26	26	25	24
10	30	30	29	29	27	26
20	33	33	32	32	30	28
50	38	37	36	36	34	31
100	41	40	40	39	36	33
200	45	44	43	42	39	35

Table 27 Mean Wind Speeds Southeast Direction (m/s) - Waglan Island Station (1975-Oct 2017)

Return Period (Years)	Duration (hr)					
	1	2	3	4	6	10
5	24	23	22	22	21	19
10	28	27	26	26	24	23
20	32	31	30	30	28	26
50	38	37	36	35	34	31
100	43	42	41	40	38	35
200	48	47	46	45	43	40

Table 28 Mean Wind Speeds South Direction (m/s) - Waglan Island Station (1975-Oct 2017)

Return Period (Years)	Duration (hr)					
	1	2	3	4	6	10
5	22	21	20	19	18	16
10	25	24	23	22	20	19
20	29	27	26	25	23	21
50	34	32	30	29	27	24
100	38	35	34	32	29	26
200	42	39	37	36	32	28

Table 29 Mean Wind Speeds Southwest Direction (m/s) - Waglan Island Station (1975-Oct 2017)

Return Period (Years)	Duration (hr)					
	1	2	3	4	6	10
5	24	23	22	22	20	18
10	28	27	26	25	23	21
20	31	30	29	28	26	23
50	35	34	33	32	29	26
100	39	37	36	34	32	28
200	42	40	39	37	34	30

Table 30 Mean Wind Speeds West Direction (m/s) - Waglan Island Station (1975-Oct 2017)

Return Period (Years)	Duration (hr)					
	1	2	3	4	6	10
5	20	19	18	17	16	15
10	23	21	20	19	18	17
20	26	24	22	21	20	19
50	30	27	25	24	22	21
100	33	30	27	26	24	22
200	37	33	29	27	26	24

Table 32 Wave Measurement at Kau Yi Chau Station (1994-2016)

Year	Percentage of Time in Service	Calm Period (H_{m0}<0.3m)	Average H_{m0} (m)	Average Peak Period T_p (s)	Maximum H_{m0} (m) [Tp (s)]	Maximum Recorded Wave Height H_{max} (m)
1994	78%	63%	0.31	6.7	1.46 [9.1]	2.45
1995	87%	77%	0.26	6.5	1.51 [11.6]	2.68
1996	60%	75%	0.27	6.3	1.57 [11.6]	2.38
1997	95%	79%	0.26	6.7	1.61 [11.6]	2.68
1998	97%	81%	0.24	6.4	1.40 [9.1]	2.92
1999	92%	75%	0.25	6.2	2.36 [9.9]	3.75
2000	76%	71%	0.28	6.3	1.70 [9.1]	2.33
2001	80%	72%	0.29	6.3	2.68 [10.7]	3.87
2002	96%	79%	0.26	6.1	2.46 [11.6]	3.42
2003	74%	76%	0.28	6.4	2.46 [12.8]	3.44
2004	87%	30%	0.34	4.1	1.37 [9.5]	2.21
2005	84%	58%	0.31	5.62	1.73 [13.21]	2.65
2006	72%	58%	0.32	6.04	2.47 [11.7]	3.83
2007	51%	40%	0.35	5.26	1.75 [3.95]	2.83
2008	67%	39%	0.41	5.32	3.31 [12.26]	5.31
2009	79%	39%	0.52	5.11	3.34 [12.26]	5.45
2010	63%	75%	0.37	5.05	2.89 [3.64]	4.82
2011	94%	78%	0.17	4.90	2.29 [10.72]	3.52
2012	86%	77%	0.18	5.08	2.59 [10.5]	4.14
2013	75%	81%	0.15	4.99	1.72 [11.98]	2.70
2014	58%	61%	0.31	5.42	2.07 [3.66]	3.35
2015	75%	11%	0.47	4.50	1.86 [10.95]	2.96
2016	55%	70%	0.16	4.56	0.97 [8.57]	1.55

Note 1. The percentage of time in service refers to the time at which the recorder is operational.
2. For the maximum H_{m0}, the corresponding peak period T_p is shown in brackets.
3. For data beyond 2016, CEDD website http://www.cedd.gov.hk/ should be referred.

Table 33 Wave Measurement at West Lamma Channel Station (1994-2016)

Year	Percentage of Time in Service	Calm Period (H_{m0}<0.3m)	Average H_{m0} (m)	Average Peak Period T_p (s)	Maximum H_{m0} (m) [Tp (s)]	Maximum Recorded Wave Height H_{max} (m)
1994	84%	55%	0.33	7.5	1.68 [9.1]	2.42
1995	53%	47%	0.36	7.3	1.45 [3.9]	2.47
1996	41%	56%	0.32	7.1	1.71 [11.6]	2.83
1997	70%	60%	0.28	6.7	2.52 [5.8]	3.99
1998	34%	51%	0.32	8.0	1.08 [12.8]	1.93
1999	51%	50%	0.33	7.3	3.28 [9.9]	4.68
2000	72%	38%	0.38	6.5	1.95 [9.9]	3.01
2001	77%	45%	0.35	6.6	3.03 [10.7]	4.01
2002	27%	51%	0.33	7.4	2.29 [10.7]	3.41
2003	96%	38%	0.37	6.9	3.38 [12.8]	5.45
2004	75%	32%	0.37	6.4	1.59 [10.3]	2.57
2005	89%	43%	0.35	6.89	2.01 [11.98]	3.11
2006	77%	41%	0.37	7.29	2.99 [10.95]	4.64
2007	82%	47%	0.34	6.95	2.29 [7.79]	3.69
2008	95%	41%	0.36	7.24	3.49 [13.93]	5.46
2009	97%	34%	0.36	7.19	2.81 [11.19]	4.47
2010	83%	47%	0.33	6.87	1.33 [10.10]	2.24
2011	72%	54%	0.29	6.07	2.81 [13.56]	4.34
2012	88%	60%	0.22	5.93	0.72 [5.97]	1.18
2013	98%	75%	0.15	5.45	1.79 [11.19]	2.84
2014	99%	51%	0.28	6.41	2.47 [11.7]	3.89
2015	75%	52%	0.27	6.57	1.76 [10.09]	2.77
2016	91%	39%	0.36	6.73	2.08 [5.83]	3.40

Note 1. The percentage of time in service refers to the time at which the recorder is operational.
2. For the maximum H_{m0}, the corresponding peak period T_p is shown in brackets.
3. For data beyond 2016, CEDD website http://www.cedd.gov.hk/ should be referred.

Add Table 42 as follows:

Table 42 Rise in Mean Sea Levels Due to Climate Change

End of Design Life (Year)	Sea Level Rise (m)
2020 – 2029	0.08
2030 – 2039	0.13
2040 – 2049	0.18
2050 – 2059	0.23
2060 – 2069	0.29
2070 – 2079	0.36
2080 – 2089	0.43
2090 – 2099	0.49

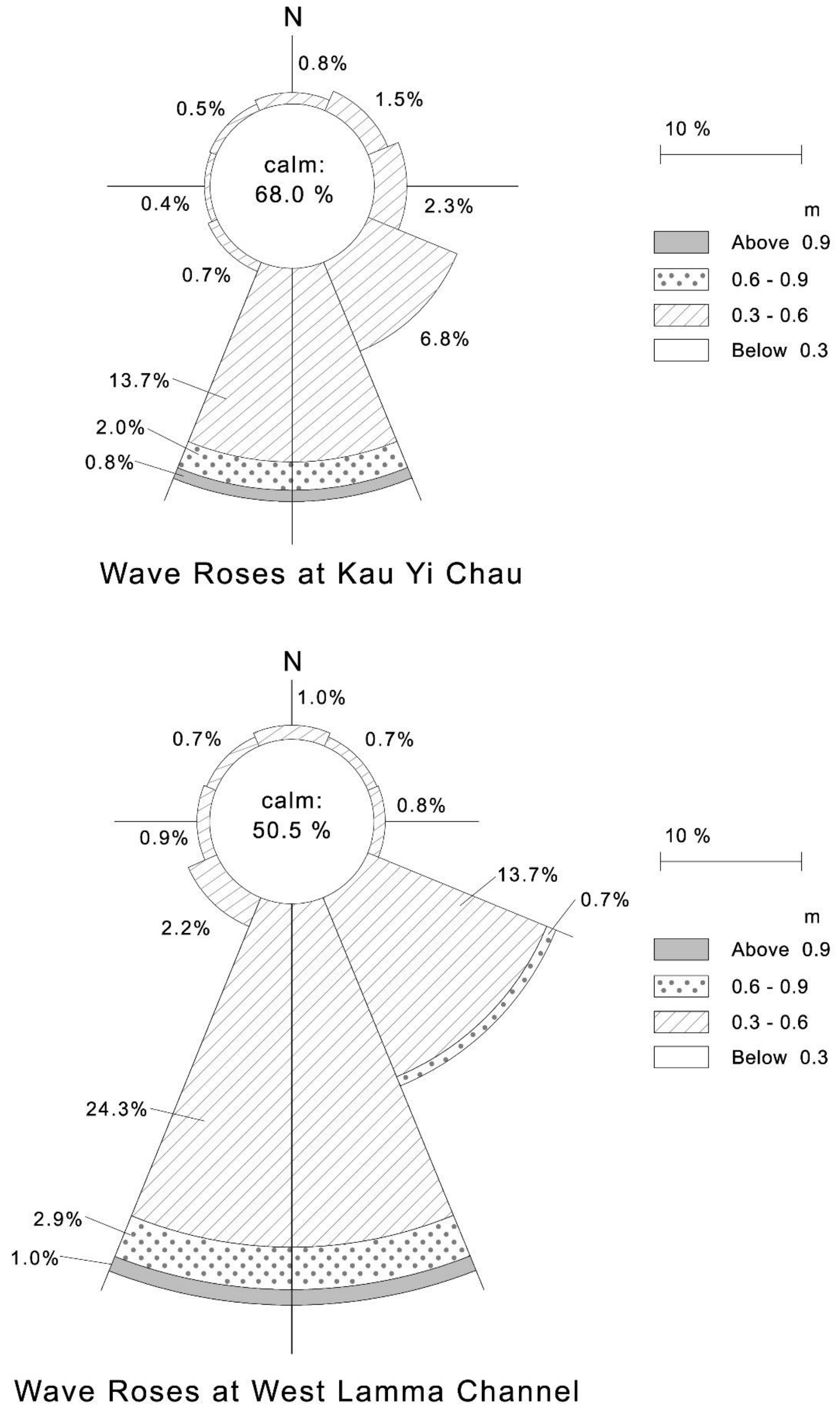
Note 3 The effect of vertical land displacement is not considered.

Add Table 43 as follows:

Table 43 Change in Wind Speeds Due to Climate Change

	Return Period Event (years)	2010 - 2030	2030 - 2050	2050 - 2100
Wind Speed Increase (% per year)	5	0.02	0.02	0.02
	10	0.02	0.02	0.02
	20	0.02	0.02	0.02
	50	0.01	0.01	0.01
	100	0.01	0.01	0.01
	200	0.00	0.00	0.01

(r) FIGURES **Figure 7 is updated as follows:**



Notes:

1. Data Collection Period 1994-2016.
2. Wave heights with occurrence percentage less than 0.5% are not shown.

Figure 7 – Wave Rose at Kau Yi Chau and West Lamma Channel Wave Stations

PART 2 – Guide to Design of Piers and Dolphins

(a) Section 2.4.2 – Exposure to Waves, Winds and Currents

Add the following sentence after the last sentence of the 1st paragraph:
Variation in loads throughout structure design life as result of climate change (including variations in hydrostatic load and, normal wind and wave environmental loads) may be expected over the design life of the structure and structural performance should be checked at the beginning and end of the design life of the structures.

(b) Section 2.6.3 – Deck Level

Amend the 2nd sentence of the 1st paragraph to read as follows:
A typical level for the main deck of piers for ferries, pleasure crafts and similar types of vessels in the Territory is about +4.0 mPD to +5.0 mPD.

Add the following sentence after the last sentence of the 1st paragraph:
Wave overtopping at deck level should be checked to ensure that overtopping rates are acceptable for the intended usage of the pier.

(c) Section 2.7.5 – Arrangement of Fenders

Amend the 1st bullet point of the 1st paragraph to read as follows:
The design of the vertical position of the fenders should take into account the range of freeboard of the vessels so that all vessels using the pier can be in contact with the fenders during berthing under all possible tidal levels (see Figure 5a) throughout the structure's design life including the possible effects of climate change.

Amend the 1st sentence of the 2nd paragraph to read as follows:
For public piers designed for pleasure yachts, trading vessels, motor launches, fishing vessels, kaitos and sampans, from past experience fenders extending from about +0.15 mPD to +4.15 mPD are considered appropriate in order to cater for a wide range of vessel sizes over a 50 year design life.

PART 3 – Guide to Design of Reclamation

(a) Section 2.4 – Layout

Add the following sentence after the last sentence of the 5th paragraph:
In addition, the effects of climate change over the life of the reclamation should be investigated and incorporated in the design.

(b) Section 2.5 – Formation Level

Amend the last bullet point of the 1st paragraph to read as follows:

- Implications of climate change over the design life, including sea level rise and changes to wave conditions.

Add the following paragraph after the 2nd paragraph:
In addition to determining the site formation level, due considerations should also be given to the impact on the drainage provisions of the existing adjoining lands where the formation level of the reclamation is higher than that of the adjoining lands. Appropriate drainage provisions will need to be considered to avoid flooding or overloading the existing drainage system due to the level difference.

PART 4 – Guide to Design of Seawalls and Breakwaters

(a) Section 2.2.5 – Selection

Add a bullet point after the last bullet point of the 1st paragraph:

- Effects of climate change.

(b) Section 3.2.4 – Environmental Effect

Amend the 2nd sentence of the 1st paragraph to read as follows:

Hence, it is necessary to undertake hydraulic study and environmental impact assessment over the life of the structure, including the effects of climate change, to ensure that the changes in flow and wave climate during and after construction will have no unacceptable effects on :

(c) Section 4.4 – Settlement

Add the following sentence after the last sentence of the 1st paragraph:

In addition, consideration of settlement of proposed or adjacent developments should be taken account of when estimating overtopping or tidal flooding effects.

(d) Section 5.2 – Wave Run-up

Add the following sentence after the 3rd sentence of the 1st paragraph:

Variations in wave run-up throughout structure design life as result of climate change (including variations both water level and increased wind speed) should be checked at the beginning and end of the design life of the structures.

(e) Section 5.3.1 – Mean Overtopping Rate

Add the following sentence after the 1st sentence of the 2nd paragraph:

Variations in wave overtopping throughout structure design life as result of climate change (including variations both water level and increased wind speed) should be checked at the beginning and end of the design life of the structures.

Add the following paragraph after the last paragraph:

Designers should determine the amount of overtopped water that would flow into the existing drainage system behind the seawall. Appropriate drainage provisions will need to be considered to avoid flooding or overloading the existing drainage system due to the overtopping wave. Designers should take particular attention in determining the overtopping rate at locations where sharp change in alignment of seawall or change in types of seawall occurs. Physical model or computer model may be used to determine the overtopping rate and the hydraulic performance of the structures when complicated situations are encountered.

(f) Section 6.2.2 – Weight of Armour Units

Add the following sentence after the 1st sentence of the 1st paragraph:

Reader can make reference to Van Gent M.R.A., Smale A.J. and Kuiper C. (2003) which discusses stability of rock slopes with shallow foreshores.

(g) Section 6.2.2(3) – Crest and Rear Face Armour

Amend the 3rd sentence of the 1st paragraph to read as follows:

For determining the size of these armour units, reader can make reference to Coastal Engineering Manual (CEM, 2002) and The Rock Manual (CIRIA, 2007) which discuss analytical methods for sizing crest and rear face armour.

(h) Section 6.2.6 – Crest

Amend the last sentence of the 1st paragraph to read as follows:

An allowance for the settlement that will occur in the design life of the structure and its foundation, including the effects from any adjacent reclamation should also be included in determining the crest elevation.

(i)	Section 6.3.3 – Design Wave Height	**Amend the 1st paragraph to read as follows:** The design wave height for assessing the structural stability should be taken as the maximum wave height H_{max} experienced as a result of increased wind speed variation throughout design life of structure.
(j)	REFERENCES	**Add the following references:** CEM (2002). Coastal Engineering Manual. US Army Corps of Engineers. CIRIA (2007). The Rock Manual - The Use of Rock in Hydraulic Engineering (2nd edition). Construction Industry Research and Information Association, United Kingdom. Van Gent M.R.A., Smale A.J. and Kuiper C. (2003). Stability of Rock Slopes with Shallow Foreshores, Proceedings of Coastal Structures 2003, Portland. ASCE.

PART 5 – Guide to Design of Beaches

(a)	Section 2.1 – General	**Add the following sentence after the last sentence of the 1st paragraph:** Variations in water levels and wind speeds may be expected over the design life of the beach as a result of climate change, and beach response should be checked at the beginning and end of the design life of the beach.
(b)	Section 2.5 – Closure Depth	**Add the following sentence after the last sentence of the last paragraph:** Variations in water levels and wave conditions may be expected over the design life of the beach as a result of climate change, and closure depth should be checked at the beginning and end of the design life of the beach.

(B) Eco-shoreline

PART 4 – Guide to Design of Seawalls and Breakwaters

(a) CONTENTS	**Add the following section:** Section 3.4 Eco-shoreline
(b) Section 3 – Layout Considerations	**Add the following section:**

3.4 Eco-shoreline

A properly designed artificial seawall should be able to serve the stabilization and protective function while offering a larger variety and surface area of intertidal habitats for increasing biodiversity in the area. Where applicable, design of eco-shoreline should be considered instead of traditional seawall with a view to enhancing the ecological value of seawall. Eco-shoreline can also promote water-friendly culture and improve marine environment for public enjoyment.

There are some designs of eco-shoreline which have been successfully applied in other countries, including:

- The use of sloping/terraced seawall or creation of artificial tidal pool/ mudflat to provide additional habitat for intertidal organisms and increase the biodiversity.
- Incorporation of different structures (e.g. protrusions, cavities, pools, artificial reefs, etc.) into the seawall to increase the complexity. This also helps to mimic the natural shoreline and provide a microhabitat for organisms to settle in.
- Shoreline rehabilitation with suitable vegetation (e.g. mangrove, marsh plants, etc) to improve visual amenity, stabilize the foreshore and control sediment erosion.