For discussion
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Review of Studies on Climate Change and its Implications on the Design of Coastal Structures

PURPOSE

This paper provides an update on the review of studies on climate change and its implications on the design of coastal structures.

BACKGROUND

2. Civil Engineering and Development Department (CEDD) is responsible for the maintenance of about 130 kilometres of coastline and coastal infrastructures including seawalls, breakwaters, piers, dolphins, etc.

3. CEDD publishes the Port Works Design Manuals (PWDM) providing design guidelines, and recommending standards and methodologies for the design of coastal structures. The design of coastal structures shall take into account environmental, geotechnical, functional and aesthetical considerations. Sea level and wind speed are most relevant to the design of coastal structures. On the other hand, changes in rainfall intensity and temperature due to climate change would be of minimal significance on the functionality and stability of coastal structures. For a coastal structure with a design life of 50 years, different combinations[1] of wave conditions and water levels shall normally be considered in the design.

1 For extreme loading conditions, four combinations including (1) extreme wave condition at 100-year return period and extreme water level at 10-year return period; (2) extreme wave condition at 10-year return period and extreme water level at 100-year return period; (3) extreme wave condition at 50-year return period and extreme water level at 50-year return period; and (4) extreme wave condition at 100-year return period and mean lower low water level shall normally be considered.

4. Under the influence of climate change, it is believed that the frequency of occurrence of extreme sea level[2] events will increase. Coastal infrastructures would be exposed to more severe storm surges, and thus there would be adverse impacts imposed on the functionality and stability of coastal structures.

5. To evaluate the impacts on coastal infrastructures, CEDD has completed a study to review climate change situation in Hong Kong focusing on storm surges and wind speeds, and is in the process of updating the current design standards in the PWDM.

CLIMATE CHANGE IMPACTS

6. In the Fifth Assessment Report[3] (AR5) published by the Intergovernmental Panel on Climate Change [4] (IPCC), four Representative Concentration Pathways[5] (RCPs) namely RCP2.6, RCP4.5, RCP6.0 and RCP8.5 are used to describe four possible climate futures, all of which are considered possible depending on how much greenhouse gases are emitted in the years to come and the success of large scale carbon storage technology. With the agreement reached in COP21[6], it is forecasted that the climate situation in Hong Kong might be more or less following the

2 Extreme sea level refers to the combination of mean sea level, normal high tide and storm surge arising from extreme event.

3 The Fifth Assessment Report (AR5) was published by the IPCC in September 2013 reporting the latest findings of scientific research and assessment, adaption and mitigation in respect of climate change.

4 The Intergovernmental Panel on Climate Change (IPCC) is a scientific body established by the United Nations Environmental Programme (UNEP) and the World Meteorological Organization (WMO) in 1988.

5 Representative Concentration Pathways (RCPs) are four greenhouse gas concentration trajectories adopted in AR5 published by the Intergovernmental Panel on Climate Change (IPCC). The four RCPs including RCP2.6 (low), RCP4.5 (medium-low), RCP6.0 (medium-high) and RCP8.5 (high) represent a larger set of mitigation scenarios and are selected to have target radiative forcing about 2.6, 4.5, 6.0 and 8.5 W/m^2 at year 2100 respectively.

6 The Paris Climate Conference is officially known as the 21st Conference of the Parties (or "COP21") to the United Nations Framework Convention on Climate Change (UNFCCC), the United Nations body which is responsible for climate and based in Bonn, Germany. The COP21 which was held in Paris from 30 November to 12 December 2015 also served as the 11th Meeting of the Parties to the Kyoto Protocol.

greenhouse gas concentration level scenarios of RCP4.5 and RCP6.0 subject to the global efforts being made in combating climate change.

7. Based on the Global Climate Model results of the AR5 and the use of pattern scaling method, it is able to make a local prediction of climate change in Hong Kong. It is predicted that the mean sea levels and extreme wind speeds which are relevant to the design of coastal structures in Hong Kong will change as follows :-

(a) Mean Sea Level Rise

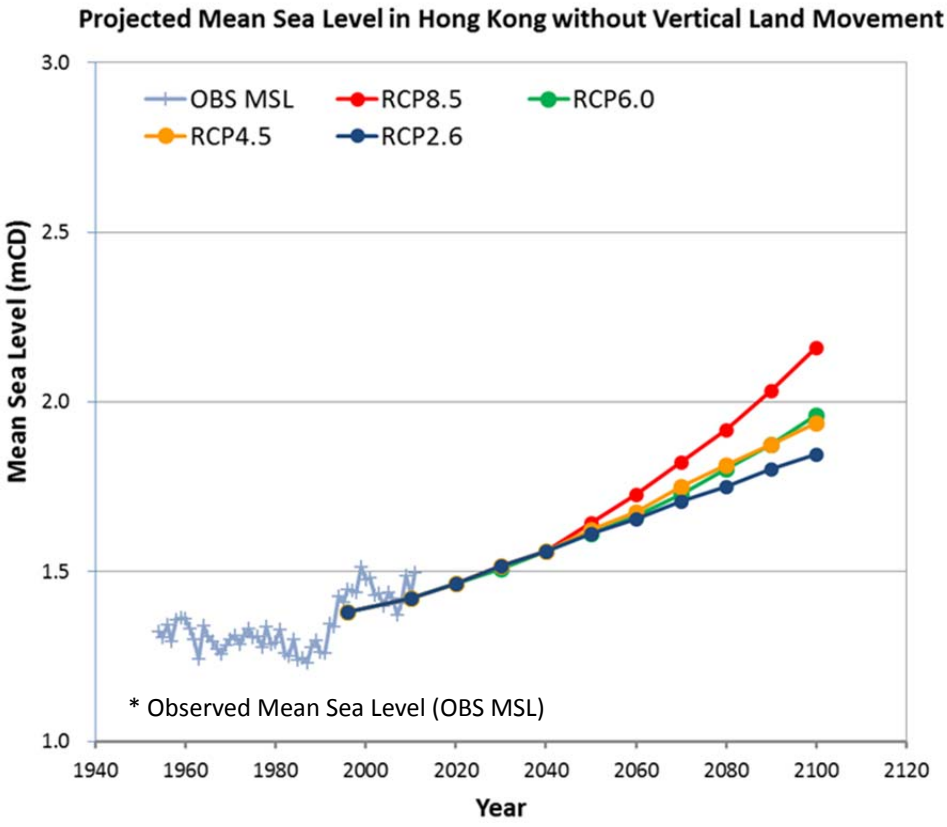
The projected mean sea levels in Hong Kong for Years 2010, 2030, 2050 and 2100 with reference to Base Year 1996[7] are summarised in Table 1 and shown in Figure 1. It is predicted that the mean sea level will continue to rise by the end of 21st century. Possible vertical land movement, which is not related to climate change, is not taken into account here.

Table 1 - Projected Mean Sea Level Rise (in metre) in Hong Kong with reference to Base Year 1996

Scenario	Yr 2010	Yr 2030	Yr 2050	Yr 2100
RCP8.5	0.04	0.14	0.26	0.78
RCP6.0	0.04	0.13	0.23	0.58
RCP4.5	0.04	0.14	0.24	0.56
RCP2.6	0.04	0.14	0.23	0.46

7 All these changes are referenced to the baseline time-average value in the period from 1986 to 2005 (assuming that the Base Year is 1996 which is the middle of the period 1986 to 2005).

Figure 1 - Projected Mean Sea Levels (mCD[8]) against Observed Mean Sea Level Data (mCD) at Quarry Bay



(b) Extreme Wind Speeds

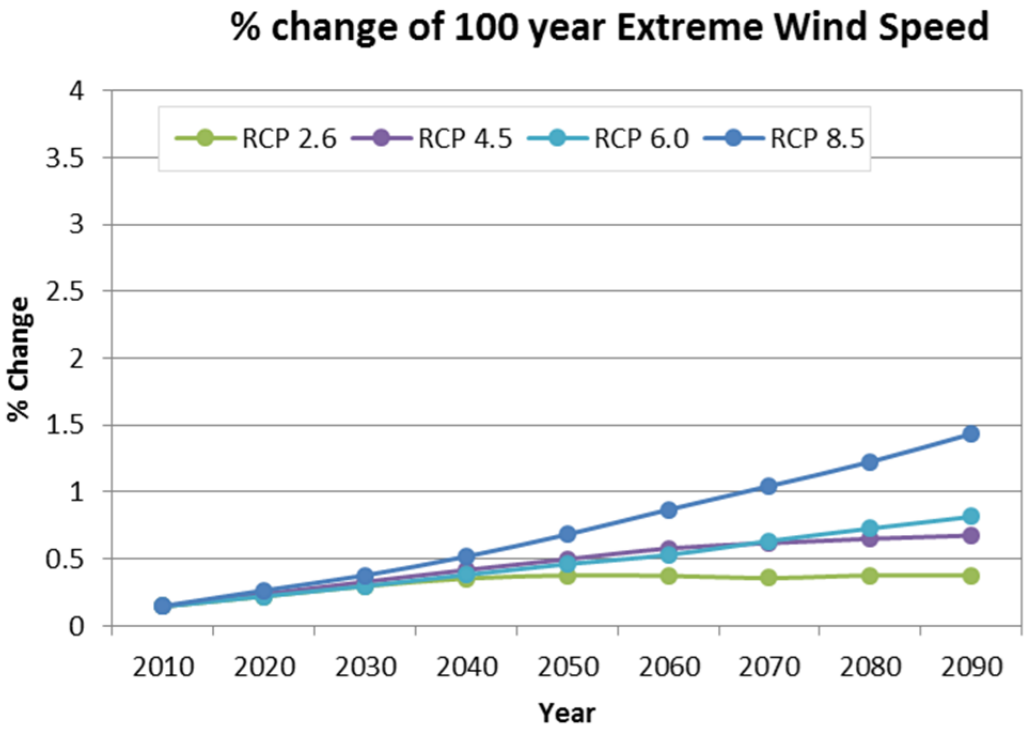
Projection of the changes of the extreme wind speeds (for 100-year return period event) in Hong Kong for Years 2010, 2030, 2050 and 2090 with reference to Base Year 1996 are summarised in Table 2 and shown in Figure 2.

Table 2 - Projected Change of Extreme Wind Speeds (%) in Hong Kong for 100-year Return Period with reference to Base Year 1996

Scenario	Yr 2010	Yr 2030	Yr 2050	Yr 2090
RCP8.5	0.15	0.38	0.68	1.44
RCP6.0	0.14	0.30	0.46	0.82
RCP4.5	0.14	0.33	0.50	0.68
RCP2.6	0.14	0.30	0.38	0.38

8 "mCD" refers to Chart Datum in metre.

Figure 2 - Projected Change of Extreme Wind Speeds (%) in Hong Kong for 100-year Return Period with reference to Base Year 1996



IMPLICATIONS ON DESIGN OF COASTAL STRUCTURES

8. Coastal protection is the defence against flooding and erosion in relation to land and infrastructures. Based on the findings of the study, as a result of the effects of climate change, there will be increasing challenges on coastal protection in Hong Kong. It is therefore necessary to update current design standards in the PWDM with a view to maintaining the same functionality and stability of coastal structures. For example, seawalls and breakwaters may be designed with raised crest levels to eliminate coastal flooding resulting from the projected sea level rise, extreme sea level due to storm surges, and wave run-up and overtopping due to wave actions. The formation levels of new reclamation areas may be designed to a higher level to cope with the projected sea level rise and extreme sea level due to storm surges. In addition, some coastal structures, such as piers and

dolphins, may be designed to be more robust to resist stronger waves and winds under more extreme weather.

9. We are coordinating with other relevant Government departments on the climate change parameters and their design standards before the promulgation of the new PWDM. Further review on the PWDM will be conducted timely as and when necessary, e.g. new report released by the IPCC or latest parameters available.

IMPLICATIONS ON EXISTING INFRASTRUCTURES

10. In respect of adaptation and resilience, an inter-departmental working group (namely "Climate Change Working Group on Infrastructure") led by CEDD has been established to oversee and coordinate efforts amongst works departments to align the climate change parameters, review the design standards currently in use, and conduct studies for strengthening the resilience of existing infrastructures.

11. In this regard, CEDD has commissioned a feasibility study in April 2017 to holistically examine the scope of enhancement works necessary for strengthening the resilience of existing critical infrastructures under the effects of climate change and extreme weather. It is anticipated that the findings and recommendations of the feasibility study will be available by 2018.

12. Members are invited to note the findings and recommendations of the review.

Civil Engineering and Development Department
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