Drainage Services Department Practice Note No. 2/2023

Guidelines on Flood Resilience

Version No. : 1

Date of Issue: 29 December 2023

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1. INTRODUCTION

Under the effect of climate change, the frequency and intensity of extreme weather events have been increasing. These include more extreme rainstorms events and intense tropical cyclones with significant storm surge which will cause pressure to our drainage system.

In 2017, 2018 and 2023, Hong Kong was struck by Super Typhoons Hato, Mangkhut and Saola respectively, all of them resulted in the issuance of Tropical Cyclone Signal No. 10. During Super Typhoon Mangkhut, five of the six tide stations of the Hong Kong Observatory registered record breaking storm surges. The heavy rain, storm surge and high waves associated with Mangkhut caused serious flooding in many parts of Hong Kong. The electricity supply to over 40,000 households was interrupted. In September 2023, Hong Kong experienced an extreme rainstorm, recording the highest hourly rainfall of 158.1mm, 2-hour total rainfall of 201.0 millimetres and 12-hour total rainfall of 605.8 millimetres at the Hong Kong Observatory Headquarters since 1884.

To combat climate change, the Government announced Hong Kong's Climate Action Plan 2050 in October 2021, outlining the strategies and targets for combating climate change and achieving carbon neutrality. The Climate Action Plan states that we need to *"adopt a comprehensive strategy on climate change adaptation and resilience to protect the life, health and property of the people from extreme weather and strengthen the resilience of the community."* Apart from traditional engineering measures (adaptation), resilience is also emphasized under the Climate Action Plan. Resilience and adaptation not only can complement each other, but also can add buffer to reduce loss and damage from extreme weather.

In this connection, Stormwater Drainage Manual – Corrigendum No. 1/2022 (the Corrigendum) introduced the use of resilience measures and emergency preparedness under critical circumstances (e.g. structural measures are found technically infeasible or not cost effective due to various constraints as mentioned under Section 6.9 of the Corrigendum) to fulfil the design requirements.

2. ADAPTATION VERSUS RESILIENCE

Adaptation refers to implementing drainage infrastructure works to eliminate flooding at source, whereas resilience aims at controlling flood risks or minimizing flooding impacts. In principle, a higher priority should be given to adaptation measures, resilience measures can only be considered as the last resort to alleviate flooding impact. Project proponents shall not consider resilience measures as an escape route for not to proceed with adaptation measures unless there are unsolvable constraints. With a well-planned drainage system during the planning and design stage, the effort to deploy resilience measures each time before extreme weather event can be minimized. Substantial resources and recurrent cost for resilience measures can hence be avoided. For example, for new development area or urban renewal site where site formation and drainage provisions can be planned holistically at early planning stage, a higher design formation level above the anticipated flood level can be adopted to reduce its susceptibility to flooding. By providing suitable drainage facilities under the project, flood risks to adjacent urban or village areas with relatively low topography can also be mitigated.

Similar concept can be applied to new critical infrastructure[1] such as strategic road, essential building or residential development, by elevating the road level or ground floor level above the anticipated flood level.

Generally speaking, drainage infrastructure works (adaptation) should be designed to meet the flood protection standards as stipulated in the Stormwater Drainage Manual. However, there may be situations (e.g. unsolvable site constraints) or other limitations where it is not feasible to construct or upgrade drainage infrastructure to meet the required flood protection standard, under such situations, resilience measures could be deployed to tackle the risk of flooding and enable swift recovery from floods. In such cases, the combination of adaptation and resilience measures could be considered, with adaptation being the principal means to fulfil the flood protection standard, and resilience as the secondary measure to handle residual flood risks or extreme scenario. Section 3 highlights some considerations for adopting resilience measures, and Section 4 presents a few typical resilience measures.

3. CONSIDERATIONS FOR ADOPTING RESILIENCE MEASURES

3.1 Site Constraints

In Hong Kong, land scarcity resulting from high-density urban development is a main constraint to adopting adaptation measures. Other site constraints include unfavourable geological conditions for construction, as well as congested underground conditions in urban areas. When adaptation measures are subject to unresolvable site constraints, resilience measures, reliance on emergency preparedness and formulation of emergency plan can be adopted to minimize impacts and losses due to flooding.

3.2 Cost Effectiveness and Technical Feasibility

If designers consider that adaptation measures are not cost effective, resilience measures / emergency preparedness can be an alternative. In justifying the adoption of resilience measures, designers should consider the cost effectiveness of the scheme based on various factors including but not limited to the consequences and risks of flooding if adaptation measures are not implemented, the land use of the area subject to flood risks, the frequency and scale of past flooding, the flood risks due to climate change, the strategic facilities or important highways/subways/ roads that would be affected, the disruption to traffic and pedestrian movements caused by flooding, etc.

Furthermore, designers should assess the technical feasibility for the choice of adaptation / resilience measures. For example, some adaptation measures such as pipeline upgrading and stormwater diversion may render technically infeasible in area of low topography under very high sea level; and resilience measures requiring manual operation (e.g. demountable flood barrier, water/air filled tube barrier, portable flood barrier, etc) may become impractical considering the long lead time required to set up the associated facilities. Where appropriate,

[1] Definition of critical infrastructure can be referred to the three key principles under Part 1 (i) Section 3.9 of Port Works Design Manual: Corrigendum No. 1/2022.

different combinations of adaptation and resilience measures should be considered.

3.3 Social Impact

Social impact is one of the considerations to be taken during the design of drainage infrastructure. There are situations where full adoption of adaptation measures may not be the preferred solution due to social impacts. For example, high flood wall may affect public's enjoyment of scenery or discourage public from getting close to the water bodies. Under this situation, designers may consider to adopt a combination of adaptation and resilience measures with permanent flood wall being constructed to a height similar to a conventional balustrade, with provision of demountable flood barriers to be erected on top of flood wall before extreme weather events. Opinions from relevant stakeholders for implementation of resilience measures should be sought, in particular for resilience measures comprising demountable components of which the erection and subsequent removal may cause disruption and/or inconvenience to the public.

3.4 Uncertainties from Climate Related Studies and Stochastic Nature of Weather

Climate projections under different emissions scenarios by the Intergovernmental Panel on Climate Change (IPCC) are presented in a likely range[2] to cover the probability of the outcome. With consideration of acceptable risks, median[3]/mean values are usually adopted for the design of adaptation measures in Hong Kong. Similarly, median/mean values from other climate related studies such as frequency analysis for extreme sea level are usually adopted for adaptation design. For critical infrastructure, higher design values could be considered taking into account the risk tolerance level and technical feasibility. It should be noted that uncertainties exist in all analyses and, together with effects due to the stochastic nature of weather, there is always a chance that the true value will fall beyond the design value. In this connection, resilience measures and emergency preparedness become important tools to handle residual flood risks.

3.5 Interim or Quick-win Solutions

For controlling and reducing flood risks in areas where long-term drainage infrastructure works are yet to be implemented, resilience measures can be adopted as interim or quick-win solutions.

4. RESILIENCE MEASURES

As discussed in Sections 2 and 3, resilience measures can be an alternative to replace or supplement adaptation measures. Most of these measures are generally at lower cost and easy to install/implement.

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[2] The probability for the likely range to cover the outcome is at least 66%.

[3] In a given core emissions scenario and time horizon, the probability of mean sea level rise being higher than the median (i.e. 50th percentile) of mean sea level rise projection is 50%.

4.1 Key Design Considerations

As mentioned in Section 2, adaptation should have higher priority over resilience in drainage design. When resilience measures are required, designers should take into account the following design considerations:

(a) Designers should conduct flood risk assessment to identify the flood extent, flood depth, flood duration, rate of rise of floodwater, etc., before selecting appropriate resilience measures.

(b) According to the Hong Kong Observatory, given the stochastic nature of weather, localised heavy rain can be extremely difficult to forecast well ahead. For those fast developing and localised heavy rain events, time allowed for setting up resilience measures may not be sufficient due to the relatively short notification. Automatic resilience measures or measures that required no setup such as elevating platform should be adopted as far as practicable.

(c) The forecast for tropical cyclones and related storm surges is relatively more predictable than heavy rain, allowing a longer notification time in general. To reduce flood risks due to storm surge, designers may consider including storm surge alert from the Hong Kong Observatory by setting the threshold sea level as the triggering criterion for implementation of resilience measures and related emergency plan. Designers should make reference to the recorded maximum sea levels attained at different tide stations as shown on **Annex I** in designing the resilience measures.

(d) Other factors for the selection of appropriate resilience measures include site conditions, manpower required for operation, pre-requisites for deployment, setup costs, maintenance costs, etc.

(e) When designing resilience measures for protecting populated premises, emergency access should be considered such that the flood barriers would not hinder rescue operations or evacuation procedures. Suitable supporting facilities such as temporary access at higher levels should be considered. Where possible, alternative exit routes should be provided for escape in case of emergency.

(f) Resilience measures including double or several lines of defence should be provided for flood sensitive underground facilities such as car parks, tunnels, subways, railways, etc.. As there is always a chance that the resilience measures may be destroyed by floating objects or not effective in protecting the facilities by whatsoever reasons, double or several lines of defence would minimize influx of floodwater and reduce the damage/risk to a minimum level.

(g) Even after various resilience measures have been implemented, water seepage or minor leakage can still happen. To ensure the proper functioning of resilience measures, sump pits and pumps with discharge points above the anticipated flood levels can be provided to pump floodwater out.

(h) When designing for critical infrastructure (e.g. stormwater / sewage pumping stations, sewage treatment works, effluent polishing plants, etc.), designers should check whether the infrastructure is situated in a flood-prone area. If it is, a higher design formation level above the anticipated flood level or suitable resilience measures should be provided, to protect the infrastructure itself or those essential equipment from being damaged.

4.2 Some Typical Resilience Measures

4.2.1 Wet Floodproofing

Wet floodproofing refers to measures that allow the flow of floodwater while minimizing damage to flood sensitive components. Examples of these measures include making provisions in building layout, adopting water resistant materials, and placing flood sensitive components in locations free from flooding. Little human intervention is required before or during the floods.

4.2.1.1 Elevated Platform

Elevated platform is an effective measure to prevent floodwater entering into building or facility located in low-lying or coastal area as well as underground facility. During the design stage of new building/facility, designers should assess the potential overland flow path and flood depth and consider to raise the entire building/facility at higher level or raise all entrances with steps and/or ramps so that floodwater cannot enter. This approach can save cost and manpower required for setting up dry floodproofing measures such as demountable flood barrier described in Section 4.2.2.

Figure 1 Elevated Entrance for an Underground Facility in Hong Kong

4.2.1.2 Protection for E&M Equipment

Where entire building/facility or its entrances cannot be elevated to a location free from flooding, essential or flood sensitive equipment (usually electrical and mechanical (E&M) equipment) within the facility can be elevated to minimize the risks of flooding and seawater inundation. Floodwater can damage nearly all electrical components except those designed for submerged purpose. Seawater intrusion is especially damaging due to the corrosive effects of seawater on E&M components.

Figure 2 E&M Equipment on an Elevated Platform

While the loss of essential equipment due to flooding (together with the cost and time required for replacement or repair work) is likely to be high, cost-benefit analysis and life-cycle cost analysis may be necessary to justify the higher capital investment of elevating the equipment. In determining the elevation height of these essential equipment, where a more stringent design is desirable, designers can make reference to the extreme sea levels as shown in Appendix 1 of the Corrigendum. Higher projection values under climate change (e.g. possible worse climate scenario, higher end of likely range instead of median/mean value of sea level rise projection) can also be considered.

Apart from elevating the essential equipment, designers should allowing sufficient area, access, space, headroom, etc. in the building/facility for maintenance activities, for example sufficient lifting clearance should be provided to facilitate future replacement or upgrading of the equipment. Additional entrances at higher level should be provided to facilitate access even when the surroundings are flooded and access to these entrances should also be provided. Proper internal drainage such as floor drains and emergency pumping should be provided within the facility to maintain a dry and safe work environment.

4.2.2 Dry Floodproofing

Dry floodproofing is a common measure to block floodwater intrusion into a building/facility or basement area by installing temporary or permanent flood barriers at entrances, access points or openings such as doors, windows, service openings and smoke vent outlets, etc. Temporary dry floodproofing measure will usually be deployed when high water level is forecast, such as storm surge caused by tropical cyclone, or at the time when flooding is likely to emerge.

Designers should note that the deployment and installation of most temporary dry floodproofing measures can be labour intensive, making them less favourable to protect against flash flood or any circumstance when the notification time of flood alert is short. Designers should provide the maintenance manual specifying the frequency for regular inspection and any maintenance requirements. Designers should also consider tripping hazards in case of emergency evacuation or collapse of any part of the barrier. Sections 4.2.2.1 to 4.2.2.7 below discuss some of the dry floodproofing measures. Specifications for flood resistance products can be referred to BS 851188-1:2019 and BS 851188-2:2019.

4.2.2.1 Demountable Flood Barrier

Demountable flood barrier can be installed manually in front of the entrances of building, carpark and village house to prevent floodwater intrusion, and in open spaces to contain floodwater within the area. This type of barrier is widely used in Hong Kong to minimize flooding impact. For example, demountable flood barriers were installed at various flood-prone locations including entrances of village houses in Tai O, gaps between village houses in Lei Yue Mun, and gaps between flood walls along Tai Po River / Lam Tsuen River to minimize flooding due to storm surges / overtopping waves.

Figure 3 Demountable Flood Barriers in Tai O

Figure 4 Demountable Flood Barriers in Lei Yue Mun

Figure 5 Demountable Flood Barriers along Tai Po River and Lam Tsuen River

Demountable flood barrier can withstand relatively high water level. It is easy to transport and can be tailor-made to fit the size of opening and does not require extensive maintenance. Compared to engineered flood wall, demountable flood barrier has the advantage of being detachable while not in use, minimizing physical obstruction and visual impacts during normal weather conditions. Figure 6 shows an example of demountable flood barrier mounted on an existing floodwall in Tai O which can be stored in planters and seating areas adjacent to the flood wall when not in use.

Figure 6 Demountable Flood Barrier Mounted on an Existing Floodwall

When selecting demountable flood barrier, designers should consult the end-users and consider other site-specific factors for installation. For example, the barrier should be light enough for workers / villagers to install, easy to transport during inclement weather, durable in design. In addition, the ground surface for installing the barrier should be flat to avoid seepage. Depending on the design of the demountable flood barrier, installation of anchor sockets / pre-formed ground plates for demountable supports may be required for slot-in flood barriers. Depending on the size and length of demountable flood barrier, sufficient manpower and lead time for installation should be allowed. Designers should prepare a comprehensive plan with pre-set installation trigger point(s) and action plan for agreement by the operator or maintenance party. Regular drills are also required to ensure workers are familiar with the operation.

4.2.2.2 Self-rising Flood Barrier

Self-rising flood barrier is an automatic type barrier that does not require manual operation. The barrier is installed vertically underground in a steel or concrete trench. Floodwater will flow into the trench through an inlet pipe when water level reaches a predetermined height and the barrier will float and rise above ground. Figure 7 displays the operation mechanism of the self-rising flood barrier. When floodwater recedes, the barrier will lower to its resting position.

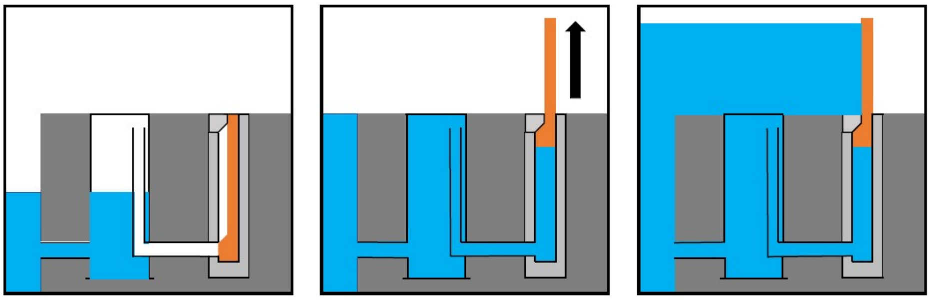

Figure 7 Schematic Diagram for Self-rising Flood Barrier

Self-rising flood barrier is ideal for unmanned site or location where footprint for the barrier is limited. Lead time and manpower for deployment and operation of the barrier is not required and storage area for the barrier is also not required. However, the construction and maintenance costs are relatively high, especially regular checking for blockage of the inlet pipes is necessary. Designers need to consider having alarm system to alert the public before the flood barrier starts operation.

4.2.2.3 Flip-up Flood Barrier

Flip-up flood barrier lays flat on ground when not in use and will be flipped up to form a vertical barrier. It can be operated manually or triggered automatically by power switch when water level or rainfall recorded by the water-level sensor or rain gauge reaches a per-determined threshold.

Flip-up flood barrier is suitable for location such as pedestrian and vehicle entrance where unrestricted access is required during normal weather condition. However, similar to self-rising flood barrier, both the construction and maintenance costs are relatively high. Considerations should be given to the provision of back-up power supplies and alarm systems for alerting the public to before the flood barrier starts operation. Designers should pay attention to the surface finish of the barrier since it form part of the ground surface, and skid resistance may be an important consideration.

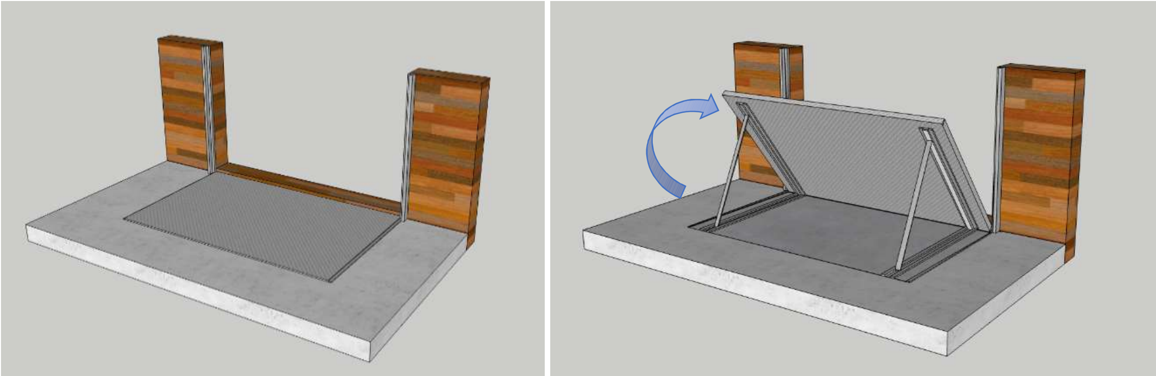

Figure 8 Schematic Diagram for Flip-up Flood Barrier

Figure 9 Flip-up Flood Barrier at Tottenham Court Road Station, London

4.2.2.4 Swing Gate

Similar to flip-up flood barrier, swing gate can be installed at the access entrance or opening of permanent river wall. Under normal conditions, the gate can be opened and allow access for pedestrians or vehicles.

Manpower required for operating the gate is minimal and maintenance requirements are low. A demountable centre support can be installed so that a pair of swing gates can be provided at larger entrance or opening. However, pre-installation is required and depending on the design, footing of the frame of the swing gate may form an obstruction for barrier free access.

Figure 10 Swing Gate at South Ferry Subway Station, New York

Figure 11 Swing Gate in Hull, United Kingdom

4.2.2.5 Rolling Gate

Similar to swing gate, rolling gate can close an entrance quickly with minimal operational effort. Rolling gate can make efficient use of space and is suitable for location where 'swing area' cannot be provided. Compared to other types of flood barrier and swing gate, rolling gate is more suitable for large opening such as entrance for vehicular access. Rolling gate is easy to operate. However, the drawback of rolling gate is a relatively high construction and maintenance costs.

Rolling gate can be equipped with drive motor to minimize operation effort and manpower. The drive motor can also be linked with water-level sensor or rain gauge to become fully automated, thereby shortening the lead time required for deployment. Similar to other automated measures, designers should also consider having alarm system to alert the public before it starts operation. .

Figure 12 Rolling Gate in Kanazawa, Japan

4.2.2.6 Water/Air Filled Tube Barrier

Water/air filled tube barrier is flexible resilience measures that provides protection against flooding by forming a strong and stable cylindrical tube in front of the area requiring protection. It can be connected together to form a long line of defence. When the flood threat passes, water and air inside the barrier can be drained and released, and the barrier can be stored for use in the next event.

Cost of water/air filled tube barrier is low. The tube barrier is made of lightweight material which is easy to install, especially flexible for installing at curve area and corner, and can be rolled or folded compactly for storage. However, this type of barrier is not suitable for use on sloped surface and is vulnerable to damage by sharp objects. For water filled tube barrier, water source needs to be identified in the vicinity of the deployment location. The barrier should not be stored under sunlight to prevent aging of the material.

Figure 13 Air Filled Tube Barrier

4.2.2.7 Portable Flood Barrier

Portable flood barrier can be deployed to enclose opening, access entrance or manhole opening. As well as traditional sandbags, portable flood barrier is widely used in emergency situations that require rapid response.

Depending on the design, portable flood barrier is usually low in cost, maintenance free, lightweight, and easy to assemble to form a flood defence line. Pre-installation for parts / connections are not required. Manpower and time required for installation depend on the length of the defence line. With the advantages of easy installation and transportation by vehicle, portable flood barrier can be deployed to any location where temporary and emergency flood protection is required. It can also be used for diverting floodwater to an alternative pathway. However, durability and ability to withstand impact from floating objects would depend on the design and materials used for individual flood barrier product.

Figure 14 Portable Flood Barrier

4.2.3 Combined Wet and Dry Floodproofing

To form double defence or several lines of defence for flood sensitive premises, wet and dry floodproofing measures can be implemented concurrently. For example, while flood gate can be installed at entrance and all opening are located above the anticipated flood level as far as possible, those opening at level lower than the anticipated flood level should either be plugged or installed with demountable barrier or similar device. Sump pump can be installed to automatically pump out flood water in case of seepage from flood gate or barrier happens. Essential equipment can be elevated to provide extra protection and water resistant materials or water resistant protection boxes can be provided for items not being elevated. To determine the importance of the essential equipment or priority for implementing resilience measures, designers can rank the essential equipment according to the cost of replacement, criticality to system operation and readiness for mitigation.

Figure 15 Flood Sensor and Remote Monitoring Unit

Figure 16 Weatherproof Enclosure for Electrical Installation

5. EMERGENCY PREPAREDNESS

The objective of emergency preparedness is to minimize potential threats to communities and/or major infrastructure located in flood-prone areas, where there is a risk to life and damage due to flooding incidents during severe weather events.

5.1 Emergency Plan

The emergency preparedness should include the establishment of an emergency plan to specify the personnel, materials and plant and tools required for flood combating measures, as well as the actions required before, during and after severe weather events which may cause flooding. The plan should also include trigger levels for relevant actions/plan and activation time so that flooding impacts can be mitigated and essential public services can be sustained at a minimum level or resumed as quickly as practical.

Resilience measures discussed in Section 4.2.2 can form part of the emergency plan to protect areas prone to flooding where there are risks to life and damage. However, if the situation deteriorates and the flooding situation becomes worse than expected, access prohibition and evacuation should be conducted to minimize casualties. Evacuation routes and shelter places should be planned in advance.

The emergency plan should also facilitate the recovery of facilities. Damage to electrical system by floodwater may cause fire and electrocution hazards which would delay reoccupation of the facility. Hence, the emergency plan should clearly indicate whether electrical system(s) need to be shut down when isolation from floodwater is not feasible.

5.2 Flood Monitoring

Water level sensor can be installed to provide real-time monitoring of the flood level at location of concern. The recorded water levels can also be used as triggers for implementation of relevant actions/plan in the emergency plan. Closed-circuit television (CCTV) can be installed for real-time monitoring of the flooding situation. The information gathered can be used to make decision before the flooding becomes worse, to review the effectiveness of the emergency plan and to conduct post event analysis as necessary.

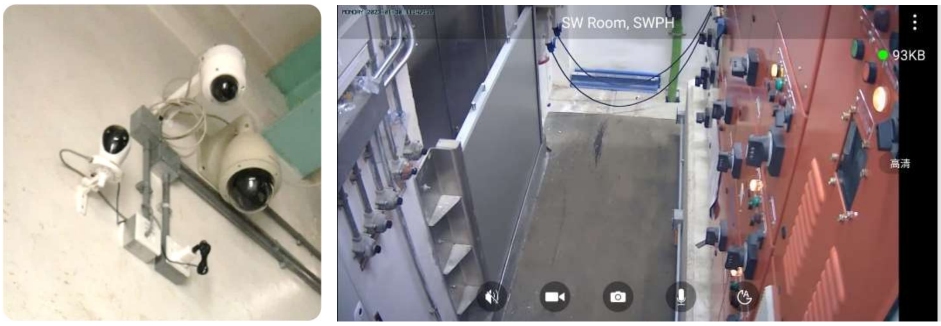

Figure 17 CCTV for Remote Monitoring

5.3 Emergency Drills

Regular emergency drills aim to enhance the preparedness of all personnel involved in the emergency plan and familiarise them with the emergency plan including the evacuation routes, the shelter places, ensuring the availability of essential plant and tools and the promoting the knowledge of appropriate actions during severe weather events. These drills can also help to test the adequacy, efficiency and effectiveness of the emergency plan. To achieve these objectives, the frequency and scale of drills should be clearly specified in the emergency plan. Typically, emergency drills should be conducted before the onset of rain and tropical cyclone seasons. Public should preferably be involved in order to enhance their awareness of potential hazards and the importance of flood protection measures.

Figure 18 Annual Emergency Drill at Tai O

5.4 Sandbags

Sandbags are the most common form of flood barrier available and are widely used in emergencies. They can be deployed to designated location manually before extreme weather event, and moved back to storage area after use.

Sandbags are cheap, easy to transport, readily available, and fit for various topographies and site conditions. No special skills are required for installation. However, they are not suitable for protecting area where flood level may be high or on sloped surface.

For low-lying areas with scatter development in Hong Kong, sandbags can be considered if site conditions are not suitable for other resilience measures or installation of other measures is not cost effective. Sandbags can also be used to strengthen the floodproofing ability of other resilience measures such as demountable flood barrier on uneven ground surface.

As an alternative, similar products are available which use absorbent materials instead of sand. These products are lighter and more portable than traditional sandbags, and allow for rapid deployment in emergency situations. The materials can absorb floodwater and expand as they do so, fitting closely into doorways to keep floodwater out. However, they are not reusable and have limited shelf-lives.

Figure 19 Demountable Flood Barriers with Sandbags

6. WORKING PROCEDURE

Under Sections 6.8 and 6.9 of the Corrigendum, a combination of structural measures and resilience measures / emergency preparedness to fulfil design requirements or as mitigation measures under critical circumstances is allowed.

When resilience measures / emergency preparedness is necessary to form part of the flood protection scheme, designers should demonstrate the necessity of resilience measures in lieu of structural measures, and provide details of the proposed resilience measures and relevant emergency plan during the stage of Drainage Impact Assessment (DIA). Reference to ETWB TC(W) No. 2/2006 for public sector projects and DSD Advice Note No. 1 for private sector projects can be made for DIA process.

Project proponents shall identify the agents for management, maintenance and operation of the resilience measures and implementation of the emergency plan. The project proponents shall advise the provision of necessary resources and allow adequate recurrent consequences for the operation and maintenance of the resilience measures and the emergency plan. The choice of resilience measures and implementation of the emergency plan shall be agreed with the identified agents and supported by the Project Steering Group of the project.

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Annex I Records for Maximum Sea Level and Maximum Storm Surge during Passage of Tropical Cyclones

This Annex summarized the maximum sea level and maximum storm surge attained at different tide stations for the top 3 tropical cyclones with highest sea level at Quarry Bay/North Point tide station recorded by the Hong Kong Observatory since 1954.

Typhoon Wanda (Sep 1962)

Station	Maximum Sea Level (above chart datum) [mCD]	Maximum Storm Surge (above astronomical tide) [m]
North Point	3.96	1.77
Tai Po Kau	5.03	3.20

Super Typhoon Mangkhut (Sep 2018)

Station	Maximum Sea Level (above chart datum) [mCD]	Maximum Storm Surge (above astronomical tide) [m]
Quarry Bay	3.88	2.35
Shek Pik	3.89	2.34
Tai Po Kau	4.71	3.40
Tsim Bei Tsui	4.18	2.58

Super Typhoon Hato (Aug 2017)

Station	Maximum Sea Level (above chart datum) [mCD]	Maximum Storm Surge (above astronomical tide) [m]
Quarry Bay	3.57	1.18
Shek Pik	3.91	1.54
Tai Po Kau	4.09	1.65
Tsim Bei Tsui	4.56	2.42