IEM

The Institution of Engineers, Malaysia

IEM GUIDELINE ON

FLOOD ABATEMENT EQUIPMENT

Engineering Guide of Designation, Testing and Documentation

FIRST EDITION, DECEMBER 2021

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Content

Foreword by President Ir. Ong Ching Loon

Floods, including flash floods, are one of the deadliest and most damaging form of natural disasters we face in this part of the world. They can be triggered by monsoons, heavy rain, overflowing rivers, or even clogged drainages. Moreover, as floods tend to strike without warning, agencies as well as the residents should be well-prepared to respond within short notice.

Buildings in the flood-prone areas are required to install necessary flood abatement equipment based on the Flood Risk Assessments (FRA). To ensure that every piece of the puzzle functions as intended, the testing and commissioning of these equipment must be carried out diligently. Any weakness in the system might result in the building being overwhelmed by storm water, and that is certainly not what we hope for after investing heavily in flood abatement equipment.

In view of this, the importance of a Guideline on these measures cannot be over-emphasised. One of my aspirations for IEM is to compile the immense knowledge and expertise of our talented members in all the engineering disciplines for publication as guidelines or handbooks of IEM for adoption by the engineering industry not just in Malaysia but internationally. I wish to congratulate the Chairman of the Disaster Risk Reduction Advisory Board (DRRAB) of IEM, Ir. Loo Chee Kin, as well as all committee members for contributing towards the informative & successful publication of this Guideline. We would also like to extend our heartfelt gratitude to the regulators such as the Department of Irrigation and Drainage (JPS), Department of Occupational Safety and Health (DOSH), National Disasters Management Agency (NADMA), National Hydraulics Research Institute of Malaysia (NAHRIM), as well as municipalities such as the Penang Island City Council (MBPP) as we would not be able to achieve this without the valuable input from all of you.

With proper procedures established, engineers and all the other technical professionals will be able to enhance the efficiency of the flood abatement equipment. By adopting the Guidelines that are in line with the world's best practices, we shall be able to minimise casualty and damage to properties in the unfortunate event of floods. It is my sincere hope that this guideline will be beneficiary to all.

Thank you.

Preface

This Guideline was initiated by IEM as to fulfil an immediate need in the industry. A Guideline may be considered for further development as a Standard or constitute part of the input into the development of a national standard.

This Guideline was developed through consensus by committees which comprise balanced representation of authorities, manufacturers, users, consumer groups and others interested stakeholders. To the greatest extent possible, this Guideline is aligned to Malaysian Standards or adaptation of international standards.

This Guideline is published by IEM which retains its ownership and copyright. IEM reserves the right to withdraw or amend this Guideline on receipt of authoritative advice that it is appropriate to do so.

The use of this Guideline is voluntary except in so far as they are made mandatory by regulatory authorities by means of regulations, local by-laws or any other similar ways. Compliance with this Guideline does not of itself confer immunity from legal obligations.

The expected benefit of the Guideline for the following key groups would be:

- Engineers
    - Knowing the equipment has met a standardised performance specification and has been certified by test
.
    - Potential to selected optional testing when situation warrants.
- End users
    - There is known performance of the equipment and rigorously testing in the equipment certification.
    - Comfort the equipment had been designed and installed to a specific standard.
    - The equipment comes with complete manual and instructions. There will be established deployment time and prescribe maintenance.
    - The needed resources for deployment are known and can be written into the flood emergency response plan.

- Contractor
  - There is established and uniform performance criteria for the equipment.
  - Potentially eliminate the need for individual design review or making factory acceptance test.
  - Manufacturer would provide the needed documentations for site preparation and installation.
- Manufacturer
  - The manufacturer's designer can engineer the equipment to the requirements in this Guideline and select materials to meet the stipulated performance.
  - There are uniform testing perimeters and it could lead to a certification program.
- Authority and Insurance
  - The equipment has met a set of specific performance and certified criteria.

Committee representation

Acknowledgement is given to the following organizations that were involved in the development of this Guideline:

The Institution of Engineers Malaysia (IEM)
Agensi Pengurusan Bencana Negara (NADMA)
Department of Irrigation and Drainage (DID or JPS)
Department of Occupational Safety and Health (DOSH)
Enovate PLT
Ground Data Solutions Sdn Bhd
Majlis Bandaraya Pulau Pinang (MBPP)
National Hydraulic Research Institute of Malaysia (NAHRIM)
Persatuan Insurans Am Malaysia (PIAM)
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IEM Disaster Risk Reduction Advisory Board (DRRAB)
IEM Mechanical Engineering Technical Division (METD)

0. Introduction

Flood occurrences would seem like a common phenomenon in Malaysia. Various engineering measures had been made to mitigate flood. When a building is located in a flood prone area, additional measures have to be taken to keep the water out.

In any building, the engineered flood solutions could have limitation and other challenges. This is because a building would have openings for people, vehicles and utilities. At times, these could lead into below ground levels, such as basement, tunnels or underpasses, where the water could flow into and then pool. The water pool could get deep if the water flowing in is not stopped. The pooled water will damage the mechanical and electrical utilities, parked cars or cut-off connections within the building. This will shut down the building operations, devalue the property, cause property damage, economic loss, injury and loss of life.

It is intended that this Guideline will form the basis of a product conformity certification scheme, to provide assurance to potential users or specifiers of flood protection products that these have been tested and verified by a third party.

1. Scope

This Guideline specifies the requirements for general designation, testing, documentation for the installation, operation and maintenance, and marking for the flood abatement equipment. The flood abatement equipment is intended for basement spaces such as carpark, below grade utility spaces, tunnels, underpasses or similar below ground level spaces. This would include flood abatement equipment which could be used for parameter flood protection for a building or group of buildings. The flooding could be from a body of water (such as river, drain, lake, sea, etc.) or rainfall related flood conditions.

This guideline is intended to be used to evaluate the components and performance of flood abatement equipment. This Guideline sets the performance requirements for flood abatement equipment. This Guideline is not intended to restrict new developments in design and materials.

Exclusions, this standard does not cover the structure where this flood abatement equipment could be installed or mounted to. Flood waters will produce high hydrostatic or flood dynamic loading on a structure, hence the engineer or designer should take appropriate engineering measures and ensure that the structure or attached building element as well as the foundation can withstand anticipated flood loading. As necessary, strengthening should be considered before or during the installation of the flood abatement equipment.

The flood abatement equipment described are not intended for permanent installation, and attention is drawn to the need to ensure a free passage to persons in the event of an emergency. The equipment should only be installed or deployed in the event of an imminent flood and should be removed, stowed or folded away as soon as danger from flooding is over.

2. Normative references

The following normative references are indispensable for the application of this standard.

Planning Standards and Guidelines: Multi-storey Car Parks, Department of Town and Country Planning (Peninsular Malaysia), Planning Guidelines JPBD 7/2003.

Guideline on Flood Prevention for Basement Carpark, Department of Irrigation and Drainage (DID), September 2006.

Hydrological Procedure No 1, Estimation of the Design Rainstorm in Peninsular Malaysia, Department of Irrigation and Drainage (DID), 2015.

PAS 1188 - 4: 2009 Flood protection products - Specification Part 4: Demountable products, BSI British Standards - Publicly Available Specification.

ANSI/FM Approvals 2510 - 2014, American National Standard for Flood Abatement Equipment.

MS ISO 9227: 1996 - Corrosion tests in artificial atmosphere.

MS ISO 37: 2015 Rubber, vulcanized or thermoplastic - Determination of the tensile stress-strain properties.

MS ISO 815-1: 2009 Rubber, vulcanized or thermoplastic - Determination of compression set - Part 1: At ambient or elevated temperatures.

PAS 1188 - 1: 2014 Flood protection products - Specification Part 1: Building aperture products.

PAS 1188 - 2: 2014 Flood protection products - Specification Part 2: Temporary products

PAS 1188 - 3: 2014 Flood protection products - Specification Part 3: Building skirt systems

MS 2426: 2011 Planning and designing for basement parking - Code of practice

3. Terms and definitions

For the purposes of this Guideline, the following terms and definitions apply.

Annual Return Interval (ARI) - The average elapsed time in years between floods of a given size occurring. Also known as return period, recurrence interval or repeat interval. See Annex D for further explanation.

Automatic Flood Equipment - An installed in-place equipment that will automatically deploys without the need of human interaction when flood conditions are detected. Types of equipment are active equipment by electrical, pneumatic or hydraulic activated by water sensors.

Basement - Storey entirely below the ground level.

Basement Parking - The parking space that operates below the ground level.

Certified Height - The tested height, as in the test specimen. The equipment should have the manufacturer's specified maximum water depth. It is the height above the base on which the flood protection equipment is installed and for which the flood protection equipment is intended to physically retain water.

Climate Change Factor (CFF) - Climatic projection and calculation due to climate change by the possible increase in inter-annual and intra-seasonal variability with increased hydrologic extremes. The probability of increase in rainfall would lead to a raise in river flow and return for extreme precipitation events and hence the possibility of more frequent floods.

Computed Flood Level (CFL) - The calculated flood water level for Flood Risk Assessment (FRA) base on hydrologic computation for the required Annual Return Interval (ARI).

Deflection - The measure horizontal distance a test specimen moves from its original location during or after a test.

Deployment Time - The amount of time required to remove the equipment from storage (if applicated) till it is completely deployed or operating an automatic flood equipment.

Dry-Side - The side of the test rig protected by the flood equipment. In actual installation, the side protected from the flood waters.

Emergency Flood Equipment - Any mobile equipment that can be transported and then fitted or installed in place in a relatively short period during a flood event.

Factory Production Control - Internal control of production exercised either by the manufacturer or by their representative on the responsibility of the manufacturer.

Flood Abatement Pump - Pump used for the removal of unwanted water from the protected area.

Flood Proofing Elevation (FPE) - The calculated level to apply a flood abatement equipment and waterproofing level for an ARI event. Meaning the level protect against the damaging effects of floods. The FPE is the Computed Flood Level (CFL) plus freeboard.

Flood Protection Equipment - Equipment used to limit or restrict the flow of water, which when installed, forms part or all of the flood protection system.

Flood Protection Strategy - A strategy with engineered system that aims to reduce the risks of flooding to people and property.

Flood Risk Assessment (FRA) - A study of the chance of experiencing a flood, expressed in terms of a return period.

Freeboard - A safety factor above the Computed Flood Level (CFL). See Annex E for details.

Hydrologic Computation - Calculation of the rainfall and runoff process and relates to the derivation of hydrograph for given floods.

Leakage Rate - The rate at which water passing through, at the end of any intersection or between the flood protection equipment and the floor.

Manual Flood Equipment - An equipment that requires human intervention to put in place in the desired manner.

Overtopping - Water flowing over the top of a flood equipment.

Wet-Side - The side of the test rig that is imposes the test water. This would refer to the flood water side in an installed flood abatement equipment.

4. Testing

The Guideline stipulate mandatory tests, component required tests and optional tests for the flood abatement equipment. These test conditions represent typical conditions that may be experienced during a flood. These tests include testing the equipment on a concrete base for leakage and observed equipment deformation or failure.

The equipment manufacturer shall prepare a test specimen identical to the production equipment for testing. Prior to the test, the specimen and its manual shall be assessed for usability prior to testing. Where the content of the equipment guide/user manual is unclear or the instructions cannot be physically implemented, clarification shall be provided by the manufacturer and the equipment manual updated for clarity.

4.1 Required mandatory test

The flood abatement equipment should be tested for hydrostatic leakage test, wave leakage test and current leakage test. These are mandatory test for all flood abatement equipment.

Before a test is undertaken, the test specimen shall be installed in accordance with the manufacturer’s instructions. For a system that requires part-installation, the permanent sections shall have been correctly installed in accordance with the manufacturer’s instructions and recommendations.

The test specimen shall be tested full scale and shall include intermediate joints and internal and external corners, where these are a part of the flood protection equipment design.

4.1.1 Hydrostatic leakage test

The equipment shall be capable of withstanding the hydrostatic loads created by floodwaters of various heights. The leakage rate shall not exceed not exceed 1.0 litres per hour per metre length of equipment, measured along its base where it forms the seal. The measured deflection of the test specimen shall be not more than 150 mm for any point on the test specimen from the initial setup.

Fill the wet-side of the test specimen to 33% x h ± 10 mm, where h is the manufacturer specified maximum water depth for the equipment and maintain the water level for a minimum of 1 hour. Continue the test at 66% x h ± 10 mm, and maintain the water level for a minimum of 1 hour. And then at 100% x h ± 10 mm, hold the level for a minimum of 18 hours. The water should be topped up during the test, so as to maintain the test water level.

Measure the leakage rate over 15 minute intervals until the leakage rate has either stopped or stabilized.

4.1.2 Wave leakage test

The equipment shall be capable of withstanding wave-induced hydrodynamic load conditions from various water depths and wave heights. The measured deflection of the test specimen shall be not more than 150 mm for any point on the test specimen from the initial setup.

The leakage rate shall not exceed not exceed 3.0 litres per hour per metre length of equipment measured along its base where it forms the seal, in low wave testing condition. No leakage rate measurement would be required in medium and high wave testing conditions.

The wave leakage test shall consist of six tests and shall be conducted on the same test specimen. This test shall consist of three different size wave heights (low, medium, and high) at the two following two still water depths:

- 66% of height
- 80% of height

Impact the test specimen with waves generated perpendicular to the face of the specimen with waves of the following height and duration:

- Low Waves, 50 to 75 mm wave height at 2 seconds wave period. The test duration shall be at least 30 min. Leakage and deflection to be measured and recorded.
- Medium Waves, 150 to 200 mm wave height at 2 seconds wave period. The test duration shall be at least 10 min. Deflection to be measured and recorded.
- High Waves, 250 to 300 mm wave height at 2 seconds wave period. The test duration shall be at least 10 min. Deflection to be measured and recorded.

4.1.3 Current leakage test

The equipment shall be capable of withstanding water hydrodynamic load conditions from a swift flowing water. The leakage rate shall not exceed not exceed 3.0 litres per hour per metre length of equipment measured along its base where it forms the seal. The measured deflection of the test specimen shall be not more than 150 mm for any point on the test specimen from the initial setup.

The testing shall be conducted at a water height of 66% x h ± 10 mm, where h is the manufacturer's specified maximum water depth of the equipment. The water flow current shall be applied parallel to the face of the test specimen. The water velocity may be slowly increased to 2.0 m/s and then shall be maintained steady for 1 hour.

A minimum channel width of 300 mm should be created for the water flow. The water flow velocity shall be measured at half the water depth and about 150 mm from the front face of the test specimen, and the horizontal midpoint of the section of equipment exposed to the current. Measure the leakage rate for the duration of the test at intervals no greater than 15 minutes.

4.1.4 Test facility and rig

Test facility shall be capable of accommodating the test specimen and the test rig shall be able to create the water level, wave and current as stipulated by this Guideline.

The test rig shall be capable of generating currents of 2.0 m/s ± 0.2 m/s parallel to face of the test specimen. The wave height should be 50 to 300 mm and mean wave period of 2.0 s ± 0.5 s perpendicular to the face of the test specimen.

The apparatus to measure static water levels, water surface elevations (from which wave height is calculated) and current velocities should be accurate to 1 mm, 1 mm and 0.1 m/s respectively. The apparatus to measure leakage rate over the time periods specified to a tolerance of ±5% or 0.5 litres, whichever is the greater. The apparatus to measure any horizontal movement of the test specimen that occurs between the start and end of the test shall have a tolerance of ±2 mm. The measuring apparatus in the test rig should be with a current valid calibration.

Water used in the test rig should be recycled or recirculated. The pumping system should be such that the water temperature rise should not exceed 45°C.

4.2 Component required

These tests are required based on the material used on the equipment. These tests are to assess the durability and reliability of the equipment. The test in this section should be applied as applicable to the material and component on the equipment, which are; hydrostatic test strength for pressure retaining components, cycling durability, salt spray, tensile strength, accelerated aging and compression set tests.

The specific component test need not be performed or repeated, if the material used on the equipment has the relevant test certification. The component material test should be for the same material, from the same manufacturer and tested to the same standard. If the standard is different, it should be sighted in the standard as equivalent standard.

4.2.1 Hydrostatic test strength for pressure operating components

Any hydraulic or pneumatic system in the components or sub-assemblies (example pipes, accumulators, receiver tanks, pistons, hoses, etc.) in the equipment shall be subjected to a test pressure of 150% of the maximum system operating pressure, for one hour. The hydraulic or pneumatic system should be tested as a completed system. The test medium shall be the fluid used in the final installation.

4.2.2 Cycling durability test

If the equipment has moving parts, then this test shall apply. This test shall be performed for automatic or semi-automatic operated equipment. This test would not apply for equipment that would be installed manually. The test should be performed on equipment which would be folded or stowed (example by hinge, rollers, etc.) manually.

The test specimen shall be cycled 500 times through its operational position, from its fully open to close and close to open positions. After the cycle testing, the components shall be visually inspected for any signs of excessive wear, misalignment or damage which would compromise proper operation.

Lubrication, adjustment or such, during the cycle testing is permitted, provided the need to do so is described in the equipment manual.

Where the flood abatement equipment is designed for automatic operation, there shall be means to allow manual human intervention for its operation and full deployment. This manual deployment shall be cycled tested for 20 times.

4.2.3 Salt spray test

The equipment and components with more than one type of metal shall not deteriorate due to galvanic corrosion. The salt spray test shall be for at least 168 hours and should performed to MS ISO 9227: 1996 - Corrosion tests in artificial atmosphere.

4.2.4 Tensile strength and accelerated aging test

This shall apply to components on the equipment which has components made from rubber, elastomer or plastic. The tensile strength should be to MS ISO 37: 2015 Rubber, vulcanized or thermoplastic - Determination of the tensile stress-strain properties.

For the accelerated aging test, the component shall be subjected to an air-oven aging test for at least 14 days at 70°C, and then tested to MS ISO 37: 2015.

4.2.5 Compression set test

This test shall apply to components on equipment which has components made from rubber, elastomer or plastic. The compression set test should be to MS ISO 815-1: 2009 Rubber, vulcanized or thermoplastic - Determination of compression set - Part 1: At ambient or elevated temperatures.

4.3 Optional test

These are optional test for selected equipment. These tests should be performed for equipment under one or more of the following conditions:

- Equipment higher than 1.0 m.
- Perimeter flood protection.
- Coastal or riverine use.
- When subjected to external loading.

The optional test in this section are overtopping, debris impact and outside load condition.

4.3.1 Overtopping

The equipment shall not float, overturn or have a catastrophic failure if the water level exceeds the height of the equipment. The measured deflection of the test specimen shall be not more than 150 mm for any point on the test specimen from the initial setup.

Fill the wet-side of the test specimen until the water level equals 100% of structure height plus an overflowing water cascade of at least 25 mm ± 10 mm on the crest. Maintain the water level for one hour.

4.3.2 Debris impact

The equipment shall be capable of withstanding multiple impacts from floating debris.

There are two options for this test. The manufacturer may elect which testing would perform for the equipment.

4.3.2.1 Debris Impact A - Dynamic Impact

The equipment shall be capable of withstanding impacts of 600J from a rigid falling object simulating floating debris. The max permanent deflection from the impacts shall be not more than 25 mm and any permanent dents at the point of impact shall not impair the functionality of the barrier.

The test procedure shall be per ANSI/FM Approvals 2510, Section 4.3.4 Dynamic Impact Load Test. The Hydrostatic Leakage Test shall be repeated on the same test specimen after this Dynamic Impact test.

4.3.2.2 Debris Impact B – Drag log

The equipment shall be subjected to two tests with two different size logs. The measured deflection of the test specimen shall be not more than 150 mm for any point on the test specimen from the initial setup.

The testing shall be conducted at a water height of 66% x h ± 10 mm. Two tests shall be conducted with two different size logs;

- 300 mm diameter log of 275 kg weight
- 430 mm diameter log of 350 kg weight

The cut edges of the logs shall be perpendicular saw-cut with no round edges. The logs will be dragged at 2 m/s at a trajectory angle of about 70° to the test specimen. The pulling action shall be shut-off right before the log impacts the test specimen. The use of other substituting material for the log is permit, so long as the dimension, buoyancy and weight are matched.

4.3.3 Outside load condition

When an equipment could be folded and be load upon (example by vehicle, foot traffic, etc.), then deflection of the equipment and component should be performed. Finite analysis should be performed by industry or academic recognised software.

The vehicle axial loading on the equipment should be declared by the manufacturer but shall be no less that 6-tonnes per axial. If the equipment is high (i.e. wide when folded), then the analysis should be with two or more axials load and rolled on the equipment. The deflection or material failure in the analysis should be with a safety factory of at least 2.0.

The analysis could be like a single span bridge. The analysis meshing should be appropriate and enable meaningful output display. Analysis should be done as static non-linear analysis and under cyclic loading. Cyclic loading should be the application of repeated or fluctuating stresses, strains, or stress intensities to locations on structural components.

4.3.4 Power supply and control for automatic equipment

Where the equipment is to deploy automatically, the power supply shall have adequate reserve. The recommended reserve power should be for at least two months standby followed by three cycles to fully deploy and stow away. The manufacturer shall demonstrate this by battery sizing calculation or pneumatic/hydraulic system reserve tank sizing. If a back-up generator is the power source, then the generator and electrical switching shall inside the flood protected area or be elevated above the flood elevation.

Where the equipment has an automatical flood water monitoring and control system, the water level sensors, controller and actuation systems should be equipped with the necessary self-diagnostics, meaning the system should signal a trouble alarm should a device be missing or is faulty. The control should have backup and standby power supply. Water level data logging should be considered. The controls shall be inside the flood protected area or be elevated above the flood elevation. These shall be in suitable areas or be protected against vandalism.

When the equipment is to be automatically deployed, the equipment shall be equipped with audible sound and visual indications, so as to provide a warning the equipment is closing. If it can pose a pinch hazard, then sensor(s) should be provided to ensure human body parts are away before the equipment can be deployed fully.

5. Flood risk assessment

A qualified building surveyor or engineer should perform a Flood Risk Assessment (FRA). The FRA is required to assess the flooding potential as well as flood depth and flood proofing elevation (FPE) at the entrance/exit point of the basement or below grade spaces with respect to the design flood level at the main drain, river system and rain water collection point. The assessment process would require hydrologic and hydraulic computation to be performed to determine the flood level and FPE at the entrance/exit point of the basement or below grade spaces.

The assessment should be in accordance to Department of Irrigation and Drainage (DID) - 'Guideline on Flood Prevention for Basement Carpark' - September 2006.

Note, the DID guideline is recommending a design for 100-year or 200-year annual recurrence interval (ARI) flood level and with a freeboard. Other stakeholders (such insurance company, local authority or property owner) may stipulate a longer ARI, such as 500-year ARI and a more conservative freeboard.

The equipment height selected shall be higher that the FPE. Climate Change Factor (CFF) should be considered per Hydrological Procedure No 1 entitled 'Estimation of the Design Rainstorm in Peninsular Malaysia' if the protected building is critical or expected to be occupied for many decades.

The FRA shall ensure all relevant routes for water entry have been identified and that the structural integrity of the building is not compromised by the flood abatement equipment. Means to remove water should be considered. See Annex C for further consideration points.

6. Equipment documentation

6.1 Certification of equipment

The tested specimen height shall then form the certified equipment height. The manufacturer may manufacturer equipment with lower height than the tested specimen, provided the material specification and components remain the same as the tested specimen.

The equipment length will be the manufacturer declaration, as long as the equipment support, joints, etc. had followed the spacing and dimensions in the test specimen. If the equipment has any corners, the permitted angles shall be as in the test specimen.

6.2 Deployment time

The deployment time shall be equal to or less than the time listed in the equipment manual. The manual shall state the manpower requirements, total man-hours, tools and other resources (e.g. electrical power outlet, pneumatic air, etc.) to remove the equipment from storage (if applicated) till it is completely deployed. The manual shall detail the steps and precautions for the deployment of the equipment. The deployment time would be measured during the equipment install in the Hydrostatic Leakage Test.

The manual shall state the resources and steps to disassembled or restored the equipment. These procedures would be followed and verified for test specimen after all test are completed.

This deployment and disassemble should documented with a video. This video should be made available during conformity certification as well as to end users.

6.3 Document manual

The flood abatement equipment manual shall, at a minimum, include the following:

a) A statement on the need for a Flood Risk Assessment (FRA) and shall be carried out by a suitably qualified building surveyor or engineer prior to installation of a flood abatement equipment.

b) The certified height and length of the flood abatement equipment.

c) Optional test the flood abatement equipment had been tested and certified shall be clearly stated.

d) A statement of the flood abatement equipment's application including appropriate installation locations and exposures.

e) The manpower requirements, total man-hours, tools and other resources (e.g. electrical power outlet, pneumatic air, etc.) from removal of the equipment from storage (if applicated) till it is completely deployed. The manual shall detail the steps and precautions for the deployment of the equipment (such as ergonomics, health and safety advice as well as mass of individual components and specialist lifting requirements, if applicable).

f) The maximum period of safe use during a flood. If periodic inspection is needed during the flooding period, the type of inspection, tools and frequency should be stated. If adjustment, tightening or similar is needed, these should be stated, including material or tools needed to perform these.

g) Procedure on disassembly, cleaning, drying and storage of the equipment after the flood. If there is special storage requirement, these should be stated.

h) Prescribe frequency and procedure for inspection and maintenance.

i) Prescribe the testing requirement of the equipment, especially if these are automatic or having moving parts. The testing should semi-annually and be before any flooding season or when flood warning is issued, as a minimal.

j) List of recommended spare parts and consumables, as applicable.

k) A quick reference for installation.

l) A troubleshooting guide, including what to do if damage should occur during deployment.

m) For automatic flood abatement equipment, how to manually operate and deploy the equipment shall be stated.

n) The expected leakage rate of the flood abatement equipment and recommended flood abatement pump capacity.

o) Diagrams and operating procedure for the electrical, pneumatic or hydraulic system, as applicable.

p) Allowable loading on the equipment when folded, as applicable.

q) The equipment supplier or manufacturer's contact details, helpline and after sales number.

6.4 Equipment marking

The flood abatement equipment shall be permanently marked with the following information:

a) The number and date of this Guideline and certification date.

b) The name of the manufacturer and address.

c) The certified height of the flood abatement equipment, including optional test certified.

d) The model or type.

e) The designation “flexible” or “rigid” as appropriate, where flexible (such as geotextiles and geosynthetic fabrics) or rigid (such as steel, aluminium, concrete, glass-reinforced plastic, wood or fibreglass) refer to the form of material the equipment is made of.

f) Date of manufacture (month and year).

g) An automatic equipment shall be permanently marked with manual deployment instructions, and condition when the equipment will be deployed automatically and warning available (sound, visual indications, etc.)

6.5 Installation information

The flood abatement equipment manufacturer shall stipulate the following installation information:

- Foundation requirements.
- Special construction considerations.
- Application limitations.
- Power sources (e.g. electrical outlet, pneumatic air, etc.).
- Any special storage requirement, especially for parts or component which would be disassemble and storage is required. If there is potential of theft or misplacement of these, the manufacturer shall provide or prescribe storage or locking method to prevent these.

6.6 Tools

If any special tool is needed for the deployment of the flood abatement equipment, the manufacturer shall provide at least two sets of those tools. The manufacturer shall make available spare set of the tool for purchase.

7. Factory quality control

7.1 Quality program

The manufacturer shall have a documented and maintained quality program. The manufacturer program should be to MS ISO 9001.

If the manufacturer has subcontracting of parts or sub-assemblies, the manufacturer shall retain the overall control of the quality and ensure that he receives all the information that is necessary to fulfil his responsibilities.

The manufacturer shall keep a record of the agent, installing contractor and end user of the equipment. The manufacturer should make it an effort to ensure the end user is performing the necessary test and maintenance, especially if the equipment is automatic deployment.

These record of individual equipment or equipment batches, should including the related manufacturing details and characteristics, identifiable and traceable component or raw material suppliers, equipment serial number and markings as well a copy of manual supplied to the end user.

The manufacturer shall regularly inspect and, where appropriate, test the finished equipment. Tests shall be carried out in accordance with the quality system. The results of finished equipment inspection and testing shall be recorded. The record shall include the equipment identification, the date and time of manufacture, and for each equipment the test methods, the test results, the required limits, the inspection result and the identification of the person carrying out the inspection.

7.2 Equipment modifications

In the case of modification of the equipment or components, a reassessment of the equipment shall be performed for those aspects, which may be affected by the modification, and should include the applicable test.

Annex A
(normative)

NAHRIM Hydraulics and Instrumentation Laboratory Test Facility Description

Performance testing of flood abatement equipment and other physical model could be conducted at National Hydraulic Research Institute of Malaysia (NAHRIM), Hydraulics and Instrumentation Laboratory, located in Seri Kembangan, Selangor. The research facility consists of wave basin and multi-functional flume.

Wave Basin:

Basin size at 30 m wide by 50 m long with 1.2 m height. One end of the facility contains 4 electric-driven piston-type wave generators, each driving a 6m wide multi element wave paddle. All 4 wave generators are synchronized so that they all run together as a 24 m wide generator. At the other end of the facility along the basin width contains an absorbent material like a foam with 45° slope facing the wave generator. Guide vanes contain the wave train for the first 20 m in front of the wave generators. The generators are computer controlled and capable of producing monochromatic or spectral wave field such as JONSWAP, Pierson-Moskovitz, International Towing Tank Congress (ITTC), Derbyshire Coastal / Ocean, BTTP, Neumann, Bretschneider and user defined wave spectrum. It also can generate a bi-directional wave up to 45° angle from right to left or vice versa. The maximum wave height that can be generated is 0.45 m with wave period range from 1 to 5 sec. This facility supported by 8 wave probes to measure the wave height. It also equipped with port and harbour testing equipment's such as ship movement detection, mooring line force and fender force measurement during ship berthing.

Multi-Functional Flume:

The size of the multi-functional flume is 1.5 m wide by 100 m long with 2 m height. One end of the facility contains 2 electric-driven piston-type wave generators, each driving a 0.75 m wide wave paddle. At the other end of the facility contains a 1.5 m width absorbent material like a foam with 45° slope facing the wave generator. The generators are computer controlled and capable of producing monochromatic or spectral wave field such as JONSWAP, Pierson-Moskovitz, International Towing Tank Congress (ITTC), Derbyshire Coastal / Ocean, BTTP, Neumann, Bretschneider and user defined wave spectrum. The maximum wave height that can be generated is 0.45 m with wave period range from 1 to 5 sec. This facility supported by 8 wave probes to measure the wave height. This multi-functional flume can circulate continues flow of 1,000 L/s. The maximum velocity generated at 1 m depth of water inside the flume is around 0.6 m/s. The facility is also equipped with tsunami generator that can generate a tsunami bore up to 0.5 m height.

Annex B
(normative)

Guideline on Flood Prevention for Basement Carpark

The most current version of 'Guideline on Flood Prevention for Basement Carpark' from the Department of Irrigation and Drainage (DID) should be used for the Flood Risk Assessment (FRA). The version available when this Guideline was written was September 2006.

Although the document is 'Guideline on Flood Prevention for Basement Carpark', the same FRA approach should be used if the equipment is use for below grade utility spaces, tunnels, underpasses or similar below ground level spaces.

The concept of the flood proofing elevation (FPE) is as illustrated in Figure 1.

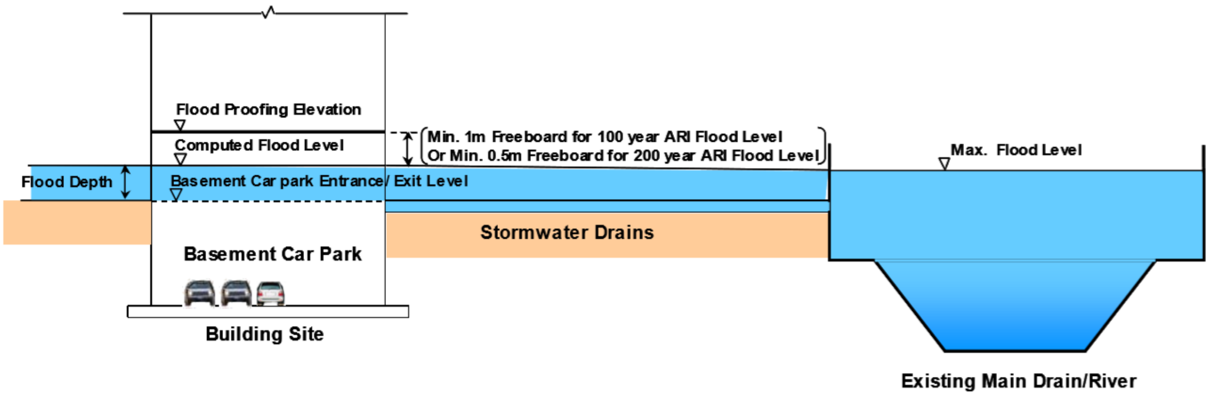


Figure 1 – Illustration of The FPE Design Requirement

It is recommended that the submission for the FRA should consist of the following:

- The basement or below grade space layout and cross-sectional plans.
- Stormwater drainage plan.
- Stormwater drains longitudinal profile.
- Hydrologic and hydraulic computations.
- Flood proofing measures shop drawings.
- Flood surveillance and warning system.

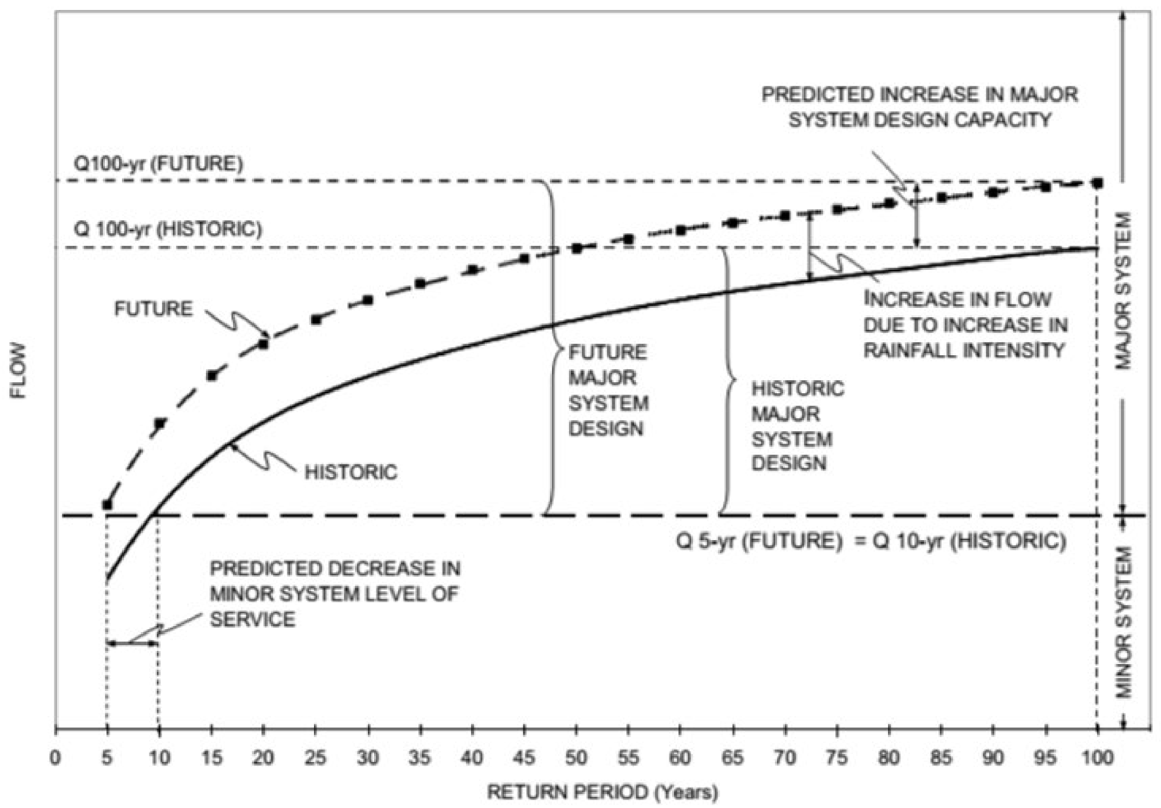
All the plans shall be duly endorsed by qualified engineer.

Annex C
(normative)

Climate Change Factor

The Hydrological Procedure No 1 entitled 'Estimation of the Design Rainstorm in Peninsular Malaysia' from the Department of Irrigation and Drainage (DID), updated 2015 had included Climate Change Factor (CFF). Based on the studies done by researches, the climate change factors are being implemented as adding certain percentage to the design storm.

Design storms which have derived based on historical data will no longer valid for the design of hydraulic infrastructure especially with higher return periods. It is expected that future changes in rainfall intensity due to climate change are expected to alter the level of protection of hydraulic infrastructure. Increased rainfall intensity will result in more frequent flooding. Therefore, engineers have no choice but to adapt to climate change impact to design storms. There will be two consequences which would result in the operation and design of hydraulic infrastructure. The first consequence to which a structure is designed is no longer constant over time. Secondly the level of protection to which the structure was designed will more frequently. Such consequences are shown below.



Annex D
(normative)

Flood Return Period

A return period, also known as a recurrence interval or repeat interval, is an average time or an estimated average time between events. Flood severity is normally designated by a recurrence interval of the flood (i.e. 25-year, 100-year, 500- year). The recurrence interval of an event gives the average length of time between occurrences. The theoretical return period between occurrences is the inverse of the average frequency of occurrence. For example, a 10-year flood has a 1/10 = 0.1 or 10% chance of being exceeded in any one year and a 50-year flood has a 0.02 or 2% chance of being exceeded in any one year.

If a location is built on a 25-year recurrence interval flood level, should the plant be around for five years, the chance of flooding is 18.13% and if it was occupied for 50 years, the chance increases to 86.47%.

Conversely, a common misconception is that a 100-year flood is likely to occur only once in a 100-year period. In fact, there is approximately a 63.4% chance of one or more 100-year floods occurring in any 100-year period. As an illustration, on the Danube River at Passau, Germany, the actual intervals between 100-year floods during 1501 to 2013, it ranged was from 37 to 192 years (Eychaner, J.H. (2015) Lessons from a 500-year record of flood elevations Association of State Floodplain Managers, Technical Report 7).

Flood recurrence interval	Time period being considered				
	1	2	5	10	50
10	9.52%	18.13%	39.35%	63.21%	99.33%
25	3.92%	7.69%	18.13%	32.97%	86.47%
50	1.98%	3.92%	9.52%	18.13%	63.21%
100	1.00%	1.98%	4.88%	9.52%	39.35%
250	0.40%	0.80%	1.98%	3.92%	18.13%
500	0.20%	0.40%	1.00%	1.98%	9.52%

Annex E
(normative)

Flood Protection Strategy

The installation of flood abatement equipment is and should be part of a flood protection strategy. The first strategy would be to elevate the building platform above the flood exposure level. The level can be determined by the Flood Risk Assessment (FRA).

When a building is identified as possibly flood exposed, the flood proofing elevation (FPE) should be confirmed by the FRA. Suitable flood abatement equipment should be installed at all openings. The building structure should be able to withstand the expected water hydrostatic and dynamic forces. Wooden structure would fair badly even with several centimetres of water. Reinforced concrete would far better, but the structural design should be verified if it can withstand horizontal forces exerted by increased water height. The foundation should be engineered for the flood abatement equipment as well as stability and possible seepage below the foundations.

As there could be water seepage into building, important utility equipment, such as electrical panels, fan, motors and other equipment, should installed on plinths. Floor drains should be designed and provided behind the flood abatement equipment to channel the water away to collection sumps.

Appropriate perimeter waterproof of the site or building should be considered by the builder, such as using nonpermeable concrete. In existing building, these should be assessed by a qualified and experienced contractor, engineer or surveyor. The walls should have waterproofing and any wall penetrations should be sealed with watertight sealants. When the wall penetrations could be further used, such as IT or power cable ducts, these should be sealed with watertight cable entry or duct products. Pipes (such as sewer, rain water, floor drainage, sanitary, etc) should be fitted with non-return valves, backflow valves, penstock valves, or other similar products, and as applicable these should be type approved by the relevant water authority. Failing to address any of these will allow water entry and could then lead to flooding inside the building.

Flood pumps should be provided inside the site or building to remove seeped water and water accumulation inside. The water could be from the rainfall, seepage, leakage or even water generated by the operation or inhabitant inside the site or building. Calculations should be made on the anticipated water before the sump is sized and the pumps are installed. Such flood pump should be type rated for pump water with grit, as flood water is not entirely clean. Each pump should preferable have its own discharge pipe with a non-return valves and the discharge pipe outlet should be above the FPE.

The pump and flood abatement equipment which are electrically operated should be connected to emergency power. The generators and power panels for these should be located above the FPE or located within the flood protected area. The availability of power from the utility company should not be assumed, unless an FRA had proved their power substation and associated power distribution panels are higher than the FPE plus freeboard.

Freeboard is a safety factor to account for uncertainties in the calculation and modelling inaccuracy, changes in the river flow, increased run water off due to development, climate change and as a buffer against unexpected waves, such as by the large moving vehicle or boat. Specifying a freeboard in the design criteria will cushion any unexpected change over the lifetime of a site or building.

Floating debris in the flood water could damage flood abatement equipment. The bigger and faster the water flow, the larger the force will be when it hits the equipment. When an equipment fails during a flood, it could cause a mini tsunami inside the site or building. Hence, flood abatement equipment is used to protect critical or important facility, as parameter flood protection, coastal or riverine protection, etc., then is should be debris impact tested.

Overtopping is a real concern when the flood abatement equipment is not constructed of rigid material. Flexible equipment could lose its shape or form when overtopped, and consequently the whole flood equipment could be compromised. In other case, the foundation on the dry side could be eroded and affects the stability of the flood equipment.

The power supply or driver for automatic flood abatement equipment could fail or malfunction. Hence, the equipment should have ability for it to be operated by manual human intervention. This method of deployment should be independent of the primary driver. Example of this could be hand wheel operating the gears, manual pump on a hydraulic system, wrench, etc. It is expected the manpower needed to operate it should not exceed that of a normal able person. The expected time for such human intervention should be tested and stated. The manufacturer is expected to provide the necessary training to the user.

Annex F
(normative)

Flood Insurance

The insurance definition of flood is, the overflowing or deviation from their normal channels of either natural or artificial water courses, bursting or overflowing of public water mains and any other flow or accumulation of water originating from outside the building.

Flood insurance is not a standard or automatic cover under a typical property fire insurance in Malaysia. The building owner will have to add flood as a special or extended peril in the basic insurance. Additional premium is payable for this flood coverage. The type of property fire insurance is dependent on the sum insured, and the typical structure is below:

- Fire Tariff - sum insured below RM 10 million.
- Self-Rating - RM 10 to 50 million.
- Special Rating - above RM 50 million.
- Large and Specialise Risks - above RM 300 million.

The Fire Tariff has extended flood coverage provided the coverage is elected. The rate is 0.086%. The excess is 1% of the total sums insured against such peril or the first RM2,500 of the loss, whichever is less.

In the Self-Rating, the tariff rate is applied. There is peril rate available discount, which is 50% to 82%, depending on sum insured.

There is peril rating formula in Special Rating, which is discount of 50% to 90%, depending on sum insured. The special rates have to be agreed and approved by the Rating Committee, which is a committee appointed by PIAM.

The Scheme for Insurance of Large & Specialised Risks (SILSR) is open for locations when qualified by the Scheme Manager. This has been implemented since 1 January 1994. The idea of the scheme is to provide the most favourable cover at internationally competitive terms for Malaysian risk owners. Terms and coverage could be specific to the insurance company, arrangement by the insurance consultant and the insured requirements, which is called 'wording' under the scheme. The pricing and coverage under this scheme would be subject to global insurance conditions. Examples of events which had affected the global appetite for flood risk would be the 2012 flooding in Thailand and hurricanes in the US.

The insurance company could elect to not provide flood coverage if the location is a flood prone or have a history of flooding. When coverage is provided, additional terms could be imposed. Flood coverage could be provided if the location has flood mitigation steps.

As Malaysia is undergoing insurance liberalization, the above could change after the initial publication of this Guideline.

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