GENERAL SPECIFICATION
FOR
CIVIL ENGINEERING WORKS

SECTION 23
WATER RETAINING STRUCTURES
SECTION 23

WATER RETAINING STRUCTURES

GENERAL

General requirements 23.01 The works and materials specified in Clauses 23.02 to 23.07 shall comply with the sections stated, unless otherwise stated in this Section.

Earthworks 23.02 Earthworks shall comply with Section 6.

Formwork 23.03 Formwork and finishes to concrete shall comply with Section 14.

Reinforcement 23.04 Steel reinforcement shall comply with Section 15.

Concrete 23.05 Concrete shall comply with Section 16.

Joints in concrete 23.06 Joints in concrete shall comply with Section 16.

Drainage systems 23.07 Drainage systems shall comply with Section 5.

GLOSSARY OF TERMS

Water retaining structure 23.08 Water retaining structure is a structure, or part of a structure, including walls, floors, roofs, columns and footings, which is stated in the Contract to be constructed for storing, conveying or excluding water, sewage or other aqueous liquids.

MATERIALS

Sliding layers 23.09 Sliding layers below floor slabs of water retaining structures shall be of a proprietary type of polyethylene sheeting approved by the Engineer. Polyethylene sheeting shall be impermeable and shall have a nominal thickness of 1.1 mm.

MATERIALS PROVIDED AND EQUIPMENT LOANED BY THE EMPLOYER

Materials provided by the Employer 23.10 (1) Water and sterilising chemicals for cleaning, sterilising and testing water retaining structures as stated in Clauses 23.24 and 23.32 will be provided by the Employer for one set of tests. The water and sterilising chemicals shall be obtained from the locations stated in the Contract or from other locations agreed by the Engineer and shall be mixed by the Contractor.

(2) Further to sub-clause (1) of this Clause, the Contractor shall be responsible for providing the water and sterilizing chemicals for re-testing when the water retaining structures tests do not comply with the test requirements and compliance criteria specified in the Contract.
**Equipment loaned by the Employer**

23.11 The equipment for recording water levels in tests on water retaining structures as stated in Clause 23.32(4) that is to be included in Contracts entered into with the Water Supplies Department will be loaned by the Employer.

---

**SUBMISSIONS**

**Particulars of sliding layers**

23.12 Particulars of the source and type of proposed sliding layers for water retaining structures shall be submitted to the Engineer for approval at least 14 days before the first delivery of the sliding layer to the Site.

**Particulars of materials and methods of construction for water retaining structures**

23.13 (1) The following particulars of the proposed materials and methods of construction for water retaining structures shall be submitted to the Engineer:

(a) Sequence and method of concreting bays in floor slabs, walls and roof slabs and in columns and footings,

(b) Details of alternative locations of construction joints if required,

(c) Details of type and size of waterstops at construction joints and box-outs,

(d) Sequence and method of testing roofs for watertightness, and

(e) Details of method of testing water retaining structures for watertightness including:

   - Arrangement of pumps and equipment
   - Source of water
   - Equipment for measuring fall in water level
   - Device for dampening the oscillatory motion of the water surface
   - Filling rate
   - Method of correction for evaporation and rainfall.

(2) The particulars shall be submitted to the Engineer at least 28 days before the relevant work starts.

**Samples of sliding layers**

23.14 Samples of the proposed sliding layers for water retaining structures shall be submitted to the Engineer at the same time as particulars of the sliding layer are submitted.
### STORAGE OF MATERIALS

**Storage of sliding layers** 23.15 Sliding layers for water retaining structures shall be stored in accordance with the manufacturer’s recommendations in a dry weatherproof store.

### DRAINAGE SYSTEMS

**Drainage systems** 23.16 Measures shall be taken to prevent concrete and deleterious material from being deposited in drainage systems under floors and on roofs of water retaining structures. After construction and before testing, the drainage system shall be thoroughly cleaned by rodding and flushing to remove any deleterious material that may impede the flow of water into or through the drainage system. The lines and levels of drainage systems shall be within 20 mm of the specified horizontal alignment and within 10 mm of the specified vertical alignment.

### CONSTRUCTION OF WATER RETAINING STRUCTURES

**Laying sliding layers** 23.17 Polyethylene sheeting in sliding layers below floor slabs of water retaining structures shall be laid flat without creases. Laps shall be at least 225 mm and there shall be no gaps at the edges of bays.

**Floor slabs of water retaining structures** 23.18 If reinforcement is continuous across the joint between bays in the floor slab of water retaining structures, the bays shall be concreted contiguously, in sequence, with a minimum period of 48 hours between completion of concreting one bay and commencement of concreting the adjacent bay.

**Walls of water retaining structures** 23.19 (1) If reinforcement is continuous across the joint between bays in the wall of water retaining structures, the bays shall be concreted contiguously, in sequence, with a minimum period of 72 hours between the completion of concreting the lift in one bay and commencement of concreting the adjacent lift in the adjacent bay.

(2) Unless otherwise permitted by the Engineer the first lift in each bay in the walls of water retaining structures shall be concreted not more than 7 days after completion of concreting the adjacent base of the wall. Individual lifts shall be concreted in one continuous operation without cold joints, whether or not the full height of the wall is concreted in one lift. If the full height of the wall is not placed in one lift, succeeding lifts shall be concreted within 7 days of concreting of the adjacent lift unless otherwise permitted by the Engineer.

**Roof slabs of water retaining structures** 23.20 If reinforcement is continuous across the joint between bays in the roof slab of water retaining structures, the bays shall be concreted contiguously, in sequence, with a minimum period of 48 hours between completion of concreting one bay and commencement of concreting the adjacent bay.
Built-in pipes in water retaining structures 23.21 Puddle flanges on built-in pipes in water retaining structures shall be located centrally within the formwork. Waterstops shall be fixed around the perimeter of box-outs to the built-in pipes.

PROTECTION OF WATER RETAINING STRUCTURES

Protection of water retaining structures 23.22 (1) Immediately after the roof slab of water retaining structures has been tested, the slab shall be protected with damp sacks or by other methods agreed by the Engineer from exposure to conditions that may affect the slab. The protection shall be continued until the roof drainage system has been constructed or the fill material has been deposited and compacted.

(2) Materials shall not be stockpiled on roof slabs of water retaining structures. Construction plant or other vehicles shall not stand or run on floor slabs or roof slabs of water retaining structures unless permitted by the Engineer.

DEPOSITION OF FILL MATERIAL

Deposition of fill material 23.23 (1) Fill material shall not be deposited behind sections of walls of water retaining structures until at least 7 days after completion of concreting to the section of wall.

(2) Fill material shall be spread out evenly and shall not be stockpiled on roofs to water retaining structures. Weed killer or other chemicals shall not be applied to fill material on the roofs of water retaining structures for potable or fresh water.

(3) Deposition of fill material on or adjacent to water retaining structures shall be carried out after the watertightness test on the structure has been completed, unless otherwise permitted by the Engineer.

CLEANING AND STERILISATION OF WATER RETAINING STRUCTURES

Cleaning and sterilisation of water retaining structures 23.24 (1) Immediately before water retaining structures are tested for watertightness, all dust, debris, unused materials and equipment shall be removed from the structure and the interior of the structure shall be washed and brushed down with water.

(2) Water for washing water retaining structures for potable or fresh water shall be fresh, potable water incorporating a mixture of sterilising chemicals added before the structure is washed at a concentration instructed by the Engineer. The structure shall be maintained in a clean condition after cleaning.
Treatment and disposal of effluent

(1) Whereas the cleansing effluent is not fit for discharging into the natural stream course or the storm water drainage system, it should be discharged to the washout chamber or into the sewerage system subject to the approval of the Engineer and the agreement of the Drainage Services Department.

(2) If the cleansing effluent requires de-chlorination, the outlet pipe of the washout chamber should be blocked and the cleansing effluent shall be pumped from the washout chamber to the de-chlorination plant for de-chlorination before discharging to waste. The discharge of cleansing effluent from the washout shall be stopped under the following situation whichever first occurs as directed by the Engineer:-

- The bottom deposits are visually discovered in the cleansing effluent discharged into the washout chamber; or
- Any part of the compartment floor is not submerged; or
- At level as instructed by the Engineer.

(3) The outlet pipe of the washout chamber shall then be kept blocked. The remaining sludge inside the compartment shall then be discharged to the washout. The sludge shall be pumped from the washout chamber to a mobile “centrifuge and microfiltration plant” or equivalent mobile treatment plant approved by the Engineer for treatment. Treatment of sludge with the mobile “centrifuge and microfiltration plant” shall be as detailed in Appendix 23.1. If equivalent mobile treatment plant is used, the Contractor shall submit details of the plant, including but limited to, method statement, detailed description of the types and capacity of different components of the plant, the particulars and dosage of chemicals used in the treatment process, layout, previous job records, etc. to the Engineer for approval. The Contractor shall also carry out trials to demonstrate to the Engineer that the proposed mobile treatment plant shall meet the specification in Appendix 23.2.

(4) Sludge cake samples shall be taken in hourly intervals and the samples shall be sent to the HOKLAS (Hong Kong Laboratory Accreditation Scheme) accredited laboratory for testing their dry solid content. The results shall be recorded in the form as shown in Appendix 23.3. The sampling record shall be submitted to the Engineer within two weeks after cleaning works.

(5) Subject to the approval of the Environmental Protection Department, the sludge cake produced shall be disposed of at landfill site.

(6) Samples of filtrate from the microfiltration plant or in case if equivalent mobile treatment plant approved by the Engineer is used, samples of the final effluent from the mobile treatment plant, shall be taken at hourly intervals and the samples shall be tested for turbidity on site and sent to the HOKLAS accredited laboratory for testing their suspended solids content. If the turbidity of the filtrate or in case of equivalent mobile treatment plant approved by the Engineer is used, the final effluent from the mobile treatment plant, is higher than the limit specified by the Engineer, the Contractor is required to stop the discharge and rectify the situation before restart of operation. The testing results shall be recorded in the log record as shown in Appendix 23.4. The sampling record shall be submitted to the Engineer within two weeks after cleaning works.
# TESTING: DRAINAGE SYSTEMS FOR WATER RETAINING STRUCTURES

**Testing: drainage systems for water retaining structures** 23.26 Drainage systems under floors and on roofs of water retaining structures shall be tested in accordance with the following requirements:

(a) Water shall be poured at different locations agreed by the Engineer along the drainage system and the flow of water observed at junction pits, outfalls and other discharge points.

(b) A mandrel shall be pulled through each completed section of pipeline of 300 mm diameter or less. The mandrel shall be 750 mm long and 12 mm less in diameter than the nominal diameter of the pipe.

**Compliance criteria: drainage systems for water retaining structures** 23.27 The results of tests on drainage systems for water retaining structures shall comply with the following requirements:

(a) The water shall in the opinion of the Engineer be freely discharged by the drainage system.

(b) The bore, linearity and jointing of pipes shall comply with the specified requirements.

**Non-compliance: drainage systems for water retaining structures** 23.28 If the result of any test on the drainage system for water retaining structures does not comply with the specified requirements for the test, the Contractor shall investigate the reason. Remedial or replacement work approved by the Engineer shall be carried out and the drainage system shall be retested.

---

# TESTING: WATERTIGHTNESS OF ROOFS

**Testing: watertightness of roofs** 23.29 (1) The roofs of water retaining structures shall be tested for watertightness over the complete area of the roof, including perimeter joints. Roofs shall not be tested in sections unless permitted by the Engineer.

(2) Water shall be allowed to be ponding on the roof for a period of 3 days and topped up to maintain a depth of at least 75 mm. The test shall be carried out before fill material is deposited or drainage systems are constructed on the roof.

**Compliance criteria: watertightness of roofs** 23.30 There shall be no leaks or damp patches visible on the soffits of roofs of water retaining structures during or at the end of the test for watertightness.

**Non-compliance: watertightness of roofs** 23.31 If the result of any test for watertightness of the roof of a water retaining structure does not comply with the specified requirements for the test, the Contractor shall investigate the reason. Remedial or replacement work approved by the Engineer shall be carried out and the roof shall be retested.
TESTING: WATERTIGHTNESS OF STRUCTURES

Testing: watertightness of structures 23.32

1. Water retaining structures shall be tested for watertightness as stated in Clause 23.32(2) to (7). Each compartment of structures, which incorporate division walls, shall be tested separately with adjoining compartments empty. The complete structure shall also be tested.

2. The structure shall be filled with water at an approximately uniform rate not exceeding 2 m depth in 24 hours to the levels stated in Table 23.1. The water used for testing water retaining structures for potable or fresh water shall be fresh potable water. The permission of the Engineer shall be obtained before filling starts. The structure or each compartment of the structure being tested shall be kept full for 7 days before testing allow for absorption.

3. After the period for absorption, the water shall be topped up to the specified level and the test shall begin. During testing, the oscillatory motion of the water surface shall be dampened. The test period shall be 7 days.

4. The equipment for recording water levels shall be installed in a temporary enclosure of minimum dimensions 2 m x 2 m x 2.5 m high with a lockable door. The enclosure shall be located over stilling wells, manhole openings or other points of recording water levels. The temporary enclosure shall be removed on completion of the test. The equipment shall be calibrated before testing starts and at regular intervals agreed by the Engineer and shall be readable and accurate to 0.5 mm.

5. The fall in water level in water retaining structures shall be measured at hourly intervals between 8 a.m. and 5 p.m. each day. The total fall shall be measured at the end of the test period.

6. Except as stated in Clause 23.32(7), structures shall be emptied after completion of testing and maintained in a clean and dry condition. The water shall be removed at an approximately uniform rate not exceeding 2 m depth in 24 hours. The permission of the Engineer shall be obtained before emptying starts.

7. Unless otherwise instructed by the Engineer, the water used for the final tests on water retaining structures for potable or fresh water shall be retained in the structure and shall not be wasted or contaminated.

Compliance criteria: watertightness of structures 23.33

The results of tests for watertightness of water retaining structures shall comply with the following requirements:

(a) The total fall in water level at the end of the test period, after adjustment for evaporation and rainfall, shall not exceed 1/500 times the maximum specified depth of water in the test or 10 mm, whichever is less.

(b) There shall be no leaks or damp patches visible on the surface of the structure, including any division walls, during or at the end of the test.
Non-compliance: watertightness of structures

If the result of any test for watertightness of a water retaining structure does not comply with the specified requirements for the test, the Contractor shall investigate the reason. Remedial or replacement work approved by the Engineer shall be carried out and the structure shall be retested.

Table 23.1: Tests on water retaining structures

<table>
<thead>
<tr>
<th>Type of structure</th>
<th>Part of structure tested</th>
<th>Test water level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water retaining structures other than for sewage</td>
<td>Structure with division wall - each compartment of structure</td>
<td>100 mm below top of division wall</td>
</tr>
<tr>
<td></td>
<td>Structure with division wall - complete structure</td>
<td>Top water level of structure</td>
</tr>
<tr>
<td></td>
<td>Structure without division wall</td>
<td></td>
</tr>
<tr>
<td>Water retaining structures for sewage</td>
<td>Structure with division wall - each compartment of structure</td>
<td>Top water level of structure</td>
</tr>
<tr>
<td></td>
<td>Structure with division wall - complete structure</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Structure without division wall</td>
<td></td>
</tr>
</tbody>
</table>

TESTING: WATER STERILITY

Samples: water sterilisation

After the test for watertightness of a water retaining structure for potable or fresh water has been completed, samples of the water in the structure shall be taken by the Engineer. The number of samples and location of sampling shall be as instructed by the Engineer.

Testing: water sterilisation

Each sample of water shall be tested to determine the bacteriological content. The colour, odour, appearance, turbidity, conductivity and pH value of the water samples shall be of quality acceptable for potable water.

Compliance criteria: water sterilisation

The results of tests for bacteriological content of the water and the parameters stated in Clause 23.36 shall demonstrate that in the opinion of the Engineer the structure has been adequately sterilised for potable or fresh water.
APPENDIX 23.1

TREATMENT OF SLUDGE WITH MOBILE “CENTRIFUGE AND MICROFILTRATION PLANT”

**Plant**

23.1.1 The mobile “centrifuge and microfiltration plant” shall be capable of producing a final effluent with suspended solid of not more than 5 mg/litre and turbidity of not more than 2 Nephelometric Turbidity Units (NTU).

**Procedures**

23.1.2

1. The sludge shall first be pumped to a mobile centrifuge for dewatering. The specifications of the mobile centrifuge shall be:
   - Nominal capacity shall be not less than 8 cubic metres per hour.
   - Dry solid content of the sludge cake produced shall be more than 30% by weight.
   - The mobile centrifuge shall not be washed or cleaned on site.
   - A water meter or other measuring device should be installed at the inlet pipe of the centrifuge to measure the amount of sludge treated, in cubic metres.

2. The centrate shall be treated by a mobile microfiltration plant with the following specifications:
   - Nominal capacity shall not be less than 8 cubic metres per hour.
   - The filter shall be capable of treating the centrate generated by the mobile centrifuge.
   - The filter media shall be backwashable using the filtrate (the volume of water for backwash shall not be greater than 20% of water filtrated).
   - All chemicals used for cleaning the filter shall be disposed of at the Chemical Waste Treatment Facility as approved by the Engineer.
   - The suspended solid content and turbidity of the filtrate shall meet either Criteria A or Criteria B of the table below, as directed by the Engineer.

<table>
<thead>
<tr>
<th></th>
<th>Criteria A</th>
<th>Criteria B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suspended Solid Content</td>
<td>Not more than 10 mg/litre</td>
<td>Not more than 5 mg/litre</td>
</tr>
<tr>
<td>Turbidity</td>
<td>Not more than 4 NTU</td>
<td>Not more than 2 NTU</td>
</tr>
</tbody>
</table>

   - A water-meter or other measuring device should be installed at the outlet pipe for the wash water to measure the amount of wash-water produced, in cubic metres.
   - A water-meter or other measuring device should be installed at the outpipe for the filtrate to measure the amount of filtrate produced, in cubic metres.

3. The wash-water discharged from the mobile microfiltration plant shall be returned to and treated by the centrifuge.
APPENDIX 23.2

SPECIFICATION OF THE MOBILE TREATMENT PLANT

23.2.1 The mobile treatment plant shall be capable of producing a final effluent with suspended solid of not more than 5 mg/litre and turbidity of not more than 2 NTU. Dry solid content of the sludge cake produced shall be more than 30% by weight. In addition, the mobile treatment plant should meet the following requirements:

- Nominal capacity shall not be less than 8 cubic metres per hour.
- The plant shall not be washed or cleaned on site.
- The plant shall be easily dismantled into small units for easy transportation.
- The design of the plant shall be compact, such that the area occupied by the plant will be approximately the plan area of two standard containers.
- The suspended solid content and turbidity of the final effluent shall meet either Criteria A or Criteria B of the table below, as directed by the Engineer.

<table>
<thead>
<tr>
<th></th>
<th>Criteria A</th>
<th>Criteria B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suspended Solid Content</td>
<td>Not more than 10 mg/litre</td>
<td>Not more than 5 mg/litre</td>
</tr>
<tr>
<td>Turbidity</td>
<td>Not more than 4 NTU</td>
<td>Not more than 2 NTU</td>
</tr>
</tbody>
</table>

(NTU: Nephelometric turbidity units)

- A water-meter or other measuring device shall be installed at the inlet and outlet of the mobile treatment plant to measure the amount of influent and final effluent, in cubic metres.
- If filtration is adopted, the filter media shall be backwashable using the filtrate (the volume of water for backwash shall not be greater than 20% of water filtrated). All chemicals used for cleaning the filter shall be disposed of at the Chemical Waste Treatment Facility as approved by the Engineer. The wash water shall be returned to the inlet of the mobile treatment plant for treatment.
## APPENDIX 23.3

### SAMPLE RECORD FOR SLUDGE CAKE PRODUCED

<table>
<thead>
<tr>
<th>Time</th>
<th>Sludge Cake</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sample No.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX 23.4

SAMPLING RECORD FOR FILTRATE PRODUCED BY THE MICROFILTRATION PLANT OR FINAL EFFLUENT PRODUCED BY THE MOBILE TREATMENT PLANT

Contract No.:  
Name of installation:  
Date:  
Recorded by:

<table>
<thead>
<tr>
<th>Time</th>
<th>Filtrate/Final Effluent*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sample No.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>