Design of Tank sluice with tower head

The earthen dam of an irrigation tank has the following data.

<table>
<thead>
<tr>
<th>Data</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top width of bund</td>
<td>2m</td>
</tr>
<tr>
<td>Side slopes of bund</td>
<td>2:1</td>
</tr>
<tr>
<td>R.L of top of bund</td>
<td>128.5</td>
</tr>
<tr>
<td>F.T.L</td>
<td>125.5</td>
</tr>
<tr>
<td>M.W.L</td>
<td>126.5</td>
</tr>
<tr>
<td>Average lower water level</td>
<td>123.0</td>
</tr>
<tr>
<td>G.L</td>
<td>122.5</td>
</tr>
<tr>
<td>Good foundation</td>
<td>121.5</td>
</tr>
</tbody>
</table>

A canal is to draw water through sluice irrigation 160 hectares at an average duty of 700 hectares/cumecs. Assume conveyance loss as 15%. The details of the canal on the downstream side are bed level—122.00

FSL – 122.50, TBL --- 123.50, side slope 1½ : 1

Draw a scale 1) Longitudunal section along the c.l of the barrel
2) Half plan at top and half at foundation
3) cross section of the tower head and of the rectangular barrel

Solution: Item 1: Sluice opening

Discharge required = Area/duty = 160/700 = 0.228 m³/s
Add 15% for conveyance loss, design discharge = 0.15 x 0.228 = 0.262 m³/s The sill or floor of the barrel will be at the canal bed level i.e 122.00

Low water level at -123.00

.. Total avail head= l.w.l – sill level= 123.00 - 122.00= 1m

However assume on the effective head, h= 0.3m

(note: the effective head _h_ may be taken as 25% to 60% of the total head, depending on the discharge)

Discharge through circular opening is given by

**Type the formula**

(note: Minimum diameter of opening = 30cm, Maximum diameter = 50cm. if required area is large , think of 2 or more opening of diameter about 40cm, instead of 1 large opening)

Diameter = 0.48m, say 50cm diameter
For the above circular opening assume a barrel size of 65cmx75cm high. The minimum size of the barrel is 60x75cm high.

Item no 2. Rectangular barrel

The figure shows a vertical section through the top of earth bund. It cuts the rectangular barrel at, but it cuts the earth bund along the barrel.

Internal six of the barrel has been assumed as 65cmx75cm high. Assume cross section of side wall as shown, which will be checked for stability. Assume density of earth as 2200 kg/m^3, of masonry as 2100 kg/m^3.

a) Design of R.CC roof slab

Clear span = 0.65m bearing width= 0.2m
Effective span =l= 0.85m
Assume 15cm thick slab
Self weight = 0.15x2500= 375kg/m
Weight of earth= 5.6x2200= 12320kg/m
Total mdl= 12695kg/m
M= w l^2/8 = 1146.5kgm.
For M20 and CTD bars k=9.1 j=0.9
Required effective depth = \( d = \sqrt{\frac{H}{K_b}} = \sqrt{146.5 \times 10^2 / 9.1 \times 100} = 11.22\text{cm} \)

Assume an overall depth of 15cm

Take \( d = 15 - 3 = 12\text{cm} \)

\( A_{st} = 4.62\text{cm}^2 \)

Spacing of min 12mm diameter = \( 1.13 \times 10^2 / 4.62 = 20\text{cm c/c} \)

Dist steel 0.12/100 (100x15)

Spacing of min 8mm diameter

b) Stability of side wall

Assume dia = 30, \( K_a = 1 - \sin \varphi / 1 + \sin \varphi = \frac{1}{3} \)

\( \gamma_{\text{earth}} = 2200 \text{kg/m}^3 \)

\( \gamma_{\text{manonary}} = 2100 \text{kg/m}^3 \)

The lateral earth pressure on the side wall is given by \( P_a = K_a \gamma_{\text{earth}} Z \)

kg/m\(^3\) \( Z = \) depth below the surface of earth

Pa at the top of wall = \( 1/3 \times 2200 \times 5.6 = 4107 \text{kg/m}^2 \) (\( Z = 5.6\text{m} \))

Pa at bottom of wall = \( 1/3 \times 220 \times 6.5 = 4767 \text{kg/m}^2 \)

consider 1m length of wall (perpendicular to paper)

active earth pressure = \( P_a = (\text{area of pressure diagram}) \)

\( P_a = (4107 + 4767)/2 \times 0.9 = 3993\text{kg} \)
Taking the moment about A of all forces

<table>
<thead>
<tr>
<th>Item</th>
<th>Magnitude of force in kg</th>
<th>V (kg)</th>
<th>H (kg)</th>
<th>Lever arm from A (m)</th>
<th>Moment about A</th>
</tr>
</thead>
<tbody>
<tr>
<td>W1</td>
<td>(1/2x 0.6x0.9)2100</td>
<td>567</td>
<td>-</td>
<td>0.7</td>
<td></td>
</tr>
<tr>
<td>W2</td>
<td>(0.5x0.9)2100</td>
<td>945</td>
<td>-</td>
<td>0.25</td>
<td></td>
</tr>
<tr>
<td>W3</td>
<td>(1/2x 0.6x0.9)2200</td>
<td>597</td>
<td>-</td>
<td>0.9</td>
<td></td>
</tr>
<tr>
<td>W4</td>
<td>(0.9x5.6)2200</td>
<td>11088</td>
<td>-</td>
<td>0.65</td>
<td></td>
</tr>
<tr>
<td>R</td>
<td>W1/2 = 6665/12695x1.05/2</td>
<td>6665</td>
<td>-</td>
<td>0.1</td>
<td></td>
</tr>
</tbody>
</table>

\[ \Sigma V = 19862 \text{kg} \]

\[ P_a = 3993 \text{kg} \]

\[ 3993 \text{kg} \]

\[ Y = 0.439 \text{m} \]

Position of resultant from A = \( x = \frac{\sum M}{\sum V} = 0.367 \text{m} \)

\[ \text{eccentricity of the resultant} = \frac{b}{2} - x = ( \frac{b}{2} - \text{base width} ) E = 0.182 \text{m} \]

\[ e < \frac{b}{6} \]

Hence there will be no vertical tension on the base.

Max. vertical compressive stress is given by

\[ F_v = \frac{\sum V}{b} (1 + \frac{6e}{b}) \]

\[ F_v = 36112 \text{kg/m}^2 = 36.112 \text{t/m}^2 < 60 \text{t/m}^2 \] (Hence safe)

Item No3: Tower head.

The gate, the RCC diaphragm of circular opening is provided in a masonry well. The top of the well may be kept 30cm above MWL.
Top of the well be at 126.80
Assume internal dia as 1.25m. Assume the thickness of the wall as shown

(note: The tower head is designed as a thick layer. The loading on (1m ht of the cylinder. The cylinder of the external earth pressure acting radially inwards. The internal radial pressure due to water is not considered. Under this loading, there will be both radial as well as the circumferential stress as shown. The hoop and radius stresses in the material are given by $f_r = a + \frac{b}{r^2}$, $f_h = a - \frac{b}{r^2}$

$Cd = 3.75 - 3.4 = 0.35m$
Hatched area $A = \frac{1}{2}(0.35 + 3) \times 1.7$
$= 2.85 m^2$

Further $l = ai = 3.75m$, $H = 4.8$
$C = 1 + 4.5 \frac{A}{A} = 1.71$

Lateral earth pressure at any depth $- hl$ below the top of the well is given by
$Pa = Ka \cdot \text{rearth. H}$
$Ka = \left(1 - \frac{\sin \Phi}{1 + \sin \Phi}\right) = 1/3$
Design of thick cyl

\[ H = \text{depth below top of well} = 4.8 \text{m} \]

\[ \text{Pa} = \frac{1}{3} \times 1.71 \times 2200 \times 4.8 \text{ kg/m}^2 \]

\[ = 6019 \text{ kg/m}^2 \text{ external loading} \]

Radial stress \( F_r = a + b/r^2 \)

Boundary condition on radial stress

i) \( \text{At } r_1 = 0.625 \text{m} \quad F_r = 0 \)

ii) \( \text{At } r_e = 1.325 \text{m} \quad F_r = \text{Pa} = 6019 \text{ kg/m}^2 \)

\[ a + \frac{b}{(0.625)^2} = 0 \]

\[ a + \frac{b}{(1.325)^2} = 6019 \]

\[ b = -3024, \quad a = 7741.5 \]

The hoop stress is given by \( f_h = a - b/r^2 \)

At inner radius \( r_i = 0.625 \text{m} \)

\[ f_h = 7741.5 + \frac{3024}{(0.625)^2} = 15483 \text{ kg/m}^2 < 60t/\text{m}^2 \text{ (hence safe).} \]

A rectangular cistem is provided at the downstream of the barrel to decipate the K.E of water. The size of the cistem is as shown in the drawing. The top of the cistem wall as well as the downstream wall will be kept at the canal TBL.

The water faces of all walls will be kept vertical.
Note. The top of the floor of the barrel is at 122.00, which is the sill level. This c.c floor will be extended to form the foundation for all walls such as the side walls of the barrel, cistem walls and upstream wing walls (but not for head walls) Thus the bottom of all these walls will be at 122.00. Note. The figure shows the rough layout plan of the tank sluice as indicated below.