Analysis And Design of Ground Level Reservoir

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Abstract — In this paper will discuss on analysis and design of ground level reservoir of rectangular shaped for storage of water for drinking purposes. Accordingly the population forecasting, volume of GLR, location, lateral soil pressures & water pressures, wind and earthquake load are considered. The design of GLR wall faces horizontal & lateral forces due to soil & water pressure acts as cantilever, using LSM considering load of dead load, live load, & Seismic load for safe & economical design.

Keywords: Ground Level Reservoir, RCC Walls, Wall Footings-Toe & Heel, Flat Slab

I. Introduction

A ground-level reservoir is a water storage structure constructed at or near the natural ground surface. It plays a critical role in modern water supply systems by storing treated water before distribution to consumers. Unlike elevated reservoirs, which rely on gravity for pressure, ground-level reservoirs typically require pumping systems to maintain adequate pressure in the network. These reservoirs ensure operational flexibility, provide emergency reserves, and help balance supply and demand during peak usage periods. They are widely used in urban, rural, and industrial water supply schemes due to their cost-effectiveness and large storage capacity.

Ground-level reservoirs (also called service reservoirs or ground storage tanks) have specific uses, mainly related to water storage and distribution. Here are the key purposes:

1) Drinking Water Storage
   They store treated water before it is pumped into the distribution network for households and industries.
2) Pressure Management
   Helps maintain consistent water pressure in the supply system, especially in areas with varying elevations.
3) Emergency Backup
   Acts as a reserve during pump failures, maintenance, or sudden demand spikes.
4) Firefighting
   Provides a reliable water source for firefighting in urban and industrial areas.
5) Operational Flexibility
   Allows treatment plants to operate continuously while meeting fluctuating demand.
6) Supply During Peak Hours
   Balances supply and demand by storing water during low-demand periods and releasing it during peak usage.

A. *Types Of Water Retaining Structures Based Upon Shape*

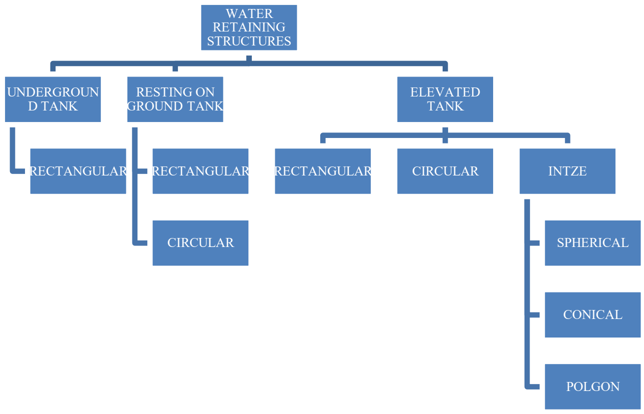


Fig. 1.1: Types of Water Retaining Structures

B. *Underground Water Tank*

An underground reservoir is a water storage structure constructed below the ground surface to store treated water for domestic, industrial, and emergency use. These reservoirs are designed to optimize land utilization, protect water from contamination, and minimize evaporation losses. They are particularly suitable for urban areas where space is limited and security is a priority. Underground reservoirs ensure a reliable water supply, maintain operational flexibility, and serve as emergency reserves during droughts or firefighting situations. Their design requires careful consideration of structural stability, waterproofing, and maintenance access due to the challenges posed by subsurface construction.

Fig. 1.2: Underground water tank

C. *Resting On the Ground Level Water Tank (Partially Underground)*

A ground-level reservoir resting on the natural ground surface is a water storage structure designed to store treated water before distribution. Unlike underground reservoirs, these are constructed above the ground but at a low elevation, making them easier to build and maintain. They serve as balancing reservoirs in water supply systems, ensuring a steady supply during peak demand and providing emergency reserves.

Ground-level reservoirs are commonly used in urban and rural areas due to their cost-effectiveness and large storage capacity. However, they require adequate land space and pumping systems to maintain pressure in the distribution network.

Fig. 1.3: Resting on ground level water tank

D. Elevated water tank

An elevated reservoir is a water storage structure built at a height above ground level, typically supported by columns or a tower. Its primary purpose is to store treated water and supply it to consumers using gravity, ensuring consistent pressure throughout the distribution network. Elevated reservoirs are commonly used in urban and rural water supply systems where maintaining adequate pressure without continuous pumping is essential. They also serve as balancing reservoirs, emergency reserves, and help meet peak demand efficiently. The design of elevated reservoirs requires careful consideration of structural stability, load-bearing capacity, and safety standards due to their elevated position.

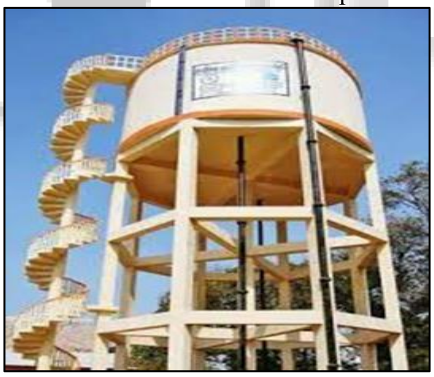


Fig. 1.4: Elevated water tank

II. GROUND LEVEL RESERVOIR

A. Design Criteria for Underground or Partly Underground Liquid Retaining Structures

Water level is assumed at the ground level for design of all the structures. All underground or partly underground liquid containing structures shall be designed for the following conditions

- Reservoir full: Liquid depth up to full height of wall: no relief due to soil pressure from outside to be considered.
- Reservoir Empty: Structure empty (i.e., empty of liquid, any material, etc.): full earth pressure and surcharge pressure wherever applicable, to be considered.
- Stability checks: Analyse forces: Calculate the active and passive earth pressures and any surcharge loads that will act on the wall. Perform stability checks:
- Overturning: Calculate the overturning moment from the lateral earth pressure and the restoring moment from the wall's self-weight. Ensure the restoring moment is significantly greater than the overturning moment. A factor of safety of at least 1.5 is typically required.
- Sliding: Calculate the total horizontal force pushing the wall and compare it to the total resisting force, which is primarily friction. The resisting force must be greater than the applied force to prevent the wall from sliding.
- Bearing capacity: Calculate the bearing pressure under the base of the wall and confirm it is less than the soil's allowable bearing capacity. This is typically checked using a bearing capacity analysis, such as the Terzaghi approach.
- Uplift force: A minimum factor of 1.2 shall be ensured against uplift or floatation.
- Crack width: All the liquid retaining structures shall be design for maximum design crack widths of 0.1mm for direct tension and flexure as per IS 3370.

B. Foundations

- The minimum depth of foundations for all structures, equipment's, buildings and frame foundations and load bearing walls shall be as per IS 1904 but in any case this shall not be less than 1.0 meter in the original soil.
- Maximum safe bearing capacity of soil strata shall be taken as determined by the Geotechnical reports investigations.
- Special attention is drawn to danger of uplift being caused by the ground water table. All underground structural slabs shall be designed for uplift forces due to ground water pressure.
- EGL (Existing ground level) and FGL (Finished ground level) shall be marked showing foundation/sub-structure details and related design documents.
- Machine/static equipment foundations shall be separated from adjoining parts of buildings, other foundations and floor/pavement slabs. Joints at floor/pavement slabs shall be suitably sealed.
- Foundations and structures for machines subject to vibrations shall be so proportioned that the amplitude and frequency of the foundation/structure are within the permissible limits as per relevant BIS codes (or as required by the machine vendor).
- Machine foundations shall be designed and detailed as per IS: 2974.

C. Design Requirements:

The following are the design requirements for all reinforced or plain concrete structures.

1) All blinding and levelling concrete shall be a minimum 100 mm thick in concrete grade M10 unless otherwise Liquid Retaining Structures:
2) All structural reinforced concrete shall be of a minimum M30 grade with a maximum 20 mm aggregate size for footings, base slabs and for all other structural members.

3) The reinforced concrete for water retaining structures shall have a minimum cement content of 420 kg/m3
4) The minimum reinforcement in walls, floors and roofs in each of two directions of right angles within each surface zone shall be as per 7.1 of IS: 3370 part 2.
5) The nominal cover of concrete for all steel, including stirrups, links, sheathing and spacers shall be as per 7.2 of IS: 3370 Part 2.
6) Structure shall be provided with screed concrete for basement and floors and water proofing for roofs.
7) Any structure or pipeline crossing below roads shall be designed for Class A of IRC loading.
8) Construction of floors and walls of Liquid Retaining structures shall be as per 9.4 & 9.5 of IS: 3370 Part 1.

III. DESIGN LIFE & DESIGN LOADINGS:

A. Design Life

The design life of all structures and buildings shall be 60 years

1) Design Loadings

All buildings and structures shall be designed to resist the worst combination of the following loads/stresses under test and working conditions; these include dead load, live load, wind load, seismic load, stresses due to temperature changes, shrinkage and creep in materials, dynamic loads.

a) Dead Load

This shall comprise all permanent construction including walls, floors, roofs, partitions, stairways, fixed service equipment's and other items of machinery.

Dead loads shall be in general as per I.S. 875 Part (I). However, the following minimum loads shall be considered in design of structures:

b) Live Load

Live Load (LL) shall include the superimposed loads due to the use/occupancy of the structure/building not including dead, wind or earthquake load. Live loads shall be in general as per I.S. 875 Part (II). However, the following minimum live loads shall be considered in the design of structures:

1) Live load on roofs: 1.50 kN/m^2
2) Live load on floors supporting equipment such as pumps, blowers, compressors, valves etc.: 10.00 kN/m^2
3) Live load on all other floors, walkways, stairways and platforms: 5.00 kN/m^2
4) Live load Surcharge for Structures equivalent to: 1.2m height of earth fill.

(i)	Weight of water	9.81 kN/m^3
(ii)	Weight of soil (irrespective of strata available at site and type of soil used for filling etc). However, for checking stability against uplift, actual weight of soil as determined by field test shall be considered	20 kN/m^3
(iii)	Weight of concrete	24.00 kN/m^3
(iv)	Weight of reinforced concrete	25.00 kN/m^3

Table 1:

c) Wind Load

Wind loads shall be as per I.S. 875 Part (III).

d) Earthquake Load

Earthquake load shall be computed as per I.S. 1893. An importance factor appropriate to the type of structure shall be considered for design of all the structures of 1.5 be adopted.

e) Dynamic Load

Dynamic loads due to working of plant items such as pumps, blowers, compressors, switch gears, travelling cranes, etc. shall be considered in the design of structures.

B. Forecasting Population, Water demand & Tank Capacity

1) Determine the population of the community by Using census data originate a survey to obtain population figures.

Year	Population	Water Demand MLD
2011(census)	13000	
2025 (3%/yr)	(0.03x14) =0.42, 13000x1.42=18460	2.6MLD
For 30yrs 2055	(0.03x30) =0.9, 18460x1.9=35074 40000 Say incldg colleges	5.76MLD

Table 2:

2) Once the population is known, the demand for water can be calculated. Demand can be estimated by considering the type of distribution system used. The daily demand for water in human consumption is 125liters/day/person
   - Average day = 120 liters/day
   - Peak day = 1.2 x 120 = 144Liters/day
   - A general rule to follow is that the capacity of the storage tank should be 20percent of the peak day water demand.
   - For 40000x144=5760000litres = 5.76MLD required.
   - Proposed Tank Size : 48m (Length) X 32m (Breadth) X 4.0m (Water Height) = 6144cum = 6.144 MLD

C. Description and data of Rectangular Ground Level Reservoir

The Ground Level Reservoir (GLR) has the capacity of 6144 cum. One common inlet chamber is provided to draw water from filters to GLR. A free board of 500mm is considered. Water from sunken is conveyed to pump water. The Size of the common sump is 15m x 5m. A common cover slab to GLR is provided.

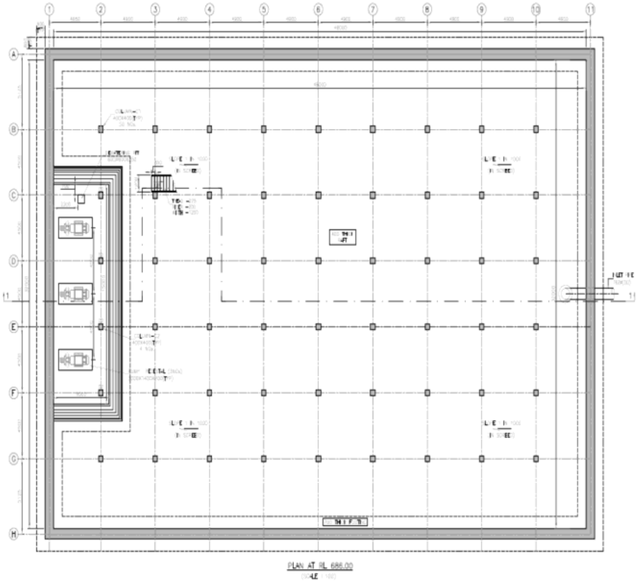


Fig. 2.1: Description of Rectangular Ground Level Reservoir

1) *Ground Level Reservoir and data:*
   - Finished Ground level (FGL) =689.00 m
   - Natural Ground level (NGL) = 689.00 m
   - Lowest water level (L.W.L) = 687.00 m
   - Maximum water level (M.W.L) = 690.00 m
   - Top Raft Level=686.00 m
2) *Design Constants*
   - Unit weight of water =9.81 Kn/m2
   - Unit weight of Concrete=25 Kn/m2
   - Unit weight of Soil=20kn/m2
   - Unit weight of surcharge=20 Kn/m2
   - Grade of Concrete=M30
   - Grade of Steel=Fe500
   - Tensile stress under direct tension, bending & shear σst = 0.87fy
   - Ru = 0.133*fck=3.99
   - Minimum reinforcement (Clause no. 8.1.1 of IS 3370 (Part 2):2009)
   - Min % of steel =0.35%
   - Maximum spacing of bars=300mm
3) *IS Codes/ Documents*
   - a.IS:456- 2000 - Plain & reinforced concrete - Code of Practice (Fourth revision)
   - b. SP: 16: Design Aids for reinforced concrete to IS 456
   - c. SP: 34 -1987 Hand Book on Concrete Reinforcement and Detailing.
   - d .IS:3370 - 2009 - Code of practice for concrete structures for the Storage of Liquids
   - Part-I: General Requirements
   - Part-II: Reinforced Concrete Structures
4) *Plant Site Information:*
   - Location of the Site: Harohalli, Karnataka
   - Basic Wind speed: 33 m/s (considered)
   - Seismic Zone: Zone II
   - Soil Properties:
   - Net Safe Bearing capacity considered for design = 200 Kn/m2

D. *Design of Reservoir Walls:*

1) *Design Data:*
   - Length of each compartments = 48 m
   - Width of each compartment =32 m
   - Depth of water in each compartment =4 m
   - Free Board (excluding slab thickness) = 0.5 m
   - Height of water pressure including free board =4.5 m
   - Height of the wall below FGL = 3 m
   - Height of wall above the FGL = 1.7 m
   - Total height of the wall =4.7 m
   - Thickness of wall footing =0.75 m

E. *Design Philosophy:*

The reservoir walls are designed as propped cantilever wall considering prop action at top cover slab level, Fixed at base slab at +686 level. The liquid retaining face of the wall is designed as LSM & as per IS 3370

Wall is designed for following two conditions:

1) Tank Full with water and no soil pressure from outside
2) Tank empty and soil pressure from outside

Case i) Tank Full with water and no soil pressure from outside

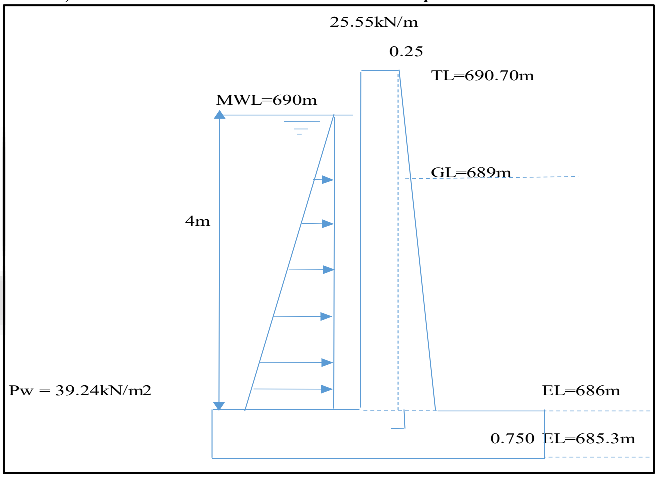


Fig. 2.2: Tank Full with water and no soil pressure from outside

Wall is designed for bottom edge fixed and top edge free (cantilever).

Therefore Mux= w x X^2 / 6 (where as w= γw x H)

Water Height=4.0m

Minimum Reinf.=0.35%

Load due to water=39.24 kN/m²

BM water=104.64 Kn-m

Case ii) Tank empty and soil pressure from outside

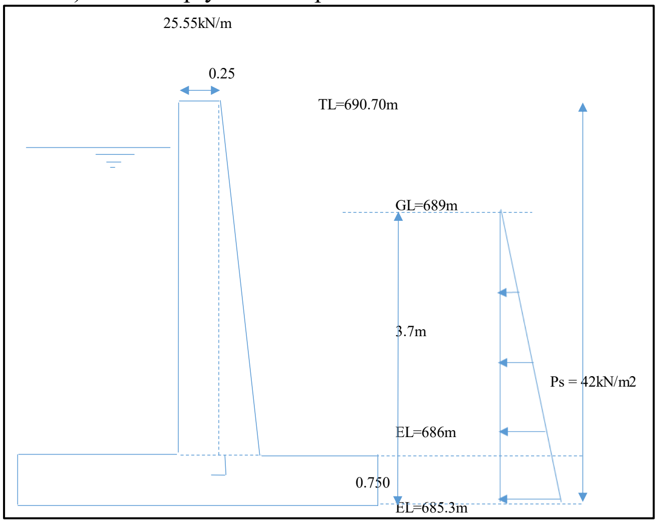


Fig. 2.3: Tank empty and soil pressure from outside

- Therefore Mux= (Ka x ϒs x h³/6+ka q h x h/2
- Soil Height=3.0m
- Surcharge weight of 1.2m Height
- Load due to soil Ka x ϒs x h =30 kN/m²
- Load due to surcharge ka q=12 kN/m²
- Total pressure @ bottom= 42Kn/m2
- BM soil= 99Kn-m
- D Reqd √(M/RuB) Here Ru = 0.133 x fck = 198.34mm
- Ast req=[(0.5xfck/fy)x(1-sqrt(1-((4.6xMu)/(fckxbxd^2))))]xbxd=537.988mm2
- Minimum Ast Reqd=0.35%(BD)=875mm2

1) *Reinforcement Calculations*
   - Thickness of the wall =750 mm
   - Clear cover to all reinforcement on water face=60 mm
   - Clear cover to all reinforcement on soil face=50 mm
2) *Vertical reinforcement:*
   - Diameter of vertical reinforcement on water face=20 mm
   - Diameter of vertical reinforcement on soil face=20 mm
   - Effective depth of the wall on water face=680mm
   - Effective depth of the wall on soil face=690mm
   - Area of steel Reinforcement on water face:
   - Dia of bars proposed to be used=20 mm
   - Area of each bar=314.2mm²
   - Minimum percentage of steel required=0.35 %
   - Minimum area of steel required=875mm²
   - The spacing of bars required at the bottom face =359.1mm
   - Provided spacing of bars =100mm C/C
   - Area of steel provided at the bottom=3142mm²
3) *Y20 @ 100c/c on water face in vertical direction*
   - Horizontal Reinforcement
   - Dia of horizontal reinforcement bar=20 mm
   - Minimum percentage of steel required in each direction on each face = 0.35 %
   - Minimum area of steel required = 875 mm2
   - Spacing of reinforcement required =359 mm
   - Spacing of reinforcement provided= 150 mm
4) *Y20 @ 150c/c on each face in horizontal direction*
   - Stability check for Wall- W1 (Case I: Tank Full and No Soil outside)
   - Width of wall at the base tb=0.75 m
   - Width of wall at the top tt=0.25 m
   - Width of footing near water face L1 =1.6 m
   - Width of footing near soil face L2 =1.2m
   - Total Height of wall (H1) =4.7m
   - Height of straight portion of wall (H2) =0 m
   - Height of taper portion of wall (H4) =4.7 m
   - Height of water level =4.0 m
   - Depth of footing below the GL (H3) =3.0m
   - Thickness of footing at the water edge (t1) =0.75m
   - Thickness of footing at soil edge (t2) =0.75m
   - Thickness of footing at face of wall (t3) =0.75m
   - Base width, b =3.55m
   - Net safe bearing capacity of soil = 200 kn/m2
   - Gross safe bearing capacity of soil = 226.1kn/m2
   - Load from Flat slab = 25.57 kn/m

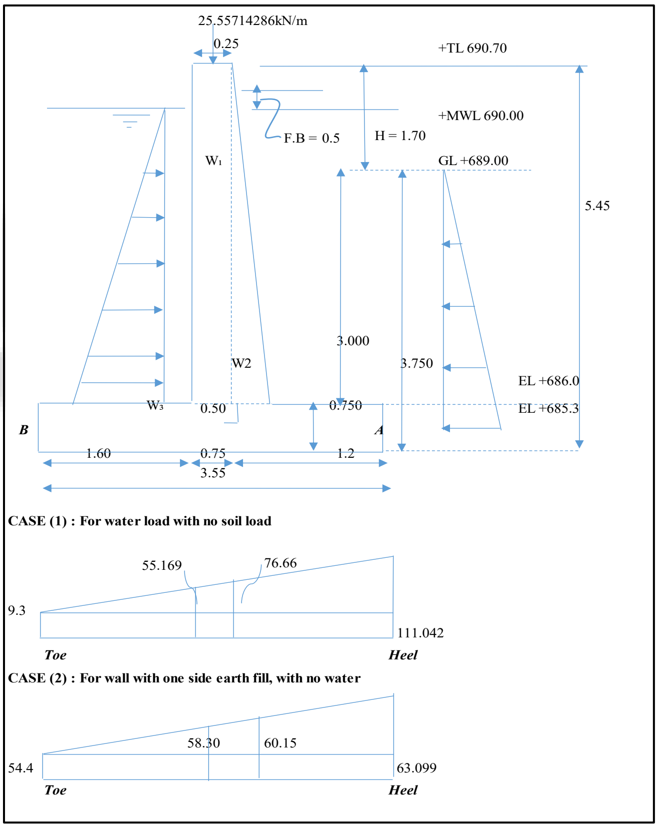


Fig. 2.4: Pressure Distribution Diagram for footing

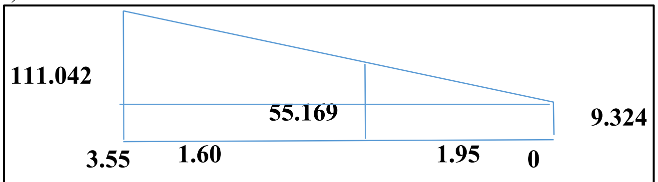
F. Design of Wall Footing

CASE (1): For tank full condition and no earth load outside

Sl. NO	Description	Load in (kN)	Lever arm (m) form A	Moment about A (kN-m)
1	Load from Roof Slab P1= 25.56	25.557	1.825	46.642
2	W1= 0.25 * 4.70000000000005 * 25	29.375	1.825	53.609
3	W2= 0.5 x 4.7 * 0.5 * 25	29.375	1.530	44.944
4	W3= 0.75 x 3.55 x 25	66.563	1.775	118.149
5	Wt. of Water= 1.6 x 4 x 9.81	62.784	2.750	172.656
6	Moment due to water pressure	78.480	2.083	-163.500
Total Load (W)		**213.7kN**		**272.500**

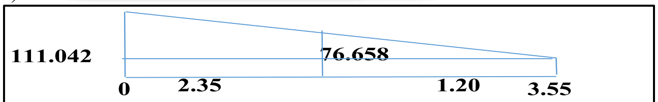
- Z =272.50 / 213.7 =1.28 m
- Eccentricity e = b/2 -Z = 0.5 m
- b/6 =3.55 / 6 =0.592m HENCE OK
- Pmax = 111.043 kN/m² <200 kN/m² HENCE OK Pmin = 9.3 kN/m² >0 kN/m² NO TENSION
- Check for over turning:
- ΣMR / ΣMO = 392.4 / 163.5 = 2.4>1.5 Hence SAFE

1) *Toe Slab*



toe Slab	**1.60**	
Upward pressure	udl	9.32 kN/m²
	uvl	45.84 kN/m²
Downward pressure	SW	18.75 kN/m²
water		39.24 kN/m²
	Total	-41.19 kN

2) *Heel Slab*



heel Slab	**1.20**	
Upward pressure	udl	76.66 kN/m²
	uvl	34.38 kN/m²
Downward pressure	SW	18.75 kN/m²
	soil	0.00 kN/m²
	Total	90.12 kN

Fig. 2.5: Pressure Distribution for Toe & Heel for case (i)

Provided Steel (bottom face) Main reinforcement of 16mm dia bars @ 100mm c/c spacing in the bottom face of heel slab portion.

Provided Steel (top face) Main reinforcement of 16mm dia bars @ 100mm c/c spacing in the top face of heel slab portion.

Provided Steel (top & bottom) Distribution reinforcement of 16mm dia bars @ 100mm c/c spacing in the top & bottom face of toe & heel slab portion.

Check for uplift

Selfweight of the raft slab	66.56	kN
Weight of wall	58.75	kN
Dead Weight of columns	35.56	kN
Total dead weight against the uplift	160.87	kN

Uplift pressure	36.79	kN/m²
Uplift force	130.60	kN
Check for uplift	1.23	> 1.2

Safe for uplift

G. Design of Flat Slab

The Top slab is designed as a Flat Slab:

- Size of column inside the tank
- Width = 400 mm
- Depth = 400 mm
- Clear cover = 45mm
- Factor of safety = 1.5
- Size of critical interior panel of flat roof slab:
- Length= 4.9m
- Width=4.5m
- Size of critical exterior panel of flat roof slab:
- Length =5.125m
- Width=4.9m
- Loads acting on the flat slab:
- Assume thickness of flat slab at middle strip =200mm
- Assume thickness of flat slab at Drop=250mm
- Average thickness=225mm
- Total load acting on the flat slab = 9.725kN/m2
- Total factored load acting on slab1=14.5875 kN/m2

Check for requirement of direct design method:

1) No. of spans is more than 3
2) Long span/short span = 5.125/4.9 < 2
3) Columns are not staggered
4) Successive spans in each directions are equal
5) Design Live load = 2 < 3xD.L (3x5.625)

Therefore all the requirements are satisfied and, therefore, empirical direct design method can be used.

- Width of colum strip 2*0.25*4900 =2450mm
- Length of column strip 2*0.25*4500=2250mm
- Width of Middle strip 4900-2450= 2450mm
- Length of Middle strip 4500-2250= 2250mm
- Minimum Length of the drop 1/3*4900=1633.333mm
- Minimum width of the drop 1/3*4500=1500 mm
- Size of the drop= 2450mm Size of column head is the 1/4 to 1/5 of the average span 1/5*(4900+4500)/2=940 mm 1/4*(4900+4500)/2=1175 mm

Provided size of column head=1700 x 1700 mm

1) *Design Moments in Longitunal direction:*

Absolute sum of the positive and average negative BM in each direction (Mo) = WxLn/8

Where:

W = design load on an area L2 xLn

Ln = Clear span extending from face to face of columns

Ln = 5.125-1.7 =3.425m

\> 0.65*4.9=3.185 mm

W = 14.5875x4.9x3.425 =244.81kN

Mo1 = 244.81x3.425/8 =104.81kN-m

The total design moment is distributed initially into total negative and positive moments in the panel.

Distribution of total design moments in longitudinal direction as panel moments:

The division of positive and negatives moment depends on the ratio of $\alpha c = \Sigma kc/ks$

Where Σkc and ks are stiffnesses of columns and slab respectively.

$\alpha c = \Sigma kc/ks$ = Sum of stiffnesses of columns meeting at the joint / stiffness at slab

At the roof level we have columns below the roof level of size 400mm and height of 4700

Height of the column=4700m<

$\Sigma kc = Ic/Lc\ (400x400^3/12)/4700 = 453900.71$N-mm

$ks = Is/Ls(4900x200^3/12)/5.125 = 637398.37$N-mm

$\alpha c = \Sigma kc/ks = 453900.71/637398.37 = 0.71$

Factor $\beta = (1+1/\alpha c) = 2.41$

2) *Design Moments in Transverse direction:*

Absolute sum of the positive and average negative BM in each direction (Mo) =WxLn/8

Where:

W = design load on an area L2 xLn

Ln = Clear span extending from face to face of columns = 4.9-1.7 =3.2m

W = 14.5875x5.125x3.2 =239.24kN

Mo1 = 239.24x3.2/8 =95.7kN-m

The total design moment is distributed initially into total negative and positive moments in the panel.

Distribution of total design moments in longitudinal direction as panel moments:

The division of positive and negatives moment depends on the ratio of $\alpha c = \Sigma kc/ks$

Where Σkc and ks are stiffnesses of columns and slab respectively.

$\alpha c = \Sigma kc/ks$ = Sum of stiffnesses of columns meeting at the joint / stiffness at slab

At the roof level we have columns below the roof level of size 400mm and height of 4700

$\Sigma kc = Ic/Lc\ (400x400^3/12)/4700 = 453900.71$N-mm

$ks = Is/Ls\ (5125x200^3/12)/4.9 = 697278.91$ N-mm

$\alpha c = \Sigma kc/ks = 453900.71/697278.91 = 0.65$

Factor $\beta = (1+1/\alpha c) = 2.54$

Design Moments:

It will be seen that the negative moments at the common edges of slabs are not equal.

The maximum of negative moments at the common edges of the slab are considered for design.

Check for depth for flexure:

Thickness of flat slab required at column strip

= 22.73x1000000/(0.133*30*1000)=75.48 mm

Thickness of flat slab provided =200mm

Thickness of flat slab required at middle strip

= 8.79x1000000/(0.133*30*1000) =46.94mm

Thickness of flat slab provided =150mm

Min area of steel reqd. = 437.5mm2

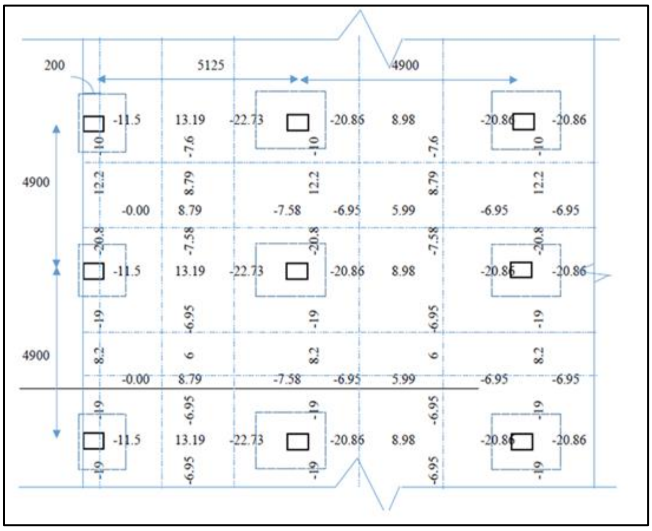


Fig. 2.6: Distribution 0f Moments in Flat Slab

Column strip Reinforcement:

- Max -ve steel required in column strip = 267.232mm2/m Top steel
- Max +ve steel required in column strip = 206.916mm2/m Bottom steel

Hence provide 10mm dia bar at 150mm spacing as bottom reinforcement in column strip

Hence provide extra bars of 10mm dia bar at 150mm spacing at bottom of drop

Middle strip Reinforcement:

- Max -ve steel required in middle strip = 117.716mm2/m Top steel
- Max +ve steel required in middle strip = 136.801mm2/m Bottom steel

Hence provide 10mm dia bar at 150mm spacing as top reinforcement in Middle strip

Hence provide 10mm dia bar at 150mm spacing as bottom reinforcement in Middle strip

- Check for Deflection at column strip: Refer Clause 40.2.1.1 of IS 456:2000
- L/d ratio for continuous slab L/d = 26
- Area of +ve Steel req. in column strip along long span, A reqd. =267.23 mm2
- Area of +ve Steel prov. in column strip along long span, Aprov. =523.60mm2
- Steel stress of Service Load, fs =0.58fy(Ast req/Astpro) =148.00 N/mm2
- Percentage of steel provided=0.26
- Modification factor, a=2
- Required Depth, d=94.23 mm < 200, Safe in deflection Refer Clause 23.2.1, 24.1 of IS 456:2000
- Check for Deflection at middle strip: Refer Clause 40.2.1.1 of IS 456:2000
- L/d ratio for continuous slab L/d = 26
- Area of +ve Steel req. in column strip along long span, A reqd. =136.80 mm2
- Area of +ve Steel prov. in column strip along long span, Aprov. =523.60mm2
- Steel stress of Service Load, fs =0.58fy(Ast req/Astpro)=75.76 N/mm2
- Percentage of steel provided=0.35

- Modification factor, a=2
- Required Depth, d=94.23 mm < 150, Safe in deflection Refer Clause 23.2.1, 24.1 of IS 456:2000
- Crack width of Wall, Wall footing, Flat Slab, Base slab <0.1mm & and Safe in Shear.

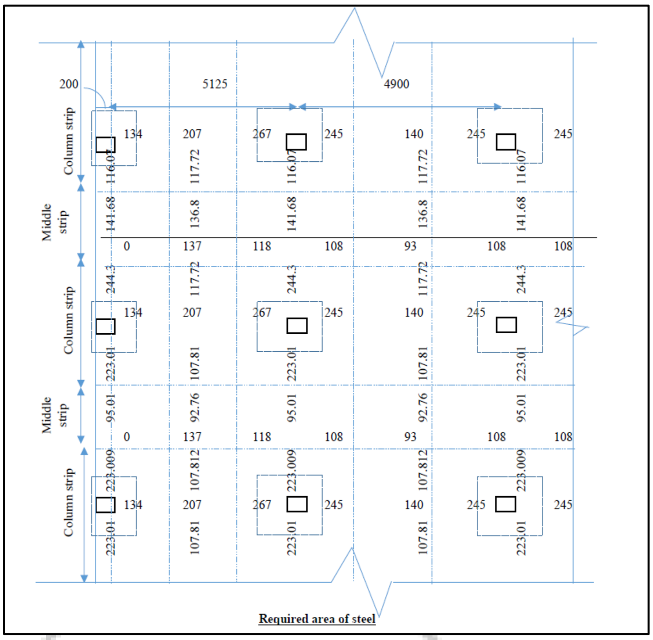


Fig. 2.7: Reinforcement area of steel

IV. Conclusion

Design of water retaining structures is tedious method particularly design of ground level reservoir involves a lot of mathematical formulas and this project by designing reservoir gives the solution for all those problems. Thus, providing safe economical design for storage of water to supply consumers.

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