Design of Cascade Aerator for urban area water treatment plant

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ABSTRACT

A potable water parameters consist of chemical, physical, and biological properties and should be tested based on the desired limiting values/ranges of parameters concern. Conventionally drinking water treatment plant consists of aeration, chemical dosing coagulation, flocculation, sedimentation, and filtration and disinfection units which will be decide based on quality of raw water sample , each unit are generally optimized to realize the specified water quality effluent, both in design and operation stages. The study was carried out to requirement of aeration process and design of aeration unit for the water quality and its suitability for drinking purpose.

Keywords- Need of aeration, Design parameters, and cascade Aerator and Parshall flume.

INTRODUCTION

As we know that nowadays water is the most critical issue for the domestic as well as urban area people, because with increasing the standard of life style, future development of civilization and industrialization in all sectors somewhere we started consuming the polluted water around our surface as well as sub surface resources. In order to get healthy life of all the people around the world we need filtration or treatment of the water. In order to protect our self-from the any type of disease as we know that contamination of the water is very natural which affects directly or indirectly to the life of the human beings for the prevention we need to treat the water before the supply to the households we encountered number of units one by one for the treatment of the water in the treatment plant by the conventional method of treating raw water for drinking purpose.

Different units of Water treatment plant-

1) Aerator, Parshall flume & flash mixer
2) Chlorine/chemical mixing unit
3) Coagulation and flocculation tanks
4) Filters (Slow sand filter or rapid sand filters)
5) Clear water storage
6) Back water storage

In this paper we are going to see the RCC design of Parshall flume design for the aerators.

Aeration -This is often adopted to get rid of objectionable tastes and colour and also to get rid of the dissolved gases like carbon dioxide, hydrogen sulphide etc. The iron and manganese existing in water also oxidized to some extent. This process is optional and isn't adopted in cases where water doesn't contain objectionable taste and odour. In our case we adopted cascade aerator. With cascade aerators, aeration is accomplished by natural draft units that blend cascading water with air that's naturally inducted into the water flow. Cascade water is pumped to the highest of the aerator, and cascades over a series of trays. Air is of course inducted into the water flow to accomplish iron oxidation and a few reductions in dissolved gasses.

Methodology

In the view of the methodology some point are need to be discussed here that Cascade aerator is the unit which connected to influent Raw water at one end and Parshall flume in another end which will further connects to the flash mixer chamber. In this paper we will only see the design of cascade aerator RCC structure –

Design of cascade aerator units–

Design steps –

1) Load calculations

2) Calculation of bending moment – required

3) Area of steel required and provided

3) Design for shear at base

4) Crack width for flexural effect.

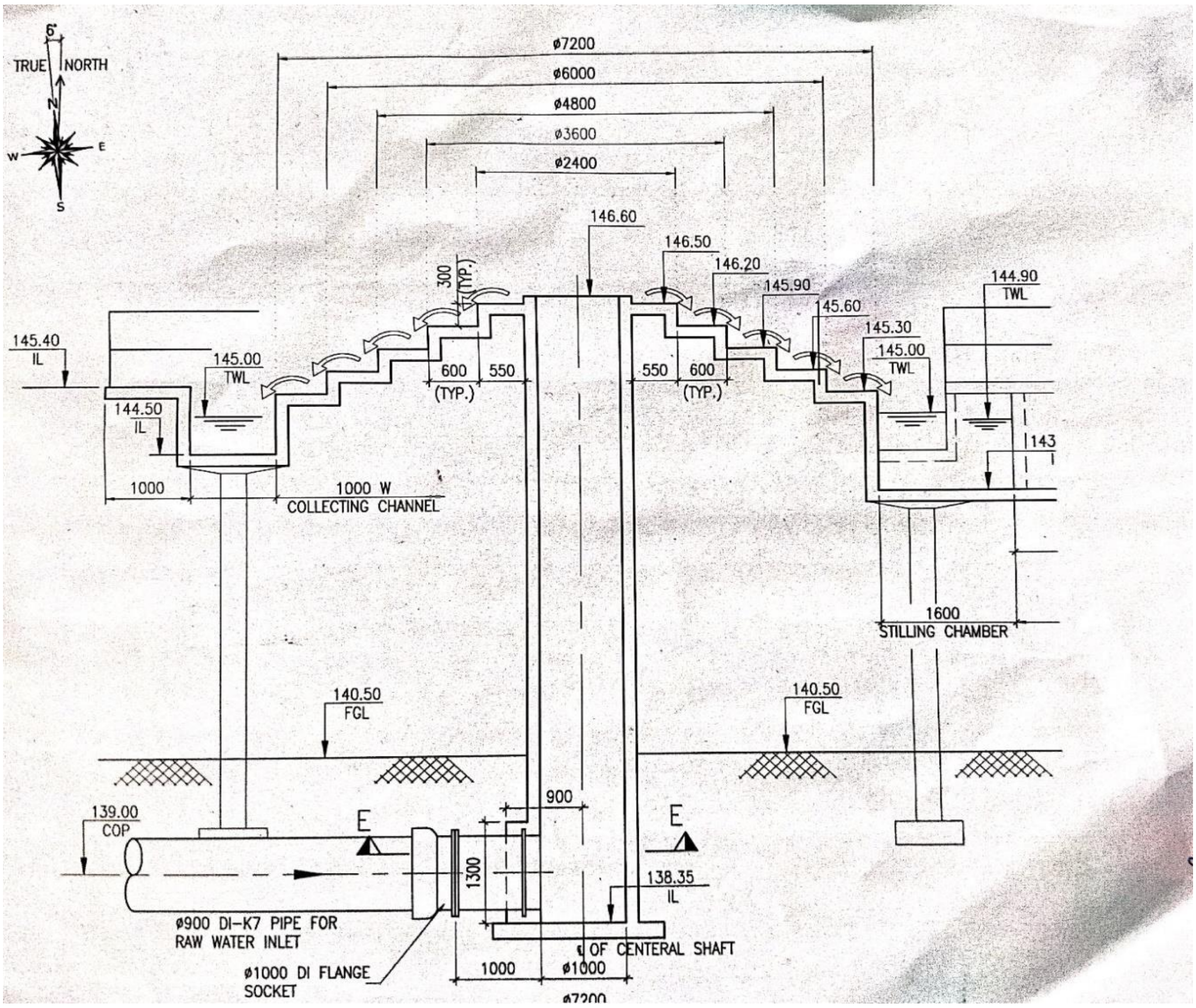

Fig-1 showing typical cross sectional view of cascade aerator.

Different Components of cascade aerator-

Base slab of cascade aerator

1) Central shaft

2) Steps (pan)

3) Collecting channels

4) Silting chamber

5) Footing

- **Design of Cascade Aerator:-**

1) Base slab of cascade aerator

2) Design of central shaft

3) Design of shaft as annular column

4) Design of foundation of Central shaft

5) Design of conical slab

6) Design of walkway

1) Design of Base Slab of Cascade Aerator:-

- Base slab is designed as one way spanning from Beam at one end and central shaft at other Ends.
- Horizontal Span =2.90 M (Refer Dwg.)
- Slope of The Slab=63.00

Degree Loading Adopted:-

- Typical clear trough length 0.60 M
- RCC step Height as per Dwg =0.30 M
- step Load/Sqm = 4.50 KN/Sqm
- Self-Load Base Slab
- Slab thickness Provided 0.175 M
- Slab load 4.38 KN/Sqm
- Total UDL 8.88 KN/Sqm
- Load on Projected length 19.5 KN/Sqm
- Say 20.00 KN/Sqm

- Width of the strip at column Center Line 1.00 M
- Diameter at this Location 7.20 M
- Diameter at Central shaft location 1.00 M
- Load intensity at Beam Location 20.00 KN/M (1 x 19)
- Slab width at Central Shaft Loc. 0.139 M = 1x 1/7.2

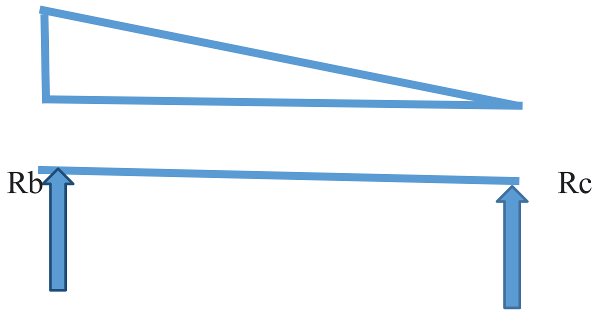

Fig-2 (showing reaction due to cantilever action)

- Load intensity at Central shaft 2.78 Kn/M =0.139 x 19
- Total Load on the Slab Strip =33.03 Kn
- Reaction on the Beam end = Rb =20.68 Kn
- Reaction at Central shaft= Rc =12.35 Kn

Check for shear at Central shaft location:

- Shear check is made at distance " d " from wall face
- Diameter at critical shear =1+2*0.2+2*0.175 1.75 M =1x1.7/7.2
- Width of the section 0.24 M
- Shear stress (d=15-4.5-0.5) 0.34 Mpa
- V= 0.34 Mpa

Refer Table 61 SP16

- Percentage required 0.20 % Concrete
- Grade M30
- Ast rqd = 1.50 Sqcm/M
- Total Steel Required 8.25 Sqcm
- Provided 22nos- Y10 at top& bottom

Check for shear at Beam location:-

- Shear at this section 20.68 KN
- B= 100.00 Cms
- d=17.5-4.5-0.5 12.50 Cms
- Shear Stress 0.17 Mpa
- Nominal OK

2. Design of central shaft:-

  - Design for Hoop forces:-
  - Check for 1000 dia section:-
  - Critical section at level 138.35 M
  - Maximum water Level 146.60
  - Water height 8.25 M
  - Shaft Diameter 1.00 M =8.25x10x1/2
  - Hoop force 41.25 Kn
  - Wall section Provided 0.20
  - M = 41.25x1000/1000/200
  - Stress developed 0.21 Mpa
  - Nominal Provided Minimum steel 0.35 % Ast= 3.50 Sqcm
  - Provided Y10-200 C/C Both Faces

Forces developed at the kink point due to vertical Load:-

  - Load from cascade aerator 279.25 kn
  - Load/ Meter 88.89 kn/m
  - Self-Load of the Shaft:- Wall Height 8.25 M
  - Wall thickness provided 0.20 M
  - Wall Load / Meter 41.25 kn/M
  - Total Load/M 130.14 kn/m
  - Say 126.00 Kn
  - Horizontal force developed 25.20 Kn

Stress in steel=130Mpa

  - Hoop force developed 13.86 Kn
  - Ast rqd 1.07 Sqcm
  - Provided 2 Nos 10 Extra Both Face

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Check for 1M dia section:-

- Critical section at level 138.35 M
- Maximum water Level 146.60 M
- Water height 8.25 M
- Shaft Diameter 1.00 M
- Hoop force 41.25 Kn
- Wall section Provided 0.20 M
- Stress developed 0.21 Mpa
- Nominal Provided Minimum steel 0.35%
- Ast= 3.50 Sqcm
- Provided horizontal steel Y10-200 C/C Both Faces

3). Design of Shaft as Annular Column:-

Normal Case:-

- Reaction from the Aerator Slab 279.25 Kn
- (154.5-148.4) Self Load of the Shaft :- H= 8.25 M
- Self-load of the Shaft= 142.55 Kn
- Total Load on the Shaft 421.80 Kn
- Compressive Stress Developed 0.67 Mpa
- Nominal for M30 Concrete , Provided Min. 0.8 % 50.24 Sqcm
- Steel Provided 50 Nos Y12 on Both Faces

Check for Seismic Case: - (56.5 Sqcm)

- Seismic zone Zone II
- Basic seismic Coefficient 0.10
- Importance Factor 1.75
- Performance Factor 3.00
- Sa/g adopted 2.50 (maximum)
- Design horizontal Seismic coefficient as per Cl 6.4.2 of IS 1893 =0.07
- (due to load from aerator) Horizontal Force at Top 20.36 Kn
- Horizontal force self-Load shaft 10.39 Kn
- Water Load in the Shaft 64.76 kn

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- Horizontal force due to water 4.72 Kn
- Ht=8.25 M
- B.M due to seismic forces 117 kn-M
- say 114.00 kn-m
- Diameter of the shaft 1.00 M
- Ast=(fst=130) 10.20 Sqcm/M
- Total steel 35.22 sqcm
- Each face 17.61 sqcm
- Provided 25.00 Nos Y12 E.F

4) Design of the Foundations for the Central Shaft:-

- Loading from the aerator = 279.25 Kn
- Loading from self-load central shaft =142.55 Kn
- Water load in the shaft =64.76 Kn
- Foundation provided
- L =1.80 M
- B =1.80 M
- Thickness =0.30 M
- Self-Load Footing =24.30 Kn
- Soil Load on footing Area on which load is acting =2.46 Sqm
- Soil height =2.15 M
- Soil Load on footing =95.01 Kn
- Total vertical Load 605.87 =Kn
- say =593.00 Kn

Allowable =310 KN/Sqm at 2 mt.

- depth Base pressure normal Case =183.02 KN/Sqm
- Seismic Moment =135.1 kn-m
- say =131.00 kn-M
- Additional base pressure =134.77 KN/Sqm
- Maximum base pressure developed = 317.80 KN/Sqm
- Minimum base pressure developed=48.25 KN/Sqm (for seismic case)
- Gross allowable= 387.50 KN/Sqm

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- Design Vertical pressure Max= 232.50 KN/Sqm
- Maximum footing offset= 0.30 M
- B.M in footing as cantilever =10.46 kn-M
- D required as uncracked section =177.16 MM
- Thickness provided =300.00 MM
- Cover to steel= 50.00 MM Bar
- Diameter adopted= 12.00 MM
- d= 244.00 MM
- b= 1000.00 MM
- Mu/b/d/d =0.26 Mpa
- Refer table 4 SP16,
- Fy 500
- Pt= 0.12
- Ast= 292.80 Sqmm
- Min steel provide= 0.35% 5.25 Sqmm
- Ast provided= 5.65 Sqmm
- Provided at bottom Y12-200C/C B both ways Provided at top Y12-200C/C T bothway

5) Design of conical slab:-

- Provided Thickness =175 MM
- Length of slab= 3 M Slab
- Thickness provided= 0.175 M
- Dead Load of the slab =4.375 KN/Sqm
- Step load= 3.75 KN/Sqm
- Floor Finish provided 50Th. =1.20 KN/Sqm
- water Load 3 KN/Sqm Total UDL on slab=W 12.33 KN/Sqm
- M= Maximum B.M =WL^2/8 13.866 Kn-M
- D provided= 175 MM
- Cover to steel =40 MM Bar
- Diameter =10 MM
- Effective depth =130 MM
- Mu=1.5xM 20.79844 Kn-M

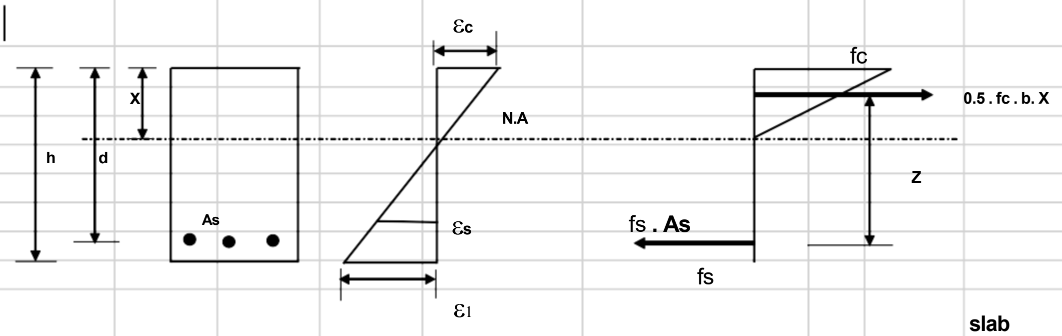
- Mu/b/d/d= 1.2 Mpa
- As per table 4 SP16 Fe500
- Pt= 0.3160 %age
- Ast= 410.800 Sqmm/M
- Provided T10-175 mm
- Ast. Provided = 448.57 Sqmm/M

For hoop tension in conical slab =

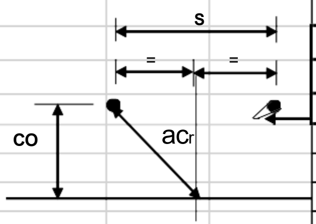
= Ww+ Ws/2x3.14 + Wwx tana/2x3.14

- Ww water resting on conical slab = 3 Kn/m^2
- Ws selfwt. Of slab = 8.25 Kn/m^2
- Hoop tension = 4.636 kn/m
- Ast. = 35.659 mm^2
- Ast. Of each face = 17.83 mm^2
- Hence provided 10dia @ 175 c/c mid layer
- Actual Ast. = 2*1000*78.5/175= 1256.00 mm^2
- Crack width of slab –

CRACK WIDTH FOR FLEXURE EFFECT



slab



Grade of Concrete Used (fcu)	=	N/mm^2	30
Grade of Steel Used (fy)	=	N/mm^2	500
Area of Reinforcement " As "	=	mm^2	448.57
Width of Section b	=	mm	1000
Depth of Section h	=	mm	175
Effective Depth of Section " d "	=	mm	130
Minimum Cover to Tension Reinforcement " CO "	=	mm	40
Maximum Bar Spacing " S "	=	mm	175
Bar Dia	=	mm	10
" acr " = (((S/2)^2 + (CO + DIA/2)^2)^(1/2)-DIA/2)	=	mm	93.39
Distance From the Point Considered to the Surface of Nearest Longitudinal bar			
Applied Service Moment " Ms "	=	KNm	13.87
CALCULATION :			
Moduli of Elasticity of Concrete " Ec " = 5000x (sqrt(fcu)) =		KN/mm^2	27.39
Moduli of Elasticity of Steel " Es " =		KN/mm^2	200.00
Modular Ratio " α " = (Es/Ec)	=		14.61
"ρ" = As/bd	=		0.00345
α.ρ	=		0.05
Depth of Neutral Axis, " **X** " = d.α.ρ(((1+(2/α.ρ))^0.5)-1)	=	mm	35.24
Lever arm " Z " = (d - X/3)	=	mm	118.25
Reinforcement Stress " fs " = Ms/(As*Z)	=	N/mm^2	261.40
Concrete Stress " fc " = (fs*As)/(0.5*b*X)	=	N/mm^2	6.66
Strain at Soffit of Concrete Slab "ε1 " = (fs/Es)*(h-X)/(d-X)	=		0.00193
Strain due to stiffening effect of Concrete between the Cracks " ε2 "	=		0.00077
ε2 = b . (h-X)2/(3.Es.As.(d-X)) for Crack Width of 0.2mm			used
ε2 = 1.5 .b . (h-X)2/(3.Es.As.(d-X)) for Crack Width of 0.1mm			not used
Average Strain for Calculation of Crack width " εm "	=		ε1 - ε2
	=		0.00116
Calculated Crack Width , " W " = 3.acr.εm/(1+2.(acr-CO)/(h-X))			
Calculated Crack Width " W "	=	mm	0.185

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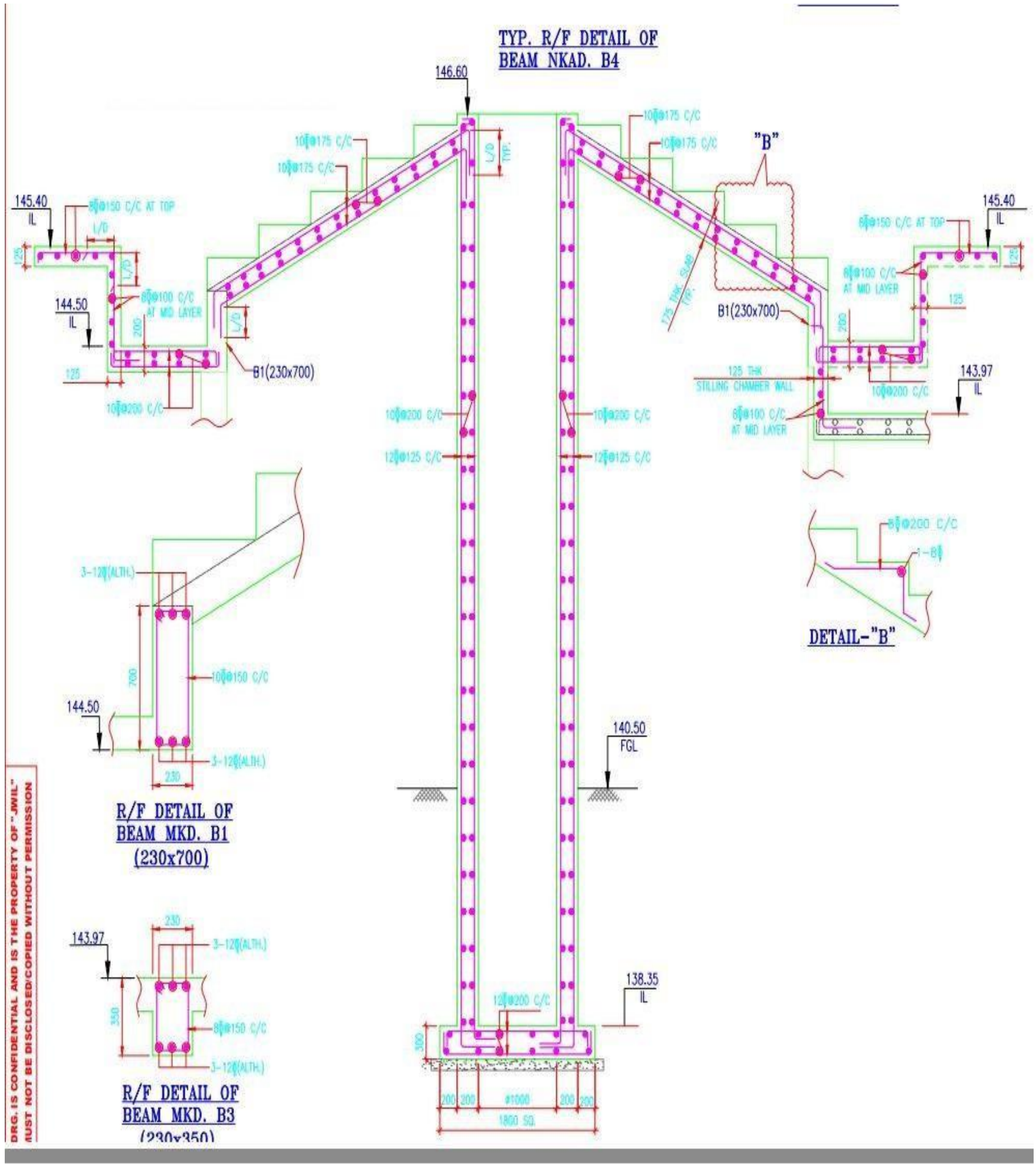
6) Design of Walkway:-

Provided 125 MM

- Thick Total width of walk way = 1 M
- Clear span of walkway=1.0-0.125 =0.875 M
- Slab thickness provided= 0.125 M
- Dead Load of the slab = 3.125 KN/Sqm
- Floor Finish provided 50Th.= 1.20 KN/Sqm
- Live Load =3 KN/Sqm
- Total UDL walkway=W 7.33 KN/Sqm
- M= Maximum B.M =1x1xW/2 4.038 Kn-M
- Depth Provided= 125 MM
- (Tension at top)
- Cover to steel = 20 MM
- Bar Diameter = 8 MM
- Effective depth= 101 MM
- Mu=1.5xM =6.057 Kn-M
- Mu/b/d/d = 0.6 Mpa
- As per table 4 SP16 Fe500
- Pt of steel % = 0.1410 %age
- Ast= 142.410 Sqmm/M
- Provided =T8mm-150 c/c =335 Sqmm/M


TYP. R/F DETAIL OF
BEAM NKAD. B4
146.60
"B"
145.40
IL
144.50
B1(230x700)
125 THK
STILLING CHAMBER WALL
143.97
DETAIL-"B"
R/F DETAIL OF
BEAM MKD. B1
(230x700)
140.50
FGL
138.35
R/F DETAIL OF
BEAM MKD. B3
(230x350)
1800 SQ.
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Conclusion

As a conclusion we have the RCC structure details for the different small units contain cascade aerator we are able to decide the RCC quantity as well as steel quantity consumed by the particular units of the cascade system which is the finals AIM of this paper summary of the design are mentioned below ,Design parameters Base slab of cascade aerator - Horizontal Span =2.90 M (Refer Dwg.), Slope of The Slab=63.00 , Diameter at Central shaft location 1.00 M ,Provided 22nos- Y10 at top& bottom, B= 100.00 Cm, d=12.50 cm, Design of the Foundations for the Central Shaft: - Foundation provided, Length 1.80 M, Breadth =1.80 M, Thickness 0.30 M, Provided at bottom Y12-200C/C B both ways provided at top Y12-200C/C T both way.

Design of Conical slab includes, Length of slab= 3 M Slab, Thickness provided= 0.175 M, D provided= 175 mm, Cover to steel =40 mm Bar, Provided T10-spacing 175 mm.

Design parameters outputs for the of walk way includes Thick Total width of walk way = 1 m,Depth provided= 125 mm,Cover to steel = 20 mm,Bar Diameter = 8 MM, Effective depth= 101 mm,Pt of steel % = 0.1410 %age, Ast= 142.410 Sqmm/m ,Provided =T8mm-150 c/c =335 Sqmm/M.

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