Case Study on Water Distribution System of Village Dawalikhurd Burhanpur MP

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Abstract— This paper concerns for the design of rural water distribution systems in developing countries. Most of population of India is staying in rural area. At end of nineteen century community is not getting water at their resident in the village. But water is basic need of human being and it is directly effete on human health. Indian government is decided to provide safe, regular and adequate water to the community at their resident. This paper is helpful to water supply engineers are facing the problem of designing new distribution network in haphazard developed rural area. For designing of best economical water distribution system LOOP version 4 heuristic software is used with a case study. Design procedure satisfied all constraints with a minimum total cost. The constraints include residual nodal pressure, velocity of flow in pipe, pipe material, reservoir level, peak factor and available commercial pipe diameters. In investigation, it is found that water distribution network cost occupied almost 70% of the total cost of water supply system. Extensive research has been done to minimize cost through optimization in design of water distribution network. In addition to the simulation tool, optimization techniques to identify the least cost design of distribution systems, while achieving the most equitable distribution of water have been developed.

Keywords: Water Distribution System, Village

I. INTRODUCTION

A. Water Distribution System

The purpose of distribution system is to deliver water to consumer with appropriate quality, quantity and pressure. Distribution system is use to describe collectively the facilities used to supply water from its source to the point of usage.

After complete treatment of water, it becomes necessary to distribute it to a no. of houses, states, industries, and public places by means of a network of distribution system. The distribution system consists of pipe of various size, valves, meters, pumps, distribution reservoir, hydrants, stands posts, etc. The pipe lines carry the water to each and every street, roads. Valves control the flow of water through the pipes. Meters are provided to measure the quantity of water consumed by individual as well as by the town .Hydrant are provided to connect the water to the fire fighting equipments during fire. Service connections are done to connect the individual building with the water line passing through the street. Pumps are provided to pump the water to the elevated service reservoir or directly in the water main to obtain the require pressure in the pipe lines

II. STUDY AREA:

In this paper, the brief notes about the study area selected, methodology adopted for data collection, population of dwalikhurd village in 2060 and total water requirement in that year will be worked out. The methods adopted for obtaining the data are by direct measurements, quantitative estimates or by interview with staff of Water and Sanitation Management Organization.

Following data are collected for present study:

1) Hydrological data: Average rainfall of burhanpur district Is 978.9mm.
2) Geological data: dwalikhurd village in burhanpur district in the madhyapradesh state of india
3) Water quality data: The Available water is of good quality.
4) Public survey: Opinion poll regarding need of village people has been carried out mape of dwalikhurd village

A. Population Forecast:

ARITHMETIC INCREASE METHOD		Increment per decade
Year	Population	
1980	1059	516
1990	1575	514
2000	2089	520
2010	2609	520
2020	3129	
TOTAL		2070

B. Population for the Year.

1) Arithmatic Increase Method -

In this method is based on the assumption that the population increase at a constant Rate i,e dp /dt=constant=k' The projections are given in Table 2.8

C. Arithmatic Method

X=2070/4=517.5

$P_n = P_0 + n.x$

P_0 = Last known census

n = No. of decades

1) *population after 1 decade beyond 2020*

$P_{2040} = P_{2020} + 2\times X$

$P_{2030} = P_{2020} + 1 \times 517.5$

= 3646.5

2) *population after 2 decades beyond 2020*

$P_{2040} = P_{2020} + 2\times X$

= 3129 +3× 517.5

= 4164

3) *population after 3 decades beyond 2020*

$P_{2060} = P_{2020} + 3 \times X$

= 3129+3 ×517.5

=4681.5

4) *population after 4 decades beyond 2020*

$P_{2060} = P_{2020} + 4\times X$ = 3129+4×517.5

=5199

Proposed population of year 2060 after 40 years is 5199

Domestic water demand= 135×populationDomestic water demand= 135×5199=701865

Generally domestic water demand adopted 135 litre but in some cases it will be 200 for minimum domestic water consumption given below in table.

D. Total Of Per Capita Demand For An Average Of Village

USE	DEMAND IN (l/h/d)
Domestic use	200
Fire demand	15
Commercial use	20
Civic or public use	10
Wastes	25
TOTAL	270 per capital demand

PER CAPITA DEMAND IN (litres / day) =270 x 5199

PER CAPITA DEMAND IN (litres / day) = 1403730

III. DESIGN PARAMETERS & DESIGN OF TANK

. The circular elevated over head water tank is designed both manually and analytically for 1403730liters.

A. Dimension Of Tank

Capacity of tank is 1403730 litres

Volume=area of circular tank

Assume H=6M

1403.73 = $\pi/4XD^2Xh$

$1403.73=\pi/4XD^2X6$

Diameter of tank is 17 m.

Thickness of tank of the wall is 0.3 m.

Freeboard is providing 0.2 m.

So the total height of tank is 6.2 m.

We design the circular tank in our project for storing water whose capacity is 1403730 litres and having dimension of the tank 10x17x0.3 m.

1) *STEP-1 DESIGN OF ELEVATED CIRCULAR WATER TANK*

D = 17 m.

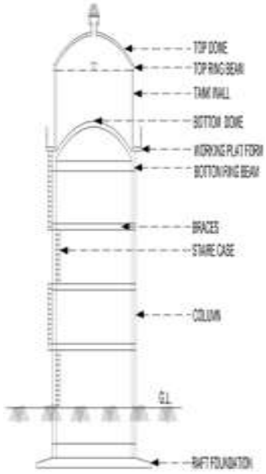
Radius = 8.5m.

Height of tank=6m

Concrete Mix = M25

Steel Fe - 415

COMPONENT PARTS OF WATER TANK



2) *STEP-2 DESIGN OF TOP DOME*

D = 17m.

Rise ,h = 1/7× D= 1/7× 17 = 2.42m. = 2.5m.

Radius $(2R\text{-}h) \times h = \underline{(D/2)^2}$

$(2R\text{-}1.5)1.5 = (17/2)^2$

3R = 72.2525+6.25

=78.5m. R = 78.5/3 = 26.16m.

Semi central angle,

$\Theta = Cos^{-1}(R\text{-}h /R)$

$\Theta = Cos^{-1}(26.16\text{-}2.5) / 2.75$, $\Theta = 25^0$

Assume thick of dome 75mm & live load be 1.5 KN/M^2

Self Weight . Of dome = 0.75×1×1×25 = 1.875KN/M^2

Live load = 1.5KN/M^2

Finishing load = 0.5KN/N^2

Total = 3.875KN/M^2

Maximum meridional thrust

T_1 = WR/1+CosΘ

$3.875\times26.16/1+Cos25^0$ = 53.17KN/M

Maximum circumferential force =

T_2 WR (cos Θ-1/1+cosΘ)

= 3.875×26.16 ×(Cos25-1/1+cos25)

= 101.37× (cos25-53.17×1000/75×1000 = 0.70N/MM^2

STEP-3 DESIGN OF TOP RING BEAM

$T = T_1 Cos\Theta\times D/2$ = 53.17Cos25×17/2

T = 53.17×0.9063×8.5 = 409.59KN

Area of steel =Ast = T/σ_s

= 409.59×1000/150

Ast = 2730.6mm^2

Area of concrete required is given by

T/Act +m×(Ast provided)= σ_t 409.59×1000/Ac+11×678.58 = 1.3

409.59×1000 = 1.3 Ac + 7464.38

49590 = 1.3Ac + 9703.69,

=1.3Ac = 409590 – 9703.69

Ac = 399886.3/1.3 = 307604 mm^2

Provide 250×300mm top

Ring beam with 6 bars of 12mm. Main reinforcement Nominal stirrup of 8mm at 22mm c/c
STEP-4 DESIGN OF TANK WALL =
Depth of water tank = 6m.
Diameter of water tank = 17m.
Maximum hoop tension in the wall
$= \gamma hD/2 = 9.8\times6\times17/2$
= 499.8KN/M
$Ast = 499.8\times1000/\sigma_s$
$= 499.8\times1000/150 = 3332mm^2$
$Spacing = \pi/4\times12^2/Ast \times1000$
$= \pi/4\times12^2/3332 \times1000 = 3393mm^2$
Provide 12mmØ@ 150mm c/c on each face
Ast provided at base
$\pi\ /4 \times12^2/150 \times100\ = 753\ mm^2$
Let thickness of wall be t
T(Hoop tension)/100t + Ast (provided) = σ_t
499.8×1000/1000t+11×753 = 1.3
499.8×1000 = 1.3 (1000t + 8283)
499800 = 1300t+ 10767.9
1300t = 499800 – 10767.9
t = 489032.1/1300 t= 376mm.
Provide 300mm thickness
Vertical steel
Bottom 4/3 = 1.333m is under cantilever moment
$= \gamma HD^2/6 = 9.8\times6\times1.333^2/6 = 17.41KN/M$
For M25 Concrete and
Fe 415 steel
$\Sigma_{bc} = 8.5N/MM^2$
$\sigma_s = 150$
m = 11
n = 0.384
j = 0.87
k = 1.423
Effective depth = D= 150 – 35 = 115mm.
$Ast = 17.41\times10^6/150\times0.0872\times115 = 1157mm^2$
$Spacing = \pi/4 \times Ø^2/ Ast$
$= \pi/4 \times10^2/1157 \times1000 = 678mm \approx 650m$
$Ast_{min} = 0.3/650 \times150\times100 = 307mm^2$
$Spacing = \pi/4 \times10^2/307/2 \times1000$ 513.33 > 300mm ok
STEP-5 DESIGN OF BASE SLAB
Total load from dome $=T_1 \sin \Theta\times2q\ \Theta/2$
$=53\times\sin25^0\times2q\ 17/2$
= 53×0.4226×2×q×8.5 =1196.20KN
Weight of ring =0.25×0.30×2q×D/2×25
=0.25×0.30×2q×8.5×25 = 100KN
Weight of wall = 0.15×(6-0.3)×2q×25 = 134KN
Total weight $= \gamma H\times q\times D^2/4 = 9.8\times6\times q\times17^2/4 =$ 13346.4KN
On edge of slab
T= D/35 = 17/35
= 0.38 say 300mm
Self weight of slab = 0.3×1×25
$= 7.5KN/M^2$
Total self weight = 17+2×0.15 = 17.3M.
$= 7.5\times\pi/4 \times17^2 = 136KN$
Total downward load
= 1196.20+1762+136 = 3094.2KN
Uniformly distributed downward load of q
$7250/\pi/4 \times17.3^2 = 30.84\ KN/M^2$
II) Upword ring load of W = 3094.2KN

For case (1) loading
$Mr = 3q/16\ (q^2-r^2)$ and M_Θ
$= 3qq^2/16 – ar^2/16$
Q = 17.376/2 = 8.688M.
In case II for r<b
$Mr = Mr = W/8\pi\ [\ 2\log_e a/b +1-b^2/a]$
For r > b $=Mr= W/8\pi[2\log_e q/r – (b/a)^2+ (b/r)^2]$
Nothing that a = 8.688m b = 7.25m
Design moment-
$M_x = 3/11\times wa^2= 3-16 \times3.875\times(17.300/2)^2$
$0.1875\times3.875\times74.822 = 54.1KN/M^2$
$D= \sqrt{54.1} \times 106 / \sqrt{1000} \times 1.423(K)$
D = 7355.270/37.722 = 194.9M
D = 194.9 & t = 300mm
$Ast = 54.1\times10^6/150 \times0.872\times194.9$
54100.000/25492.92 = 2122.15mm
$Spacing = \pi/4 \times25^2 / 2122.15 \times 1000$
= 231.30mm ≈ 230mm C/C
STEP-6 DESIGN OF BOTTOM RING BEAM
Radius = 7.25m.
Total load on it from slab 3094.2KN
= 3094.2/ 2×π×7.25 = 67.925KN
Depth of beam = 1/15 th of diameter Ø = 1/15×17 = 1133mm
$= b \times\Theta\times \gamma = 0.350\times0.1133\times25 = 0.991KN/M$
With finishing , say 6KN/M
Load on ring = 67.925KN/M + 6 = 73.925KN/M
No. of column supporting beam, n= 8
D = 360/8 = 45= π/3 radians
Maxi. Shear at support= WRØ/2
=73.925×7.25×π/3 /2 = 280KN
Support moment $KWR^2Ø$
$0.089\times73.925\times7.25^2\times\pi/3$
0.089×73.925×52.56×1.047 = 362.0623601 KN/M
Mid span moment
K'WRØ = 0.045×73.925×52.56×1.047 = 183.065 KN/M
Maximum torsonal moment
$K''WR^2Ø$
$= 0.009\times73.925\times7.25^2\times\pi/3 = 36.62KN/M$
Keeping the effective cover of 50mm d = 550mm
d'/d = 0.1
$M_4/bd^2 = 1.5\times362.06\times10^6/350\times550^2$
= 5.12 (
Reffering to table IS456-200 in sp – 16)
Pt = 1.333 and Pc = 0.146
Ast = 1.333×350×550/100 = 2566mm
$Asc = 0.146\times350\times550/100 = 281mm^2$
Provide 9 bars of 20mmØ as tensile steel and 2 bars of 20mm Ø as compression steel
Check for torsion at ∝ = 12.75 = 0.2225 radian
It's distance from support =7.25×0.222 = 1.613125M
Torsion moment T = 36.62KN/M
$T_u = 1.5\times36.62 = 54.93KN\text{-}M$
Bending moment $-362.062360 – 73.925\times1.613^2/2$
$362.062360 – 73.925 \times(1.613)^2/2$
$M_u = 313.97KN\text{-}M$
$M_u = 1.5\times313.97$

Particulars	Features
capacity	1403730 liters

= 470.96KN-M
$M_e = 470.96+54.93\times1+1133/350/1.7$

470.96+54.93×1.9058
M_e = 575.65KN-M
At support Mu = 1.5×362.062 = 543.093KN-M
Shear reinforcement
V = 543.093KN
Vu = 1.5×543.033 = 814.6395
τv = 814.6395×1000/350×550
= 4.23N/MM^2
4.23<3.1 N/MM OK
Section does not increase , Hence, b= 350mm
Ast provide 2827MM^2
= 2827×100/350×550
= 1.5N/MM^2
τc = 0.74 N/MM (from its code) (from IS: 456-200 table-19)
Vus = Vu – τc × bd
814.639×1000 – 0.74×350×550 = 672189N
Using 2 legged 12mm stirrups
SV = 0.87×fy×Ast×d/Vus
= 0.87×415×2×π/4×12^2×550/672189
=66.822236mm ≈100mm
Provided 12mm 2 legged stirrups at 100mm c/c
Side reinforcement = 0.1×350×550/100
= 192.5mm^2
Provide one bar of 16mm dia. at mid depth on both faces.
Design components results

IV. CONCLUSIONS:

In our project we design the water distribution network for dawali khurd village. Whose current population of 2020 is 3129 and by calculating of 40 years proposed population of 2060 is 5199 according to this population we calculate the water demand of the village that is 1403730 litre per day in which we include domestic water demand which require for domestic use, fire demand which required for emergency fire frightening, commercial demand the water required for small commercial work, civic and public use which required for hospitals, schools, government offices, bank etc. Wastage of water it is also include in water demand because the water is wasted during water supply by leakage or after water supply by consumer.

According to this water demand and total annual water demand we design a tank whose capacity is 1403730 litres to carrying that capacity we design a tank of dimension 6x17x0.3m. The tank is easy to maintain and having high serviceability and long life the tank is full in 4 to 5 hours.

The source of water for provide water is use a tube-well of 90ft depth and a well of 70ft depth both are perennial but the availability of water is good in rainy season and low in summer season but sufficient water is always available due to the water source of river for fill the tank.

At the end of the analysis it was found that the resulting pressures at all the nodes and the flows with their velocities at all links are sufficient enough to provide water to the study area.

V. FUTURE SCOPE

The function of water distribution system is to deliver water to all customers of the system in sufficient quantity for potable drinking water and fire protection purposes at the appropriate pressure with minimal loss of safe and acceptable quality and as economically as possible .

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