International Journal of Research in Advent Technology, Vol.6, No.7, July 2018
E-ISSN: 2321-9637
Available online at www.ijrat.org

Behavioral Study of Cylindrical Tanks by Beam on Elastic Foundation

Prof. S. C. Gupta[1], Imran Hussain[2], Durga Prasad Panday[3]
Sr. Associate Professor, Department of Civil Engineering[1]
Research Scholar M.Tech Structures, Department of Civil Engineering[2]
Assistant Professor, Department of Civil Engineering[3]
University of Petroleum and Energy Studies, Bidholi via Premnagar, Dehradun -248007, India[1, 2, 3]
Email: scgupta@ddn.upes.ac.in[1], imranhssn159@gmail.com[2], dpanday@ddn.upes.ac.in[3]

Abstract- This paper presents the solution of real life manhole problem whose geometrical shape is circular cylindrical shape, which has to be constructed for connecting main sewer line in 20 MLD sewage treatment plant based on SBR technology at Mothorowala, Dehradun, in the state of Uttarakhand, India. An optimum Study was conducted by varying the thickness vice versa the dimensionless parameter H^2/Dt changes for the given H & D. To arrive at optimum solution, the bending moments and hoop tension of the manhole were carried out for boundary condition bottom fixed and top free under different possible load conditions.

Index Terms– Hoop Tension, Bending Moment, Beam on Elastic Foundation, Axisymmetrical radial displacement.

1. INTRODUCTION

Cylindrical tanks are used to contain aqueous and granular material. There will be radial pressure which is constant at any one level and varies along vertical direction, this type of loading leads to the axisymmetrical radial displacement of tank walls either inward or outward depending on loading condition and capacity of walls. The loading and deformation of walls are shown in figure (2). As for the behavioral study of cylindrical tank, the governing parameter is the dimensionless parameter H^2/Dt. The reference [4] provides the coefficient values depending on dimension less parameter ranging from 0.4 to 16 for the calculation of hoop tension, bending moment and shear force at different points of cylindrical or circular tank along its length or height. In real life problem when the value of dimensionless parameter exceeds 16, the reference [4] does not provide any guidelines for the analysis of cylindrical tanks. Hence the applications of coefficients of reference [1] are found to be fruitful, as these coefficients [1] were calculated and derived from the Beam on Elastic Foundation (B.E.F) method. For the analysis of circular manhole or say cylindrical tank was done using coefficients of reference [1].

This paper presents the solution of real life manhole problem whose geometrical shape is circular cylindrical shape, which has to be constructed for connecting main sewer line in 20 MLD sewage treatment plant based on SBR technology at Mothorowala, Dehradun, in the state of Uttarakhand, India. An optimum Study was conducted by varying the thickness vice versa the dimensionless parameter H^2/Dt changes for the given H & D. To arrive at optimum solution, the bending moments and hoop tension of the manhole were carried out for bottom fixed and top free under different possible load conditions which are given below,

a) Boundary condition: Bottom Fix and Top free
b) Load Condition (L.C):
   1. Sewage pressure
   2. Dry soil pressure and
   3. Saturated soil pressure

2. BEAM ON ELASTIC FOUNDATION

This method was developed on the major assumption that the reactive forces of the supporting medium or supporting element are proportional to deformation of beam at that point i.e, at the point of loading. This assumption was first proposed by E. Winkler in 1967 [1-3].

Hence if we consider unit width of elemental strip shown in figure 1 and 2, as a foundation or supporting medium which is subjected to certain loading, then the assumption of E. Winkler holds good. And also the Hook's law is well satisfied i.e; stress is directly proportional to strain. Which is nothing but the internal resistances are directly proportional to the rate of change of deformation [1-3].

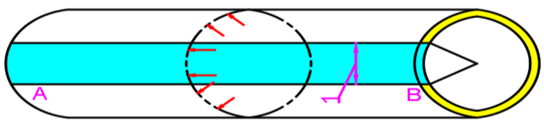


Figure 1 Showing unit width of strip.

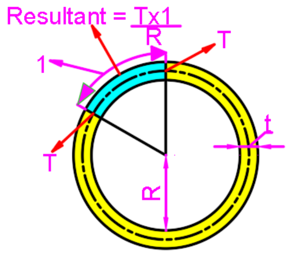


Figure 2 Showing resultant force of unit width of strip.

The reaction of wall for per unit length is,

$$ky \quad (1)$$

Equation (1) is called subgrade modulus given in reference [1-3].

The governing differential equation is

$$EI\,(d^4y/dx^4) = -ky + q \quad (2)$$

Equation (2) and its further explanation are given in reference [1-3].

3. BEHAVIORAL STUDY OF MANHOLE

3.1. *Analytical Modeling*

Height of manhole = 6.0 M, Internal diameter = 2.0 M, Density of water = 10 kN/M^3, Density of sewage = 16 kN/M^3, Density of dry soil = 19 kN/M^3, Density of saturated soil = 9 kN/M^3, Wall thickness = t meter, shown in table 1, Angle of repose of soil = 30^o, Grade of concrete = M30.

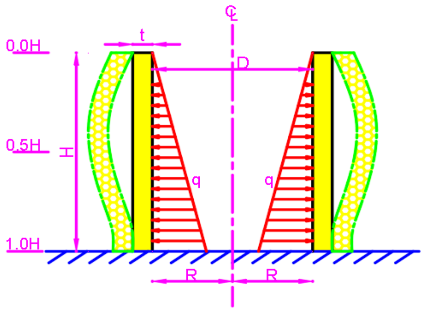


Figure 2 shows the manhole which is subjected to general loading of intensity q kN/M^2.

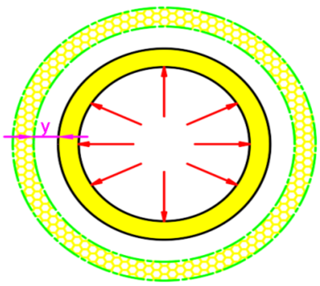


Figure 3 shows deflected profile of manhole walls.

Table 1 Showing wall thickness and value of dimensionless parameter H^2/Dt

Si. No.	Wall Thickness in M	H^2/Dt
1	0.2	90
2	0.15	120
3	0.125	144
4	0.12	150

4. RESULT AND DISCUSSION

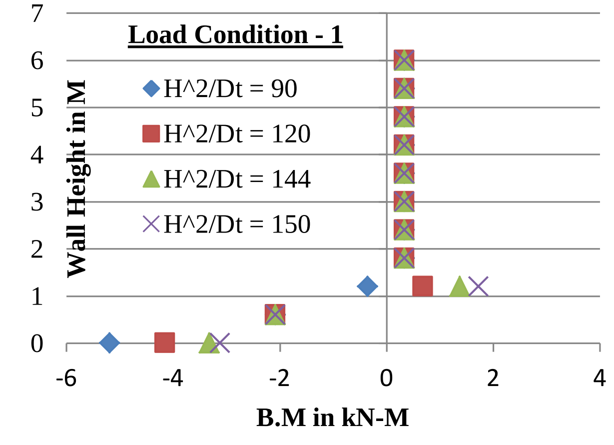
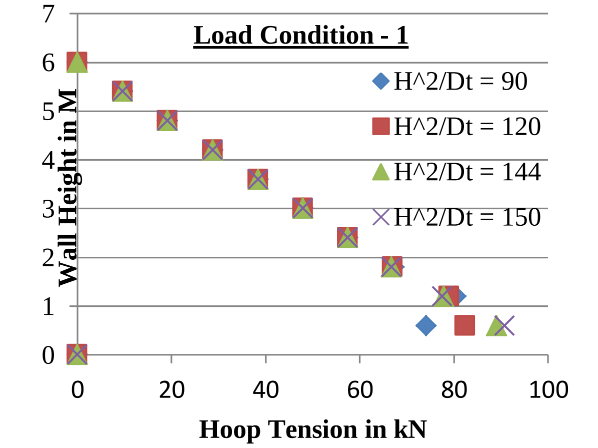
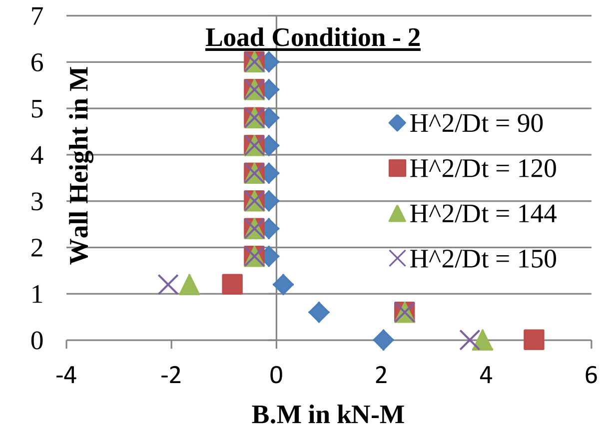
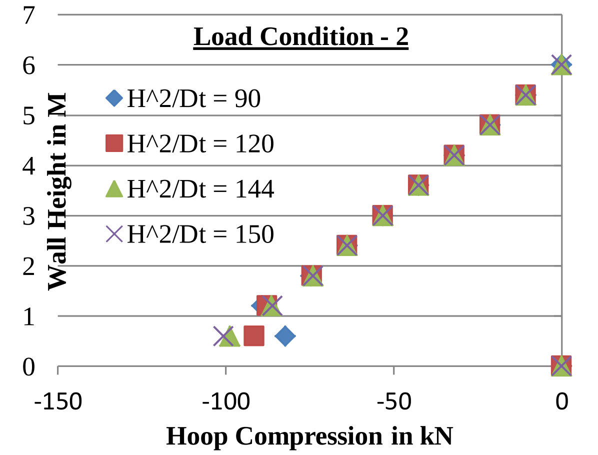
The analysis results of Manhole for all four loading conditions were shown in table A.1 to A.3. The table A.2 shows the variation of Bending Moment (B.M) and Hoop Tension or Compression for the different wall thickness, the negative B.M shows tension on sewage face and positive Hoop shows tension on sewage face. It is observed that as the wall thickness reduces the value of dimensionless parameter H^2/Dt increases and if wall thickness increases the dimensionless parameter H^2/Dt decreases. As the wall thickness increases the cost of construction will become uneconomical since the minimum steel requirement as per reference [4] has to be satisfied and the volume of concrete also increases. Hence by iteration the optimum thickness selected for the manhole is 125mm or 0.125M whose dimensionless parameter is 144. The maximum B.M and Hoop Compression values are -3.94 kN-M and -177.12 kN correspondingly. And the maximum concrete tensile bending stress and maximum concrete direct tensile stress are 1.513 N/MM^2 and -1.42 N/MM^2 correspondingly which are shown in table A, and this maximum concrete tensile bending stress and maximum concrete direct tensile stress values are less than permissible stress in tensile bending and direct tension which are given in table 1 of reference [4]. Hence to obtain the economical sections of circular cylindrical tanks or Manholes, the application of the reference [1] coefficients are fruitful for the practicing engineers and research workers.

Table A.1 Showing comparative results for value of dimensionless parameter H^2/Dt = 90, 120, 144 and 150

H^2/Dt	**Max. B.M in kN-M**	**Max. Concrete Tensile Bending Stress in N/MM^2**	**Max. Hoop Tension / Compression in kN**	**Max. Concrete Direct Tensile Stress in N/MM^2**
90	-5.184	0.778	-183.02	-0.92
120	4.925	-1.313	-179.74	-1.2
144	**3.94**	**-1.513**	**-177.12**	**-1.42**
150	3.694	-1.539	-176.47	-1.47

Table A.2 Showing bending moment and hoop tension or compression for value of dimensionless parameter

H^2/Dt = 90, 120, 144 and 150

L.C	**Figure 4 Showing Bending Moment in kN-M**	**Figure 5 Showing Hoop Tension / Compression in kN**
1		
2		

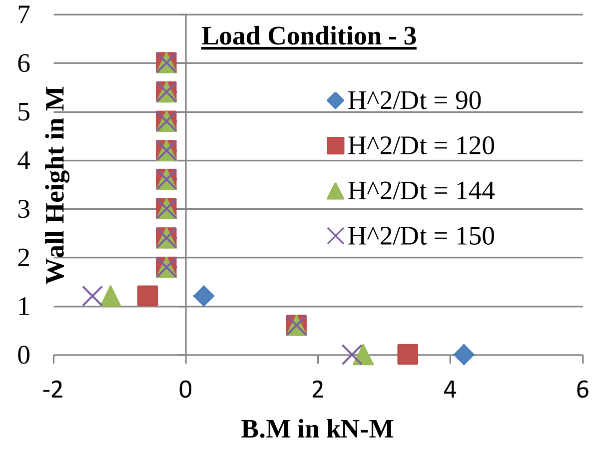
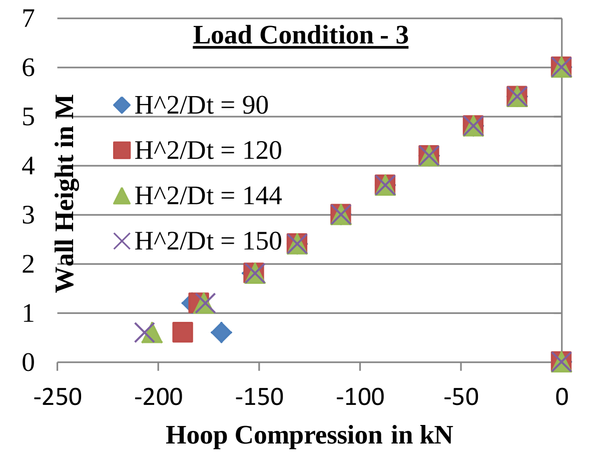
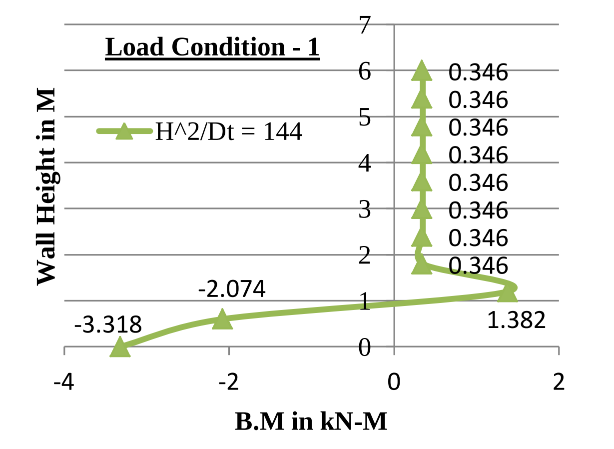
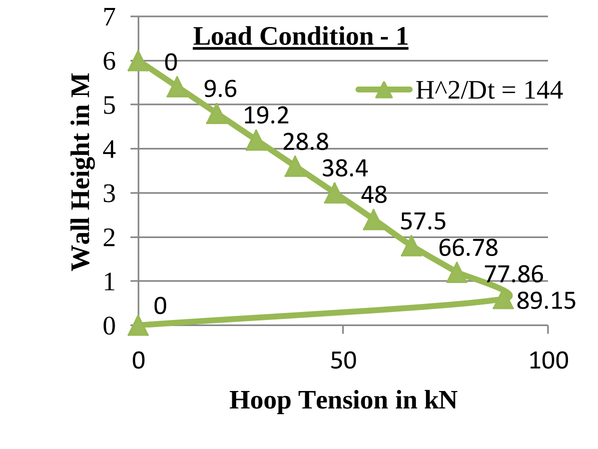
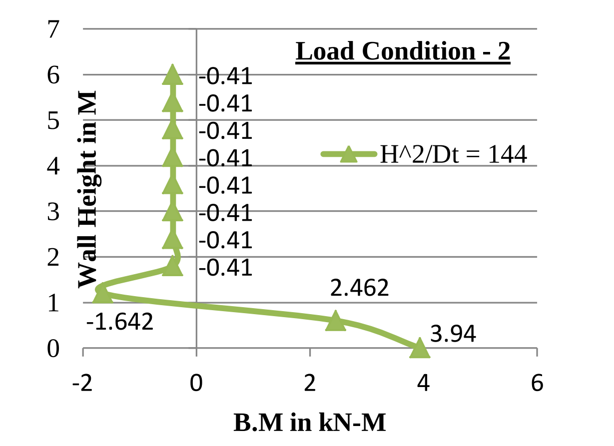
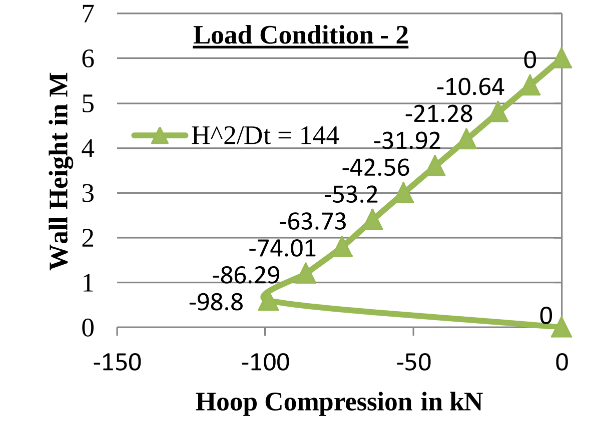
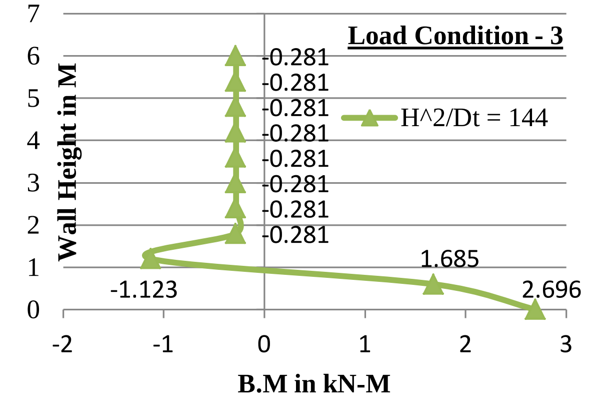
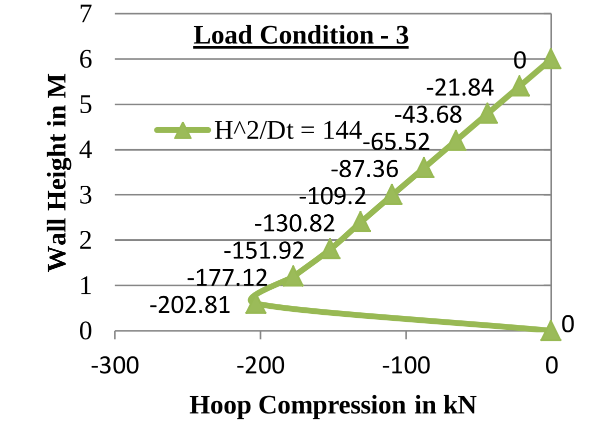
<table>
<tr>
<td>3</td>
<td>
</td>
<td>
</td>
</tr>
</table>

Table A.3 Showing bending moment and hoop tension or compression for value of dimensionless parameter

$H^2/Dt = 144$

<table>
<tr>
<th>L.C</th>
<th>Figure 6 Showing Bending Moment in kN-M</th>
<th>Figure 7 Showing Hoop Tension / Compression in kN</th>
</tr>
<tr>
<td>1</td>
<td>
</td>
<td>
</td>
</tr>
<tr>
<td>2</td>
<td>
</td>
<td>
</td>
</tr>
</table>

<table>
<tr>
<td>3</td>
<td>
</td>
<td>
</td>
</tr>
</table>

REFERENCES

[1] Imran Hussain, Prof. S. C. Gupta. (2018), "Analytical Solution for Hoop Tension and Bending Moment Coefficient for Long Cylinders by Beam on Elastic Foundation", *International Journal of Research in Advent Technology, Vol.6, No.5, May 2018*, pp. 791-796.

[2] S. Timoshenko. (1940) Strength of Materials (2nd edn), USA, Lancaster press, INC., Lancaster, PA.

[3] M. Hetènyi. (1979), Beams on Elastic Foundation (11th edn), USA, The University of Michigan Press.

[4] IS: 3370 (Part I-IV) – 2009, 1967, "Indian Standard", Code of Practice for Concrete Structures for the Storage of Liquids.

[5] Edmund S. Melerski. (2006) Design Analysis of Beams, Circular Plates and Cylindrical Tanks on Elastic Foundations (2nd edn), London, UK, Taylor & Francis Group.

[6] Amin Ghali. (2000) Circular Storage Tanks and Silos (2nd edn), London & New York, UK, Taylor & Francis Routledge.

[7] Anand Daftardar, Shirish Vichare, Jigisha Vashi. (2017), "Analytical Solution for Hoop Tension in Liquid Storage Cylindrical Tanks", *International Journal of Engineering and Applied Sciences, Vol.4, No.7, July 2017*, pp. 99-104.

[8] Edmund S. Melerski. (1991), "Simple Elastic Analysis of Axisymmetric Cylindrical Storage Tanks", *Journal of Structural Engineering, ASCE, Vol. 117, No. 11, November 1991*, pp. 3239-3260.

[9] Sadanandan N. Sirosh and Amin Ghali. (1989), "Reinforced Concrete Beam columns And Beams on Elastic Foundation", *Journal of Structural Engineering, ASCE, Vol. 115, No. 3, March 1989*, pp. 666-682.

[10] L. M. Shirima, M. W. Giger. (1992), "Timoshenko Beam Element Resting On Two-Parameter Elastic Foundation", *Journal of Structural Engineering, ASCE, Vol. 118, No. 2, February 1992*, pp. 280-295.