Effect on Underground Water Pipeline with Change in Seismic Zone

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ABSTRACT

Depending upon the sort of structure, the varied sorts of forces are acted upon and its stability is checked for imposed loads. Much of the concentration is on the steadiness of frame structures like buildings.However, other structures like underground pipeline, tunnel, culverts, etc. are equally important. The aim of this dissertation is to review the effect of the seismic forces on the underground water pipeline subjected to fluid pressure, earth fill pressure or surcharge, uplift forces, lateral side pressure, etc.

The underground pipeline is analyze manually. Afterward the pipeline is modelled and analyze from moderate to severe seismic zones and comparative study is shown during this report. Out of the four cases, the outside and interior node location along the circumference is studied. Similarly plate elements are studied for stresses, on the idea of study the conclusions are drawn.

Keyword:-Pipe, Earthquake, Bell-out, Plate Corner Stress, Node, Displacement, Reaction

1. Introduction

1.1 Aim:

To study the effect on water pipeline with change in seismic severity.

1.2 Objectives:

- To study about the stresses, relation between hoop stresses and longitudinal stresses and design principles for underground pipeline.
- To analyze the pipeline under external stresses to which it is subjected.
- To study the seismic resistance of concrete pipeline.
- To develop the model for the same using STAAD-Pro.
- Comparing the results of pipeline for various seismic severity.

1.3 Scope:

Conveyance of water, gases, oil, etc. to the society plays very important role in social and economic growth of any country. Supply of water to the society is one of the major task. Water can be supplied society by various ways such as through open channel, buried pipelines, etc. open channel conveyance of water is possible for irrigation water to the field by means of canals. Though leads to large amount of losses due to direct exposure to the atmosphere. This deficiency can be overcome by means of water distribution through pipeline.

Use of underground pipeline leads to further advantages such as low losses due to evapotranspiration, infiltration, contamination free quality of water and it is possible to provide flow under pressure, etc. Though as pipeline is underground it is subjected various stresses due to soil acting as surcharge, loading due to various traffic operations, temperature changes, etc. and hence it should be resistant to all the stresses coming over it during its useful lifetime. Generally water supply pipeline mains are designed for design period of 30 years.

We know that every second there are different activities within earth core. Earthquake prone zones are highly susceptible to the tectonic activities and lead to damage not only to living properties but to the non-living structure as well. Water supply pipelines also known as lifelines because for water is the one of the life supporting element must to preserve life. And during such disastrous situations plays very important role. Hence technical approach is required towards earthquake resistant design of underground pipeline is necessary which gives a technical person an opportunity of doing something new.

1.4 Necessity

Pipes are the only conveyance system which widely used nowadays. Day-by-day increasing traffic activities leads to increase in impact over the subsoil below the road or any other transport media, consequently underground pipelines may also be subjected to this impact where-ever road crosses pipeline. This may leads to damage and hence it is necessary to take in to consideration that traffic effect. Various disasters may also influence the buried pipelines. Earthquake is one of the major issue. During this disasters pipeline plays very important role for conveying water to the earthquake prone areas and hence it is necessary to withstand the pipeline against lateral vibrations. Generally pipelines are designed for period of 30 to 50 years. It is a very long duration during which piped system may get subjected to pessimistic conditions. To account for this all the probabilities in upcoming future leads to need for proper design considerations.

2. MANUAL PIPELINE DESIGN FOR PIPELINE FORCES

For the design, modelling and Comparisons purpose following problem is considered as:
Consider a reinforced concrete pipe laid under positive embankment condition.
Internal diameter of pipe (d)-700 mm
Wall thickness or pipe thickness (t)-50 mm
External diameter of pipe (D) = 700+2×50 = 800 mm
Width of trench (Assumed), B=800+300+300= 1400 mm
Unit weight of fill material (W) - 18 KN/m^3
Height of embankment fill over the top of pipe, H= 2 m
Bedding and foundation material – Positive embankment condition: Bedding Type
A: Earth foundation
Velocity of water in pipe, V=3 m/s
Settlement ratio, r_s= +0.8 (for positive embankment condition) Projection ratio, P= 0.75

Step 1: Calculation of Internal water pressure and hoop tension acting on pipeline

a) Internal water pressure or Static pressure:

$$P_s = 9.81\left(\frac{3\pi}{4}\right)\left(\frac{d^2}{4}\right)$$

$$P_s = 9.81\left(\frac{3\pi}{4}\right)\left(\frac{0.7^2}{4}\right)$$

$$P_s = 2.8315 \text{ KN/m2}$$

b) Water hammer pressure

$$P_{h,max} = \frac{14.6}{\sqrt{1+\frac{Kd}{t}}} \times V$$

For concrete pipes K=0.1

$$P_{h,max} = \frac{14.762}{\sqrt{1+\frac{0.1\times0.7}{0.05}}} \times 3$$

$$P_{h,max} = 28.5865 \text{ KN/m}^2$$

c) Total internal pressure acting on pipe

$$\text{Total internal pressure} = \text{Static load pressure} + \text{Water Hammer Pressure}$$

$$P = P_s + P_h$$

$$P = 2.8315 + 28.5865$$

$$P = 31.42 \text{ KN/m}^2$$

d) Hoop stress:

$$\sigma = \frac{31.42 \times 0.7}{2 \times 0.05}$$

$$\sigma = 219.94 \text{ KN/m}^2$$

e) Longitudinal stress:

$$\sigma = \frac{31.42 \times 0.7}{4 \times 0.05}$$

$$\sigma = 109.97 \text{ KN/m}^2$$

Step 2: Vertical load on pipeline due to fill material

As per IS 783-1983 load due to fill for positive embankment condition is given by,

$$W_e = C_e \gamma D^2$$

The value of C_e can be obtained from Fig. 1 of IS 783-1983, Page No. 9

For $\frac{H}{D} = \frac{2}{0.8} = 2.5$ and r_s×P = 0.8×0.75 = 0.6

C_e = 4 after interpolation

$$W_e = C_e \gamma D^2$$

$$W_e = 4 \times 18 \times 0.8^2$$

$$W_e = 46.08 \text{ KN/m}$$

Step 3: Vertical load on pipe due to superimposed loads (Traffic Load)

As per IRC equivalent single Wheel load is 41 KN i.e.
P= 41 KN
S=0.3 m

$$We = Cp \times \frac{P \times \propto}{l}$$

α = 1 When load is Static

$$We = Cp \times \frac{P \times \propto}{l}$$

$l = 1.15H + 2D + s$
$l = 1.15 \times 2 + 2 \times 0.8 + 0.3$
$l = 4.2\ m > 3m$

$l = 3m$

And from fig. 3 of IS 783-1983, for $\frac{l}{2H} = \frac{3}{2\times 2} = 0.75$ and $\frac{D}{2H} = \frac{0.8}{2\times 2} = 0.2$,

$C_p = 0.2$

After interpolation

$$We = 0.2 \times \frac{41 \times 1}{3}$$

$We = 2.734\ KN/m$

Step 4: Horizontal side pressure load due to side support offered by compacted fill:

Let the angle of internal friction for soil is, Ø= 30°

$$K_a = \frac{1 - Sin\emptyset}{1 + Sin\emptyset}$$

$$K_a = \frac{1 - Sin30}{1 + Sin30}$$

$$K_a = \frac{1}{3}$$

At Top level of pipe,

$$Side\ Pressure = K_a \gamma H$$

$$Side\ Pressure = \frac{1}{3} \times 18 \times 2$$

$$Side\ Pressure = 12\ KN/m^2$$

At Bottom level of pipe,

$$Side\ Pressure = K_a \gamma (H + D)$$

$$Side\ Pressure = \frac{1}{3} \times 18 \times (2 + 0.8)$$

$$Side\ Pressure = 16.8\ KN/m^2$$

Our calculated side pressure distribution is trapezoidal. But for calculation purpose, equivalent pressure distribution is assumed which is rectangular in nature i.e. UDL.

$$Equivalent\ Side\ Pressure = \frac{12 + 16.8}{2} KN/m^2$$

$$Equivalent\ Side\ Pressure = 14.4\ KN/m^2$$

Which is acting on half perimeter on each side.

Therefore,

$$Effective\ perimeter = \frac{\pi D}{2} = \frac{\pi \times 0.8}{2} = 1.2566\ m$$

$$Side\ Pressure\ per\ meter = 14.4 \times 1.2566 = 18.1 KN/m$$

Step 5: Uplift Pressure Intensity:

$$\sigma_p = \gamma(H + D) \quad \sigma_p = 18(2 + 0.8) \quad \sigma_p = 50.4\ KN/m^2$$

Which is acting on half perimeter at bottom. Therefore,

$$Effective\ perimeter = \frac{\pi D}{2} = \frac{\pi \times 0.8}{2} = 1.2566\ m$$

$$Side\ Pressure\ per\ meter = 50.4 \times 1.2566 = 63.335\ KN/m$$

Step 6: Selection of bedding

As already mentioned, we assume the Type A bedding: Earth foundationFor Type A bedding, projection factor (P) is 0.75

$$P = \frac{h}{D}$$

Where, h- Distance from the top of the pipe down to undisturbed foundation level

$h = P \times D \qquad h = 0.75 \times 0.8 \qquad h = 0.6m$

Step 7: Calculation of Load factor (F_e)

For positive embankment condition and Type A bedding for earth foundation
From section B- 10.4 of IS 783-1983 for projection ratio P = 0.75
F_e =3.9 (After interpolation)

Step 8: Selection of minimum test load

$$Total\ Load\ acting\ pipeline = Vertical\ Dead\ load\ due\ to\ fill + Vertical\ load\ due\ to\ superimposed\ loads$$

Here internal water load is not considered because we are analyzing the pipeline for critical load condition and the versed condition is when the internal loads are considered as zero.

$$\text{Minimum required strength or load} = \frac{48.08}{3.9}$$

$$\text{Minimum required strength or load} = 12.52\ \text{KN/m}$$

3. Base Shear Manual Analysis for Pipe in Horizontal X direction

Step 1: To Find Seismic Weight:

Total Seismic Weight = Wt. of fill over pipe + Wt. of pipe + Wt. of water inside pipe

a) Weight of fill over pipe

$W_1 = \text{vertical fill load per meter} \times \text{stretch length}$

$W_1 = 46.08 \times 3$

$W_1 = 138.24\ \text{KN}$

b) Weight of pipe

$W_2 = \text{perimeter} \times \text{thickness} \times \text{stretch length} \times \text{Density of pipe material}$

$W_2 = \pi \times 0.8 \times 0.05 \times 3 \times 25$

$W_2 = 9.425\ \text{KN}$

c) Weight of water inside pipe

$W_3 = \text{Volume of pipe} \times \text{Density of water}$

$W_3 = \frac{\pi}{4} \times 0.7^2 \times 3 \times 10$

$W_3 = 11.55\ \text{KN}$

Total seismic Weight is,

W = 138.24+9.425+11.55

W= 159.22

Step 2: To Find Seismic Coefficient for Various Zones:

a) For Zone II

$A_h = \frac{ZIS_a}{2Rg}$

Z=0.1

I= 1.5

for important structures

R=5

for SMRF

$T = \frac{0.09h}{\sqrt{d}}$

$T = \frac{0.09 \times 2.8}{\sqrt{3}} = 0.1455$

for the value of T, the $\frac{Sa}{g} = 2.5$

$A_h = \frac{0.1 \times 1.5 \times 2.5}{2 \times 5} = 0.0375$

b) For Zone III

Z=0.16 and all other parameters are same as that of zone II

$A_h = \frac{0.16 \times 1.5 \times 2.5}{2 \times 5} = 0.06$

c) For Zone IV

Z=0.24 and all other parameters are same as that of zone II

$A_h = \frac{0.24 \times 1.5 \times 2.5}{2 \times 5} = 0.09$

d) For Zone V

Z=0.36 and all other parameters are same as that of zone II

$A_h = \frac{0.36 \times 1.5 \times 2.5}{2 \times 5} = 0.135$

Step 3: To Calculate Horizontal Base Shear:

a) For Zone II

Base Shear = A_h×W

Base Shear = 0.0375×159.22 = 5.971 KN

b) For Zone III

Base Shear = 0.06×159.22 = 9.5532 KN

c) For Zone IV

Base Shear = 0.09×159.22 = 14.33 KN

d) For Zone V

Base Shear = 0.135×159.22 = 21.5 KN

4. COMPUTATIONAL MODELLING AND ANALYSIS OF UNDERGROUND PIPELINE

For computational modelling In STAAD Pro, we have consider the pipe of stretch 3 m having internal diameter of 700 mm. All the loads calculated above such as load due to fill material, lateral side pressure, uplift pressure and traffic load is converted into nodal forces. Then analysis is done with the same loads for different Seismic zones.

After that, on the basis of analysis, various contour maps are studied in STAAD Pro for different zone, which are shown below in Figures, shows the variation of absolute stress for load combination 5 for various plates along the considered stretch.

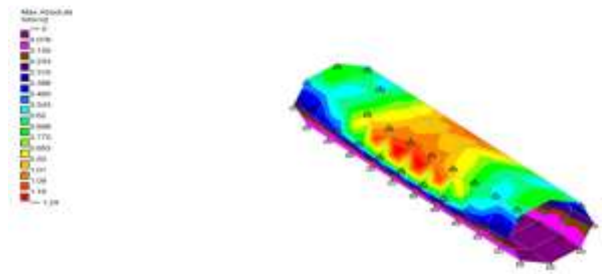

Fig.1: Plate Stress Contour Map for Zone II

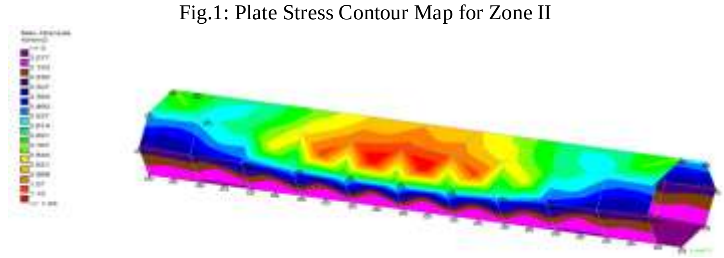

Fig.2: Plate Stress Contour Map for Zone III

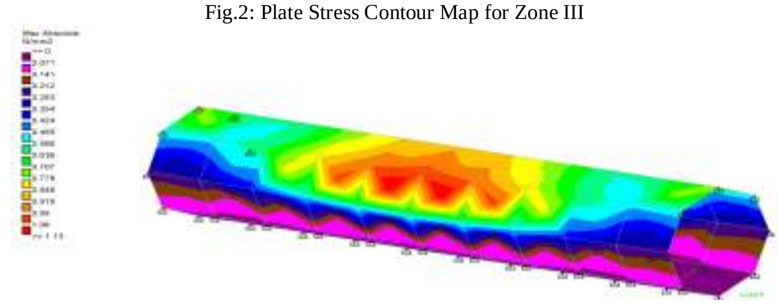

Fig.3 :Plate Stress Contour Map for Zone IV

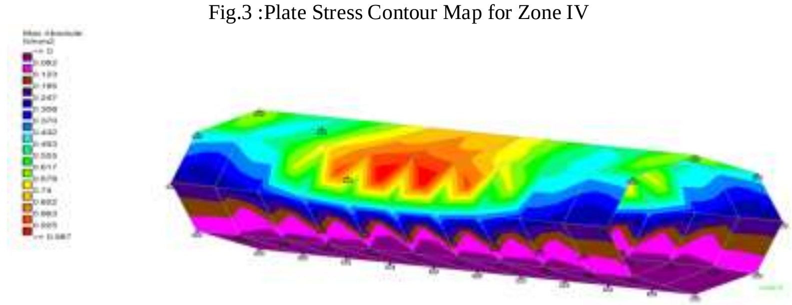

Fig. 4: Plate Stress Contour Map for Zone V

5. OBSERVATION AND REMARKS

The underground pipeline for the stretch of 3m under the ground level at 2m is modelled and analysed for seismic forces for soft soil in zone II, III, IV and V. from the analysis of all these cases, the comparative tables are shown for displacement, stresses, bending, shear and reactions as under.
Case 1: Analysis for zone II
Case 2: Analysis for zone III
Case 3: Analysis for zone IV
Case 4: Analysis for zone V

Fig. 5 Considered Node for Observations for Support Reaction

Table No. 1: Reaction Values for nodes under different seismic zones

Node	Location	Case No	Fx	Fy	Fz	Mx	My	Mz
1	Top Exterior	Case 1	0	8.655	-24.873	-0.209	0	0
		Case 2	0	8.726	-24.757	-0.208	0	0
		Case 3	0	8.518	-24.105	-0.206	0	0
		Case 4	0	8.206	-22.939	0.202	0	0
3	Middle Exterior	Case 1	1.190	4.945	12.120	-0.109	0.083	0.002
		Case 2	1.043	5.051	12.192	-0.108	0.084	0.003
		Case 3	0.742	4.928	11.881	-0.108	0.083	0.004
		Case 4	0.934	4.732	11.413	-0.107	0.0800	0.005
5	Bottom	Case 1	0	-7.751	0	0	0	0
	Exterior	Case 2	0	-7.676	0	0	0	0
		Case 3	0	-7.676	0	0	0	0
		Case 4	0	-7.676	0	0	0	0
20	Downword	Case 1	0.740	-4.740	3.662	-0.017	0.036	-0.337
	Intermediate	Case 2	0.438	-4.233	4.393	-0.017	0.037	-0.373
		Case 3	-0.394	-4.097	4.286	-0.017	0.036	-0.356
		Case 4	-1.015	-3.866	4.130	-0.016	0.034	-0.331
44	DownwordS	Case 1	1.062	-1.836	3.5	0.007	0.011	-0.555
	Central	Case 2	0.763	-1.316	3.5	0.006	0.011	-0.559
		Case 3	0.327	-1.265	3.5	0.007	0.011	-0.533
		Case 4	0.458	-1.188	3.5	0.007	0.011	-0.495
45	Bottom central	Case 1	0	-6.002	0	0	0	0
		Case 2	0	-5.851	0	0	0	0
		Case 3	0	-5.851	0	0	0	0
		Case 4	0	-5.851	0	0	0	0

From the table it is observed that the horizontal forces (Fx) perpendicular to direction of pipe are zero at the top and bottom nodes that is node numbers1, 5 and 45. The horizontal reaction value along longitudinal axis of pipe is present for the top and middle node only that is node no. 1, 3, 20 and 44. Further it is observed that with increase in seismic severity, the value of Fy reduces for the same node. The values of Mx, My and Mz are present for the middle located nodes along the circumference.

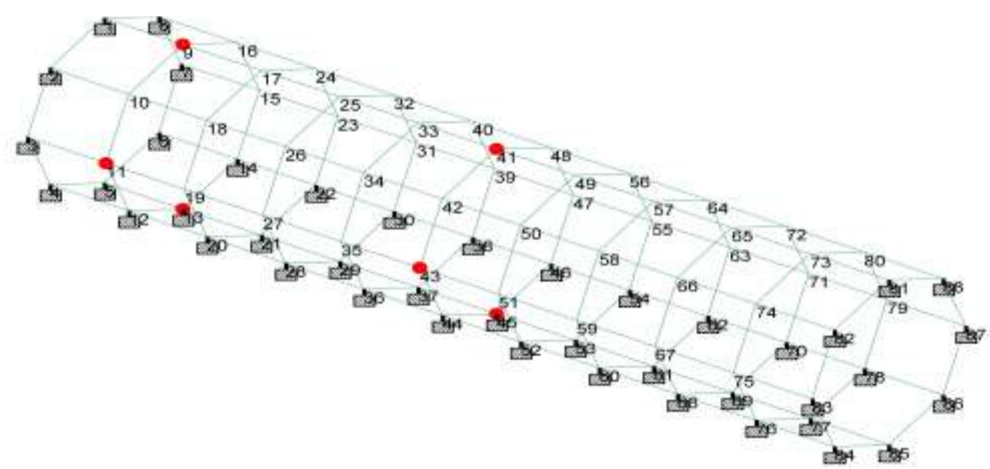

Fig. 6: Considered Nodes for Node Displacement Observations

Table No. 2: Displacement Values for Nodes under Different Seismic Zone

Node	Location	Case No.	Hz	Vertica	Hz	Resultant	Rotational		
			X(mm)	Y(mm)	Z(mm)	(mm)	rX	rY	rZ
9	Exterior	Case 1	0	-0.040	0.015	0.040	0	0	0
	top	Case 2	0	-0.041	0.015	0.042	0	0	0
		Case 3	0	-0.039	0.015	0.040	0	0	0
		Case 4	0	-0.036	0.015	0.036	0	0	0
11	Exterior	Case 1	-0.026	-0.012	-0.008	0.030	0	0	0
	middle	Case 2	-0.026	-0.013	-0.008	0.030	0	0	0
		Case 3	-0.025	-0.012	-0.008	0.029	0	0	0
		Case 4	-0.023	-0.012	-0.007	0.027	0	0	0
13	Exterior	Case 1	0	0	0	0	0	0	0
	bottom	Case 2	0	0	0	0	0	0	0
		Case 3	0	0	0	0	0	0	0
		Case 4	0	0	0	0	0	0	0
41	Top	Case 1	0	0.117	0.020	0.117	0	0	0
	center	Case 2	0	-0.118	0.019	0.118	0	0	0
		Case 3	0	-0.112	0.020	0.112	0	0	0
		Case 4	0	-0.103	0.020	0.103	0	0	0
43	Middle	Case 1	-0.071	-0.032	0.007	0.078	0	0	0
	center	Case 2	-0.071	-0.033	0.007	0.078	0	0	0
		Case 3	-0.067	-0.031	0.007	0.074	0	0	0
		Case 4	-0.062	-0.029	0.007	0.069	0	0	0
45	Bottom	Case 1	0	0	0	0	0	0	0
	Center	Case 2	0	0	0	0	0	0	0
		Case 3	0	0	0	0	0	0	0
		Case 4	0	0	0	0	0	0	0

From the table no. 6.2, it is observed that rotational displacement is absent for pipeline in all the seismic zones that is rX, rY, and rZ.it is also observed that the horizontal displacement for the top and bottom node in transverse direction is zero, that is node number 9, 15, 41 and 45. Whereas the vertical displacement reduces with the increase in seismic severity. The horizontal displacement in longitudinal direction is to the second place of decimal and thus, are as good as negligible. The resultant displacement of top nodes are more as compared to middle nodes as in 9 and 11 or node no. 41 and 43.

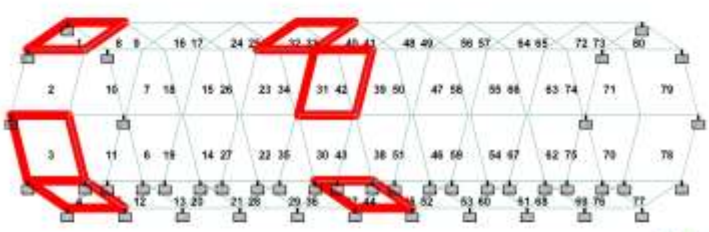

Fig. 7: Considered Plates for Plate Centre Stress Observations

Table No. 3: Centre Plate Stress under Various Seismic Zones

Plate No.	Location	Case No.	Shear		Membrane			Bending Moment		
			SQX	SQY	SX	SY	SXY	Mx	My	Mxy
1	Exterior	Case 1	-0.011	-0.072	0.079	1.192	0.342	-0.055	0.081	-0.039
	top	Case 2	-0.011	-0.073	0.07	1.189	0.34	-0.055	0.081	-0.039
		Case 3	-0.012	-0.07	-0.056	1.164	0.323	-0.052	0.077	-0.037
		Case 4	-0.014	-0.067	-0.08	1.119	0.294	-0.047	0.071	-0.034
3	Exterior	Case 1	-0.039	0.023	-0.223	-0.393	0.158	-0.039	-0.052	0.023
	middle	Case 2	-0.039	0.025	-0.236	-0.397	0.161	-0.039	-0.052	0.023
		Case 3	-0.037	0.023	-0.239	-0.388	0.16	-0.036	-0.049	0.021
		Case 4	-0.035	0.022	-0.244	-0.374	0.157	-0.032	-0.045	0.019
4	exterior	Case 1	0	0	0	0	0	0	0	0
	bottom	Case 2	0	0	0	0	0	0	0	0
		Case 3	0	0	0	0	0	0	0	0
		Case 4	0	0	0	0	0	0	0	0
33	Center	Case 1	0.073	-0.003	-0.152	-0.29	0.082	-0.478	-0.1	-0.011
	Top	Case 2	0.071	-0.003	-0.169	-0.334	0.08	-0.48	-0.101	-0.011
		Case 3	0.064	-0.003	-0.186	-0.324	0.082	-0.454	-0.095	-0.011
		Case 4	0.053	-0.003	-0.212	-0.309	0.082	-0.415	-0.087	-0.01
42	Central	Case 1	0.106	-0.008	-0.426	-0.093	-0.273	0.694	0.126	0.005
	middle	Case 2	0.108	-0.008	-0.441	-0.096	-0.273	0.695	0.126	0.006
		Case 3	0.105	-0.008	-0.443	-0.097	-0.273	0.656	0.119	0.006
		Case 4	0.101	-0.007	-0.446	-0.098	-0.272	0.597	0.108	0.006
44	Central	Case 1	0	0	0	0	0	0	0	0
	bottom	Case 2	0	0	0	0	0	0	0	0
		Case 3	0	0	0	0	0	0	0	0
		Case 4	0	0	0	0	0	0	0	0

The centre plate stress value for bottom plates are absent that is plate number 4 and 44. Further there is not considerable difference in the plate centre stresses with change in seismic severity. The plate shear stress value is more for upper plates as compared to middle plate. Whereas membrane stresses are more for middle plates with change in seismic severity.

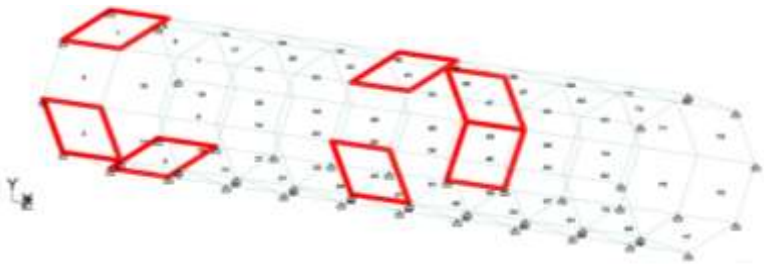

Fig. 8: Considered Plates for Plate Corner Stress Observations

Table No. 4: Plate Corner Stresses for Various Zones

Plate No.	Case No.	Node	Shear		Membrane			Bending		
			Qx	Qy	Sx	Sx	Sx	Mx	My	Mz
			(N/mm2)	(N/mm2)	(N/mm2)	(N/mm2)	(N/mm2)	(KNm/m)	(KNm/m)	(KNm/m)
1	Case 1	1	-0.016	-0.073	0.27	0.956	0.212	0.161	0.546	0.124
		2	-0.016	-0.069	0.17	0.195	0.298	-0.005	0.375	-0.147
		10	-0.002	-0.069	-0.215	0.1	0.41	-0.178	-0.355	-0.202
		9	-0.002	-0.073	-0.115	0.86	0.325	-0.197	-0.243	0.069
	Case 2	1	-0.016	-0.073	0.137	0.144	0.224	0.159	0.54	0.13
		2	-0.016	-0.072	0.008	-0.502	0.312	-0.001	0.39	-0.147
		10	-0.007	-0.072	-0.214	-0.601	0.456	-0.206	-0.387	-0.208
		9	-0.007	-0.073	-0.086	0.045	0.368	-0.172	-0.247	0.069
	Case 3	1	-0.015	-0.07	0.257	0.896	0.2	0.153	0.52	0.124
		2	-0.015	-0.069	0.159	0.185	0.274	0	0.379	-0.14
		10	-0.006	-0.069	-0.253	0.102	0.384	-0.195	-0.364	-0.198
		9	-0.006	-0.07	-0.156	0.814	0.31	-0.162	-0.227	0.066
	Case 4	3	0.006	0.043	-0.098	-0.531	0.142	-0.1	-0.335	0.023
		4	0.006	-0.003	-0.127	-0.044	0.039	0.047	0.023	0.086
		12	-0.071	-0.003	-0.303	0.072	0.071	-0.475	-0.096	0.014
		11	-0.071	0.043	-0.274	-0.415	0.174	0.411	0.234	-0.049
3	Case 1	3	0.007	0.049	-0.107	-0.577	0.141	-0.114	-0.388	0.026
		4	0.007	-0.004	-0.139	-0.034	0.038	0.053	0.029	0.097
		12	-0.079	-0.004	-0.252	0.081	0.074	-0.539	-0.111	0.017
		11	-0.079	0.049	-0.22	-0.462	0.177	0.453	0.273	-0.054
	Case 2	3	0.007	0.049	-0.109	-0.586	0.147	-0.115	-0.388	0.026
		4	0.007	-0.004	-0.141	-0.038	0.04	0.054	0.029	0.098
		12	-0.08	-0.004	-0.277	0.082	0.076	-0.541	-0.111	0.017
		11	-0.08	0.049	-0.245	-0.466	0.183	0.457	0.272	-0.054
	Case 3	3	0.007	0.047	-0.105	-0.564	0.145	-0.109	-0.367	0.025
		4	0.007	-0.004	-0.135	-0.04	0.039	0.051	0.026	0.093
		12	-0.076	-0.004	-0.287	0.078	0.074	-0.515	-0.105	0.016
		11	-0.076	0.047	-0.257	-0.446	0.18	0.438	0.257	-0.052
	Case 4	3	0.006	0.043	-0.098	-0.531	0.142	-0.1	-0.335	0.023
		4	0.006	-0.003	-0.127	-0.044	0.039	0.047	0.023	0.086
		12	-0.071	-0.003	-0.303	0.072	0.071	-0.475	-0.096	0.014
		11	-0.071	0.043	-0.274	-0.415	0.174	0.411	0.234	-0.049

5	Case 1	5	0	0	0	0	0	0	0	0
		6	0	0	0	0	0	0	0	0
		1	0	0	0	0	0	0	0	0
		1	0	0	0	0	0	0	0	0
	Case 2	5	0	0	0	0	0	0	0	0
		6	0	0	0	0	0	0	0	0
		1	0	0	0	0	0	0	0	0
		1	0	0	0	0	0	0	0	0
	Case 3	5	0	0	0	0	0	0	0	0
		6	0	0	0	0	0	0	0	0
		1	0	0	0	0	0	0	0	0
		1	0	0	0	0	0	0	0	0
	Case 4	5	0	0	0	0	0	0	0	0
		6	0	0	0	0	0	0	0	0
		1	0	0	0	0	0	0	0	0
		1	0	0	0	0	0	0	0	0
41	Case 1	4	0.074	0.001	-0.158	-0.434	0.007	-0.891	-0.181	-0.101
		4	0.074	0.002	-0.144	-0.154	0	-0.084	-0.031	-0.094
		5	0.071	0.002	-0.145	-0.147	-0.016	-0.086	-0.013	0.113
		4	0.071	0.001	-0.159	-0.426	-0.009	-0.852	-0.177	0.106
	Case 2	4	0.072	0.001	-0.175	-0.44	0.007	-0.884	-0.18	-0.099
		4	0.072	0.002	-0.161	-0.158	0	-0.094	-0.033	-0.092
		5	0.069	0.002	-0.162	-0.15	-0.016	-0.096	-0.014	0.111
		4	0.069	0.001	-0.176	-0.432	-0.009	-0.845	-0.176	0.104
	Case 3	4	0.065	0.001	-0.192	-0.423	0.007	-0.819	-0.168	-0.089
		4	0.065	0.002	-0.179	-0.155	0	-0.107	-0.034	-0.082
		5	0.062	0.002	-0.18	-0.147	-0.015	-0.108	-0.017	0.1
		4	0.062	0.001	-0.193	-0.415	-0.008	-0.781	-0.163	0.094
	Case 4	4	0.055	0.001	-0.218	-0.397	0.006	-0.721	-0.149	-0.074
		4	0.055	0.002	-0.206	-0.149	0	-0.126	-0.036	-0.068
		5	0.052	0.002	-0.206	-0.142	-0.014	-0.128	-0.02	0.085
		4	0.052	0.001	-0.219	-0.39	-0.007	-0.686	-0.145	0.078
43	Case 1	4	-0.246	-0.001	-0.345	0.087	-0.018	1.126	0.214	0.335
		4	-0.246	0.001	-0.323	-0.055	-0.008	-1.567	-0.269	0.336
		5	-0.24	0.001	-0.316	-0.066	-0.032	-1.514	-0.255	-0.343
		5	-0.24	-0.001	-0.338	0.076	-0.042	1.089	0.194	-0.343
	Case 2	4	-0.248	-0.001	-0.371	0.083	-0.018	1.138	0.216	0.338
		4	-0.248	0.001	-0.349	-0.059	-0.008	-1.579	-0.271	0.339
		5	-0.242	0.001	-0.342	-0.07	-0.033	-1.525	-0.257	-0.346
		5	-0.242	-0.001	-0.364	0.072	-0.042	1.101	0.196	-0.346
	Case 3	4	-0.238	-0.001	-0.378	0.075	-0.017	1.092	0.207	0.323
		4	-0.238	0.001	-0.357	-0.06	-0.008	-1.506	-0.259	0.324
		5	-0.231	0.001	-0.35	-0.071	-0.031	-1.455	-0.245	-0.33
		5	-0.231	-0.001	-0.37	0.065	-0.04	1.057	0.188	-0.331

	Case4	4	-0.221	-0.001	-0.387	0.063	-0.016	1.023	0.194	0.301
		4	-0.221	0.001	-0.368	-0.062	-0.007	-1.395	-0.24	0.302
		5	-0.215	0.001	-0.361	-0.072	-0.029	-1.349	-0.227	-0.308
		5	-0.215	-0.001	-0.381	0.053	-0.037	0.991	0.176	-0.308
46	Case 1	4	0.246	0.001	-0.323	-0.055	0.008	-1.567	-0.269	-0.336
		4	0.246	-0.001	-0.345	0.087	0.018	1.126	0.214	-0.335
		5	0.24	-0.001	-0.338	0.076	0.042	1.089	0.194	0.343
		5	0.24	0.001	-0.316	-0.066	0.032	-1.514	-0.255	0.343
	Case 2	4	0.248	0.001	-0.349	-0.059	0.008	-1.579	-0.271	-0.339
		4	0.248	-0.001	-0.371	0.083	0.018	1.138	0.216	-0.338
		5	0.242	-0.001	-0.364	0.072	0.042	1.101	0.196	0.346
		5	0.242	0.001	-0.342	-0.07	0.033	-1.525	-0.257	0.346
	Case 3	4	-0.106	-0.003	-0.441	0.066	0.014	1.249	0.234	0.15
		4	-0.106	-0.002	-0.451	-0.199	0.004	0.092	0.026	0.138
		5	-0.104	-0.002	-0.446	-0.189	0.016	0.079	0.007	-0.156
		5	-0.104	-0.003	-0.436	0.077	0.025	1.205	0.208	-0.143
	Case4	4	0.221	0.001	-0.368	-0.062	0.007	-1.395	-0.24	-0.302
		4	0.221	-0.001	-0.387	0.063	0.016	1.023	0.194	-0.301
		5	0.215	-0.001	-0.381	0.053	0.037	0.991	0.176	0.308
		5	0.215	0.001	-0.361	-0.072	0.029	-1.349	-0.227	0.308
47	Case 1	4	-0.099	0.001	-0.391	0.057	0.262	1.178	0.208	0.134
		4	-0.099	0.005	-0.397	-0.226	0.278	0.095	-0.013	0.145
		5	-0.099	0.005	-0.388	-0.243	0.284	0.102	0.051	-0.132
		5	-0.099	0.001	-0.382	0.04	0.269	1.176	0.217	-0.143
	Case 2	4	-0.109	-0.003	-0.439	0.074	0.015	1.305	0.244	0.154
		4	-0.109	-0.002	-0.45	-0.206	0.005	0.116	0.031	0.142
		5	-0.106	-0.002	-0.444	-0.195	0.016	0.103	0.011	-0.16
		5	-0.106	-0.003	-0.433	0.085	0.026	1.258	0.218	-0.147
	Case 3	1	-0.014	-0.064	0.236	0.809	0.182	0.14	0.476	0.121
		2	-0.014	-0.067	0.143	0.168	0.242	0.004	0.371	-0.128
		1	-0.01	-0.067	-0.281	0.1	0.346	-0.205	-0.361	-0.188
		9	-0.01	-0.064	-0.189	0.741	0.285	-0.122	-0.203	0.061
	Case 4	4	-0.102	-0.002	-0.445	0.055	0.013	1.165	0.218	0.144
		4	-0.102	-0.002	-0.454	-0.19	0.004	0.055	0.019	0.133
		5	-0.1	-0.002	-0.448	-0.181	0.014	0.043	0.002	-0.149
		5	-0.1	-0.002	-0.439	0.064	0.023	1.125	0.195	-0.138

From table number 6.4, it is observed that with the change in seismic severity from low to high, the plate corner stress value reduces. Like for node plate number 1, node number, the shear Qx value is 0.016 for case 1, 0.016 for case 2, 0.015 for case 3 and 0.005 for case 4. For the plates at the bottom all the corner node stresses are zero.

7. CONCLUSIONS

One of the important element for urban and rural design is studied in this dissertation report. This important element is underground water pipeline which is unavoidable for any of the locations. Normally the pipeline is designed for hoop tension, earth fill or surcharge, uplift pressure and moving vehicle load (if below the roadways).

But it is also necessary to check the stability of the underground pipeline subjected to lateral forces at the time of earthquake.

In this paper report four cases are modelled and analyzed for underground pipeline having same material, same dimensions, and same external and internal loads with the only change in seismic severities. Case 1 is for seismic zone II that is moderate while case 4 is for seismic sever zone V. The comparative study for the displacement, reaction values, plate centre stress and plate corner stresses are studied and it is found that, the top and bottom nodes of pipeline are not subjected to seismic forces and displacements of top nodes is more as compared to middle nodes for vertical direction.

For the considered cases it is observed that plate shear stresses are more for upper plates as compared to middle plates and there is small change in magnitude with the change in seismic severity. The plate corner stresses are reduced. The method of seismic analysis considered over here is static coefficient method and it is observed that if the seismic forces are provided from the both positive and negative direction, the resultant corner stresses are reduced.

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