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MECHANICAL STUDY REGARDING THE LIMITS OF USE OF POLYPROPYLENE PIPES

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Abstract: *The analysis in the current paper has been made for the purpose of determining the applicability limits of the buried polypropylene flexible pipes for different pipe dimensions. Analysis and study are based on the US AWWA 45 First Edition regulation and the analytical and numerical calculus performed, considering certain operational conditions as set forth by the authors.*
Key words: p*ipe, flexible, tensions, strains, efforts.*

1. INTRODUCTION

The paper wishes to present and analyze from a mechanical point of view based on AWWA 45, the possibilities and limits of practical application of buried polypropylene flexible pipes.

For this case study, analyzed and discussed in the current papes, the authors have considered the action of groundwater up to the pipe soffit, have not been considered the horizontal ground loads. The practical field of application of the problem being strictly related to the engineering of the installations, more precisely to the buried buried pipes.

The calculus has been performed based on the well known theoretical mechanics calculations and based on the theory of thin membranes applied for slim cylindrical bodies. The problem submitted for solution was studied both analytically and numerically. The axial effort and bending moments on the lower, median and upper pipe generatrix considered for the pipe flattening determination.

The calculation proposes the determination of straining modules of ground. For analysis, the following hypothesis and data have been considered. Uniform distributed overloads have been ignored as being considered negligible. The street traffic load depends on the nature of ground and the nature of traffic above pipe

2. INFORMATION

2.1 Mechanical and dimensional characteristics.

The ground category, considered for the pipe location is a mixed granular soil comprising an important clay-coarse gravel, mixture with high content of sandy gravel-clay respectively clay-fine sand or clay low plasticity [1], [2].

- p_{tv}^{LT} - Calculus long term vertical ground load.
- $\gamma_P = 18\left[\frac{KN}{m^3}\right]$ – specific weight of ground
- $h = 1.0[m]$ - buried pipe soffit depth level.
- Calculus shall be performed for the following pipe ring thickness $t = 10\ [mm]$.
- $b_T = 0.600[m]$, trench width at the pipe soffit.
- $D_E = 0.0.75[m]$, external diameter of the pipe.
- R_M, medium radius.
- $\beta = 60°$, angle between the trenches lateral wall and the ground surface at the total level.
- $K_1 = 0.6$, coefficient correlating the dependence between ground load. A good compaction level around the pipe has been considered.
- S_p^{LT}, long time pipe stiffness.
- E_C, longitudinal elasticity modulus of pipe material.

- P_{trLT}, street traffic load.
- a_T, correction factor taking into consideration the load distribution from traffic on the pipe.
- P_T, traffic load.
- q_{tv}^{LT}, load from ground.
- q_{tS}^{LT}, load caused by traffic.
- $.\lambda_P^{LT}$, the load factor on pipe dimension.
- $\Delta_V^{Initial}$, initial flattening.
- δ_{VC}^{LT}, initial flattening due to pipe own weight.
- δ_{VW}^{LT}, initial flattening due to the water weight.
- δ_{VP}^{LT}, initial flattening due to pipe by the ground load.
- δ_{SV}^{LT}, initial flattening due to pipe by bthe traffic load.
- δ_V^{TOT}, the overall pipe.
- Δ_V^{TOT}, the overall displacement.

  The axial effort and bending moments on the lower, median and upper pipe generatrix considered for the pipe flattening determination given by the soil load.
- $N_{qv(C)}^{LT}$, axial effort on the upper generatrix.
- $N_{qv(M)}^{LT}$, axial effort on the median generatrix.
- $N_{qv(R)}^{LT}$, axial effort on the lower generatrix.
- $M_{qv(C)}^{LT}$, bending moment on the upper generatrix
- $M_{qv(M)}^{LT}$, bending moment on the median generatrix.
- $M_{qv(R)}^{LT}$, bending moment on the lower generatrix

  The axial effort and bending moments on the lower, median and upper pipe generatrix considered for the pipe flattening determination given by the traffic load.
- $N_{qt(C)}^{LT}$, axial effort on the upper generatrix.
- $N_{qt(M)}^{LT}$, axial effort on the median generatrix.
- $N_{qt(R)}^{LT}$, axial effort on the lower generatrix.
- $M_{qt(C)}^{LT}$, bending moment on the upper generatrix
- $M_{qt(M)}^{LT}$, bending moment on the median generatrix
- $M_{qt(R)}^{LT}$, bending moment on the lower generatrix

The axial effort and bending moments on the lower, median and upper pipe generatrix considered for the pipe flattening determination given by the own weight of pipe.

- $N_{OW(C)}^{LT}$, axial effort on the upper generatrix.
- $N_{OW(M)}^{LT}$, axial effort on the median generatrix.
- $N_{OW(R)}^{LT}$, axial effort on the lower generatrix.
- $M_{OW(C)}^{LT}$, bending moment on the upper generatrix.
- $M_{OW(M)}^{LT}$, bending moment on the median generatrix.
- $M_{OW(R)}^{LT}$, bending moment on the lower generatrix.

  The axial effort and bending moments on the lower, median and upper pipe generatrix considered for the pipe flattening determination given by the water weight.
- $N_{W(C)}^{LT}$. axial effort on the upper generatrix
- $N_{W(M)}^{LT}$, axial effort on the median generatrix
- $N_{W(R)}^{LT}$, axial effort on the lower generatrix
- $M_{W(C)}^{LT}$, bending moment on the upper generatrix.
- $M_{W(M)}^{LT}$, bending moment on the median generatrix.
- $M_{W(R)}^{LT}$, bending moment on the lower generatrix.

  Values of the total efforts on the upper, median and lower generatix.
- $N_{TOT(C)}$, the total axial efforts on the upper generatix.
- $N_{TOT(M)}$, the total axial efforts on the median generatix.
- $N_{TOT(R)}$, the total axial efforts on the lower generatix.
- $M_{TOT(C)}$, bending moment on the upper generatrix.
- $M_{TOT(M)}$, bending moment on the median generatrix.
- $M_{TOT(R)}$, bending moment on the lower generatrix.

  Maximum normal mechanical stress due to tensile stress on the upper, median and lower generatrix.
- $\sigma_{X(C)}^{MAX}$, maximum normal mechanical stress on the upper generatrix.
- $\sigma_{X(M)}^{MAX}$, maximum normal mechanical stress on the median generatrix.

- $\sigma_{X(R)}^{MAX}$, maximum normal mechanical stress on the lower generatrix.
  Maximum normal mechanical stress due to bending moments on the upper, median and lower generatrix.
- $\sigma_{\theta(C)}^{MAX}$, maximum normal mechanical stress on the upper generatrix.
- $\sigma_{\theta(M)}^{MAX}$, maximum normal mechanical stress on the median generatrix.
- $\sigma_{\theta(R)}^{MAX}$, maximum normal mechanical stress on the lower generatrix.
- I , moment of axial inertia.
- W, the resistance module of the annular section.
- σ_{ECH}^{C}, equivalent mechanical stress on the upper generatrix.
- σ_{ECH}^{M}, equivalent mechanical stress on the median generatrix.
- σ_{ECH}^{R}, equivalent mechanical stress on the lower generatrix.
- σ_{θ}^{TOT}, total normal mechanical stress given by the bending moments on the annular section.
- σ_{X}^{TOT}, total normal mechanical stress given by the tensile stress on the annular section.
- σ_{ECH}^{TOT}, equivalent total mechanical stress.
- σ_{ECH}^{C}, equivalent total mechanical stress on the upper generatrix.
- σ_{ECH}^{M}, equivalent total mechanical stress on the median generatrix.
- σ_{ECH}^{R}, equivalent total mechanical stress on the lower generatrix.
- σ_{ADM}^{TOT}, admissible normal stress.

3. FIGURES

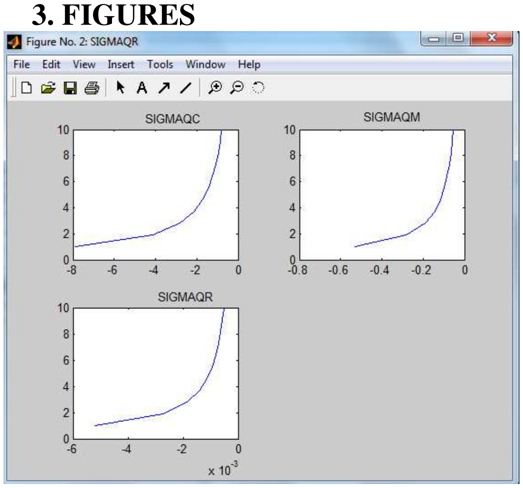

Fig.1 Variation of the normal tension due by the bending stress

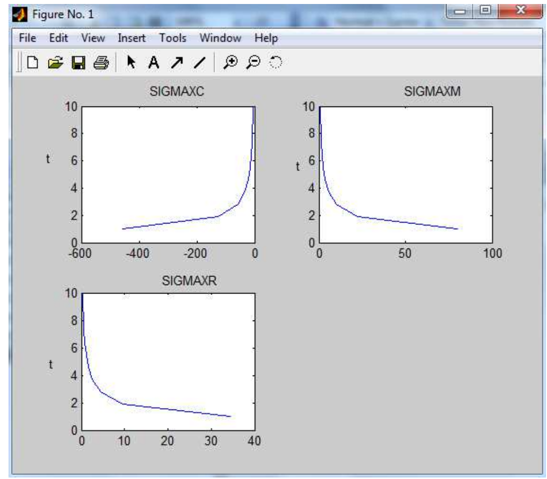

Fig.2 Variation of the normal tension due by the tensile stress

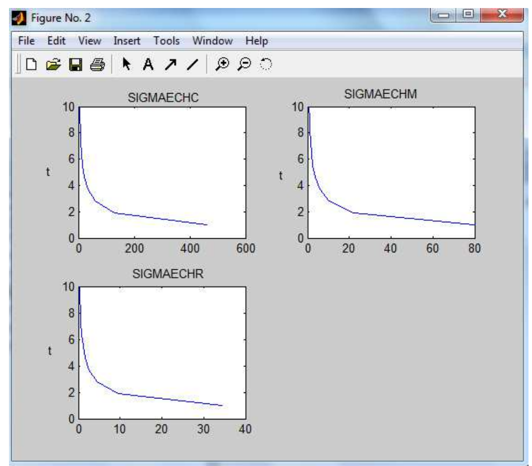

Fig.3 Variation of the equivalent normal tension on the upper, median and lower generatrix

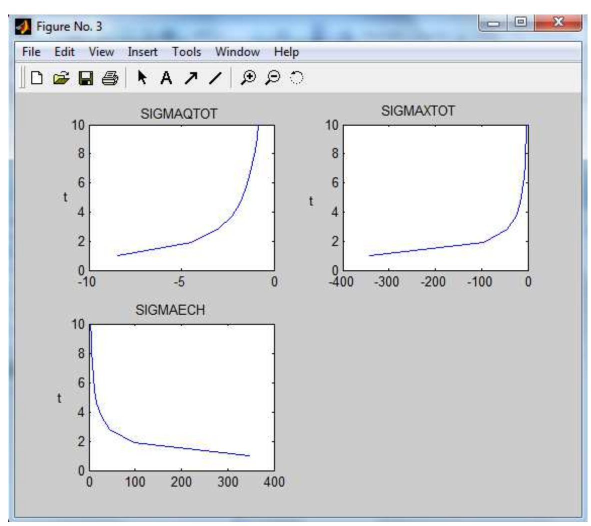

Fig.4 Variation of the total normal tension on the upper, median and lower generatrix

4. TABLES

Table 1

Maximum normal mechanical stress by the thickness of the pipe ring due to bending moments.

t	1.0	1.9	2.8	3.7	4.6
$\sigma_{\theta(C)}^{MAX}$	-7.8946	-4.155	-2.819	-2.133	-1.716
$\sigma_{\theta(C)}^{MAX}$	-0.1803	-0.094	-0.064	-0.048	-0.039
$\sigma_{\theta(C)}^{MAX}$	0.0097	0.0051	0.0035	0.0026	0.0021

t	5.5	6.4	7.3	8.2	9.1	10
$\sigma_{\theta(C)}^{MAX}$	-1.43	-1.23	-1.08	-0.96	-0.86	-0.78
$\sigma_{\theta(C)}^{MAX}$	-0.032	-0.028	-0.024	-0.022	-0.019	-0.018
$\sigma_{\theta(C)}^{MAX}$	0.0018	0.0015	0.0013	0.0012	0.0011	0.0010

Table 2

Maximum normal mechanical stress by the thickness of the pipe ring due to tensile stress.

t	1.0	1.9	2.8	3.7	4.6
$\sigma_{X(C)}^{MAX}$	-457.80	-126.8	-58.39	-33.44	-21.63
$\sigma_{X(M)}^{MAX}$	79.613	22.053	10.154	5.8154	3.7625
$\sigma_{X(R)}^{MAX}$	35.413	9.8097	4.5170	2.5868	1.6736

t	5.5	6.4	7.3	8.2	9.1	10
$\sigma_{X(C)}^{MAX}$	-15.13	-11.17	-8.590	-6.808	-5.528	-4.578
$\sigma_{X(M)}^{MAX}$	2.6319	1.9437	1.4940	1.1840	0.9614	0.7961
$\sigma_{X(R)}^{MAX}$	1.1797	0.8646	0.6645	0.5267	0.4276	0.3541

Table 3

Equivalent normal mechanical stress by the thickness of the pipe ring.

t	1.0	1.9	2.8	3.7	4.6
σ_{ECH}^{C}	461.78	128.94	59.851	34.55	22.541
σ_{ECH}^{M}	79.3434	21.9121	10.0592	5.7435	3.7049
σ_{ECH}^{R}	35.4102	9.8082	4.5160	2.5860	1.6730

t	5.5	6.4	7.3	8.2	9.1	10
σ_{ECH}^{C}	15.89	11.84	9.17	7.33	6.00	5.01
σ_{ECH}^{M}	2.58	1.90	1.45	1.15	0.93	0.77
σ_{ECH}^{R}	1.17	0.86	0.66	0.52	0.42	0.35

Table 4

Total equivalent mechanical stress by the thickness of the pipe ring.

t	1.0	1.9	2.8	3.7	4.6
σ_{θ}^{TOT}	-8.43	-4.439	-3.012	-2.279	-1.833
σ_{X}^{TOT}	-342.7	-94.95	-43.72	-25.03	-16.19
σ_{ECH}^{TOT}	347.0	97.248	45.30	26.25	17.18

t	5.5	6.4	7.3	8.2	9.1	10
σ_{θ}^{TOT}	-1.53	-1.31	-1.155	-1.02	-0.92	-0.84
σ_{X}^{TOT}	-11.3	-8.36	-6.43	-5.09	-4.13	-3.42
σ_{ECH}^{TOT}	12.17	9.09	7.08	5.68	4.67	3.91

5. EQUATIONS

The long term vertical load was determinated

$$p_{VLT} = 8.6510\left[\frac{KN}{m^2}\right]$$

Calculus shall be performed for the following pipe ring thickness

t= [1.0000 1.9000 2.8000 3.7000 4.6000 5.5000 6.4000 7.3000 8.2000 9.1000 10.0000]
The analysis of strains, tensions, and trips requires a determination of the pipe stiffness [2], [6].

$$S_P^{LT} = \frac{E_C \cdot t^3}{12 D_M^3} = 0.2428 \frac{N}{mm^2} \quad (1)$$

S_P^{LT} =[0.0002 0.0017 0.0053 0.0123 0.0236 0.0404 0.0636 0.0944 0.133 0.1829 0.2428]
The street traffic load [2]

$$P_{tsLT} = a_T D_T p_T = 0.005318\left[\frac{N}{mm^2}\right] \quad (2)$$

The load from ground and the load caused by traffic, taking into consideration the load factor on pipe dimension.λ_P^{LT} [2].

$$q_{TV}^{LT} = \lambda_P^{LT} \cdot \gamma_P \cdot h == 0.0095\left[\frac{N}{mm^2}\right]$$

(3)

$$q_{TS}^{LT} = \lambda_{PT}^{LT} \cdot p_{TS}^{LT} = 0.0059\left[\frac{N}{mm^2}\right] \le 1.5 \cdot p_{TS}^{LT}$$

$$\lambda_p^{LT} = \frac{\lambda^{LT}{}_{\max} \cdot V_S + a_{EF}^{LT} \cdot \frac{4 \cdot K_2}{3} \cdot \frac{\lambda^{LT}{}_{MAX} - 1}{a_{EF}^{LT} - 0,25}}{V_S + a_{EF}^{LT} \cdot \frac{3 + K_2}{3} \cdot \frac{\lambda^{LT}{}_{MAX} - 1}{a_{EF}^{LT} - 0,25}} = 1.0432 \quad (4)$$

Also the overall flattening of pipe produced by: initial flattening due to pipe own weight, the ones due to the water weight, inital ground load and street load, has been determined with the relationships [2], [3].

$$\Delta_V^{INITIAL} = \delta_V^{INITIAL} \cdot D_M = 0.010[m] = 10[mm]$$

$$\delta_{VC}^{LT} = \frac{c_{v,ow} \cdot t \cdot \gamma_C}{8 \cdot S_P^{LT}}$$

$$\delta_{V,W}^{LT} = \frac{c_{v,w} \cdot D_m \cdot \gamma_w}{16 \cdot S_{P,LT}} \quad (5)$$

$$\delta_{VP}^{LT} = \frac{C_{VV} \cdot q_{TV}^{LT}}{8 S_P^{LT}}$$

$$\delta_{SV}^{LT} = \frac{C_{VV} \cdot q_{ST}^{LT}}{8 S_P^{LT}}$$

δ_{VC}^{LT} =[-1.5571 -0.4313 -0.1986 -0.1137 -0.0736 -0.0515 -0.0380 -0.0292 -0.0232 -0.0188 -0.0156].

δ_{VW}^{LT} =[-14.0574 -2.0495 -0.6404 -0.2775 -0.1444 -0.0845 -0.0536 -0.0361 -0.0255 -0.0187 -0.0141]

δ_{VP}^{LT}= [-0.4364 -0.0636 -0.0199 -0.0086 -0.0045 -0.0026 -0.0017 -0.0011 -0.0008 -0.0006 -0.0004]

δ_{SV}^{LT}=[-0.2683 -0.0391 -0.0122 -0.0053 -0.0028 -0.0016 -0.0010 -0.0007 -0.0005 -0.0004 -0.0003]

The overall pipe strain has been determined.

$$\delta_V^{TOT} = \frac{\left[\delta_{v,io} + \delta_{v,ow} + \delta_{v,w} + \delta_{v,ext}\right]}{10^3} = 0.000140$$

δ_V^{TOT}=[-0.0160348 0.0025284 -0.0008428 -0.0003838 -0.0002064 -0.0001225 -0.0000772 -0.0000504 -0.0000334 -0.0000220 -0.000140]

The overall strain expressed as percentage for the points in the pipe wall thickness.

$\delta_V^{TOT} 100\,\% =$ [1.6035 0.2528 0.0843 0.0384 0.0206 0.0123 0.0077 0.0050 0.0033 0.0022 0.0014].

The overall displacement achieved in the considered points in the pipe wall:

$\Delta_V^{TOT} =$ [1.2026 0.1896 0.0632 0.0288 0.0155 0.0092 0.0058 0.0038 0.0025 0.0016 0.0010].

So,

$$\Delta_V^{TOT} < 3.75\ [mm],$$

which represents the allowable displacement of the points in the thickness of the ring.

The axial effort and bending moments on the lower, median and upper pipe generatrix considered for the pipe flattening determination [2], [3].

$$N_{qv(C)}^{LT} = n_{qv(C)}^{LT} q_{tv}^{LT} R_M = 0.084$$

$$N_{qv(M)}^{LT} = n_{qv(M)}^{LT} q_{tv}^{LT} R_M = -0.3095 \quad (6)$$

$$N_{qv(R)}^{LT} = n_{qv(R)}^{LT} q_{tv}^{LT} R_M = -0.084$$

$$M_{qv(C)}^{LT} = m_{qv(C)}^{LT} q_{tv}^{LT} R_M^2 = 2.3852$$

$$M_{qv(M)}^{LT} = m_{qv(M)}^{LT} q_{tv}^{LT} R_M^2 = -2.4218 \quad (7)$$

$$M_{qv(R)}^{LT} = m_{qv(R)}^{LT} q_{tv}^{LT} R_M^2 = -2.5132$$

The tensile stress $\left(N/_{mm}\right)$ and the bending moments $(N \cdot mm)$ due by the traffic weight [2], [3], [4], [5]

$$N_{qt(C)}^{LT} = n_{qt(C)}^{LT} q_{tv}^{LT} R_M = 0.065$$

$$N_{qt(M)}^{LT} = n_{qtM)}^{LT} q_{tv}^{LT} R_M = -0.2192$$

$$N_{qt(R)}^{LT} = n_{qt(R)}^{LT} q_{tv}^{LT} R_M = -0.065$$

$$M_{qt(C)}^{LT} = m_{qt(C)}^{LT} q_{tv}^{LT} R_M^2 = 1.1857$$

$$M_{qt(M)}^{LT} = m_{qt(M)}^{LT} q_{tv}^{LT} R_M^2 = -1.3236$$

$$M_{qt(R)}^{LT} = m_{qt(R)}^{LT} q_{tv}^{LT} R_M^2 \quad = -1.5167$$

The tensile stress $(N/_{mm})$ and the bending moment $(N \cdot mm)$ due by the own weight [7], [8], [9].

$$N_{OW(C)}^{LT} = n_{OW*(C)}^{LT} \gamma_C t R_M = 0.0717 \cdot 10^{-3}$$

$$N_{OW(M)}^{LT} = n_{OW*(M)}^{LT} \gamma_C t R_M = -08556 \cdot 10^{-3}$$

$$N_{OW(R)}^{LT} = n_{OW*(R)}^{LT} \gamma_C t R_M = -0.2007 \cdot 10^{-3}$$

$$M_{OW(C)}^{LT} = m_{OW*(C)}^{LT} \gamma_C t R_M^2 \quad = 0.00355 \cdot 10^{-3}$$

$$M_{OW(M)}^{LT} = m_{OW*(M)}^{LT} \gamma_C t = -0.0078 \cdot 10^{-3}$$

$$M_{OW(R)}^{LT} = m_{OW*(R)}^{LT} \gamma_C t R_M^2 \quad = 0.0136 \cdot 10^{-3}$$

The tensile stress$(N/_{mm})$ and the bending moments $(N \cdot mm)$ due by the water weight [7], [8], [9].

$$N_{W(C)}^{LT} = n_{W(C)}^{LT} \cdot \gamma_W \cdot t \cdot R^2 = 0.0066$$

$$N_{W(M)}^{LT} = n_{W(M)}^{LT} \cdot \gamma_W \cdot t \cdot R^2 = 0.0043$$

$$\mathrm{N_{W(R)}^{LT} = n_{W(R)}^{LT} \gamma_W \cdot t \cdot R_M^2} = 0.0407$$

$$M_{W(C)}^{LT} = m_{W(C)}^{LT} \cdot \gamma_W \cdot t \cdot R_M^3 = 0.0652$$

$$M_{W(M)}^{LT} = m_{W(M)}^{LT} \cdot \gamma_W \cdot t \cdot R_M^3 = -0.1435$$

$$M_{W(R)}^{LT} = m_{W(R)}^{LT} \cdot \gamma_W \cdot t \cdot R_M^3 = 0.2499$$

Through algebrical summing of the values of efforts determined on the lower median and soffit generator of pipe ring the total values have been achieved

$$N_{TOT(C)} = -7.8946$$

$$N_{TOT(M)} = -0.5429$$

$$N_{TOT(R)} = -0.0056$$

$$M_{TOT(C)} = -76.3007$$

$$M_{TOT(M)} = 13.2629$$

$$M_{TOT(R)} = 5.9022$$

The analysis of the tension has been perfomred by means of vectorial annd matriceal calculation, thus achieving on the soffit the maximum normal tension. On the pipe thickness a net of 11 equal spaced points has been considered [1], [3], [4], [5].

$$\sigma_{\theta(C)}^{MAX} = \frac{N_{TOT(C)}}{t} = -0.7895\left[\frac{N}{mm}\right]$$

On the pipe median the value of normal tension is :

$$\sigma_{\theta(M)}^{MAX} = \frac{N_{TOT(M)}}{t} = -0.0328\left[\frac{N}{mm}\right]$$

On the pipe lower generator the value of the normal tension is.

$$\sigma_{\theta(R)}^{MAX} = \frac{N_{TOT(M)}}{t} = 0.0097\left[\frac{N}{mm}\right]$$

The normal longitudinal tension is being determined using the following formulae. On the soffit the determined value of longitudinal tension is :

$$\sigma_{X(C)}^{MAX} = \frac{M_{TOT(C)}}{W} = \frac{6 \cdot M_{TOT(C)}}{t^2} = -4.5780[Nmm]$$

On the pipe median generatrix the determined value of longitudinal tension is :

$$\sigma_{X(M)}^{MAX} = \frac{M_{TOT(M)}}{W} = \frac{6 \cdot M_{TOT(M)}}{t^2} = 2.1393[Nmm]$$

On the pipe lower generator the value of the longitudinal tension is [1], [2], [4], [5].

$$\sigma_{X(R)}^{MAX} = \frac{M_{TOT(R)}}{W} = \frac{6 \cdot M_{TOT(R)}}{t^2} = 26.8971[Nmm]$$

For the calculation of the normal longitudinal tension the formulae for the moment of inertia and strength momentum for ring section are [2], [3], [4]:

$$I = \frac{t^3}{12}$$
$$W = \frac{I}{t/2} = \frac{t^3/12}{t/2} = \frac{t^2}{6} \tag{8}$$

Looking at the results achieved it can be observed that the normal longitudinal tension is a different size order compared to the tangent tension the latter one being much smaller.

By using the principle of overlapping effects the equivalent normal tension on the soffit median and lower generatrix. The equivalent stress has been determined using one of the strength criteria in the material strength [4], [5], [10].

$$\sigma_{ECH}^{C} = \sqrt{\left(\sigma_{\theta}^{C}\right)^2 + \left(\sigma_{X}^{C}\right)^2 + 2\cdot\sigma_{\theta}^{C}\cdot\sigma_{X}^{C}}$$
$$\sigma_{ECH}^{M} = \sqrt{\left(\sigma_{\theta}^{M}\right)^2 + \left(\sigma_{X}^{M}\right)^2 + 2\cdot\sigma_{\theta}^{M}\cdot\sigma_{X}^{M}} \quad (9)$$
$$\sigma_{ECH}^{R} = \sqrt{\left(\sigma_{\theta}^{R}\right)^2 + \left(\sigma_{X}^{R}\right)^2 + 2\cdot\sigma_{\theta}^{R}\cdot\sigma_{X}^{R}}$$

The following values are being obtained

$$\sigma_{ECH}^{C} = 5.0196\left[\frac{N}{mm^2}\right]$$
$$\sigma_{ECH}^{M} = 2.1232\left[\frac{N}{mm^2}\right]$$
$$\sigma_{ECH}^{R} = 26.8839\left[\frac{N}{mm^2}\right]$$

Considering as valid the small trips hypothesis, the overall tension on the tangent direction and longitudinal direction at the ring has been determined using the principle of overlapping effects and summing the tensions. Thus the overall tensions on the pipe ring are being obtained [4], [5].

$$\sigma_{\theta}^{TOT} = \sigma_{\theta(C)}^{MAX} + \sigma_{\theta(M)}^{TOT} + \sigma_{\theta(R)}^{TOT}$$
$$\sigma_{X}^{TOT} = \sigma_{XC)}^{MAX} + \sigma_{X(M)}^{TOT} + \sigma_{X(R)}^{TOT} \quad (10)$$
$$\sigma_{\theta}^{TOT} = 0.7664\frac{N}{mm^2}$$
$$\sigma_{X}^{TOT} = 24.4584\left[\frac{N}{mm^2}\right]$$

For a thickness of t=10[mm]

$$\sigma_{ECH}^{TOT} = \sqrt{\left(\sigma_{\theta}^{TOT}\right)^2 + \left(\sigma_{X}^{TOT}\right)^2 + 2\cdot\sigma_{\theta}^{TOT}\cdot\sigma_{X}^{TOT}} = 25.22\left[\frac{N}{mm^2}\right]$$

It can be observed that the equivalent tension is much smaller than the allowable tension, thus the tension status is being verified in the pipe ring [1], [3], [4], [5].

$$\sigma_{ADM}^{TOT} = 0.8\cdot\sigma_{ADM}\left[\frac{N}{mm^2}\right] = 32\left[\frac{N}{mm^2}\right]$$

The equivalent tensions on the soffit median and lower generatrix for the listed pipe ring thickness are being determined using the following formulae [3], [4], [5].

$$\sigma_{ECH}^{C} = \sqrt{\left(\sigma_{\theta}^{C}\right)^2 + \left(\sigma_{X}^{C}\right)^2 + 2\cdot\sigma_{\theta}^{C}\cdot\sigma_{X}^{C}}$$
$$\sigma_{ECH}^{M} = \sqrt{\left(\sigma_{\theta}^{M}\right)^2 + \left(\sigma_{X}^{M}\right)^2 + 2\cdot\sigma_{\theta}^{M}\cdot\sigma_{X}^{M}}$$
$$\sigma_{ECH}^{R} = \sqrt{\left(\sigma_{\theta}^{R}\right)^2 + \left(\sigma_{X}^{R}\right)^2 + 2\cdot\sigma_{\theta}^{R}\cdot\sigma_{X}^{R}}$$

Considering as valid the small trips hypothesis, the overall tension on the tangent direction and longitudinal direction at the ring has been determined using the principle of overlapping effects and summing the tensions. Thus the overall tensions on the pipe ring for the listed thickness values are being obtained.

$$\sigma_{\theta}^{TOT} = \sigma_{\theta(C)}^{MAX} + \sigma_{\theta(M)}^{TOT} + \sigma_{\theta(R)}^{TOT}$$
$$\sigma_{X}^{TOT} = \sigma_{XC)}^{MAX} + \sigma_{X(M)}^{TOT} + \sigma_{X(R)}^{TOT}$$

The overall equivalent tension is bein obtained using the strength criteria [4], [5].

$$\sigma_{ECH}^{TOT} = \sqrt{\left(\sigma_{\theta}^{TOT}\right)^2 + \left(\sigma_{X}^{TOT}\right)^2 + 2\cdot\sigma_{\theta}^{TOT}\cdot\sigma_{X}^{TOT}}$$

6. CONCLUSION

As a result of the study, the following have been observed:

- The overall normal equivalent tension is smaller or equal to normal allowable tension for a ring thickness between 3.7 and 10 mm.
- As a conclusion the normal equivalent tension resulting from the statically and strength calculation for the polypropylene pipe is 78.82% of the allowable normal tension.
- The overall tangent tension at soffit, median and lower generator is being lower than the allowable tension
- The normal longitudinal tension, produced by the bending moment action

for the considered loads are smaller than the allowable normal tension at soffit median and invert only for ring thickness of 3.7 mm

- The normal equivalent tension produced by the considered loads are smaller than the allowable normal tension at soffit median and invert only for ring thickness of 3.7 mm

The calculus gives an overall image of the possibility to use in practice the polypropylene pipes for the considered loads.

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STUDIUL MECANIC PRIVIND LIMITELE DE UTILIZARE A CONDUCTELOR DIN POLIPROPILENA

Rezumat:Analiza efectuata in lucrarea de fata s-a realizat in vederea stabilirii limitelor de aplicare in teren a conductelor flexibile ingropate din polipropilena pentru diferite valori dimensionale ale acestora. Analiza si studiul are la baza informatiile cuprinse in cadrul normativului american AWWA 45 First edition, iar calculele analitice si numerice efecvtuate tinand cont de anumite conditii de exploatare specifice considerate de autori.

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