BULETINUL INSTITUTULUI POLITEHNIC DIN IAȘI
Publicat de
Universitatea Tehnică „Gheorghe Asachi” din Iași
Volumul 64 (68), Numărul 4, 2018
Secția
CONSTRUCȚII. ARHITECTURĂ

VERIFICATION OF THE STABILITY OF UNDERGROUND PIPES

BY

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Received: October 17, 2018
Accepted for publication: November 23, 2018

Abstract. In this article we present the calculation for checking the stability of underground pipelines taking into account the actions to which it is subject. The material, the type of which is buried in the ground, etc. contribute to endanger the stability of the pipe so as to be considered a clear delineation of the respective existing values of the critical loads.

Keywords: underground pipes; type of soil; critical loads.

1. Introduction

The pipes are classified into flexible or rigid, depending on the stiffness of the combined effect of the deformation of the pipe and the soil (Aschilean & Iliescu, 2018). The pipes are rigid when tasks do not cause significant

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deformation, so no change in the distribution of pressures/loads (Δ > 1). Checking efforts will suffice in this case. Flexible pipes (Ancas & Atanasiu, 2011) are significant deformations occur when the load, which produce changes in the distribution of pressure/load so that the soil is dimensioned bearing component of the system/check (Δ ≤ 1). It is necessary in this case deformation and stability verification system. When the pipe behavior is not clearly necessary checks both times (Aschilean, 2009a).

2. Pressure Distribution Around the Circumference of the Pipes

2.1. The Influence of the Pipe Laying Mode

Case I - This case applies to the verification efforts and deformations rigid or flexible pipes. Routing is performed directly on the ground with rectangular vertical loads and distributed feedback. For flexible pipes 2α = 120º or 2α = = 180º (Fig. 1).

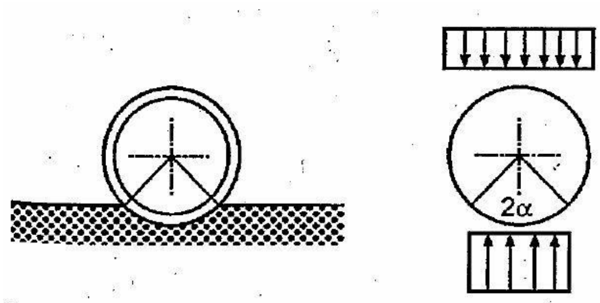


Fig. 1 – Case I – The distribution of the effort in the pipe.

Case II - If the rigid pipe is supported on concrete (Fig. 2).

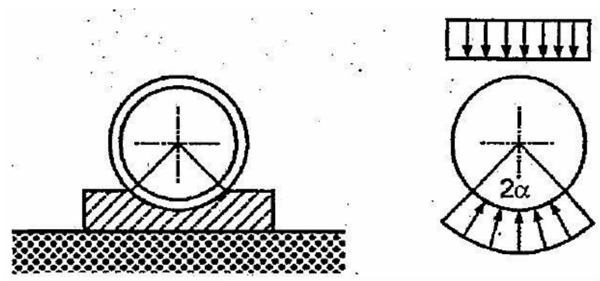


Fig. 2 – Case II - The distribution of the effort in the pipe.

Case III – Elastic pipes (Fig. 3).

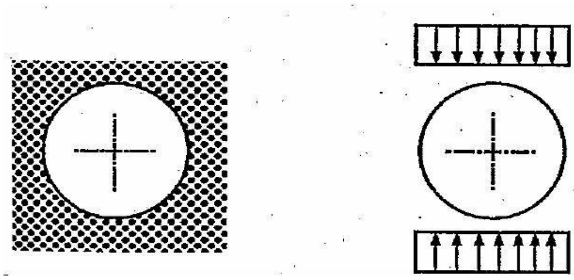
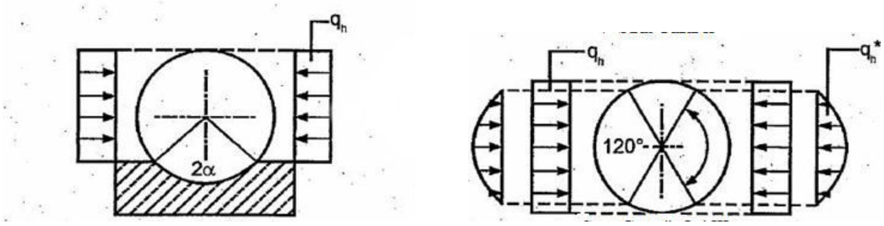


Fig. 3 – Case III - The distribution of the effort in the pipe.

2.2. The Pressure Side of the Pipe

The pressure side of the pipe is uniformly distributed on the intensity of the q^* as a result of the vertical load of the earth and, as the case may ρ_h^*, the intensity of the soil uniformly distributed in response to deformation (Aschilean & Giurca, 2018).



Case II Case I and III

Fig. 4 – The distribution of the stress in the side pressure.

2.3. Stress and Desplacements

Efforts are arising bending moment and axial force resulting from:

– vertical load in the intensity q_v:

$$M_{qv} = m_{qv} \times q_v \times r_m^2; \quad N_{qv} = n_{qv} \times q_v \times r_m; \tag{1}$$

– lateral pressure in the intensity q_h:

$$M_{qh} = m_{qh} \times q_h \times r_m^2; \quad N_{qh} = n_{qh} \times q_h \times r_m; \tag{2}$$

– loading the horizontal earth pressure q_h^*:

$$M_{qh}^* = m_{qh}^* \times q_h^* \times r_m^2; \quad N_{qh}^* = n_{qh}^* \times q_h^* \times r_m; \tag{3}$$

– horizontal pressure due to ground water q_{hw}^*:

$$M^*_{qw} = m^*_{qh} \times q^*_{hw} \times r_m^2; \quad N^*_{qw} = n^*_{qh} \times q^*_{hw} \times r_m; \tag{4}$$

– the weight of the pipeline:

$$M_g = m_g \times s \times \chi_R \times r_m^2; \quad N_g = n_g \times s \times \chi_R \times r_m, \tag{5}$$

where the curvature of the pipe wall is r_m.

Stresses arising is calculated with:

$$\sigma = \frac{N}{A} \pm \frac{M}{W} \times \alpha_k, \tag{6}$$

where: N and M effort for each charge, W – the section modulus, α_k – coeficient that takes into account the curvature of the pipe.

$$\alpha_k = 1 + \frac{1}{3} \times \frac{s}{r_m}, \tag{7}$$

where: s – rigidity (N/m^2).

2.4. Verification of the Stability

Checking stability aims to clearly delimit the existing load values, respectively critical ones. Take into account the total vertical load (land and traffic), groundwater pressure, also external water pressure and own the pipeline (Aschilean, 2009b). Additional checks may be made non-linear loads such as dynamic loads.

Consider the so-called imperfections, which are strains from two categories of cases, type A (minor manufacturing defects, defects transport and storage) and type B (deformations of the installation, other elastic deformations) (Aschilean, 2014).

Situations are taken into account are:

– laying the ground water table and $\chi \leq 5.0$;

– the presence of the tasks common point;

– cover $h \leq 0.80$m, in the case of metallic protection pipes;

– welded joints longitudinally or spirally welded pipes.

Reducing factors and preliminary deformation is taken from the diagrams (Ancaş & Profire, 2018). Critical buckling load is determined:

$$\text{crit}q_v = 2 \times k \times \sqrt{8 \times S_0 \times S} \text{ for } \Delta \leq 0.1; \ \text{crit}q_v = k \times \left(3 + 1/3\Delta\right) \times 8 \times S \text{ for } \Delta > 0.1,$$

where: S_0 is the initial specific stiffness; k – reduction factor according to the diagram Fig. 5.

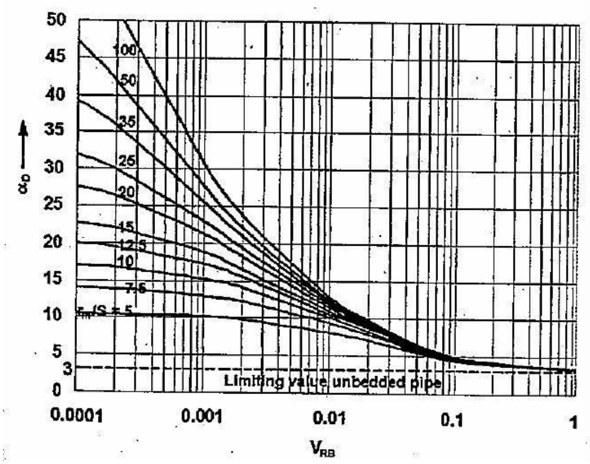


Fig. 5 – Load critical reduction factor.

Safety factor will be:

$$\chi = \frac{\mathrm{crit}q_v}{q_v}. \tag{8}$$

External water pressure p_e is calculated by the relationship:

$$\mathrm{crit}p_e = k_a \times \alpha_D \times 8 \times S_0; \tag{9}$$

$$p_e = h_w \times \chi_w. \tag{10}$$

Safety factor will be:

$$\chi = \frac{\mathrm{crit}p_e}{p_e}. \tag{11}$$

If we consider the external water pressure simultaneously and total vertical load, the safety factor is:

$$\chi = \frac{1}{\dfrac{q_v}{\mathrm{crit}q_v} + \dfrac{p_e}{\mathrm{crit}p_e}}. \tag{12}$$

It is recommended to verify the stability, increase the use of approximation by the factor β. The steps are:

– determine M_{q_v} and N_{q_v};

– calculate:

$$N_{PE} = p_i \times r_i - p_e \times r_e, \tag{13}$$

and corresponding bending moment:

$$M_{PE} = m_{pe} \times p_e \times r_m^2, \tag{14}$$

– shall be increased by the factor:

$$\beta_{PE} = \frac{1}{1 - \frac{\chi_{qv} \times p_e}{\mathrm{crit}q_v}}; \tag{15}$$

– safety factors are obtained:

$$\chi_{qv} = \frac{\sigma_p}{\sigma_{qv}},$$

respectivly:

$$\chi_{pe} = \frac{\sigma_p}{\sigma_{pew}}. \tag{16}$$

Define two safety classes:
Class A: Under normal circumstances, the possibility groundwater important consequences of possible failure.
Class B: Specific conditions, no groundwater consequences minor damage.

Table 1
Safety Factors

Material	χ necessary	
	Class A	Class B
Safety factor to breaking		
Ceramics	2.2	1.8
Reinforced Concrete	1.75	1.4
Steel, Cast Iron	1.5	1.3
GRP	2.0	1.75
PVC	2.5	2.0
Safety factor to the loss of stability		
All	2.5	2.0

3. Conclusions

Elements which constitute a water transport system must meet certain requirements of strength, stiffness and stability to the shares being placed. If buried pipelines that run under external actions are very different from water pressure up to loads of traffic, so the designer is not easy task. An inadequate design lead to lower estimated useful life of the respective pipeline and system in its entirety.

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VERIFICAREA STABILITĂȚII PRNTRU CONDUCTE ÎNGROPATE

(Rezumat)

În articolul de față se prezintă modul de calcul pentru verificarea stabilității conductelor îngropate ținând cont de acțiunile la care aceastea sunt supuse. Materialul conductei, tipul de sol în care este îngropată etc., concură la afectarea stabilității conductei astfel încăt trebuie avută în vedere o delimitare clară a valorilor pentru încărcările existente respectiv a celor critice.