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CALCULATION OF UNDERGROUND GRP PIPES

BY

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Abstract. Design lifetime of GRP pipes is 50 years but there are studies and tests show that some types of pipe can have a good operation and safety in operation and more than 100 years. Article breakdowns occurring on GRP pipes buried in the land alkaline and acidic by highlighting the main parameters that take into account the execution of the work and presents a static calculation methodology for this type of pipe.

Keywords: GRP pipes; type of soil; testing of pipe.

1. Introduction

Pipes GRP (polyester reinforced fiberglass and insert sand) were invented in the mid-twentieth century, as an application of composite GRP (turn invented before the Second World War the corporation Owens Corning). The first applications of these pipelines were in the chemical and petrochemical, and as improving production technology (allowing cost reduction) began to be used in urban sewage networks and water supply.

In Romania this pipeline began to be produced in the 1980’s anticorrosion Bucharest after craft method, with use in drains and sewers of

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large industrial complexes. Using massive utility networks in our country began in 1997, with a feed water Fagaras, reaching as today using pipes GRP be technical solution Standard for a size range between DN150 and DN3200 (largest diameter used in Romania). Basically there are counties where there is no work done with this type of pipes, drains, water supply, hydropower, heat register or water management . GRP pipes and fittings are produced in Romania 4 production capacities, the two technologies (winding and centrifugation), and the summed lengths of the pipes used so far beyond 2,500 km. Reasons for this type of pipe are present in all infrastructure projects for water/sewer related to the size range available Huge (DN100 – DN4000), ease of assembly, exceptional duration of life (rated 50, but no data experimental result, by extension, over 100 years) rigorous manufacturing process (fully automated process computer controlling the recipe manufacturing), adaptability to the specific situation of the land (almost pipes can be produced custom cases point), ease of repair , diverse range of fittings, the possibility storage/lay-ground (are inert to the action of UV rays), and last but not least the price acceptable to both competitive increases as the nominal diameter.

GRP pipes have a semi-elastic behavior (cooperates with the land, and surrenders some of its load) and anisotropic (different mechanical properties in the axial direction or roll). Compared to the other materials used in wastewater treatment GRP pipes have the following characteristics and advantages (Ancaş & Cojocaru, 2017):

– corrosion resistance: not require cathodic protection, coating, coating or other methods of additional protection against corrosion, the specific steel or ductile cast iron pipes;

– lightweight: 4 times easier than ductile iron; 10 times lighter than concrete or ceramic tiles, which reduces shipping costs and handling;

– standard lengths;

– large (virtually any length between 6 m and 18 m, in the case of GRP pipe produced by the wound): fewer joints, which increases the rate of laying and reduces the risk of damage;

– outstanding hydraulic characteristics: the internal surface a very smooth, so the rate of self-cleaning small slope required minimum drains low gravity, coefficient Hazen-Williams C = 150, coefficient Manning n = 0.009, high abrasion resistance, the velocity of the reduced pressure, thus low costs of system protection against water hammer and the shock wave;

– normal lifetime high;

– low expansion coefficient, resistance to ultraviolet radiation, which allows routing above ground.

High flexibility, enabling the elastic deformation of up to 25% of the diameter without affecting the strength of the structure.

GRP pipes are used in Romania in the following applications:
– transportation and distribution of potable water and the fresh water;
– drainage and sanitary systems;
– rainwater ;
– the hydro inflow pipes;
– capture marine and offshore discharge;
– the circulation system of the cooling water in the heat register;
– industrial;
– relining;
– irrigation, agriculture;
– desalination plants;
– mining.

The extensive use of this type of pipe, in its various embodiments, has led to the need to investigate their behavior in the land, which causes man-made or natural, have different values of pH to neutral.

Some specific cases of this kind were observed at the following locations:

1º In the adduction pipe made of GRP DN500 PN10 SN10000 in the resort area Amara/Ialomiţa recognized alkalized ground, phenomena were observed seepage through the pipe wall, accompanied by a color change thereof (Fig. 1)

Fig. 1 – Pipe alkalized land affected by Amara/Ialomiţa, Romania.

2º In the adduction pipe made of GRP DN1000 PN10 SN10000 heavily contaminated with crude oil in the refinery Darmanesti, Romania in the vicinity of the damage rate was much higher than in the same pipe laid in contaminated land (Fig. 2).

Fig. 2 – Fault in land contaminated with oil Dărmăneşti/Bacău, Romania.

3º The GRP pipe DN600 PN10 SN10000 posed in a polluted land anthropogenic (including mineral oil) of an old industrial damage Iaşi reported that could not be found in the unpolluted along the pipeline or other piping network in the vast GRP P pipes in Iaşi (Fig. 3).

Fig. 3 – Fault in Iaşi , Romania anthropogenic polluted land.

If some faults may be attributed to errors in mounting/laying, and the like on the degradation characteristics of the minimum necessary filler (especially in the case of pollution phenomena active), there are, however, clearly questions about the effect of ground pollution, and in particular the pH of the solution that land on GRP pipes.

Just these influences are addressed by the present work steps, while the literature focuses more on the influence of the fluid on GRP pipes and only passenger on physico-chemical interaction pitch-pipe (Anacş & Profire, 2017).

2. Long-Term Testing of Pipe

The standards for pipe resins reinforced with glass fiber polyester considers that the pipes are subjected to stresses which are reflected in their mechanical deformation.

Their design lifetime is 50 years. Over the years there were test results demonstrated stability in much better than expected, leading to the idea that life can be extrapolated to 150 years (if pipes GRP Gray Pipes, the example).

2.1. Corrosion Testing for Deformation Under Load

A crucial test for the gravitational GRP pipes used in sewer applications is the chemical testing of the pipe under deformation under load in accordance with ASTM D3262, 2014 and D3681 . This test is performed on a minimum of 18 samples of ring conduit to be deformed in various proportions and kept constant deformation

These rings are deformed on the inner surface subsequently exposed to a solution of 5% sulfuric acid. These conditions simulating septic condition of sewer pipes buried. Breaking time/flow is measured for each test sample.

Minimum ultimate tensile deformation extrapolated to 50, using the method of least squares regression, must be at least equal to the prescribed values for each class of rigidity.

The resulting value is used to estimate the design of the pipe to the safety margin for the entire duration of the operation.

Typically, this deformation term is 5% for underground conduits.

2.2. Hydrostatic Design Basis – HDB

A qualification test, considered as a long-term testing is determining the basis for calculating hydrostatic. This test is carried out according to ASTM 2992, 2012 consists of subjecting a minimum of 18 specimens of the line at constant hydrostatic pressure, depression on different levels, the monitoring times to the collapse (flow)

It is important that the driving testing only allow deformation of the circumferential extent, and the test is done at the first signs of seepage, which usually precedes visible deformities (Ancaş & Atanasiu, 2011). The results are evaluated on a logarithmic scale, the values of pressure (or specific tensile deformation in the circumferential direction) versus up to collapse time (flow) and then extrapolated to 50 years.

Pressure release in 50 years (in terms of specific strain) – called hydrostatic design basis (HDB) – must overcome the pressure class (strain specific to expected pressure class) according to the safety factor. Due to the combination of the charge – due to the forces of the internal pressure and external forces of geological tasks – real factor of safety against failure in the long term the pressure is higher than this safety factor.

2.3. Testing Deformation Circumferential Term

This test is conducted in accordance with ASTM D5365, 2012, and consists in monitoring the load release time constant of a series of samples (minimum 18). The results (time to failure versus deflection) are linearly extrapolated to 50 years (Ancaş & Profire, 2017).

The test is done in a total immersion in the fluid, the coefficient of 23 degrees Celsius, indicating its pH. Due to the impossibility of measuring deformation continue, it will take into account the deformation at break last measured value before the collapse (which implies an underestimation of the time of transfer, an additional safety factor).

2.4. Stiffness Term

This test is conducted in accordance with EN1225, 1997, and consists of subjecting a sample of the pipe (submerged in fluid) from a load to cause a vertical deflection initial 3% [10]. Load kept constant, the sample is monitored 10,000 hours. The results are subjected to a second order polynomial extrapolations, rigidity is determined at 50 that, according to ATV127, 2008 and AWWA M45, 2013 should not be less than 60% of the initial value assumed. Interestingly, the results reported by the GRP pipe steep lead to the conclusion impaired pipes produced by centrifugation of the product to the wound.

3. Static Analysis for GRP Pipe Buried. Relevant Parameters

A . Pipe installation conditions

It differs 4 cases of laying:

a) B1: filler compacted in layers directly on the natural ground/or backfill undisturbed, without checking the degree of compaction;

b) B2: supporting vertical panels, to the bottom of the trench. Support for compaction takes place after removal;

c) B3: supporting pile vertical panels mounted to below the bottom of the trench, removed after compaction;

d) B4: filler compacted in layers directly on the natural ground / or backfill undisturbed, to check the degree of compaction. It is suitable for land G4).

B. Module deformation

Deformation module E_s can have different values, depending on the following areas:

E1: filling the upper area of the pipe;

E2: the filling of the lateral pipe;

E3: undisturbed land side;

E4: ground on which the pipeline bed.

C. Earth pressure factor K_2

This factor is determined as follows, taking into account the stiffness of the piping system:

– for pipe stiffness $V_{RB} > 1$, K_2 is calculated in column 2 of Table 1. In this case, the pressure side is considered 0;

– $V_{RB} \leq 1$, K_2 calculated as column 3 of Table 1.

K_2 factor depends not only on the mechanical characteristics of the soil is influenced by many other factors.

Table 1
Earth Pressure Factor: S

1	2	3
Group soil	K_2	
	$V_{RB} > 1$	$V_{RB} \leq 1$
G1- non-cohesive soils	0.5	0.4
G2- weak cohesive soil	0.5	0.3
G3- cohesive soils, mixed	0.5	0.2
G4 - cohesive soils	0.5	0.1
Lateral pressure	$q_h = 0$	$q_h > 0$

D. Concentration factor and the stiffness ratio

Calculation of concentration elasticiti assumes infinite pipe, resulting in a maximum concentration factor. Pipe deformation is considered. Maximum concentration factor“$max\lambda$ ”:

$$\max\lambda = 1 + \frac{\dfrac{h}{d_e}}{\dfrac{3.5}{a^*} + \dfrac{2.2}{\dfrac{E_4}{E_1}\left(a^* - 0.25\right)} + \left[\dfrac{0.62}{a^*} + \dfrac{1.6}{\dfrac{E_4}{E_1}\left(a^* - 0.25\right)}\right]\dfrac{h}{d_e}}, \qquad (1)$$

projection effect relationship:

$$a^* = a\frac{E_2}{E_1} \geq 0.26,$$

$\max\lambda$ function is shown in the diagram (Fig. 4), for different values of a^* and $E_4 = 10 \times E_1$.

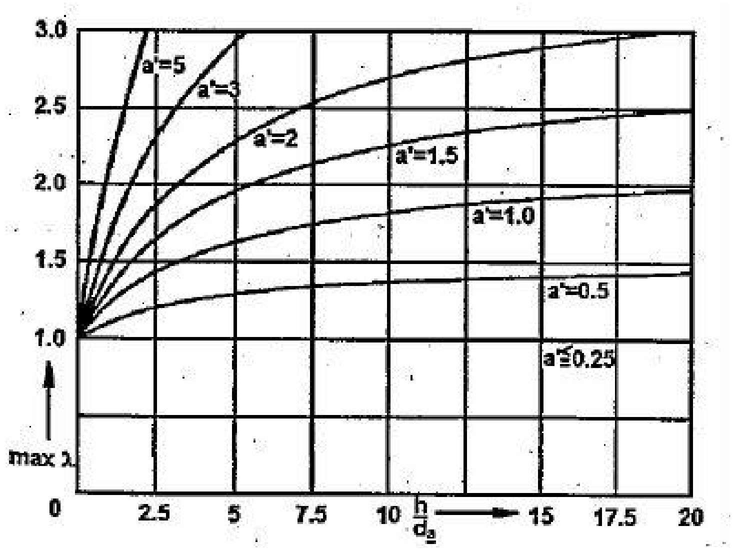

Fig. 4 – Concentration factor $\max\lambda$ for $b/d_e = \infty$ and $E_4 = 10 \times E_1\infty$.

E. Concentration factors λ_s and λ_p:

λ_p concentration factor is dependent on the value of $\max\lambda$, the rigidity ratio V_s, the relative projection $a^*$and the earth pressure factor K_2 (Fig. 5):

$$\lambda_s = \frac{4 - \lambda_p}{3}. \qquad (2)$$

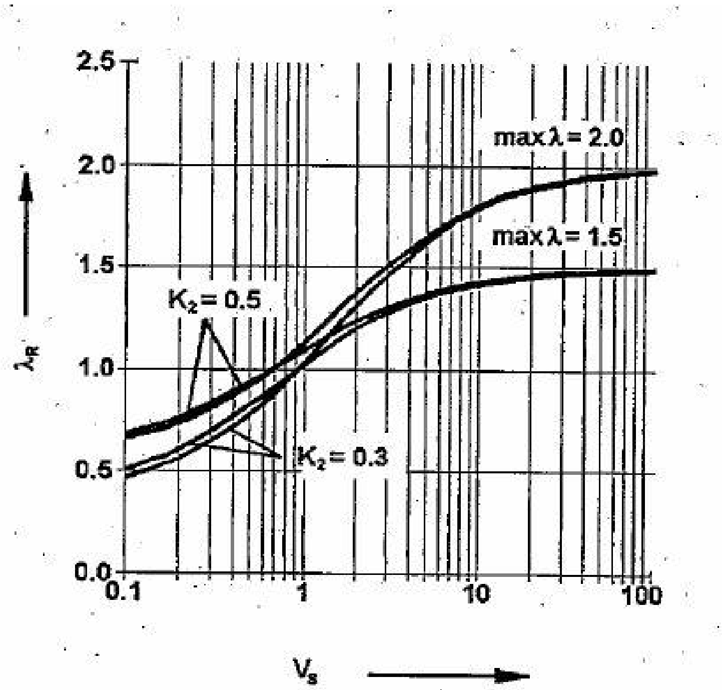

Fig. 5 – λ_p concentration factor for $a^* = 1$, $k_2 = 0.3$ and 0.5.

4. Conclusions

Deepening and application of the calculation methodology static GRP pipes laid buried and deepening analysis and tests faced GRP pipes gives us a new vision of the situations encountered in practice, situations not covered by regulations but still need to be addressed at the design stage.

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CALCULUL CONDUCTELOR GRP ÎNGROPATE

(Rezumat)

Durata proiectată de viaţă a conductelor GRP este de 50 de ani dar există studii şi teste efectuate care arată că unele tipuri de conducte pot avea o bună funcţionare şi siguranţă în exploatare şi peste 100 ani.

Articolul prezintă avariile care se produc asupra conductelor GRP îngropate în terenuri alcaline şi acide prin evidenţierea principalilor parametri ce ţin cont de execuţia lucrării şi prezintă o metodologie de calcul static pentru acest tip de conducte.