International Journal of Scientific Trends- (IJST)
ISSN: 2980-4299
Volume 3, Issue 02, February, 2024
Website: https://scientifictrends.org/index.php/ijst
Open Access, Peer Reviewed, Scientific Journal

Influence of Soil Backfill on the Sides of the Pipe on its Strength

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Abstract:
The purpose of the article is to study the stress-strain state of rigid underground pipes under various laying and loading conditions. Here attention is paid to testing pipes using a two-force scheme in underground conditions.

Keywords: Stress, strain, pipe, strength, soil.

Introduction

The aim of the article is to study the stress-strain state of rigid underground pipes in different conditions of laying and loading. Here attention is paid to the testing of pipes according to the scheme of two forces in underground conditions.
Currently, in the Republic of Uzbekistan, the use of laying rigid pipes of round cross-section in underground conditions, made of materials such as concrete, reinforced concrete, asbestos cement, ceramics, thermoplastics, etc., pipelines for water supply, sewerage, drainage and oil pipelines is being carried out.
In hydraulic engineering, industrial and civil construction, rigid pipelines for various purposes are becoming increasingly used, ranging from large-diameter main pipelines to irrigation pipes.
In addition, with the development of technology and technology, the production of pipes from various materials has improved qualitatively and quantitatively.
The construction of closed drainage systems in water supply and irrigation conditions, including rigid pipes laid in the ground, is of great importance.
In this regard, it is especially important to conduct experimental research and develop methods for calculating rigid pipelines in underground conditions.
For the construction of closed systems, plastic rigid pipes are often used; they are cheap, reliable in operation, and the service life of such pipes is very long. Although rigid pipes have been used for many years, their load-bearing capacity has not yet been sufficiently studied. This applies to experimental studies and methods for calculating pipelines laid in the ground. In particular, the influence of the backfill soil on the sides of the pipe on its strength and rigidity has not been studied.

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Therefore, we conducted a study of the stress-strain state of plastic rigid underground pipes under various conditions of laying and immersion. Conducting detailed experimental studies in order to obtain reliable results on the operation of such pipes in various conditions. Development of an engineering method for calculating these pipes under the conditions of a plane problem. Development of recommendations for the use of rigid pipes.

The main objective of this work is to study underground rigid pipes. However, for the purpose of subsequent comparison of results, some of the pipes were tested in air using a two-force scheme.

As a result of the experiments, the actual picture of the stress-strain state of the studied pipes under loads up to destruction was revealed. A comparison of the results of testing pipes in air with the results for underground pipes is presented. The dependence of the bearing capacity of rigid pipes on the density of the soil and the type of foundation under the pipe has been established. An engineering method for calculating pipes with a round cross-section has been developed.

In the experiments, the load and displacement of the pipe wall at the top and bottom, as well as at the level of the horizontal diameter, were measured; relative deformations in the circumferential direction, and for underground pipes, in addition, characteristics of soil density and soil pressure on the pipe.

This work presents loading schemes and test results in air and soil environments for ceramic pipes d=200mm.

After preparing the pipe for testing, it was laid horizontally between wooden blocks. The bars with a cross section of 10x10 cm had a length equal to the length of the pipe. The surfaces of the bars were not specially treated and were left flat. The load on the pipes was transferred in steps of 0.5 kN and the pipes were brought to destruction.

The change in the vertical diameter of the pipe when testing it according to the two-force scheme (2) is:

$$\Delta d = 1{,}788\frac{P}{E}\left(\frac{r}{\delta}\right)^3; \qquad \xi_d = A\left(\frac{r^2}{\delta^3}\right), \qquad (1)$$

where A - are some constant numbers; r – pipe radius; δ – wall thickness.

In our experiments, the ratio $(r : \delta)^3$ for a large-diameter pipe is $(10 : 2{,}4)^3 = (4{,}166)^3$,, for a small-diameter pipe $(6{,}25 : 1{,}3)^3$ = $=(3{,}472)^3$. And also the ratio $(r^2 : \delta^3)$ respectively: and . In formula (1), the reduction in the vertical diameter of the pipe is directly proportional to the ratios $(r^2 : \delta^3)$ $10^2 : 2{,}4^3 = 7{,}234$ and $6{,}25^2 : 1{,}8^3 = 6{,}698$, which corresponds to the test results.

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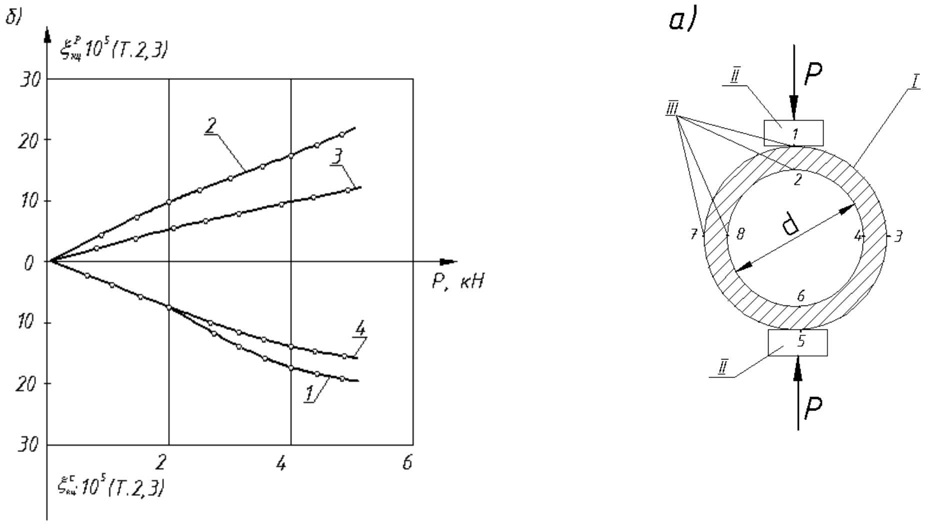

Results of testing pipes in air in the form of graphs of the deformation of the pipe wall in the annular direction in tensile zones ($\xi^P_{кц}$) and compressed zones ($\xi^C_{кц}$) from load (P) are presented in Fig. 1

Rice. 1. Loading a pipe according to the scheme of two forces in the air: a) loading scheme – I – pipe; II – bars; III – strain gauges; b) relative deformations for a pipe d = 200 mm.

It is clear from the graphs that the deformation on the tensile surface of the wall at the ends of the vertical diameter (points 2 and 6) of the pipe is greater than at the ends of the horizontal diameter (points 3 and 7) of the pipe under the same loads. The deformations in the compressed zones of the pipe wall surface (points 1 and 4) are almost the same (Fig. 2, b). The first circumstance is explained by the fact that the calculated bending moment under the load application point is much greater than in the sections at the ends of the horizontal diameter (ratio 0.318:0.182). The deformations in the compressed zones are almost the same because in the section at the level of the horizontal diameter the action of the moment is accompanied by the action of a longitudinal compressive force.

Cracks appear at loads that are approximately 0.8 parts of the breaking loads. First, on the inner surface of the pipe wall in a vertical alignment and later on the outer surface in a horizontal alignment, which corresponds to the outline of the moment diagram. The destruction of the pipe occurred by breaking it into four parts.

To identify the elastic resistance of the soil to the strength of pipes tested according to the two-force scheme, it was decided to also test pipes immersed in the ground.

The pipes were placed in a box between wooden blocks (Fig. 2, a.) and then backfilled. At the same time, the ends of the pipes were protected by gaskets so that the internal cavity of the pipe was free of sand.

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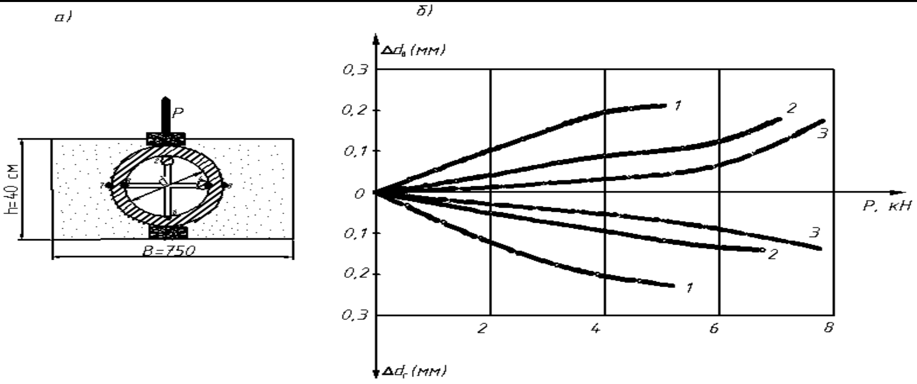

Fig2. Loading a pipe according to the scheme of two forces in a soil environment: a) loading scheme; b) relative deformations for pipes d = 150 mm, d = 200 mm.

Pipe tests were carried out in uncompacted and compacted soil.

The load on the pipes was transferred in steps of 1 kN and the pipes were brought to destruction. (Fig2.a)

As in the experiments with pipes in air, in these experiments the change in pipe diameters was more significant for large-diameter pipes.

Graphs of changes in the vertical and horizontal diameter of the pipe depending on the load are shown in (Fig. 3)

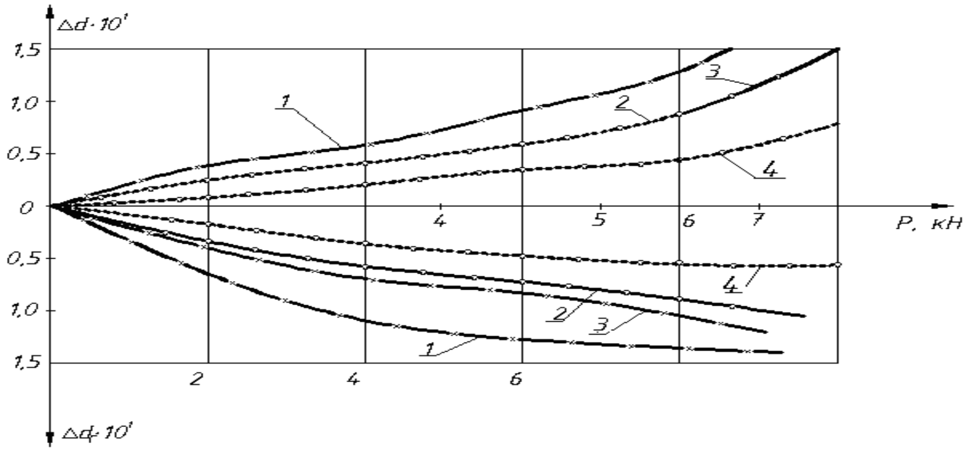

Fig.3. Change in the vertical and horizontal diameter of the pipe depending on the load 1 and 2, - d = 200 mm, 3 and 4, - d = 150 mm in uncompacted and compacted soils, respectively.

The graph shows that in compacted soil the deformation of the vertical diameter of the pipe is 1.5 times less than in uncompacted soil under the same loads.

The graph shows that the deformation of the diameters of a pipe laid in the ground is reduced by more than half compared to a pipe outside the ground under the same loads. When soil is compacted, this difference increases to 3.5 times. At the same time, the dependences d = f(p) with significant loads deviate from linear.

This means that the load-bearing capacity of rigid pipes in underground conditions is significantly greater than in the air, and with soil compaction, the strength of the pipes also improves.

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