Mathematical Modeling of Static Stress-Strain State of Parallel Tubes Located In an Elastic Environment.

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Abstract. *We consider the static ambient pressure on the tube. The environment is homogeneous elastic body. To determine the ambient pressure is used the finite element method (FEM). The algorithm (MAS) and the program in the computer. Based on the compiled program , obtained numerical results. The obtained numerical results for two and multi-line pipes are compared with available theoretical and experimental results***.**

Keywords. *Trumpet, finite element method, static pressure, Wednesday, virtual displacements, the computational domain*

Introduction

In determining the soil pressure on the pipe is necessary to consider factors such as: the number of threads, relief mounds pipe support conditions and other factors encountered in design practice. The account also other factors in the analytic solutions or extremely complex; or even impossible because of the difficulties that arise mathematical nature. A variety of factors encountered in the design practice can be considered using numerical methods. Recently, in solving various kinds of applications are widely used finite element method (FEM). A number of studies in which domestic [1,2,3,4] and foreign authors [5,6] successfully used the finite element method for the determination of soil pressure on laid singly extended pipe under different conditions of its bearing with the heterogeneity of the soil, making up the body mound constant height (plane strain).

1. Statement of the problem and solution methods.

The most common method of calculation of complex structures is the finite element method (FEM). Its peculiarity lies in the fact that the structure is a continuous medium is replaced with its analogue, composed, like bricks and blocks of a finite number of elements, the behavior of each of which can be determined in advance. Interaction of elements allows to present an overall picture of the deformation of the system. Fig. 1 depicts the cylindrical bodies in a deformed space. Stiffness characteristics of each of these elements is determined beforehand. Stress-strain state of such a complex structure can be determined using the finite element method. The advantage of the method in its universality: the possibility of using different types of cells, the arbitrariness of the area under consideration, simple techniques for building high-precision components. In an embodiment of the method, the method under consideration below- movements -with docking elements to the requirements of the natural boundary conditions are optional. The most famous version of the FEM formulation uses Virtual work:

$$\delta A=\delta A_1+\delta A_2=0.$$

In matrix form the three-dimensional body can be represented as follows:

$\iiint\{\sigma\}^T\{\delta\varepsilon\}dxdydz = \iiint\{q\}^T dxdydz+\iint\{p\}^T\{\delta u\}dS$. The same condition can be:

$$\iiint\{\sigma\}^T\{\delta\varepsilon\}dxdydz = \iiint\{\delta u\}^T dxdydz+\iint\{p\}\{\delta u\}^T dS$$

Vectors volume, surface forces and displacements as follows:

$$\{q\}=\{x,y,z\}^T \quad , \{p\}=\{p_x\, p_y\, p_z\}^T,\ \{u\}\{u_1\, v_1\, w_1\}^T\ . \quad (1)$$

Equilibrium condition (1) does not depend on what material properties and are valid for both linear and nonlinear systems. For a linearly elastic body having initial deformation physical relations take the form:

$$\{\sigma\}=[D]\{\varepsilon\}-[D]\{\varepsilon_0\}, \qquad (2)$$

where [D] is the matrix of elastic constants, {e0} is the vector of initial strains.

Displacements are given in the form of polynomials in powers x, y, z:

$$\{u\}=[A]\{\alpha\}, \qquad (3)$$

where [A] matrix, which depends on the coordinates of the element,$\{\alpha\}$- vector of coefficients of the polynomial expansion of the functions of displacements. The number of coefficients corresponding to the number of degrees of freedom of the element, and the coefficients are themselves linked to the nodal displacements. If we denote the vector of nodal displacements element through $\{u_n\}$, then the displacement field is determined by the relationship:

$$\{u\}=[\phi]\{u_n\} \qquad (4)$$

Use the relations between strains and displacements, we obtain: $\{\varepsilon\}=[B]\{u_n\}$ (5)

Matrix [B], connecting strain with angular movement is important in further calculations (Figure 1). Stress vector is defined by equations (2) and taking into account (5), it will look like:

$\{\sigma\}=[D][B]\{u_n\}-[D]\{\varepsilon_0\}$ (6)

We consider separately the left and right sides of the equilibrium condition (1). After substituting the vector strain in the left side of Equation (1) it will be expressed in terms of nodal displacements and some integral, denoted by the symbol [K]:

$$\iiint\{\delta\varepsilon\}^T[D]\{\varepsilon\}dxdydz=\delta\{u_n\}^T \iiint[B]^T[D][B]dxdydz\{u_n\} = \delta\{u_n\}^T[K]\{u_n\}$$

Here [K] matrix containing basic information about the conduct of a small section of deformable systems. It is called the stiffness matrix element is the main characteristic of the system in the FEM.

The right side of equation (1) and the volume integral over the surface can be represented as follows:

$$\iiint([\delta\varepsilon]^T[D]\{\varepsilon_0\} + \{\delta u\}^T\{q\})\, dxdydz + \iint\{\delta u\}^T\{p\}dS =$$

$$= \delta\{u_n\}^T \iiint[B]^T[D]\{\varepsilon_0\}\, dxdydz+\delta\{u_n\}^T \iiint[\phi]^T \{q\}\, dxdydz +\delta\{u_n\}^T \iint[\phi]^T \{p\}dS$$

These ratios determined vector (P) of the external forces given to nodes external forces.

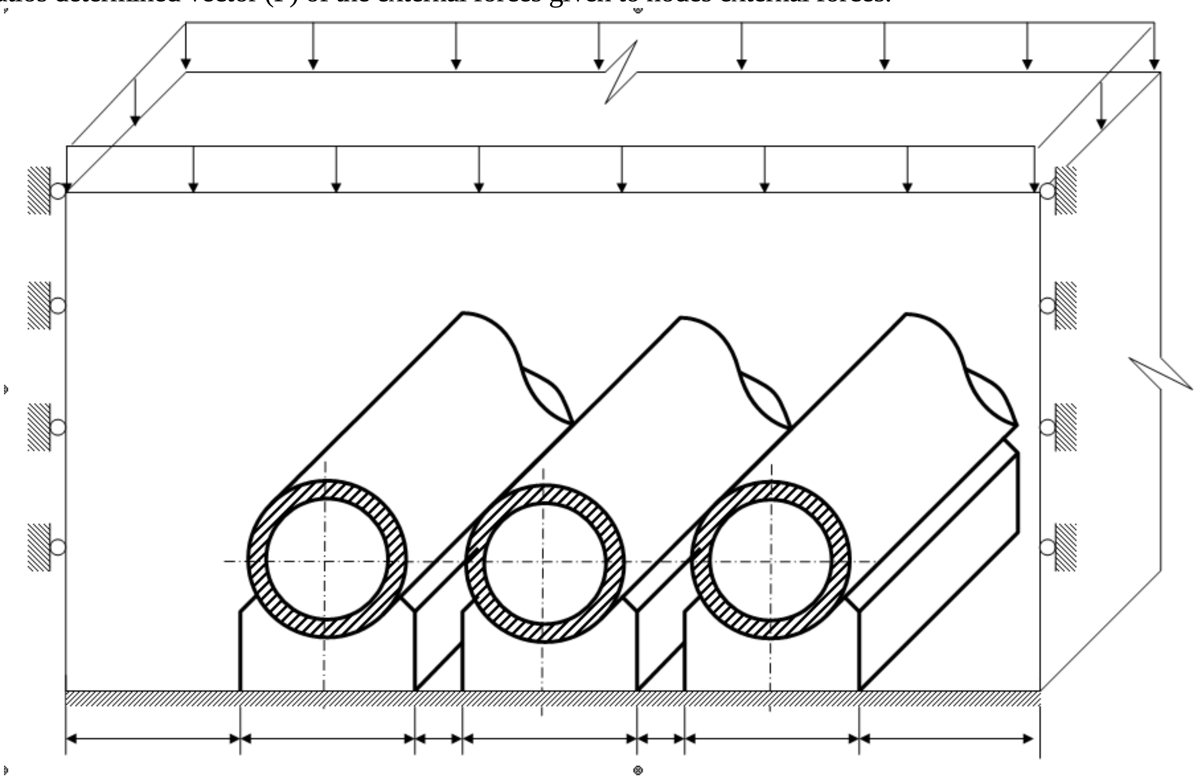

Figure 1. Design scheme МКЭ.

Thus, considering the known matrix [f] connecting displacement at any point of the element with the nodal displacements, and the matrix [V], the corresponding relations between the movements and deformations of the element units of formula (6), determine the stiffness matrix [K] and nodal force vector of the external (F): $[K]=\iiint[B]^T[D][B]\, dxdydz$

$$\{F\}=\iiint[B]^T[D]\{\varepsilon_0\}\, dxdydz+\iiint[\phi]^T\{q\}\, dxdydz+\iint[\phi]\{p\}dS$$

For each element, the equilibrium conditions take the form:

$$[K]\{u_n\}=\{F\}$$

By the same shape are provided for all ratio/

2. Method of calculation determining the static pressure in the soil pipe.

As the computational model by analogy with [7,8] adopted weighty elastic medium (Fig. 1) containing the backed circular cylinders holes and other inclusions (foundation, soil heterogeneity, etc.). In this case, for pipes according to [9] assume that the cylinder is soldered to the environment (no slippage on the ground surface of the pipe). On the external circuit protection boundary conditions are as follows [9] (Figure 1)

-on the vertical boundaries shear stresses and horizontal displacements of either zero or these boundaries are free;

- the lower horizontal border adjacent to the base of the mound no vertical and horizontal movement;

- top surface is free from any external impact or load loaded surface.

The dimensions selected for the calculation of the area should be optimal, because it affects the time the calculation by FEM, and hence the effectiveness of the program drawn up on the basis thereof. If the soil is isotropic material or system under consideration pipe - soil has a symmetry axis (as in geometry and the material), it is possible to reduce the computational domain by taking only half of its symmetrical. Breakdown of the selected computational domain spend a tetrahedral finite elements. Thus Stake grid should thicken as they approach the pipes, as it occurs around the pipes largest concentration of soil pressure.

To evaluate the convergence of the resulting approximate solution corresponding to this breakdown, the exact solution is necessary to produce a finer breakdown of the computational domain. This is followed by a comparison of solutions corresponding to both breakdowns. If they differ from each other by a value greater than a prescribed calculation accuracy, it is necessary to make even finer breakdown of the third region and the corresponding decision to decision to compare the second breakdown, etc. . It should be noted that the dense arrangement of pipes in their places of contact occur "singular point", in a small neighborhood which is impossible to achieve the required accuracy of calculations to do with some of the smallest breakdown (at these points elasticity theory is inapplicable). These points occur at the same places on the flat bearing base pipe. When determining the earth pressure on rigid circular pipe, which are in particular and concrete pipes [10,11], this difficulty is easily overcome by the following method: using FEM determined vertical and horizontal earth pressure at all points of the pipe, excluding special; the singular point is applied concentrated force directed vertically at the point of supporting the pipe or horizontally at the point of contact of their equal in magnitude to the square diagrams respectively vertical and horizontal earth pressure acting on the pipe.

Net weight of the soil mound is distributed according to [3.4] for the nodes breakdown as follows: at each node of the triangular finite element applies a downward concentrated force equal to the weight of the largest ground bounded by the element divided by the number of nodes. Surface load is distributed over the upper limit of the nodes in the form of concentrated forces. If you need to get the influence matrix (Green's function), it is necessary to carry out calculations on a single concentrated force, applying it consistently in each node the upper boundary. Modeling of the ground materials, pipes, and other impurities by means of their corresponding values of the elastic constants (E, ν) and specific gravity. This allows for pipe support conditions, soil heterogeneity and the verbosity of the mound and the grounds of a multi-stacking.

3. Parametric analysis of the stress-strain state of reinforced concrete underground circular tubes.

With this program, the MAC, the influence of these factors on the distribution of soil pressure around the mound round reinforced concrete underground pipes: the number of threads, the distance between the pipes, pipe location (extreme, average), the Poisson's ratio of soil mound type bearing pipes, changing topography along the embankment pipe length tubes.

The influence of the number of threads. Fig. 2, 3 and 4 show the dependence of the maximum soil pressure on the pipe on the number of threads and Poisson's ratio of the soil. Here we consider a bearing dense move on a flat solid base. Fig. 2, 3 and 4 that the value $\sigma_{мах}$ pipes laid in multiple threads, and 10-30% lower than the corresponding values for a single pipe laid, which is defined by SNiP2.05.03.-84.Pri This maximum pressure depends on the soil positioning the tube, i.e. the middle tube is 15-25% less than the extreme. The fact that the tube is unloaded less extreme because of its significant impact on the unloading has only one nearby medium pipe and the other - the extreme pipe, first, it is located far away from (distance 1.0DV), and secondly, between the two extremes lies the average pipe tube is a kind of "screen", which reduces the mutual influence of the two extreme unload pipes. Therefore, in particular, the maximum pressure on the extreme soil pipe is almost independent of the number of the thread (Fig. 4 $\sigma_{мах}$ value for pipes and two outer thread laying pipe of a multi-stacking a single curve is shown).

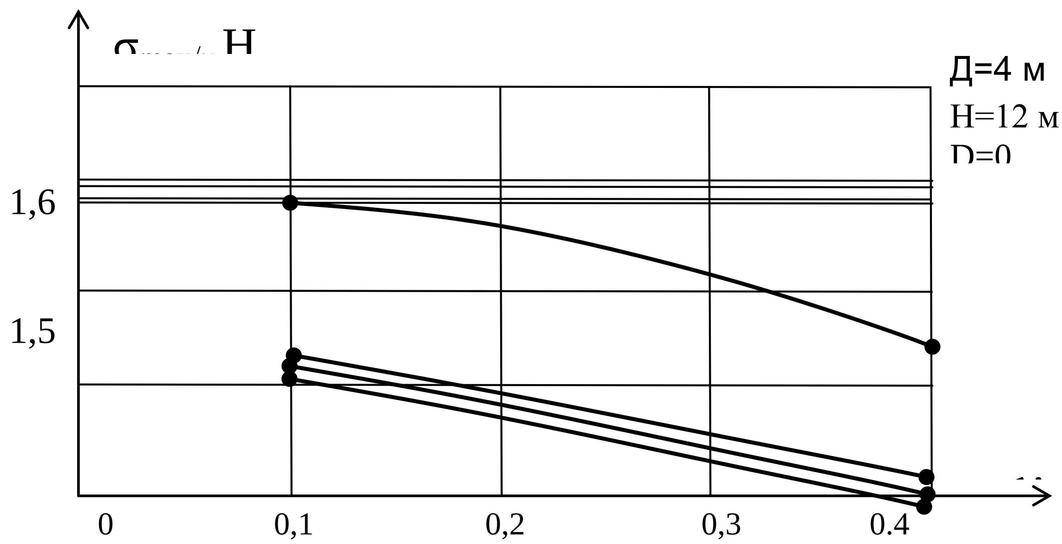

Figure 2. Graph of maximum soil pressure on the pipe (ϑ_{max}) of the number of threads and Poisson's ratio (v);

Average tube discharged to a greater extent because on both sides of it are two tubes instead of one, as in the case at the pipe. Fig. 3 and 4 shows that when the number of threads greater than three, the average value of a max for the pipe is almost independent of the number of threads. This phenomenon is related to the concept of "period" pipes and explained in [12].

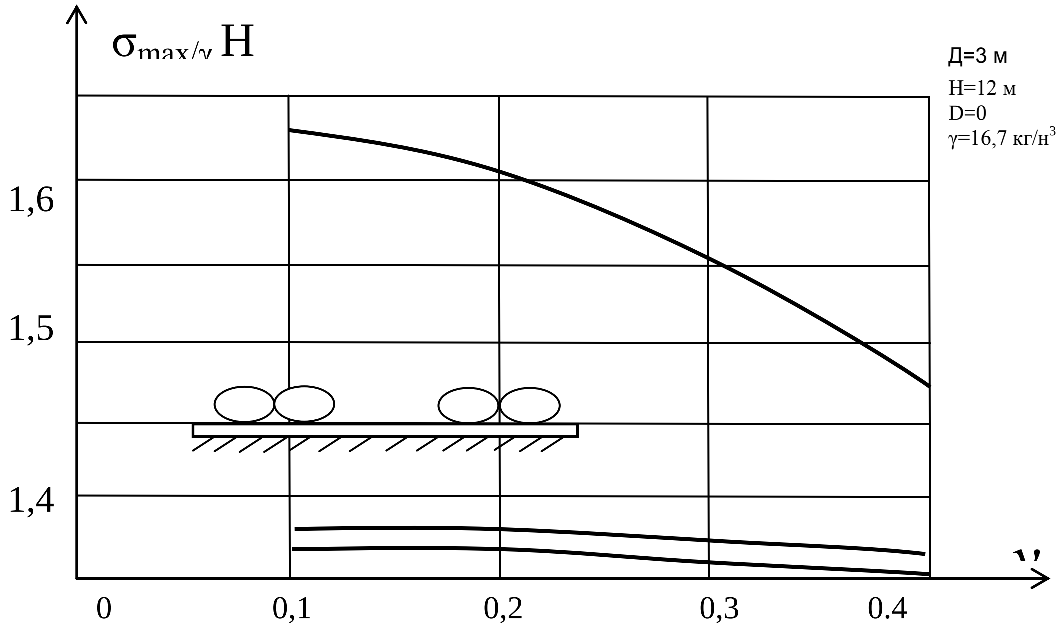

Figure 3. Plots of the maximum soil pressure on the pipe fifths accurate placement (σ_{max}) on the location of pipes and Poisson's ratio (v)

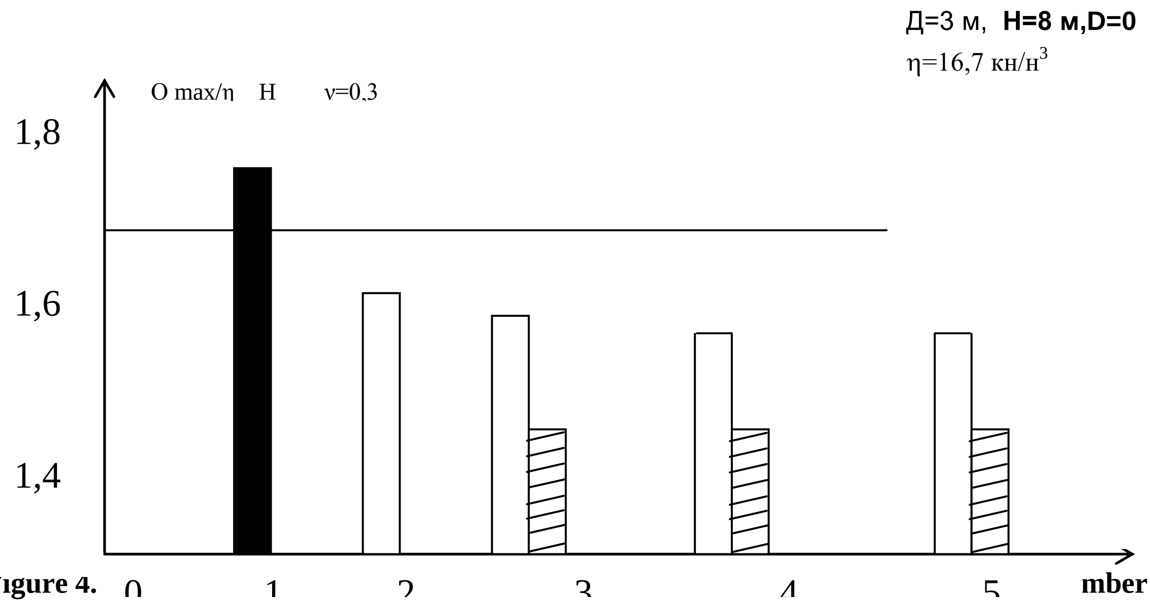

Figure 4. mber of threads (n);

- single production

- extreme development of a multi-stacking

- the average output of a multi-stacking

Fig. 2 shows that with increasing Poisson's ratio (v = 0.1 .... 0.4), the maximum soil pressure on the middle pipe is reduced, and with a decrease in the number of threads this decline is stronger and is, for example, 7% for the three thread pipe laying and 1% for the five pipes thread installation. This fact is explained by the fact that the greater the value of the coefficient v, the more dirt capacity medium distribution. Therefore, we can assume that when the number of threads and four more on the average value of $\sigma_{мах}$ practically does not depend on the coefficient v. The explanation of this phenomenon is in papers [12,13].

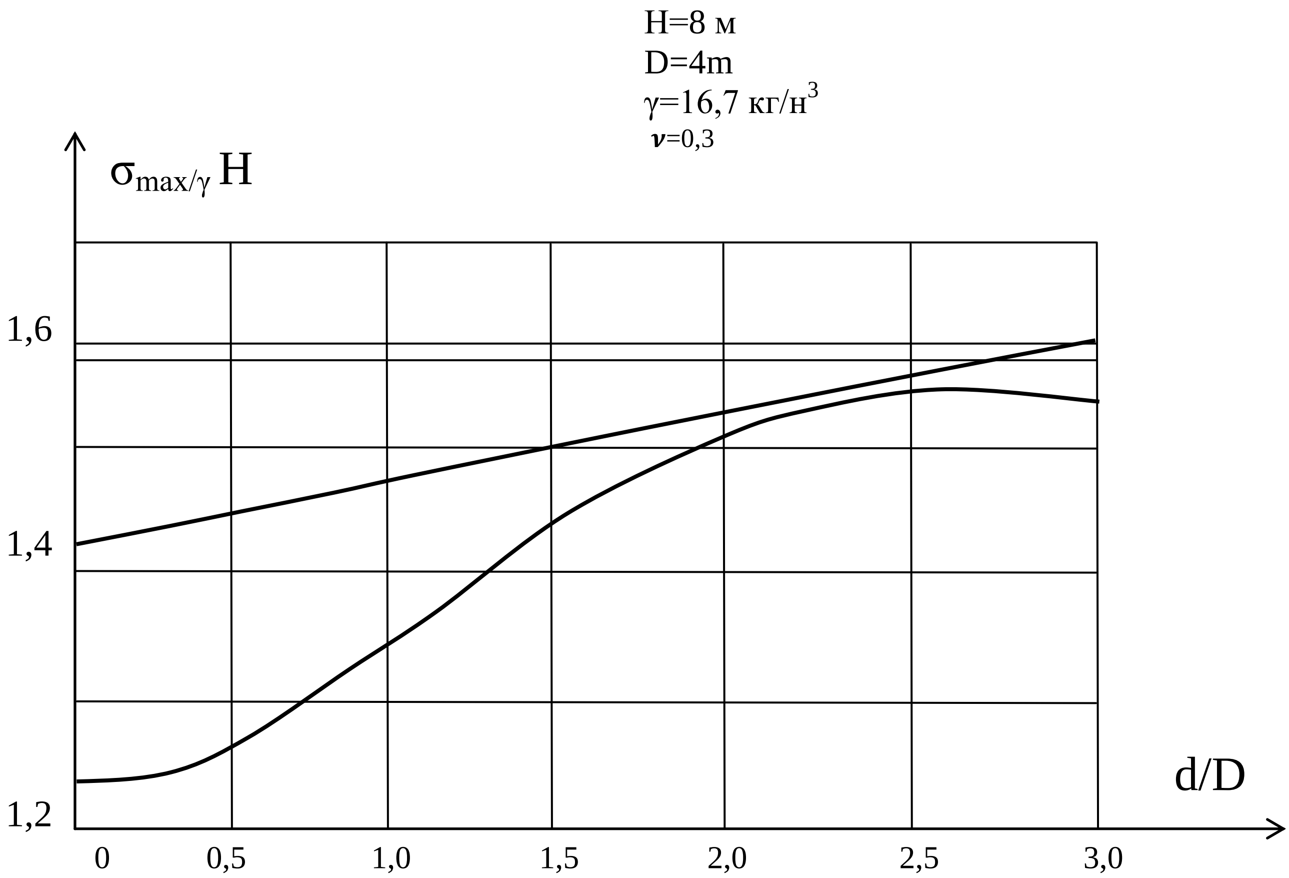

Figure 5. Graphs of maximum soil pressure (v_{max}) for pipes from a distance of light (d) between the thread;

As can be seen from Fig. 3 V with an increase of the coefficient values, the difference in magnitude σ_{max} for pipes with various numbers of threads.

Thus the maximum soil pressure on the pipe laying multiline less than a single. The maximum soil pressure at the extreme of the pipe is greater than the average. σ_{max} extreme pressure on the pipe is almost independent of the number of threads. The maximum soil pressure decreases with increasing number of threads and number of thread, more than three, this reduction becomes negligible. It follows that the difference between the maximum soil pressure on the outer and middle pipe laying multiline ($n \geq 3$) practically does not depend on the number of threads and densely packed tubes is 15-20%. Furthermore, with increasing magnitude of Poisson's ratio σ_{max} soil pipe is reduced to the extreme. When the number of threads n> 4, the average value of Amax pipe practically the coefficient *v*.

Effect of distance between pipes. The results of the analysis of the maximum soil pressure on the pipe and two double-stranded laying in the light (a) between them are shown in Fig. 5.

The graphs in Fig. 5 shows that with increasing distance between the pipes increases σ_{max} value. When $0 \leq d/D \leq 0{,}5$ σ_{max} increase slightly (3%), while $0{,}5 < d/D \leq 2{,}0$ observed a significant increase in the maximum pressure of the soil, decaying with d / D> 2. When d / D≥3 maximum soil pressure on the pipe, laid in several threads, corresponds to the maximum pressure in the pipe laid singly and coincides with the value determined by the SNIP 2.05.03-84 (90).

Thus, the mutual influence of a multi-pipe laying takes place at a distance of light between us d <3D and reduces the maximum soil pressure on them compared to a single pipe laid. σ_{max} pressure on the middle and extreme tube reaches a minimum value, stacked closely and is respectively 0.74 and 0.85 of the maximum pressure on the pipe laid singly.

Based on the dependence of the magnitude of the distance between the pipes withdrawn following formula to determine coefficients soil pressure on the pipe laying multiline: for 0 <d / D≤2,5

K^C_M=0,1(d/D)+0,75, K^K_M=0,01(d/D)^2+0,02(d/D)+0,9 (7)

where K^C_M and K^K_M – coefficients taking into account the maximum reduction in soil pressure, respectively, to the extreme and mid-pipe laying multiline compared to a single pipe laid.

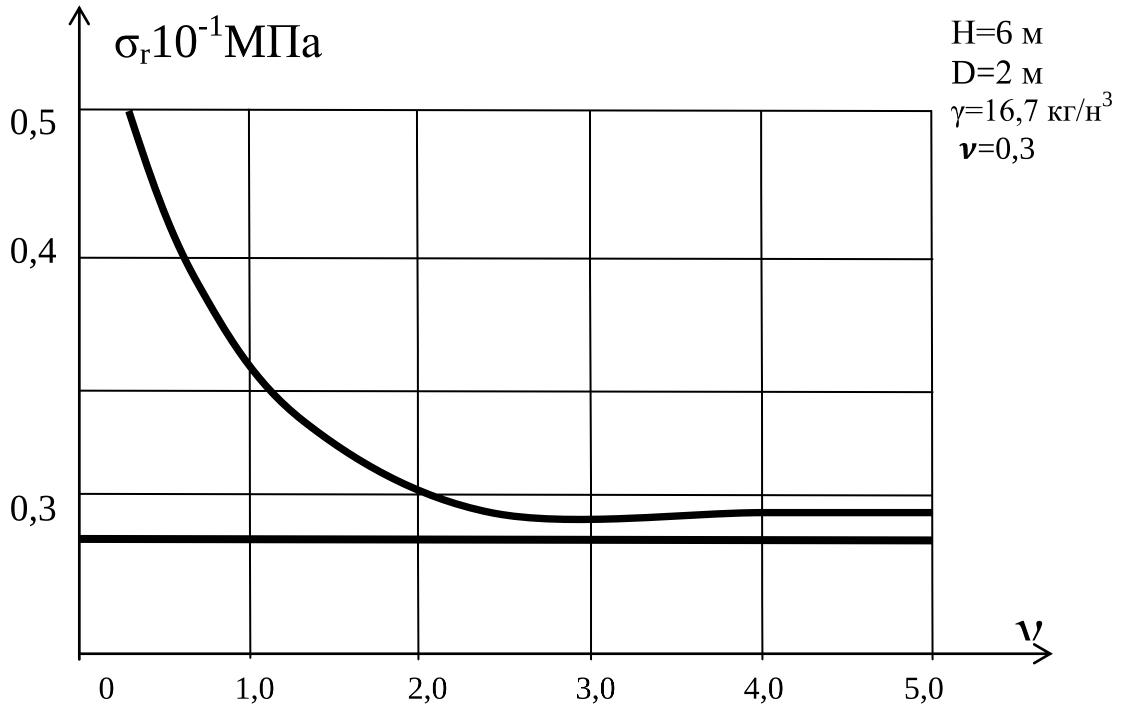

Figure 6. Graphs of maximum soil pressure (v_{max}) for pipes from a distance of light (d) between the thread;

Analysis of the influence of the distance between the pipes on the value of the horizontal earth pressure (σ_r) at the level of the horizontal diameter pipe to two-strand stacking, as Theoretical and experimental studies have shown that the magnitude of σ_r does not depend on the number of threads. Thus it is necessary to distinguish between horizontal soil pressure on the pipe from the adjacent pipe (σ_r) and opposite (free of side pipes) (σ_r).

Fig. 6, the horizontal pressure σ_r when d / D> 3 is constant and coincides with the corresponding σ = 0. When 0≤d / D≤2 is increasing drastically and d / D = 0 tends to infinity. This is due to the appearance of "special" point at which the elasticity theory is inapplicable. σ_r sharp increase with decreasing distance d is explained by the convergence of two concentrates stress, which is the tube.

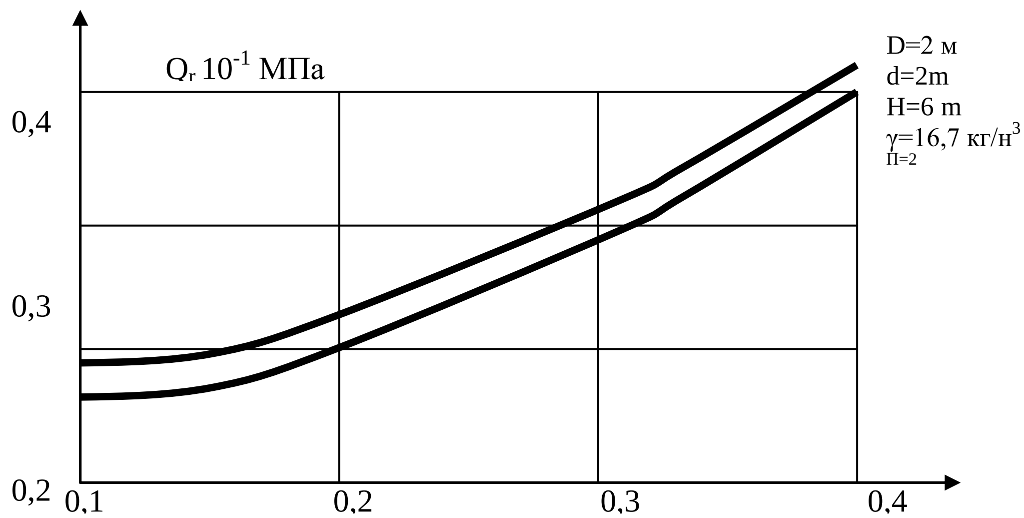

Figure 7. Dependence of horizontal pressure (σ_r) on the Poisson ratio (ν)

Effect of Poisson's ratio ν on the horizontal earth pressure is shown in Fig. 7. The graph shows that with the growth rate V and magnitude $\sigma_{г}$ the $\sigma_{г}$ " increases. And more intensively increases the horizontal pressure from the adjacent pipe. With an increase in the coefficient of ν 4 times $\sigma_{г}$ value increases by 2.8 times, and $\sigma_{г}$" "2.3 times.

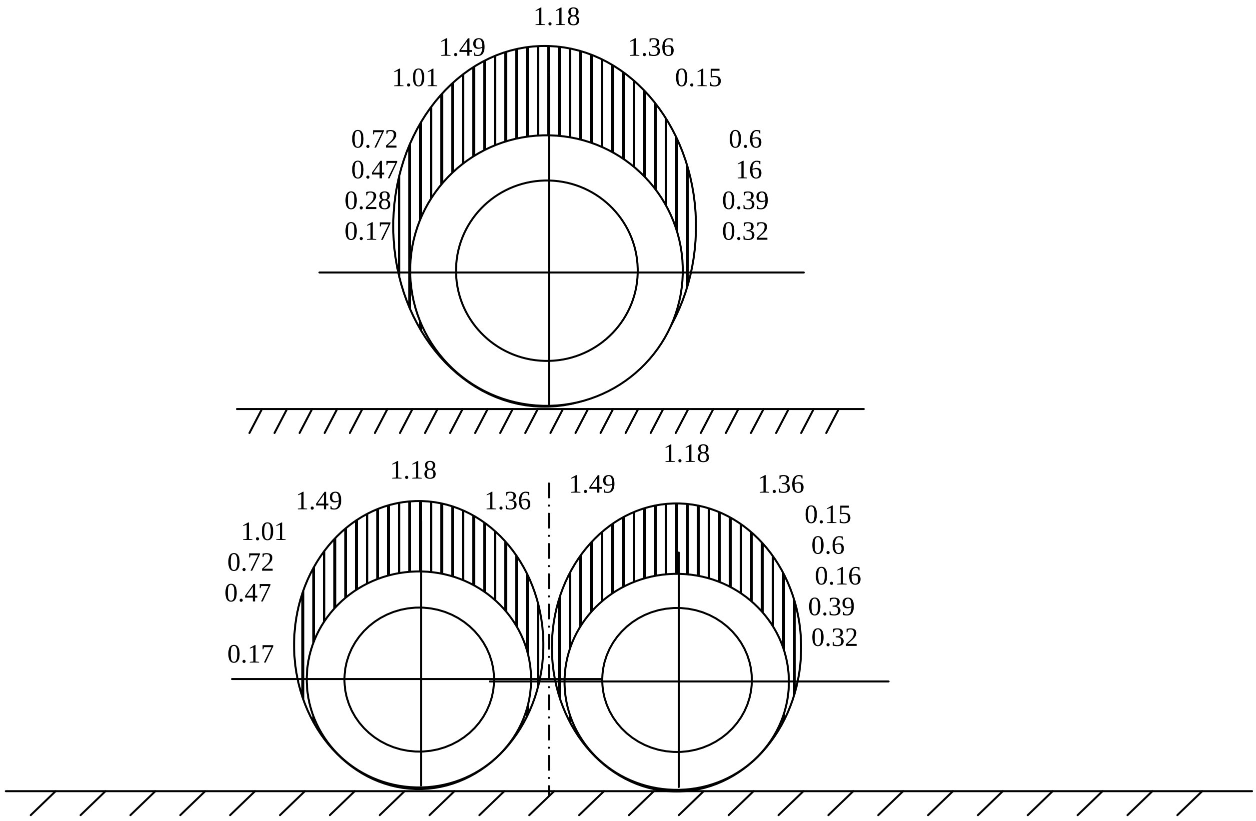

Figure 8. Plots of the radial pressure on the soil pipe double-stranded stacking

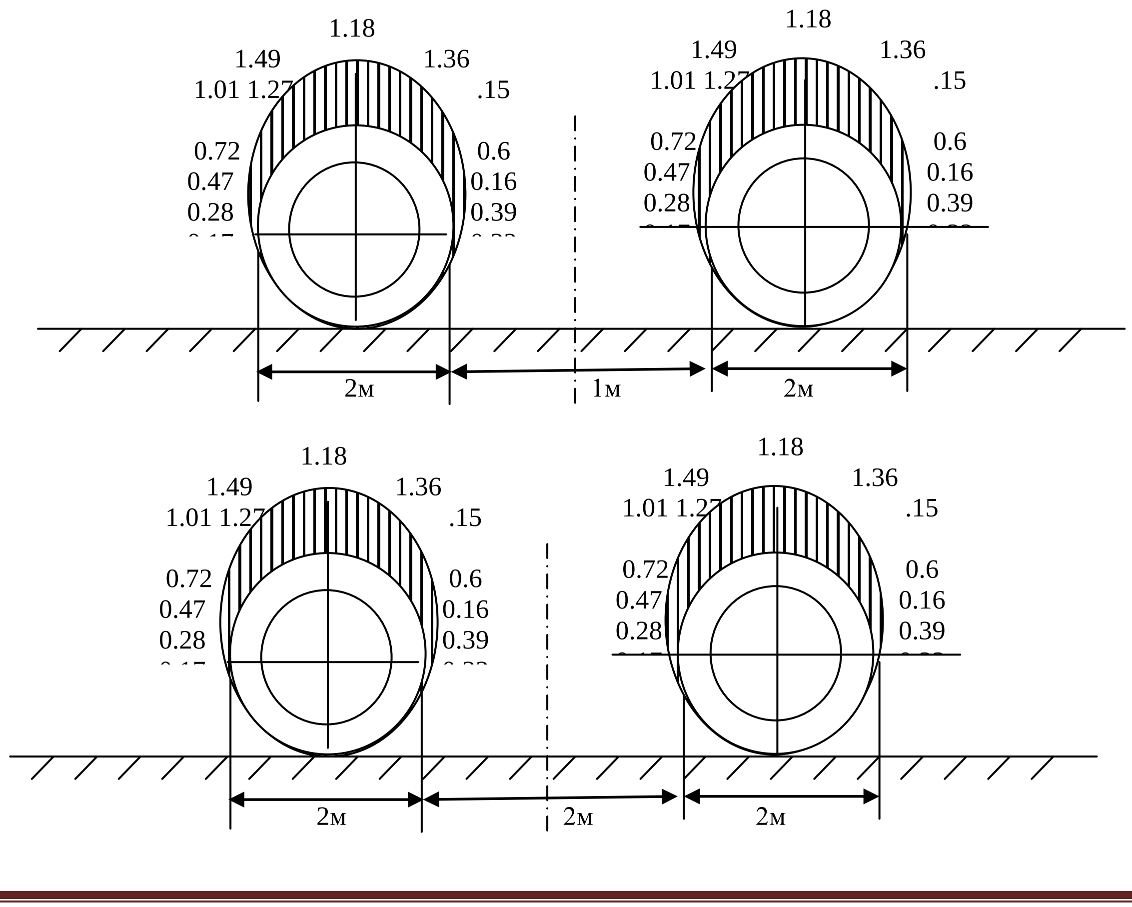

Figure 9. Plots of the radial pressure on the soil pipe double-stranded stacking

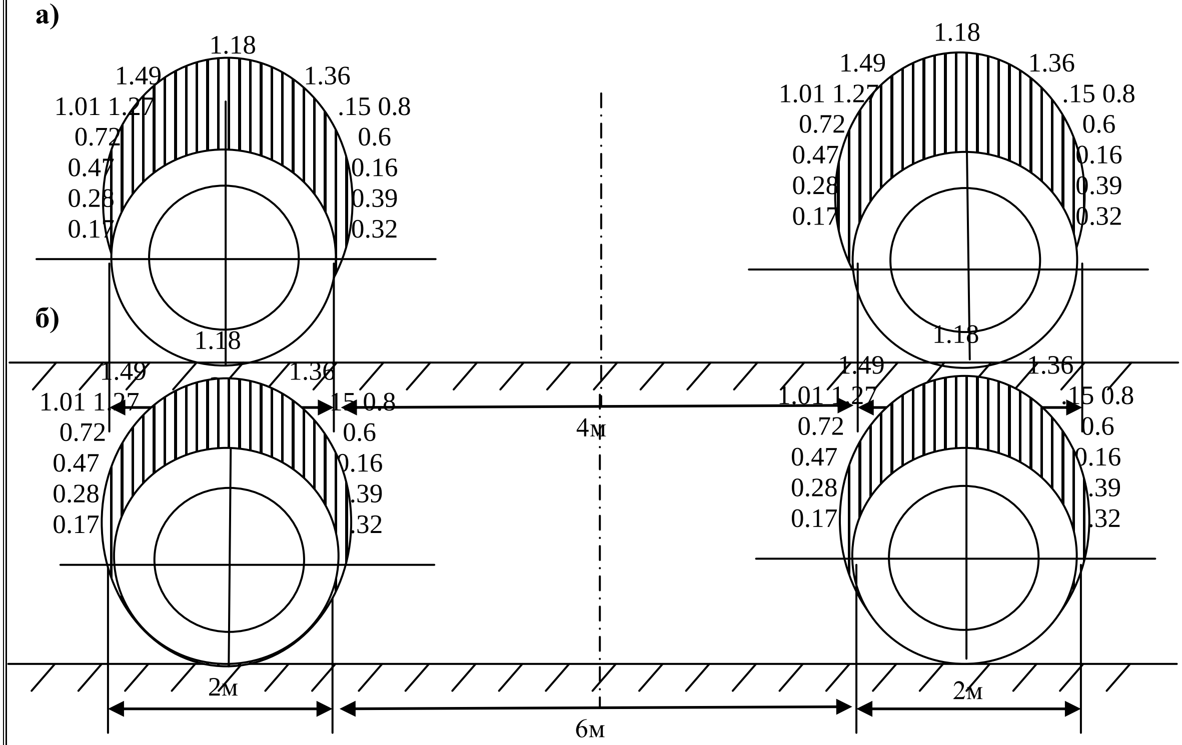

Figure 10. Plots of the radial pressure on the soil pipe double-stranded stacking Stress state of the soil around the pipe.

For a more complete analysis of soil pressure on the pipe laying multiline considered radial diagrams σ_r and tangential (τ) earth pressures at various parameters of a multi-pipe laying flat on a firm foundation.

Fig. 8-10 shows the waveforms (σ_r) for pipes laid in one and two lines at a distance of light d, equal to 0; 0.5V; 1,0D; 2,0D; 3,0D. All waveforms have the same sign and corresponds to the pressure ratio. From the diagrams shows that for d <3,0D they are asymmetric, and for d = 3, D symmetrical. The presence of asymmetry and diagrams, due to the mutual influence of a multi-pipe laying on the ground pressure distribution around each pipe. With increasing distance 6. This influence gradually weakens and no effect at that d<3,0D In this case, the pipe laying multiline diagram σ_r is almost symmetrical. Therefore, when designing pipe deviation from the vertical ordinate σ_{max} diameter can not be ignored when d> 2,0D. Ordinate the maximum radial pressure deviates from the lock tube in the direction opposite the location of a nearby pipe. The analysis shows that this effect is particularly multiline laying at d <2.0D. This is due to the fact that at one side of the tube adjacent to it is the tube that is unloaded first. The opposite side is free and no unloading effect on this side of the pipe does not get extreme. Due to this "asymmetric unloading" at the pipe and there is a shift of magnitude σ_{max}.

Fig.8-10 analysis shows that σ_{max} diagrams on the opposite half of the pipe location adjacent tubes (Fig. Left half of diagrams to ordinate σ_{max}) in all cases, the effect of two pipes with d / D <3,0 for the pressure distribution of soil around they are local and apply to the area up to 15 ° <and <180 ° (Fig. right half of the diagrams). Consequently, the value of the period for plate shifted pipe is equal to four. Analysis was carried out analogously to the period value (T) of pipes laid at a certain distance from each other. The results of this analysis are presented in Table. 1.

Table 1 Dependence period pipes in light from a distance the rebetveen.

D/D	0…0,5	0.5	1.0…2.0	2.0
T	4	3	2	1

From Table 1 it is seen that the value of T decreases with increasing distance between the pipes. This is due to a decrease in the mutual influence of the pipe when the distance between them.

This phenomena indicates a more uniform pressure on the ground of a multi-tube compared to a single pipe laid l.r.r.d. Pipe laying and double-stranded extreme pipe laying three thread practically identical.

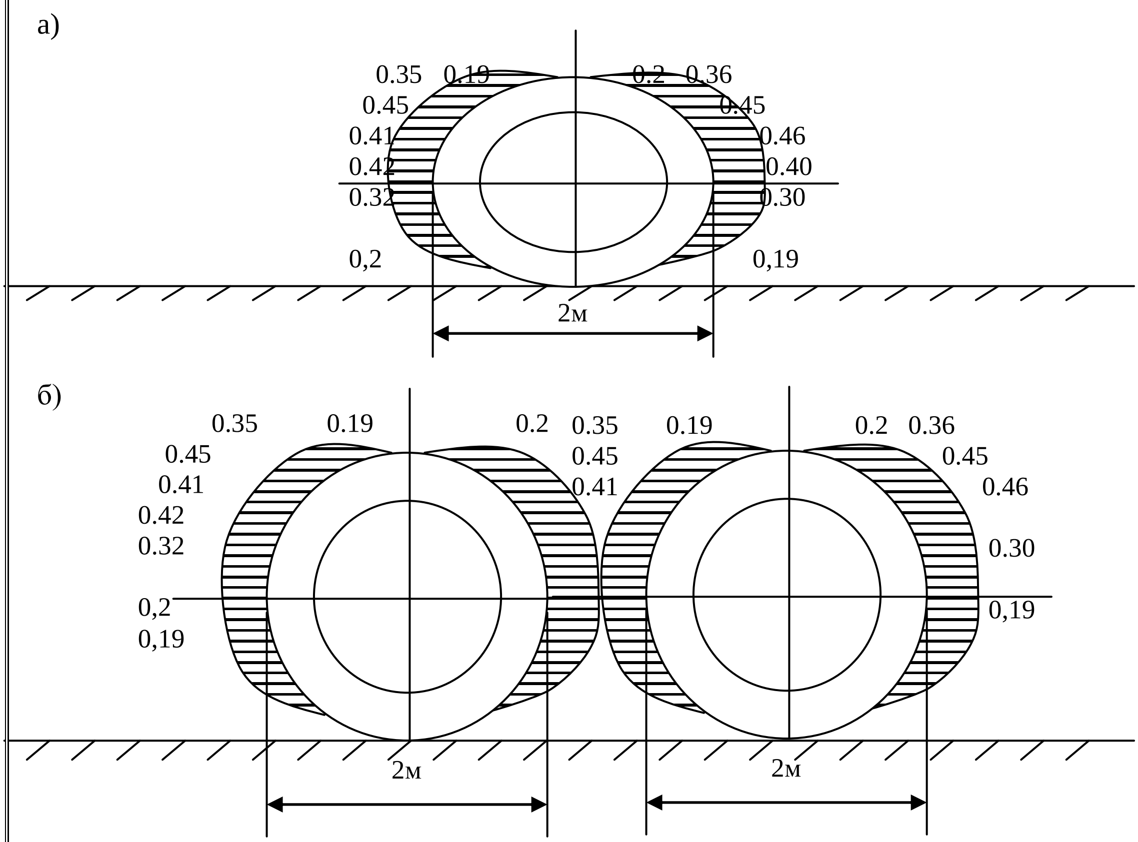

Figure 11. Plots of the radial pressure on the soil pipe double-stranded stacking

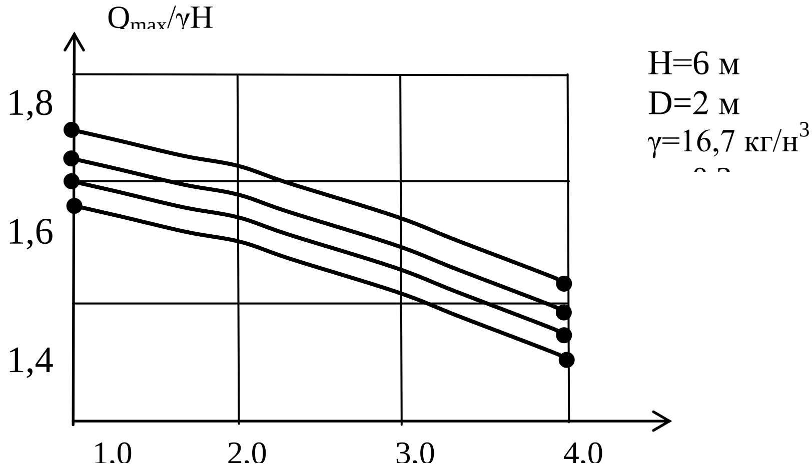

Figure 12. Plots of the maximum soil pressure (v_{max}) for pipes from a distance of light (d) between the thread;

Figure 11 shows the waveforms so for a single pipe and two-strand stacking with clear distance d = 0 ... 3 (Yu. It is characteristic that in the half pipe, free from the influence of the neighboring (Fig. Left half) τ does not depend on the parameter d and τ diagram is the same as that of a single tube. The ordinates of the right half of the diagrams τ at 0 <d <3.0D less than that of the left due to the influence of neighboring unload pipe. when d> 3.0D influence no longer affects the diagram τ orthographic drawing is similar to a single tube.

The maximum pressure for any tangent half diagrams achieved by θ= 60 ° from the vertical axis in both directions. τ_{max} highest value in all cases for the outer pipe occurs in the left half tubes (free of the influence of neighboring) and smaller than the tangential pressure on the right half of the tube is 2.2 times d = 0; 1.55 times at d = 0.5D, and 1.1 times at d = 1,0D

Influence of the type of bearing pipes.

As can be seen from Fig. 12 greatest value of σ_{max} corresponds bearing on the foundation, and the least-on base with an angle of coverage $2\alpha_0$=120°. For example, when ν = 0,1 the value σ_{max} pipe rests on the foundation, greater than the corresponding values for the tubes, is based on: a flat solid base by 3%,. solid foundation to the angle of coverage $2\alpha_0$=120° by 6%, with a base angle coverage $2\alpha_0$=120° by 8%. This phenomenon is due to the fact that more than I pipe protrudes above the bottom surface (together with the base), the more concentrated the soil pressure acting on this tube. We also note that regardless of the type of supporting σ_{max} value decreases with increasing ratio υ. When the gain is 4 times υ σ_{max} decreases depending on the type of bearing pipe 1.17-1.21 times. Given σ_{max} slight change depending on the method of supporting (2-8%) in designing the pipes resting on solid ground, this factor can be ignored.

Table. 2 shows the dependence of the maximum vertical soil pressure ($K_{max}=\sigma_{zzmax}/\gamma_{hmax}$ $_{hmax}$ - the maximum height of the mound) reinforced concrete pipe thread on the number and profile of the mound. Pipes are based on reinforced concrete foundation with an angle of coverage of up to 120 °. The wall thickness of the pipe is 0,1D

Clear distance between the tubes -0,5D. Pipes made of concrete class B 25 / ν = 0,15; E = 30000MPa, soil embankment with elastic constants ν = 0,3; E = 30MPa.

Table 2

Coefficient of K_{max} of the number of threads and the angle of the longitudinal profile of the mound.

n	1	2	3
β	1,75	1,36	1,13
$\beta=30^0$	1,24	0,92	0,79

In the first row of Table. 2 shows the results for long pipes laid on the embankment of constant height (plane strain). In the second row of Table. 6.2 presents the results for long pipes laid under the embankment with the applied stretch of pipe laid under the embankment with a variable longitudinal profile in the form of a triangle with an angle

β = slope up to 30 °.

From Table. 2 shows that the coefficient K_{max} decreases with increasing number of strings. And this fact is true both for the plane problem (first line), and for the bulk (second line). For example, the value of K_{max} for the average pipe laying technician (n = 3) 35% less than the corresponding value for a single tube (n = 1) in the case of the plane problem ($\beta= 0^0$), and by 37% in the case of three-dimensional problem (30^0) .

To analyze the effect of a longitudinal relief on the mound soil pressure on the pipe and to compare the results of a plane and three-dimensional problem the maximum height of the mound ($\beta=30^0$) was taken as the height of the mound constant height ($\beta=0^0$). From Table. 2 shows that the values in the first row are different from the corresponding values of the second row by an average of 30%. It follows that the inclusion of the variable along the pipe reduces the height of the embankment design pressure of the soil compared to calculations made by plane strain scheme. This effect was obtained for the first time.

At the same time, as follows from Table. 1, this effect is slightly weaker effect for a single tube (29%) and a little strong for pipes double-stranded (32%) and technician (30%) of installation.

The influence of the length of the pipe. Table. 3 shows the dependence of the coefficient K_{max} for concrete pipes two-strand stacking of their length 1 (β^0=0).

Table 3

Coefficient of K_{max} on the pipe length 1.

u_0	4,0	6,0	10,0	15,0
K_{max}	0,64	0,85	1,36	1,37

From Table. 3 that with a decrease in the length of the pipe factor Kmax kills. In this case, when the length 1 = 10,0D its impact on K_{max} slightly. Thus the length 1 = 10,0D is that the limit of applicability of the plane theory of elasticity (plane strain) for long pipelines at a constant altitude of the mound. In this paper Okito AA [29] derived the concept of "core", which in our case is equal to 10.0V and is the boundary between "short" and "long" pipe, ie at 1 = 10.0V plane strain scheme gives higher values of the coefficient K_{max} even at a constant height mound. This overestimation of 38% at 1 and 55 = 6.00% = 4,00 at 1.

Thus, consideration of the length of the pipe reduces the design pressure of the soil as compared with the calculation scheme plane strain if K10, IA.

Thus, consideration of the length of the pipe reduces the design pressure of the soil as compared with the calculation scheme plane strain if K10, IA.

Findings

1. Maximum static pressure soil (σ_{max}) on pipes laid in several threads at a distance of light d, 3,0D from each other by less than a single pipe by an average of 10% for the pipes and at 20% for an average . When this value increases with a rise σ_{max} parameter d, with a minimum at d = 0 (pipe laid close) and a maximum at d = 3.0V, which coincides with the corresponding value for a single tube.
2. Pressure σ_{max} decreases with increasing Poisson's ratio ν soil. The greatest value of σ_{max} corresponds bearing on the foundation, the smallest - in the profiled base with a large angle of coverage. σ_{max} extreme pressure on the middle tube and the pipe is almost independent of the number of threads.
3. Horizontal static pressure (σ_r) ground located between the tubes, decreases with increasing parameter d, reaching a minimum at d = 3,0D, equal to the corresponding value for a single tube. Horizontal earth pressure (σ_r ") to the extreme pipe on the side opposite the location of a nearby pipe equal to the horizontal pressure on the single tube and the parameter d is independent. When the distance between the pipes 0,5D <d <3,0D σ'_r value of the average 28% exceeds σ_r ". Magnitude σ'_r/ σ_r" and "increases in direct proportion to the height of the mound and decrease with decreasing Poisson's ratio of the soil.
4. Plots of the radial and tangential static earth pressure for extreme pipe laying multiline (n> 3) and two-strand stacking pipes are practically identical. Diagrams radial earth pressure for extreme asymmetrical sound a trumpet almost symmetrical to the average. In this case, the maximum ordinate of the radial pressure to extreme soil pipe and two-strand stacking with <1 <3 (that deviates from the lock tube in the direction opposite to the location of a nearby pipe. The angle of deflection depends on the parameter d and 0≤d≤3,0D changes suitably from 0 ° to 15 °.
5. Value of the maximum radial and horizontal soil pressure on the single pipe obtained by the SNP and the extended finite element method to the mound, having a constant height (plane strain) are in good agreement. This gives reason to use FEM to calculate multi-line pipes in design practice.
6. Accounting variable along the pipe reduces the height of the embankment design pressure of the soil compared to calculations made by plane strain scheme. This effect is stronger than the effect for multi-line tubes and weaker for single tube.
7. Accounting pipe length reduces the design pressure of the soil as compared with the calculation plane strain scheme if their length 1 <10,0D.

Literature

1. Avliyoqulov N.N., Safarov I.I. Modern problems of statics and dynamics of underground pipelines. Tashkent, Fan va texnologiya 2007,306 p.
2. Agapkin V.M., Borisov S.N., Krivoshein B.L. Reference Manual calculations of pipelines. - M .: Nedra, 1987.-190 p.
3. Aynbinder A.B., Kamershteyn A.G. Calculation of the main pipelines for strength and stability. - M .: Nedra, 1982.-343 p.
4. Akselrad E.L., Ilin V.P. Calculation pipelines. - L .: Engineering, 1972.-240 p.
5. Yorjonov N.S., Aytaliyev J.M., Masanov J.K. Seismic stress state of underground structures in anisotropic array. - Alma-Ata: Science. 1980. -211s
6. Samarskiy A.A. Mathematical modeling: the ideas, methods, examples / ed. 2nd, rev. - Moscow: FIZMATLIT, 2005. - 316 p..
7. Zenkevich O. The finite element method in engineering. M.: Mir, 1975.
8. Rozin L. A. Fundamentals of the finite element method in the theory of elasticity. L .: Publishing House of the LPI, 1972. 77 p.
9. Seleznev, V. Ye., Aleshin V.V., Pryalov S. N. Numerical simulation of the main pipelines. M .: in KomKniga, 2005. 496 p.
10. Borodavkin P. P., Sinyukov A. M. The strength of main pipelines. M .: Nedra, 1984. 245 p.
11. Vinogradov S. V. Calculation of underground pipelines to external loads. M .: Stroyizdat, 1980. 135 p.
12. Aleshin V. V. Numerical analysis of the strength of underground pipelines. M .: Publishing House of the Editorial URSS, 2003. 320 p.
13. Safarov I.I. Avliyoqulov *N.N.* Methods to improve the earthquake resistance of underground plastic pipe // Uzbek Oil and Gas Journal, 2005 №4.S.42-44.

14. Chichelov V. A. Calculations of the stress-strain state of pipelines operated under difficult conditions, in the nonlinear formulation. M .: IRC Gazprom, 2006. 80 p.

15. Yavarov A.V., Lalin V.V. The problem of constructing a finite element shell model underground Pipeline // Proc. rep. International Conference "Problems of strength of materials and structures in transport." St. Petersburg: Izd PGUPS, 2011. C. 106.