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Title: **DYNAMICS OF ELASTIC MEDIUM ON ACTION OF NON- STATIONARY CYLINDRICAL SOURCES**

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DYNAMICS OF ELASTIC MEDIUM ON ACTION OF NON- STATIONARY CYLINDRICAL SOURCES.

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Abstract: The article describes the phenomenon of "frame representations" and "blends", their functioning in the language, and provides an explanation of the degree and frequency of use of these units in modern Russian and modern cognition. The semantic analysis of these concepts is carried out.

Keywords: frame, frame representations, blends, frame technologies, script, attribute, slot, slot name, slot value, semantic networks, sample frames, instance frames, prototype, communication, subframes, concept.

Introduction

Consider the propagation of waves in an infinitely elastic medium (Fig. 1). The main goal is to obtain an accurate analytical expression of displacement and stress. Equation of motion of the environment of a cylindrical source

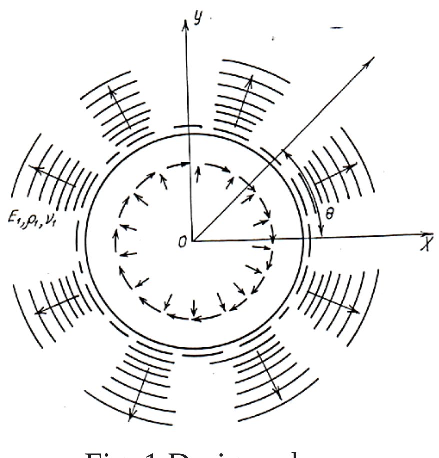

Fig. 1 Design scheme

$$\mu\nabla^2 u^{\rightarrow}+(\lambda + \mu)\ \text{graddiv} u^{\rightarrow}= \rho\frac{\partial^2 u^{\rightarrow}}{dt^2} \quad (1)$$

in coordinates (r, θ) takes the form

$$\Delta\left(\mu\cdot\Delta^2\cdot\psi - \rho\frac{\partial^2\psi}{\partial t^2}\right) l_z + \Delta\left(\frac{E}{1-v^2}\Delta^2\phi - \rho\frac{\partial^2\phi}{\partial t^2}\right) = 0 \quad (2)$$

where

$\vec{u}$= $\text{grad}_z\varphi$+$\text{rot}\vec{\psi}$

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or

$$\vec{u} = V \cdot \vec{t} + V \cdot \vec{l}_0 \left(\frac{\partial \phi}{\partial r} + \frac{1}{r}\frac{\partial \psi}{\partial \theta}\right) \vec{l}_r + \left(\frac{1}{r}\frac{\partial \phi}{\partial \theta} \frac{\partial \psi}{\partial r}\right) \vec{l}_\theta \quad (3)$$

Φ and ϕ are displacement potentials; (ζ_r) → and (ζ_θ) → - unit vectors (|(l_r) → |=|(l_θ) → |=1. Displacement potentials (3) satisfy the wave equations, т.е.

$$\Delta^2\phi = \frac{1}{C_1^2}\frac{\partial^2\phi}{\partial t^2}, \Delta^2\phi = \frac{1}{C_2^2}\frac{\partial^2\phi}{\partial t^2} \quad (4)$$

where

$C_1^2 = (\lambda + 2 \cdot \mu)/\rho, \quad C_2^2 = \mu/\rho$

Initial condition $(\vec{u}|_{t\leq 0} \equiv 0, \frac{d\vec{u}}{\partial t}|_{t\leq 0} = 0,$ (5) in the displacement potentials takes the form

$\Phi(r,\theta,t)|_{t=0} = \psi(r,\theta,t)|_{t=0} = 0$ r>α, -π<θ≤π (6)

$$\frac{\partial\phi(r,\theta,t)}{\partial t}\Big|_{t=0} = \frac{\partial\psi(r,\theta,t)}{\partial t}\Big|_{t=0} = 0.$$

r>α, -π<θ≤π

in a limitless environment t=0 transient load acts in the form

$$\left.\begin{aligned} \sigma_{rr}(\alpha,\theta,t) &= P_r(\theta,t), \\ \sigma_{0\theta}(\alpha,\theta,t) &= P_\theta(\theta,t) \end{aligned}\right\} \quad (7)$$

where $P_0(\theta,t)$ and $P_c(\theta,t)$ specified external load. The problem is solved in dimensionless coordinates.

$(\sigma_r, \sigma_\theta, \sigma_{r\theta}) = (\sigma_r, \sigma_\theta, \sigma_{r\theta}) / \mu$, $(ù, \nu) = (u, \nu) / a$,

$(\phi, \psi) = (\phi, \psi) / \alpha^2$, $r = r / \alpha$, (t ,T) = (t,T) c_2/q ,

$C = c_1/c_2 = (2/(1-v))^{1/2}$; $c_2 = 1$, θ = 1.

If the longitudinal and transverse potentials are known, it is possible to outstrip the stresses and displacements in a cylindrical (r, θ, z) coordinate system.

$$\begin{aligned} \sigma_{rr} &= c_1^2 \cdot \Delta^2 \cdot \phi - r \cdot \left[\frac{1}{r}\frac{\partial\phi}{\partial r} + \frac{1}{r^2}\frac{\partial^2\phi}{\partial\theta^2} + \frac{1}{r^2}\frac{\partial\psi}{\partial\theta} + \frac{1}{r^2}\frac{\partial^2\psi}{\partial r\partial\theta}\right] \\ \sigma_{\theta\theta} &= (I + v) \cdot C_1^2 \cdot \Delta^2 \cdot \phi - \sigma_{rr} \\ \sigma_{r\theta} &= -\Delta^2 \cdot \psi + 2 \cdot \left[\frac{1}{r}\frac{\partial\psi}{\partial r} + \frac{1}{r^2}\frac{\partial\psi^2}{\partial\theta^2} + \frac{1}{r^2}\frac{\partial\phi}{\partial\theta} + \frac{1}{r}\frac{\partial\phi^2}{\partial r\partial\theta}\right] \end{aligned} \quad (8)$$

External load Pr (θ, t) and Pθ (θ, t) can be represented as:

$$P_\theta(\theta,t) = \sum_{n=0}^{\infty} \{P_c^{(n)}(t)\, conn \cdot \theta + P_s^{(n)}(t) \sin n \cdot \theta\} \quad (9)$$

$$P_\theta(\theta,t) = \sum_{n=0}^{\infty} \{S_c^{(n)}(t)\, conn \cdot \theta + S_s^{(n)}(t) \sin n \cdot \theta\}$$

$$\left.\begin{aligned} P_c^{(n)}(t) &= \{q_c^{(n)} \cos n\cdot\Omega\cdot t - q_s^{(n)} \sin\cdot n\cdot\Omega\cdot t)\}\cdot H(t) \\ P_s^{(n)}(t) &= \{q_c^{(n)} \sin n\cdot\Omega\cdot t - q_s^{(n)} \cos\cdot n\cdot\Omega\cdot t)\}\cdot H(t) \\ S_c^{(n)}(t) &= \{r_c^{(n)} \cos n\cdot\Omega_1\cdot t - r_s^{(n)} \sin\cdot n\cdot\Omega_1\cdot t)\}\cdot H(t) \\ S_c^{(n)}(t) &= \{r_c^{(n)} \sin n\cdot\Omega_1\cdot t + r_s^{(n)} \cos\cdot n\cdot\Omega_1\cdot t)\}\cdot H(t) \end{aligned}\right\}$$

$q_c^{(n)}$, $q_s^{(n)}$, $r_c^{(n)}$ и $r_s^{(n)}$- amplitudes of external loads, H (t) - Heaviside unit functions.

Wave equation (4) taking into account (6) is solved by the method of integral Laplace transform

$$f(p) = \alpha\{f(t)\} = \int_0^\infty e^{-pt}\cdot f(t)dt, \quad (10)$$

$$\Delta^2\phi = \frac{p^2}{C_1^2}\psi,\ \Delta^2\phi = \frac{p^2}{C_2^2}\psi$$

The solution to equation (10) is expressed in terms of the modified Bessel functions

$$\left.\begin{aligned} \phi(r,\theta,p) &= \sum_{n=0}^{\infty} K_n\left[\frac{p\cdot r}{c_1}\right]\left[A_n(p)\cos n\theta + B_n(p)\sin n\theta\right] \\ \phi(r,\theta,p) &= \sum_{n=0}^{\infty} K_n(p,r)[C_n(p)\cos n\theta + D_n(p)\sin n\theta, \end{aligned}\right\}(11)$$

Where$K_n(x)$ – modified Bessel functions,

A_n,B_n,$C_n$end D_n– arbitrary constants are determined from the contact conditions. After that, we determine the corresponding voltage, which takes the following form.

$$\left.\begin{aligned} \sigma_{rr}(r,\theta,p) &= \sum_{n=0}^{\infty}\{[A_n(p)\cdot A\cdot L_n(p,c,r) + D_n(p) + B\cdot L_n(p,c_2,r)]\cos n\theta + \\ &+[B_n(p)\cdot A\cdot L_n(p,c_1,r) - C_n(p)\cdot B\cdot L_n(p,c_2,r)]\sin n\theta\}, \\ r_{r\theta}(r,\theta,p) &= \sum_{n=0}^{\infty}\{[B_n(p)\cdot B\cdot L_n(p,c_1,r) - C_n(p)\cdot A\cdot L_n(p,c_2,r)]\cos n\theta - \\ &-A_n(p)\cdot A\cdot L_n(p,c_1,r)]\cos n\theta - [A_n(p)\cdot B\cdot L_n(p,c_2,r) + \\ &+D_n(p)\cdot A\cdot L_n(p,c_2,r)]\sin n\theta, \\ \sigma_{\theta\theta}(r,\theta,p) &= (1+v\sum_{n=0}^{\infty} K_n\left(\frac{pr}{c_1}\right)\left[A_n(p)\cdot \cos_n n\theta + B_n(p)\sin n\theta\right] - \sigma_{rr}(r,\theta,p, \end{aligned}\right\}(12)$$

where

$$AL_n(p,c_p,r) = \left[p^2 + \frac{2n(n-1)}{r^2}\right]K_n\left[\frac{pr}{c}\right] + \frac{2p}{2s}K_{n+1}\left[\frac{p\cdot r}{Sp}\right]$$

$$BL_n(p,c_p,r) = \frac{2n}{r}\left[\frac{n-1}{r}K_n\left(\frac{pr}{c}\right) - \frac{p}{cp}K_{n+1}\left(\frac{pr}{cp}\right)\right],$$

$$A_n(p) = \frac{[AL_n(p,c_2,a)p_c^n(p)+BL_n(p,c_2,a)\cdot S_s^n(p)]}{\Delta_n(p)},$$

$$B_n(p) = \frac{[AL_n(p,c_2,a)p_s^n(p)-BL_n(p,c_2,a)\cdot S_c^n(p)]}{\Delta_n(p)},$$

$$C_n(p) = \frac{[BL_n(p,c_1,a)p_s^n(p)-AL_n(p,c_1,a)\cdot S_c^n(p)]}{\Delta_n(p)},$$

$$D_n(p) = -\frac{[BL_n(p,c_1,a)p_c^n(p)+AL_n(p,c_1,a)\cdot S_s^n(p)]}{\Delta_n(p)},$$

$$\Delta_n(p) = AL(p,c_1,a)AL(p,c_2,a) - BL(p,c_1,a)BL(p,c_1,a)$$

Passing from mapping (12) to the original, using the inversion theorem after mathematical transformations, we obtain the expressions for the stresses

$$\sigma_{rr}(r,\theta,t) = \sum_{k=1}^{\infty} r_{1k}\ (c_1, c_2, a, p_k)\cdot r_k(t)$$
$$\sigma_{r\theta}(r,\theta,t) = \sum_{k=1}^{\infty} r_{2k}\ (c_1, c_2, a, p_k)\cdot r_k(t)$$
$$\sigma_{r\theta}(r,\theta,t) = \sum_{k=1}^{\infty} r_{3k}\ (c_1, c_2, a, p_k)\cdot r_k(t)$$

$$r_k(t) = \int_0^{\infty} p(r)A(t-r)dr$$

$$r_{3k}(c_1, c_2, a, p_k) = -\frac{1}{p_k}\frac{\Delta_{nk}S_{mk}+\Delta_{nk}\cdot S_{mk}}{\left(\frac{\partial\Delta}{\Delta p}\right)_{p=p_k}}$$

Where are the coefficients$S_{mk}S_{mk}$, Δ_{nk}и$\Delta_{nk}$are expressed in terms of special Bessel and Hankel functions of the first and second kind of the nth order.

In a particular case, consider the propagation of radial waves about cylindrical holes, then the equation of motion (4) takes the following form:

$$\frac{\partial^2 u}{\partial r^2} + \frac{I}{r}\frac{Du}{\partial r} - \frac{u}{r^2} = \frac{I}{a^2}\frac{\partial^2 u}{\partial t^2}; \quad (13)$$

where$\alpha^2 = (\lambda+2\mu) / \rho$

Cylindrical surfaces r = α at t≥0 are subjected to unsteady loads in the form

$$(\sigma_{rr})_{r=a} = -p\delta(t-T), \quad (14)$$

Where δ(t-T) – delta - Dirac functions. To solve equation (13), the integral Laplace transform (9) is also used and takes the following form:

$$\left.\begin{aligned} &\frac{\partial^2 u}{\partial r^2} + \frac{I}{r}\frac{\partial u}{\partial r} - \left(\frac{p^2}{a^2} + \frac{1}{r^2}\right) u = 0 \\ &\left[(\lambda + 2\cdot\mu)\frac{\partial u}{\partial r} + \lambda\frac{u}{r}\right]^{r=a} = -p\cdot e^{-pt} \end{aligned}\right\}(15)$$

Solution (15) is also expressed in terms of the cylindrical Bessel functions of the first and second kind

$$\left.\begin{aligned} U(r,p) &= \frac{P\cdot e^{-pt}K_1\left(\frac{pr}{a}\right)}{\frac{p}{a}(\lambda+2\mu)\cdot K_0\cdot\left(\frac{pa}{a}\right) + \frac{2\mu}{a}\cdot K_1\left(\frac{pa}{a}\right)} \\ \sigma(r,p) &= \frac{P\cdot e^{-pt}(\lambda+2\mu)\frac{p}{a}\cdot K_0\left(\frac{pr}{a}\right) + \frac{2\mu}{a}K_1\left(\frac{pr}{a}\right)}{\frac{p}{a}(\lambda+2\mu)\cdot K_0\cdot\left(\frac{pa}{a}\right) + \frac{2\mu}{a}K_1\cdot\left(\frac{pa}{a}\right)} \end{aligned}\right\} (16)$$

In order to find the original, we use the following modified Bessel expression

$$K_n(z) = \frac{F\left(\frac{1}{2}\right)}{\Gamma\left(n+\frac{1}{2}\right)}\cdot\left(\frac{z^2}{2}\right)\int_1^{\infty} e^{-zt}\left((t^2-1)^{n-\frac{1}{2}}\right) dt(17)$$

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After some transformations (16), using (17), the following expressions for displacements and stresses can be obtained:

$$U(r,t) = \frac{\alpha \cdot P \cdot e^{-PT}}{\alpha(\lambda + r\cdot\mu)} K_1(pr) \frac{e^p}{p} / [K_o(p) + \frac{y}{p} K_1(p)] e^p$$

$$\sigma_{rr}^{`}(r,p) = -p \cdot e^{-PT} [K_0(p,r) + \frac{y}{pr} K_1(pr)] e^p / [K_0(p) + \frac{y}{p} K_1(p)] e^p$$

The results of the work were used to determine the original.

$$\int_0^e u(r,\eta,T)\cdot q(t-\eta)d\eta = \begin{cases} O \text{ для } 0 < t-T < r-1 \\ \frac{a\cdot P}{a\cdot(\lambda+2\mu)} \cdot \frac{1}{r}\sqrt{(t-T+1)^2 - r^2} \end{cases}$$

для $t - T > r - 1$

$$\int_0^e \sigma_{rr}(r,\eta,T)\cdot q(t-\eta)d\eta = \begin{cases} O, 0 < t-T < r-1 \\ -P\frac{r^2 + y((t-T+1)^2 - r^2)}{r^2\sqrt{(t-T)^2 - r^2}} & t-T > r-1 \end{cases}$$

где

$$g(t) = L^{-1}[e^pK_0(p) + \frac{e^p}{p} yK_1(p)] = (1+y((t+1)^2-1))/\sqrt{(t+1)^2} - 1)$$

let the load q be applied to the cylindrical hole at t≥0

$$(\sigma_{rr})_{r=a} = -q(t),$$

then the expression for displacement and stress takes the form:

$$\int_0^e u(r,\eta,T)\cdot q(t-\eta)d\eta = \begin{cases} O \text{ для } 0 < t-T < r-1 \\ \frac{2\cdot q}{a\cdot(\lambda+2\mu)} \cdot [\frac{t+1}{2r}\sqrt{(t+1)^2} - r^2 - r/2 \cdot \\ \cdot \log(\frac{t+1+\sqrt{(t+1)-r^2}}{r})] \end{cases}$$

for $t>r-1$

$$\int_0^e \sigma_{rr}(r,\eta,T)\cdot q(t-\eta)d\eta = \begin{cases} O, for 0 < t-T < r-1 \\ -q[\frac{t+1-y}{2r^2}\sqrt{(t+1)^2-r^2} + (1-\frac{y}{2})\cdot\log(\frac{t+1+\sqrt{(t+1)-r^2}}{r})] for t > r-1 \end{cases}$$

Were $y=2\mu/(\lambda+2\mu)$

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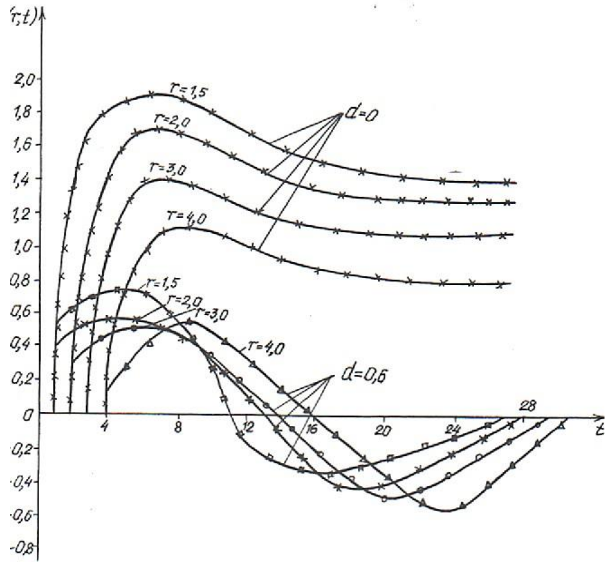
If a load is applied to the cylindrical hole in the form

$$\sigma_{rr}(r,t)=P_o e^{-dT}$$

then, as in the first case, the displacement and stress can be found using the Duhamel integral.

$$\frac{a(\lambda+r\mu)}{a\cdot P_0}\int_{r-1}^{t} q(t-з)\,u(r,\eta)\,d\eta = \int_0^{t-r+1}\frac{1}{r}\sqrt{(t-T+1)^2-r^2}\,e^{dT}dT\;\frac{1}{r}\int_{r-1}^{t} q(t-ф)\,y_{rr}(t,з)\,dз = \int_0^{t-r+1}\frac{r^2+y\{(t-T+1)^1-r^2}{r^2\sqrt{(t-T+1)^2-r^2}}e^{-dT}\,dT$$

The definitions of displacements and stresses in calculations are presented in Fig. 2 at
r = 1,5;2,0;3,0;4,0; y=0,8.



Rice. 2 Change of displacements of a cylindrical strip depending on time.

The calculation results show that displacements and stresses reach their maximum values in the initial period of time. Now let us determine the stress-strain state of a cylindrical hole in the two-dimensional case.

$$\left.\begin{aligned} y_{rr}(a,u,t) &= PH(t) \\ y_{ru}(a,u,t) &= 0 \end{aligned}\right\}$$

Here

$$P = \{\frac{P_o}{r_o}(1+\cos\frac{\pi\theta}{\theta_0})\,(\theta+\Omega t)\;,\;|\theta|\leq Q_0$$

$Q_0<|\theta|<\pi$

The expression qc(n) takes the following form

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$$q_c^{(n)} = \begin{cases} \frac{P_0}{n}\sin\theta_0\left(\frac{\pi}{\pi^2-n^2\cdot\theta^2}\right), n \geq 1 & n = \frac{\pi}{\theta_0} \\ \frac{P_0\cdot\theta_0}{2\pi}, n = 0, n = \pi/\theta_0 \end{cases}$$

$q_3^{(n)} = 0,\ K_c^{(n)} = r_0^{(n)} = 0$

The calculation results are shown in Fig. 3,4,5.

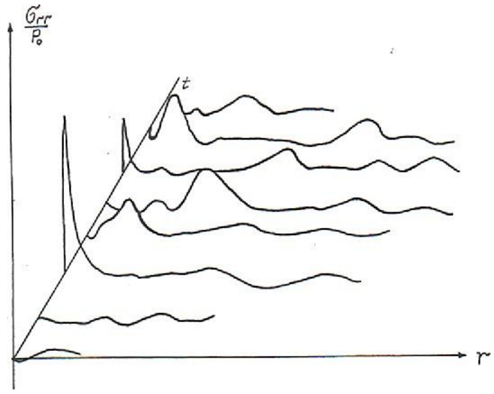

Fig. 3 Change in radial stress as a function of time at

$\theta = 0$

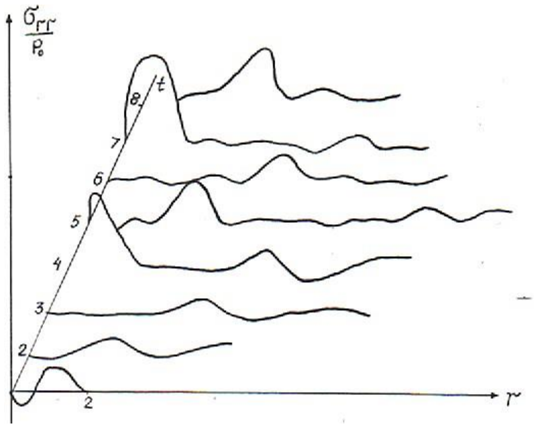

Fig. 4 Change in radial stress at $\theta = \frac{\pi}{3}$

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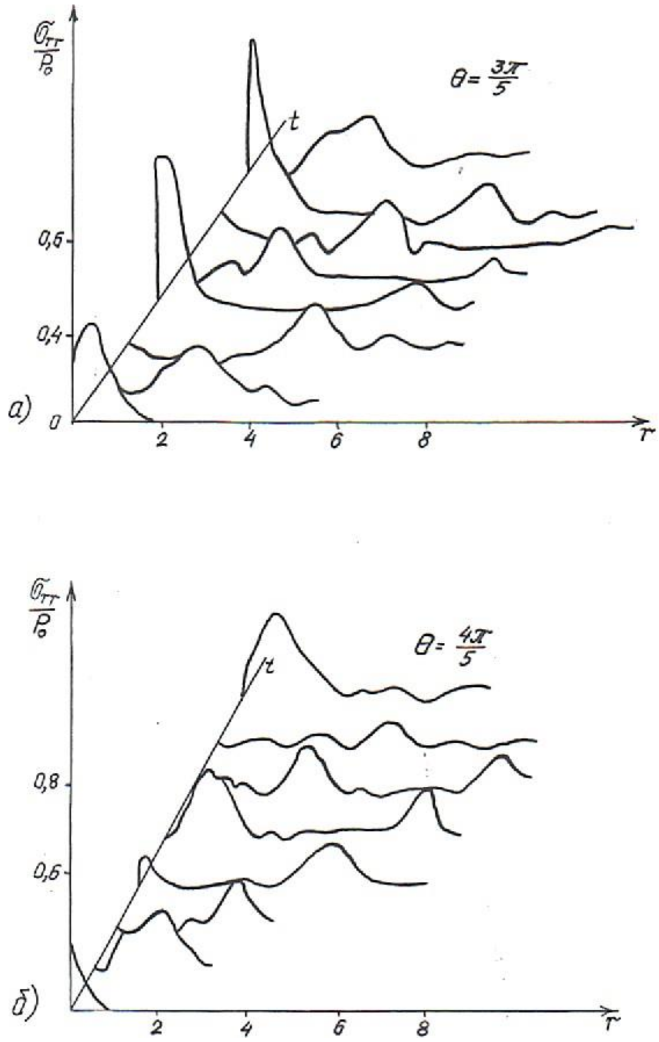

Fig. 5 Voltage change depending on time and coordinates.

(θ=0, π/3; π/6) depending on the time. It can be seen that all force factors take on a maximum value at the initial moment of time. Thus, we have obtained an accurate analytical expression of displacement and stress.

Obtaining numerical results in a particular case (for axially symmetric radial loads) is compared with the results of work [2], the results of calculations at the initial time differ by up to 20% with increasing time differs from 5% -15%.

References

1. Ditkin V.A. A.P. Prudnikov Integral transformations and operational calculus M. Fizmatgiz, 1971.-524 p.
2. Kubenko V.D. Non-stationary interaction of structural elements with the environment. -Kiev: Naukova Dumka, 1979.-183 p.
3. Morse FM, Feshbach G. Methods of theoretical physics, IL. T. //, 1969
4. Safarov I.I. Oscillations and waves in dissipatively inhomogeneous media and structures. // Tashkent, Fan, 1992, 250 p.

5. Safarov II, RazzokovSh.I., GaybullaevZ.Kh., Dynamics of a multilayer linear-elastic cylinder under non-stationary loads, // scientific conference "Mechanics and its application" TashSU. Toshkent 1993 47-49 p.
6. 3.X. Gaybullaev, B.A. Azizov Propagation of unsteady disturbances from cylindrical cavities. Scientific journal Internauka. Part 1.6 (88) Moscow 2019.https: //elibrary.ru/item.asp?id=38543929
7. Z.Kh. Gaybullaev, B.A. Azizov Propagation of free waves in two- and three-layer plane dissipative systems. Scientific journal Internauka. Part 1.6 (88) Moscow 2019.https://elibrary.ru/item.asp?id=38543929
8. Gaibulaev Z. Kh., Azizov BA, Savriyev Y.S. DETERMINATION OF THE PARAMETERS OF THE SEED WATER // Universum: technical sciences. - 2020. - No. 6-1 (75). https://elibrary.ru/item.asp?id=38543933
9. Azizov BA, Toshev II Equations of motion of soil particles on the working surface // Young scientist. - 2015. - No. 10. - S. 116-118. https://www.elibrary.ru/item.asp?id=23580721
10. Azizov BA, Toshev II Application of the direct problem of dynamics to the determination of the working surface of the loosening paw. Young Scientist. - 2015. - No. 10. - S. 118-120. https://www.elibrary.ru/item.asp?id=23580722