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ON THE PROPAGATION OF DIVIMENSIONAL WAVES IN A NONLINEAR ENVIRONMENT

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Abstract
A plane problem is considered regarding the supersonic velocity D of a monotonically killing load along the boundary of a half-plane, the material of which is modeled by an ideal medium possessing nonlinear and plastic properties.

Keywords: Plane problem, supersonic speed, ideal medium, semi-plane, shock wave, discharge, load profile, stationary and in the discharge region, movable coordinate.

Introduction

$\Sigma_p\Sigma_p$A plane problem is considered regarding the movement of a monotonically killing load at supersonic velocity D along the boundary of a half-plane, the material of which is modeled by an ideal medium possessing nonlinear and plastic properties; then in the half-plane, a shock wave with a curvilinear surface will propagate, assuming the medium on it is instantaneously loaded and unloading occurs behind the front (Fig. 1). In this case, from the condition of mass and momentum conservation on the surface, we obtain

$\rho_0 a = \rho^*(a - v_n^*), \qquad \rho_0 a v_n^* = p^*,$ (1.1)

$$v_\tau^* = 0 \quad (a = D\sin\alpha).$$

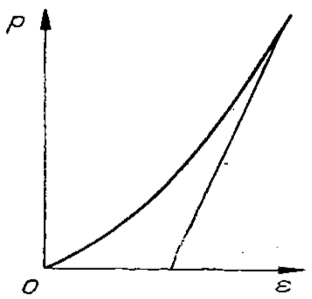

Figure 1

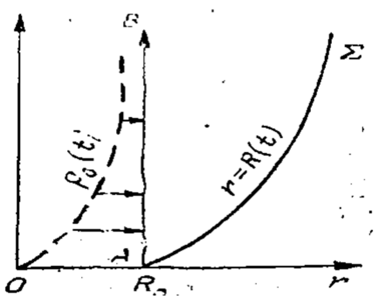

Figure-2

$\xi = Dt + x, \;\; \eta = y$Since the load profile is considered invariant as the wave propagates, the problem is stationary and in the unloading region in the movable coordinate we have the equation

$D\frac{\partial u}{\partial \xi} + \frac{1}{\rho}\frac{\partial p}{\partial \xi} = 0, \qquad D\frac{\partial v}{\partial \xi} + \frac{1}{\rho}\frac{\partial p}{\partial \eta} = 0,$(1.2)

$$D\frac{\partial\rho}{\partial\xi}+\rho\left(\frac{\partial u}{\partial\xi}+\frac{\partial v}{\partial\eta}\right)=0.$$

The boundary condition has the form

$\eta=0,\quad \xi\geq 0\quad p=f(\xi)$,(1.3) at

$f(\xi)-v_\tau^*, v_n^*-\Sigma_p; u, v-\Sigma_p$where the known monotonic killing function; the tangent and normal components of the velocities of the midpoint to the front of the velocity projection onto the axis ξ and <N; α is the angle of inclination of the front to the half-plane boundary [1, 2, 3]. φTo obtain the solution to the problem, we substitute the first equation (1.2) into the third. Then we obtain the wave equation for the velocity potential.

$$\mu^2\frac{\partial^2\varphi}{\partial\xi^2}-\frac{\partial^2\varphi}{\partial\eta^2}=0\qquad\left(\mu^2=\frac{D^2}{c_p^2}-1\right),(1.4)$$

$D>c_p$ Which has a similar solution

$$\varphi(\xi,\eta)=f_3(\xi-\mu\eta)+f_4(\xi+\mu\eta).$$

$\Sigma_p u, v$ при $\eta=\eta(\xi)$If given by a definite form, then the composite velocities of the environment, taking into account (1.1), are represented in the form

$$u=\frac{\partial\varphi}{\partial\xi}=-Dsin^2\alpha(\xi)\left[\frac{\rho^2D^2}{\alpha_2}sin^2\alpha(\xi)-\frac{\alpha_1}{\alpha_2}\right],(1.5)$$

$$v=\frac{\partial\varphi}{\partial\eta}=Dsin\alpha(\xi)cos\alpha(\xi)\left[\frac{\rho^2D^2}{\alpha_2}sin^2\alpha(\xi)-\frac{\alpha_1}{\alpha_2}\right],$$

$\eta(\xi)-\Sigma_p\xi O\Sigma_p f_i(z_i)$Where is the front surface equation? Consequently, in the case of a two-sided wave inside a curvilinear sector (Fig. 2), we obtain the Cauchy problem for (1.4) taking into account (1.5), as in claim 1, and have the formula for determining:

(1.6)

$$f_i(z_i)=\mp\frac{D}{\partial\eta}\int_0^{z_i}\frac{tg\alpha[F_i(z_i)]\{1\pm\mu tg\alpha[F_i(z_i)]\}\Phi_i(z_i)}{\{1+\mu tg^2\alpha[F_i(z_i)]\}^2}dz_i,$$

Where

$$\Phi_i(z_i)=\left(\frac{\rho_0D^2}{\alpha_2}-\frac{\alpha_1}{\alpha_2}\right)tg^2\alpha\alpha[F_i(z_i)]-\frac{\alpha_1}{\alpha_2};$$

$F_i(z_i)\ (i=3,4)-\xi\mp\mu\eta(\xi)=z_i i=3$ в (1.6)$f(\xi)$.the root of the equation is relative to ξ, and in this case, the upper sign is taken. Note that in the reverse problem statement, i.e., given the surface area of the shock wave front, condition (1.3) serves as the formula for determining the load profile

Thus, taking into account (1.5), (1.6), the solution to the problem of the propagation of a two-dimensional nonlinear wave in a half-plane is obtained. If we apply this solution in (1.3), then, in principle, we should obtain a killing load profile with a sharp front at the beginning of the coordinates and the process of unloading the medium [4, 5, 6, 7, 8,] should be carried out in the stressed region.

Analysis of the resulting velocity and pressure formulas, as well as calculation results, show that the unloading process can be achieved if the wave front velocity decreases with the depth of the half-plane [9, 10, 11, 12, 13].

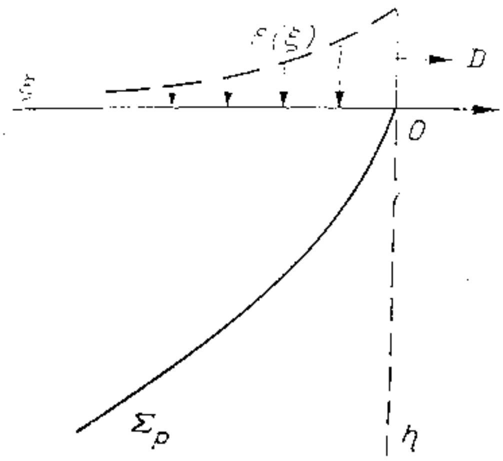

Figure-3

Note that an analogous inverse method is applied in the unloading wave problem [6].

Σ_pAs an illustration of the method, the case is considered when given as a polynomial of the second degree, i.e.

$\eta(\xi) = tg\alpha_0\xi - \frac{b}{2}\xi^2$.(1.7)

$tg\alpha_0 = 0{,}1255,\ \ b = 0{,}86 \cdot 10^{-3}\Sigma_p,\ \ b = 0{,}86 \cdot 10^{-3}; 0{,}86 \cdot 10^{-2} f(\xi) p^* u^*, v^* \Sigma_p\ \ \ b = 0{,}86 \cdot 10^{-2},\ \ b = 0{,}86 \cdot 10^{-3}.\eta = 0,\ \ b = 0{,}86 \cdot 10^{-2}\eta = 0$

The results of the analytical method calculations taking into account (1.7) and the characteristic method [1] are presented in the table, where I is the numerical characteristic method, and II is the analytical method. No fig. In Figure 4, the curves of changes and velocities along the half-plane front are plotted for the cases (curves 1, 2 respectively). From the table, the results obtained using both methods agree satisfactorily, and the load profile found by the reverse method is monotonically killing along ξ. From Fig. 4, it is noticeable that pressure and velocity components along the front decrease from the depth of the half-plane according to a linear law, and in the case of decreasing the aforementioned values, it becomes more intensive than during calculations. Calculations show that all environmental parameters, including pressure along ξ (at the half-plane boundary), decrease depending on the values of the coefficient b in different ways. In this case, the process becomes more intensive and nonlinear [14]. This means that if the wave front velocity decreases relatively quickly with the depth of the half-plane, then the environmental parameters, particularly pressure, along the half-plane boundary also decrease intensively. However, the process of setting parameters in the environment along the border occurs faster than on the front [14, 15, 16, 17, 18, 19].

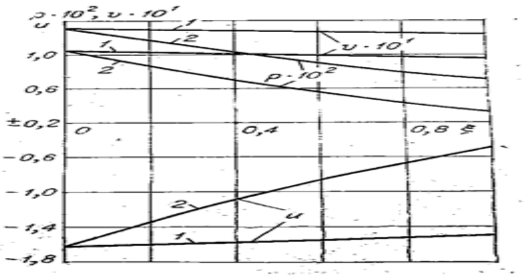

Figure-4

$\alpha_2 = 0$In general, this work presents an inverse analytical method for solving one-dimensional and two-dimensional stationary problems under short-term intensive impacts, taking into account the nonlinear plastic deformation of an ideal inelastic medium. In the case of p. 2, the results coincide with the results [4] obtained based on the application of the Mellin transform.

ξ	*he*		*v*		*p*	
	I	II.	I	II.	I	II.
0	-1,644	-1,644	13,100	13,100	105	105
0.1	-1.628	-1.628	13,025	13,020	103,956	103,937
0.2	-1.610	-1.613	12,944	12,940	102,921	102,979
0.3	-1,597	-1,597	12,861	12,860	101,896	101,958
0.4	-1,581;	-1,581;	12,780	12,780	100,882	100,937
0.5	-1,565	-1,566	12,699	12,700	99,880	99,978
0.6	-1,550	-1,551	12,621	12,620	98,888	99,021
0.7	-1,535	-1,535	12,543	12,540	97,904	98,000
0.8	-1,519	-1,520	12,466	12,470	96,928	97,042
0.9	-1,505	-1,505	12,390	12,390	95,966	96,085
1.0	-1,490	-1,490	12,314	12,320	95,009	95,127

Conclusion

The tasks under consideration can have practical applications in studying intensive impacts in water-saturated soils, as well as in water bodies.

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