

PARAMETERS OF STRESS WAVES PRODUCED BY
A SPHERICAL EXPLOSIVE SOURCE

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SYNOPSIS

The study of stress wave patterns close to explosive sources makes it possible to obtain an idea of the processes of generation of these waves in a medium with nonelastic and elastic deformations. A review of changes of their dynamic parameters on the source size, on the distance from the source and on the physical properties of medium, which have been measured in the neighbourhood of spherical high explosives in gravel sandy soil, loess, clay shale and limestone, is presented.

DETERMINATION OF CLOSE-IN ZONES OF THE EXPLOSIVE SOURCE

If the stress wave onsets t_0 , the arrival times t_1 of the maximum amplitudes A_m , the times t_2 terminating the overpressure part and the times t_w , belonging to the end of the first wave of stress waves are known in a medium, it is possible to distinguish three types of stress wave patterns. In the closest vicinity of the source the stress wave pattern has practically the form of a shock wave in gas ($t_0=t_1$, $2t_2 \gg t_w$ and $A_m \gg A_n$). At distances at which plastic deformations of the medium still occur, the stress wave pattern roughly possess the form of deformed sinusoid ($t_0=t_1$, $2t_2 < t_w$ and $A_m > A_n$). Beyond this zone with nonelastic deformations, the stress wave pattern has an oscillatory character ($4t_1 < 2t_2 < t_w$ and $A_m > A_n$). All the relationships of the dynamic parameters of stress waves, mentioned in this paper, concern the second and third types of stress wave patterns.

If the changes of the velocities V_0 , V_1 and V_2 , corresponding to the times t_0 , t_1 and t_2 of stress wave patterns, with increasing distance R from the source are known, it is possible to determine the approximate radius of the created cavity R_c and of the zone R_E of the plastic deformations around the source in a medium whose velocity of propagation of stress waves V in the elastic zone is smaller than the detonation velocity of the explosion. The distance at which V_1 separates from V_0 , is practically equal to $2/3 R_c$, and the distance from which V_0 and V_1 reach their minimum values, approximately agrees with $R_E \sqrt{1}$.

AMPLITUDES AND FREQUENCIES OF STRESS WAVES

The variations of the values of A_m with R show that the more compacter, moister, more viscose and stronger the medium,

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the less attenuated the amplitudes. Experimentally these relations are described in many forms. It seems that from a physical viewpoint the dependence A vs. R would best be expressed by the term

$$A_m = A_0 r^{-n} e^{-\alpha_m r} \quad , \quad (1)$$

where the exponent n characterizes the shape of the wave front, α_m is the attenuation coefficient of A_m in the medium and A_0 is a constant. The agreement of the coefficients α_m for gravel sandy soil, loess, clay shale and limestone with previously obtained values was achieved [2-5].

The influence of moisture $M[\%]$ on the values of A_m can be described by the relation

$$A_m = A_M e^{aM} (C^{1/3}/R)^k \quad , \quad (2)$$

where C is the charge weight, A_M , a and k are positive coefficients, determined experimentally; for loess are $A_M=0.16$ and $a=0.18$ [3].

The relation between α_m and the attenuation coefficient of spectral amplitudes α_p of the predominant frequency f_p of stress waves in gravel sandy soil is described by the equation [6]

$$\alpha_m = \alpha_p K^{0.5} f_p C^{0.2} \quad , \quad (3)$$

where K is a coefficient, determined experimentally. From (3) follows that α_m is the mean value of all attenuation coefficients of the spectral amplitudes.

The physical properties of the medium and C strongly affect the frequency variations of the stress waves with R . The character of the dependence f_p vs. R changes for different media [2-5] and, therefore, the question of its determination still remains open. The relation for estimating f_p at a distance of R_E (surface of an elastic source) was found for gravel sandy soil in the form [7]

$$f_p = \frac{\psi}{\pi D \sqrt{C}} [1 - (\psi/\phi)^2]^{1/2} \quad , \quad (4)$$

where ϕ and ψ are velocities of longitudinal and shear waves, respectively, and D is a coefficient depending on the medium. It was revealed that f_p probably varies as $C^{0.2}$ [7].

The frequency content of the stress waves was expressed by the relative width of the amplitude spectra Δf_r [8]. The values Δf_r decrease with R . The relation for gravel sandy soil reads

$$\Delta f_r = \eta \sigma^{-R/C^{1/3}} \quad , \quad (5)$$

where the coefficients η and σ depend on the physical properties of the medium; for gravel sandy soil $\eta=1.26 \pm 0.12$ and $\sigma=1.03 \pm 0.03$.

SOURCE FUNCTION OF STRESS WAVES

The source function of the stress waves in the neighbourhood of the surface of an elastic source was defined on the basis of the knowledge of source functions, used hitherto, in the form [9]

$$p(t) = p_0 t^\gamma e^{-\beta t} \sin [(\omega + \delta t) t] \quad , \quad (6)$$

where parameters p_0 , γ , β , ω and δ must be determined experimentally; they have no specific physical meaning. Function (6) satisfies the observed stress wave patterns well and has been tested for gravel sandy soil [9].

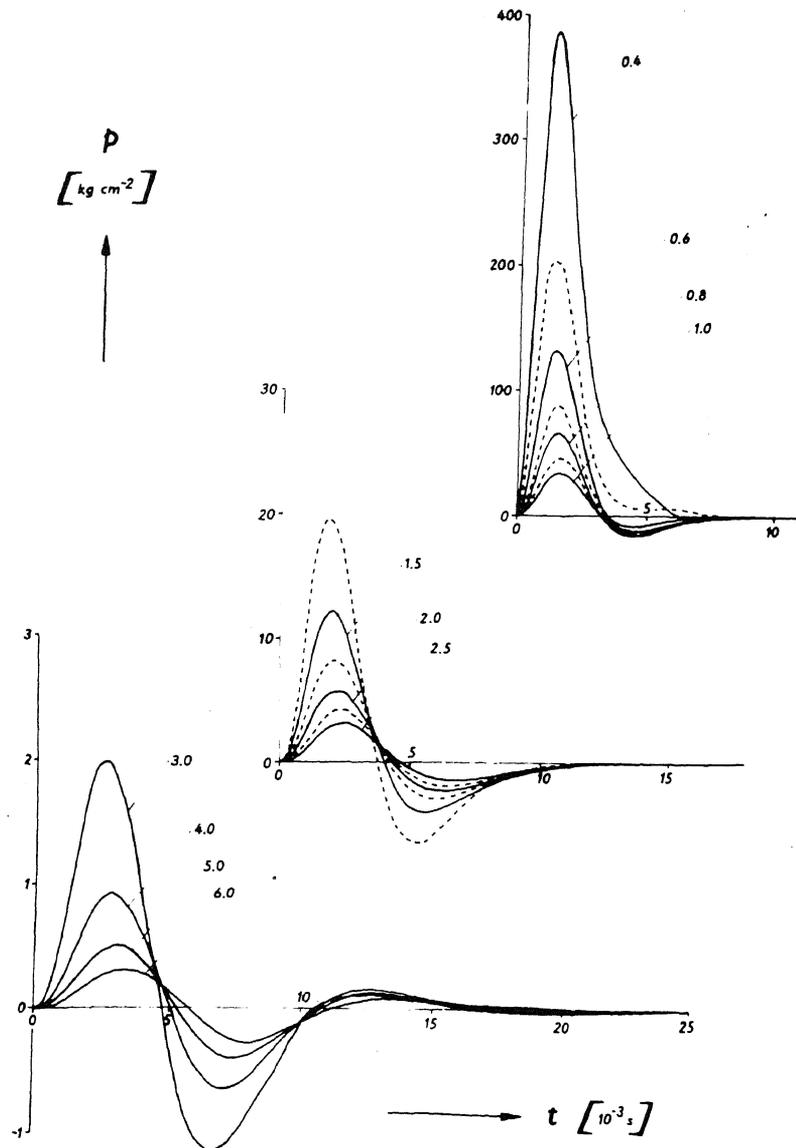
CONCLUSION

It is assumed that the data on the stress waves in the nonelastic and elastic zones of spherical explosive sources will be used for the study of these waves in focal regions and for forecasting their dynamic parameters at places of probable epicentres of earthquakes from the viewpoint of evaluating the seismic risk of the region.

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Computed stress wave patterns in gravel sandy soil according to function (6) for $C=0.05 \text{ kg}$ and for range of scaled distances from 0.4 to 6.0 $\text{m kg}^{-1/3}$ [9].