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INVESTIGATION OF SOME FEATURES OF THE MOVEMENT OF SURFACE WAVES AND THEIR INTERACTION WITH THE SURFACE OBJECTS´ BASES AND FOUNDATIONS PROVIDING SEISMIC SAFETY

The article describes the features of surface waves motion as well as the analysis of existing methods for finding the timing and patterns of change in motion R-waves along the free surface. To this end, we calculatede time - frequency performance under different formulas in R - wave and compared with each other and with values in R - wave dependsng on two main factors: the weight of the charge and the reduced distance , the results of which are shown in this paper. Indirectly, it was found that the at any epicentral distance surface wave is significantly seysmic unsafety than the body wave , which in any hypocentral distances at different points on the surface may not exceed the period of oscillation in the above point with raduced radius equal to one .

***Key words**: seismic waves, magnitude, surface, epicentral distance, period of oscillation.*

В статье рассмотрены особенности движения поверхностных волн, а также выполнен анализ имеющихся методик нахождения временных характеристик и закономерностей их изменения в процессе движения R–волны вдоль свободной поверхности. С этой целью были проведены расчёты временно – частотных показателей по разным формулам в R – волне и сравнение между собой и с значениями в R – волне в зависимости от двух главных факторов: веса заряда и приведенного расстояния, результаты которых приведены в настоящей работе. Косвенным образом было установлено, что на любом эпицентральном приведенном расстоянии поверхностная волна значительно более сейсмоопасная, чем объемная, которая на любых гипоцентральных расстояниях в различных пунктах на поверхности не может превышать величины периода колебаний в пункте при приведенном радиусе равном 1.

***Ключевые слова**: сейсмические волны, магнитуда поверхность, эпицентральное расстояние, период колебаний.*

В статті розглянуто особливості руху поверхневих хвиль, а також виконано аналіз існуючих методик знаходження часових характеристик та закономірностей їх зміни в процесі руху R–хвилі вздовж вільної поверхні.

З цією метою були проведені розрахунки частотно-часових показників за різними формулами в R – хвилі й порівняння між собою та із значеннями в R – хвилі залежно від двох факторів: ваги заряду і приведеної відстані, результати яких висвітлено у даній роботі.

Непрямим чином було встановлено, що на будь-якій епіцентральній приведеній відстані поверхнева хвиля значно більш сейсмонебезпечна, ніж об΄ємна, яка на будь-яких гіпоцентральних відстаняхв різних пунктів на поверхні не може перевищувати величини періоду коливань в пункті при приведеному радіусі, рівному одиниці.

Ключові слова: *сейсмічні хвилі, магнітуда, поверхня, епіцентральна відстань, період коливань****.***

Introduction. The main objective is the establishment of industrial seismic critical indicators of seismic vibrations at the base of the foundation, the mountain slope, the bottom of the reservoir and the like, based on various criteria (mass flow rate, limiting strain energy density, power). Accordingly, consideration of the dynamics of nucleation and motion seismic explosive waves, the occurrence of outbreaks of mountain bumps and excited or wave processes, depending on the lithological and technological factors that determine the degree of their influence on the Earth's surface, the existing engineering - building infrastructure, as well as on natural objects is one of the most urgent scientific and technical problems of Applied Geomechanics. For the study of the movement of seismic waves analytically acceptable results can be obtained only by considering this process in a homogeneous infinite elastic space, using the theory of elasticity of the linearity of "stress-strain", taking the law of decay as a function of the geometric divergence $f_{pax}(\mathrm{r}) = \left(\frac{r_u}{r_p}\right)^{\frac{x-1}{2}}$ (x-index of symmetry). However, in actual geological environment in which the seismic waves propagate are neither absolutely elastic nor homogeneous. They have a layered structure in the form of layers of rocks with different physical - mechanical (including elastic and dissipative) properties, at the top, as a rule, covered with alluvial Soft Ground. The wave pattern in the past is of particular interest because they are the location of the surface of objects exposed to these seismic vibrations. Seismic signal at the interfaces of the individual layers is subjected to variations, the value of which is greater the greater the difference in properties of the adjacent layers. Therefore, when drawing up the algorithm of motion is required to consider under the laws of geometry correction for seismic refraction of waves at the boundary speed (especially at the "rock - drifts").

Among the different types of waves generated by seismic source border greatest interest are two kinds of bulk waves: longitudinal (P) and shear (S), and converts them to achieve a free surface there along wave of a new type (surface) - more energy saturated. Thus, according to some authors [6], it is up to 68% of the seismic energy, while the longitudinal 7%, i.e. almost 10 times less, and the share of cross-fourth of the accounts. The truth is to treat all cases of massive multi-row blasts charges at relatively shallow depths. Under different conditions of excitation of oscillations, these relations will be different, but the surface wave is the main carrier of the energy potential in comparison with the bulk of the wave spectrum of species, primarily due to the prevailing low-band oscillations of the particles. The seismic waves of any species characterized by a number of parameters and distinguishing features, the most important among them the dynamic characteristics (displacement, velocity, acceleration of particles of the medium frequency range, the phase velocity V_0, the velocity of the longitudinal V_p, transverse V_S and surface waves V_R, the period of oscillation T_p, T_S, T_R), the Power output (radial stress σ_r, specific impulse I_{cp}), the specific energy intensity (the average energy flux density), etc.

In the analysis of parameters of seismic waves is widely used principle of geometric similarity and energy, expressing the law of their movement through the reduced mass of the charge $Q_{пр} = \frac{Q_{вв}^{1/3}}{r}$ or given away $\frac{r}{Q_{вв}^{1/3}}$, allowing for the connection between the parameters of the source of vibration and temperature as a function of distance. So far, the main criterion on which standards are developed seismic surface buildings, a value permissible mass velocity. A more complete and accurate picture can be obtained by considering the components of the seismic force explicitly, rather than indirectly through the mass velocity $u_{доп}$, as destruction and deformation of the protected objects are the result of switching loads, causing unbearable stress and strain in structural elements (or soils of foundations). And the process of deformation and fracture of materials and structures is the inertia and comes in the case where the application of force which lasts - that a certain period of time sufficient for the accumulation of the critical parameters of deformations. Achieving them (other things being equal) depends on the response of structures - relaxation, which can be replaced by a measure of the natural period of oscillation T_0.

As a result of recent studies, carried out at the Institute of hydrodynamics NAS found that depending on the relative timing of the "Primer - Construction of $m = \frac{T_R}{T_0}$ safety regulations Figures mass velocity (acceleration) to be adjusted by multiplying a coefficient K_m which can be significantly larger or smaller units for surface of objects depending on the value of the natural oscillations T_0 in the same values T_R. Thus, the visible period of oscillations in the wave surface serves as one of its most important characteristics. In this paper we analyzed the available methods of finding this parameter and patterns of change in motion R - wave along the free surface.

Formation and distribution of R-waves along the free surface Analyzing the experimental material on seismic vibration sensors mounted on the surface, it is clear that the first entry is a longitudinal wave P, her goes a very complex wave train formed by the longitudinal shear waves and their reflections as the border of sediment and rock, and on the day the surface. [6] The most favorable to the excitation near the free surface of these oscillations is just a layer of soil lying on rocky ground (which is the case in the vast majority of cases of blasting and the occurrence of coal seams, the development of which is accompanied by a rock burst, the two sources of seismic vibrations reaching the free surface). The surface wave is usually regarded as a movement of inertia, which is retained in the surface layer after the passage volume (direct and reflected) and then transferred from one to the other soil particles as a separate composite signal. Thus total vibrational particle motion occurs along ellipsoidal complex (in the plane X-Y) of the trajectory. These waves differ and the other characteristic to them signs of, in particular:

1. the maximum displacement speed and inversely proportional to the distance r raising compared to 0.5 P - waves $r^{(1-1,7)}$ damped by law, i.e. they decay much more slowly [5];

2. the oscillation period T_R is 2-3 times longer than the period P - wave;

3. the speed V_R of motion along the surface of the significantly less than the speed V_P and amounts to (0,9-0,92) V_S ;

4. period of 2-3 times more than that figure in P - wave [5];

5. period T_R as the distance from the epicenter increases the value $r_{np}^{\mathrm{n}_\mathrm{p}}$.

The complexity of the wave pattern in the surface layer does not go as far as possible - any adequate analysis of building, fixing the main parameters on the wave front, their interactions with each other and the parameters of the environment and changes in motion. These circumstances are forcing experts to resort to empirical research tools for obtaining the required information, which fully applies to the production of time-frequency characteristics as a function of the energy index hearth and epicentral distance to the test point on the free surface. Physical and mechanical characteristics of the environment are taken into account by introducing the integral factor of proportion. Results of experimental studies the degree of influence of time-frequency characteristics of the system "soil-structure" allows to specify the actual role of the temporary measure R-wave on the degree of surface seismic safety of buildings by conventional dynamic criteria.

In Table. 1 shows, as an example, the calculated acceptable data amount as compared with normative data chart for class III mass velocity of from 7 to 0.5 cm / s according to [2], $\lambda = 0{,}3$ and $T_0 = 0{,}2 - 0{,}4$.

Actual allowable values $u_{\text{доп}}^{\text{гр}}$ were calculated using the formula

$$u_{\text{доп}}^{\text{гр}} = \mathrm{u}_0 \frac{c}{B_{\text{зд}(\mathrm{m})}}, \textit{ where:} \tag{1}$$

$$B_{\text{зд}(\mathrm{m})} = \left[\left(1 - \frac{T^2}{T_0^2}\right)^2 + \frac{4\lambda^2}{\Pi^2 + \lambda^2} \cdot \frac{T^2}{T_0^2} \right]^{-0{,}5}, \tag{2}$$

$$C = \frac{T_0^2}{T_{\text{сем}}^2} \cdot \frac{1}{\sqrt{2\lambda_{\text{сем}}}}, \textit{ where:} \tag{3}$$

Tсем and *λсем*– performance standard seismometer (0.25 and 0.5, respectively); λ – the damping factor of the building.

The ratio $\frac{C}{B_{\text{зд}(\mathrm{m})}}$ is essentially a magnitude of the correction factor K_m^u to the standard indicators allowable mass velocity u_0. Permissible of acceleration $a_{\text{доп}}^{\text{гр}}$ were counted according to a known relation:

$$a_{\text{доп}}^{\text{гр}} = \frac{2\pi_{\text{доп}}^{\text{гр}}}{T}. \tag{4}$$

A more detailed seismic hazard assessment methodology, taking into account the relation m is described in [7], whose data were used for the revised standard indices by a factor of acceleration.

From the data in this table, it follows that the allowable acceleration for the surface of objects $a^{гр}_{доп}$ varies from the natural period T_0 of oscillation at different rates $\mathrm{m_a}$. So an increase T_0 in 2 times (from 0.2 to 0.4 s) the allowable acceleration may be taken 2 times the (constant $\mathrm{m_a}$), and the change from 0.125 to 0.5 $\mathrm{m_a}$ should be reduced to 5.23 times. At the resonance region ($m_a \longrightarrow 1$) in standard indicators a_H should be reduced by 8 times, while the calculated value $a^{гр}_{p}$ in this case is reduced by more than 40 times, and their ratio is about 5 times. Thus, the level of real dynamic effects seismic oscillations (D) with the amplitude - frequency components expressed in terms of a correction factor $K^m_a (D = a_H \cdot K^m_a)$ may be different from the accepted norms in the direction of increasing ($D > 1$) to 2.5 times or decrease ($D < 1$) of 1.6 times (at T_0=0,2 $\mathrm{m_a}$=0,125 и T = 0,025) to 8 times in the resonance oscillations. As we see time index R - wave is a significant factor in the use of seismic safety issues and, therefore, subject to detailed consideration.

Determination of the time parameters of the surface waves.

During the formation of R - wave involved the longitudinal wave propagating along the free surface and the vertical component of the shear wave. At a certain epicentral distance of influence of the latter is prevalent, as evidenced in particular the nature of the motion of particles in the R-wave on ellipsoidal path with the long axis oriented vertically. One of the challenges is to find the coordinates of the initial movement of R-wave, i.e distance from the epicenter to the point where its formation is completed by main feature - the ratio of the major axis of ellipsoidal path to a small equal to about 1.4.

This is the epicentral distance is dependent on the depth of the source (H), medium wave propagation properties and their dynamic behavior, in particular V_P, V_S, V_R , is defined as the belief that the formation occurs at the epicentral interval $r_R - r_з$ (start and end of the process). Distance to the start of nucleation R - wave is [2]:

$$r_R = \frac{\mathrm{V_S} H}{(V_p^2 - V_R^2)^{1/2}} . \qquad (5)$$

The speed of the surface wave is assumed to be (0,9-0,92) V_S or calculated using the formula:

$$V_R = \frac{0{,}87 + 1{,}11\nu}{1 + \nu} \sqrt{\frac{G}{\rho}} . \qquad (6)$$

The velocities of longitudinal and transverse waves are the known formulas of the theory of elasticity as a function of modulus of elasticity E, shear modulus G, the formation density ρ and Poisson's ratio ν .

Epicentral distance r_R^1 to calculate the time parameters of the R wave is assumed equal to:

$$r_R^1 = r_R + \frac{R_3 - \mathrm{r_R}}{2} . \qquad (7)$$

The specialists at various times offered many empirical relationships to find the period of oscillation T_R as a function $T_R = f(Q_{вв}^{1/5}), T_R = f(Q_{вв}^{1/3}, \mathrm{r}_{\mathrm{пр}}^{\mathrm{n_R}})$.

For example, in work [5] to estimate the period T_R ratio T_R=0,06$Q_{вв}^{1/5}$, suggested some of the most commonly used empirical design formulas of different authors for the most earthquake-prone cases of wave motion on the drifts are shown in Table. 2. Analyzing the ratio in Table. 2 and comparing with other published data see the different methodological approaches to the assessment of the temporal characteristics of R - waves. In some cases (such as in Equation 1, tables) as this index is essentially adopted Z - accounting period (equal to the formula 3 tables), in [5] does not take into account the period of change with distance from the foregoing that the functional relation $T_R = f(Q_{вв}^{1/5})$ - and $Q_{вв}$ moreover are acceptable raising 1/5, rather than 1/6, as in equation 1.

In the formula 2 table 2 with the same value of the coefficient of proportionality (0,06) and n_R= 0.11 $Q_{вв}$ and the index received raising 0.13 instead of 0.2.

Here, of course should be considered a convention of calculations due to the fact that the empirical coordinates do not reflect the real characteristics comparable environment, in particular the absorption coefficient. But with equal values of the coefficients of the formula should be different indicator n_R and energy component $Q^{1/6}$ should be taken as the same. It cannot be considered satisfactory as a judgment of the immutability of the profile R - waves with distance, which is regarded as an ellipse with axial ratio of 1.4. However, it can be assumed that both the shape of the ellipse, and its position from the coordinates r_R (start forming) will vary continuously, reaching only the marked configuration to complete the formation. Then the transformation of the profile will change in the reverse order, with the increase of the argument $r_{np}^{\mathrm{n_R}}$. When comparing the formulas 1 and 5, the period of oscillation of the longitudinal wave in the clays in 2 times T_R less in agreement with the available experimental data on the 2x-3x - fold increase compared to the period of oscillations T_R in P - wave.

Table 1. Permissible accelerations $a_{доп}^{гр}$ for buildings of III class when $\lambda = 0{,}3$ and permissible mass velocity 0,5-7 sm/s for three periods natural oscillations of construction 0,2 – 0,4 s.

T_0,s	U_0, according [2, table 3.20]	Permissible ground accelerations, $a_{доп}^{гр} sm/s^2$, when $m_a = \frac{T}{T_0}$													
		0,125		0,25		0,33		0,5		0,625		0,875		1,0 (resonance)	
		$\frac{a_p}{a_H}$	k_m^a	$\frac{a_p}{a_H}$	k_m^a	$\frac{a_p}{a_H}$	k_m^a	$\frac{a_p}{a_H}$	k_m^a	$\frac{a_p}{a_H}$	k_m^a	$\frac{a_p}{a_H}$	k_m^a	$\frac{a_p}{a_H}$	k_m^a
0,2	7,0	1103/1758	0,63	521/879	0,59	379/666	0,57	211/440	0,48	128/352	0,36	62/251	0,25	26,7/220	0,12
0,3	7,0	1660/1172	1,42	789/586	1,35	567/444	1,28	318/293	1,08	207/234	0,88	-	-	-	-
0,4	7,0	2211/879	2,52	1052/440	2,39	753/333	2,26	427/220	1,94	-	-	-	-	-	-
0,2	3,0	470/754	0,62	226/377	0,6	162/285	0,57	90/188	0,48	59/151	0,39	31/108	0,29	11,3/94,2	0,12
0,3	3,0	712/502	1,42	338/251	1,35	243/190	1,28	136/127	1,07	89/100	0,89	-	-	-	-
0,4	3,0	947/377	2,51	450/188	2,39	323/143	2,26	181/94	1,93	-	-	-	-	-	-
0,2	1,0	158/251	0,63	75/126	0,6	54/95	0,57	30/63	0,48	19,6/50,2	0,39	10/36	0,28	4/31	0,13
0,3	1,0	236/167	1,41	113/84	1,35	81/63,4	1,28	45/42	1,07	29,4/33,4	0,88	-	-	-	-
0,4	1,0	315/126	2,5	150/63	2,38	108/48	2,25	60/31,4	1,91	-	-	-	-	-	-
0,2	0,5	78/126	0,62	38/62,8	0,6	27/48	0,56	15,1/31	0,48	9,55/25	0,38	5,02/20	0,25	1,88/16	0,12
0,3	0,5	119/84	1,42	56/42	1,33	41/32	1,28	22,6/21	1,08	14,7/17	0,865	-	-	-	-
0,4	0,5	157/63	2,49	75/31	2,42	54/24	2,25	30/16	1,87	-	-	-	-	-	-

Note: 1. The numerator calculated acceleration parameters ($a_{доп}^{гр}$) in the denominator regulatory a_H; 2. The correction factor K_m^a is the ratio of the calculated values to the standard.

Table 2. The experimental dependence for determining the period of oscillation in the surface waves during blasting lumped and linear charges [1,4]

Number	Type of soil	Characteristics of source	Formula for calculation $T_R = f(Q_{вв}^{1/3}, \mathrm{r}_{\text{пр}}^{\mathrm{n_R}})$	Coefficient proportionality
1	Loess, loam, clays [1]	The charges centered by weight $10^2 - 10^3\,кг$	$T_R = K_R \sqrt[6]{Q_{вв}} \cdot \mathrm{r}_{\text{пр}}^{\mathrm{n_R}})$	K_R - clay 0,08, loess. Loam n$\mathrm{n_R}$=0,11– 0,06; for loess and clay
2	Loess [3]	The charges centered by weight 20-$10^4\,кг$	$T_R = 0{,}06 Q_{вв}^{0{,}13} \cdot \mathrm{r}_{\text{пр}}^{11}$	
3	Loess	The charges centered by reduced depth $H_{пр} \geq 3{,}5$	$\mathrm{T_R^Z} = 0{,}081 Q_{вв}^{1/6} \cdot \mathrm{r}_{\text{пр}}^{0{,}1}$ $\mathrm{T_R^X} = 0{,}056 Q_{вв}^{1/6} \cdot \mathrm{r}_{\text{пр}}^{0{,}15}$	
4	Clays, lam	Vertical extended charge length l roundness S=100	$T_R^{Z,X} = K_T^R \cdot Q_{пог}^{1/6} (0{,}015 \mathrm{l}_3 + 1) r_{пр}^{\mathrm{n_R}}$ $r_{пр} = \frac{\mathrm{r}}{\sqrt[3]{\mathrm{Q_{пог}} \cdot \mathrm{l}}}$	for $\mathrm{T_R^Z}$ $K_T^R = 0{,}95$, $n_R = 0{,}10$ for $\mathrm{T_R^X}$ $K_T^R = 0{,}065$, $\mathrm{R}_R = 0{,}15$
5	Clays	For the period of oscillation of the bulk wave at the boundary of the hearth	$T_P = 0{,}04 Q_{вв}^{1/6}$	

It should be pointed out that such comparisons are appropriate to perform in the settlement point in the distance r_R' which we conventionally referred to as the distance $r_{пр} = 1$, from this point increases the period T_R and its comparison with the index for volume waves on the free surface is incorrect. Finally, analysis of the formulas 1 and 3 shows in addition to the equality of the actual period T_R of formula 1 with Z - component T_R^Z of formula 3 (a difference of only about 1%) that the ratio $T_R^Z : \mathrm{T}_\mathrm{R}^\mathrm{X}$ at point $r_{пр} = 1$, representing about 1.45 indirectly confirms the order of the ratio of axes in ellipsoidal configuration trajectory for $r_{пр} = 1$. In general, the lack of information content available empirical evaluation mechanisms timing R - waves requires the fulfillment of complex research on the analysis of existing and development of new methodological approaches in the preparation and processing of the experimental data to obtain the most reliable indicators of empirical coefficients. To this end, we calculated the time - the frequency performance under different formulas in R - wave and compared with each other and with values in R - wave depends on two main factors: the weight of the charge and the reduced distance, the results of which are shown in Table. 3 - 5. For clarity, in Fig. 1 shows plots of the oscillation period in the R - wave during blasting in loess concentrated charges weighing from 20 (Figure 1.1) to 10,000 kg (Figure 1.4) as a function of epicentral distance. Fig. 2 shows similar graphs for blasting in loam vertical charge rate per unit length of the same length of 1 kg / m (fig. 2.1) to 30 kg / m (fig. 2.5).

Table. 3 shows the results of calculations using the formulas in Table 1,2,3. 2, which in the latter case were calculated as the coordinate components for X, Z, and their geometric sum.

Analysis of the data in the table leads to several conclusions concerning the evaluation time - frequency characteristics of the R - waves of different authors from among the most frequently cited. It can be considered quite reasonable to consider this option as a feature $Q_{вв}^{1/6}$. From a comparison of the values of the formula 1 T_R in clays with indicators Z - component $\mathrm{T}_\mathrm{R}^\mathrm{Z}$ according to Equation 3, we see that they agree on the entire range of the balance of the charge and given the distances. A similar equation is observed when comparing the data from the formula 1 T_R for loam to counts on X - the third component of the formula.

Thus, considering three functional dependence T_R $(Q_{вв}^{0,13}; Q_{вв}^{0,1667}; Q_{вв}^{0,2})$ can take any one of the formulas sufficiently informative for various reasons: the formula 1 because of the uncertainty of the real direction with respect to the surface and securable, in Formula 2, the functional dependence $Q_{вв}^{1/6}$ is done in a manner different from, and in the latter case ($T_R = f(Q_{вв}^{0,2})$), moreover, do not take into account the influence of the reduced distance factor $r_{пр}^{\mathrm{n_R}}$. Table. 3 shows a comparison of calculated indices by two techniques for the surface and under for longitudinal waves at various combinations of weight of the charge and the reduced distance.

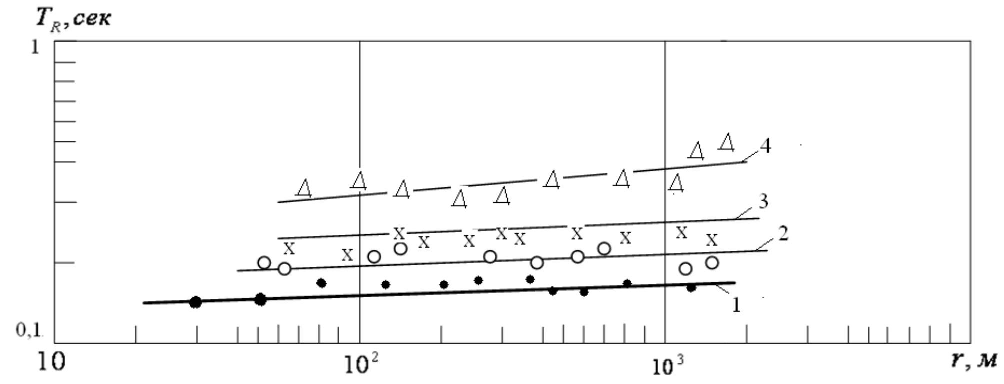

Fig. 1. Graph of dependence $T_R = f(r)$ R- wave to the explosions in the loess charge different capacity:

1 – a = 20 kg; 2 – a =160 kg; 3 – a = 1t; 4 – a = 10t

Table 3. Comparison of calculated data in the period of oscillation of volume of clay in (Formula 5, Table 2), the surface (Formula 1, Table. 2) and a total x and z components of (Formula 3 Table. 2) depending on the weight of the charge and reduced distance.

Weight, kg	T_P (by formula (2) in the clays	T_R (by formula (4) in the clays	$T^c{}_R = \sqrt{\left(T_R^Z\right)^2 + \left(T_R^X\right)^2}$						
			$r_{пр} = 1$	$r_{пр} = 5$	$r_{пр} = 12$	$r_{пр} = 50$	$r_{пр} = 100$	$r_{пр} = 150$	$r_{пр} = 200$
5	0,052	0,104	0,128	0,154	0,17	0,203	0,222	0,232	0,241
10	0,059	0,118	0,144	0,173	0,193	0,228	0,249	0,261	0,271
50	0,077	0,154	0,188	0,227	0,252	0,299	0,327	0,344	0,356
100	0,086	0,172	0,21	0,251	0,29	0,336	0,365	0,383	0,398
160	0,0932	0,186	0,23	0,276	0,307	0,365	0,395	0,416	0,43
500	0,113	0,225	0,277	0,302	0,37	0,441	0,479	0,5	0,542
1000	0,126	0,253	0,312	0,375	0,417	0,495	0,536	0,564	0,586
3000	0,152	0,304	0,374	0,45	0,499	0,594	0,645	0,693	0,739
9000	0,182	0,365	0,448	0,54	0,6	0,715	0,775	0,813	0,844

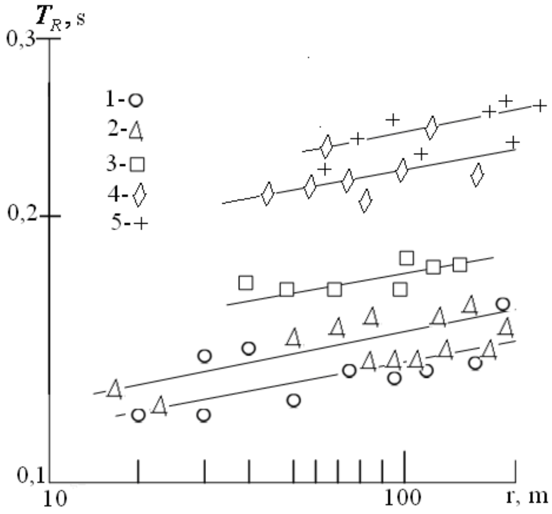

Fig. 2. The period of oscillation in the surface wave in the explosion loam cylindrical vertical charge length of 8 m and a linear weight (kg / m):

1 – 1kg; 2 – 15kg; 3 – 3.85 kg; 4 – 16.5 kg; 5 – 30 kg [1]

Table 3 shows that the total value T_R^c compared with the counted formula 1 for clay charge regardless of the distance weight r_{np}= 1 is more than 1.23 times, when r_{np} =200 in 2.32 times. Compared with the data for a longitudinal wave T_R^c in more than 2.46 times at the reduced distance r_{np}= 1 and 4.64 times at r_{np} = 200 and any weight of charge. This way at any epicentral distance the above surface wave is much more earthquake-prone than the bulk, which in any hypocentral distances at different points on the surface may not exceed the period of oscillation at a point r_{np}= 1.

Conclusions

1. Frequency timing parameters of surface waves significantly affect the critical parameters of seismic safety regulations, which, depending on the value of the coefficient m (the ratio of the oscillation period in the R-wave to the period of oscillations of the protected object) should be adjusted to increase or decrease (Table 1).
2. For a more reliable estimate of the parameters of the surface waves in use securable total rate T_R^c which is more than 20% higher than that obtained using Formula 1, Table 2.
3. Cumulative oscillation period in R-wave increases in the range of the above range 1 - 200 1.88 times at any weight studied charge (Table 3).
4. In the given distance r_{np}= 200 total period T_R^c of 4.64 times greater than the values obtained using the formula of Table 1, 2.
5. Value Z and X component varies with 1.45 when r_{np}= 1 to 1.11 r_{np}= 200, i.e. 1.3 times more. This indirectly confirms the volatility profile of R-waves along

the free surface in the direction of reducing the ratio of the axes ellipsoidal trajectory of the particles.

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