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ПОВЕРХНОСТНЫЙ СЛОЙ ГРУНТА - КАК ГЕНЕРАТОР КОЛЕБАНИЙ СДВИГА ГРУНТА

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UPPER SOIL THICKNESS IS THE STRONG INTENSIFIER OF DESTRUCTIVE EFFECT OF SEISMIC WAVES AND GENERATOR OF SHEAR SOIL OSCILLATIONS

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It is formulated and based the specific property of upper soil thickness to be the strong intensifier of destroying effects of seismic waves caused by quick braking of waves in upper soil layers. This effect produces the intensive acceleration of upper soil mass, which makes shear shocks on building's foundations and cut off their columns and walls.

Wave impulse displacements of upper soil then produce its own shear low-speed oscillations. The parameters of them are found in this article.

It is discovered the specific mechanism of mutual transformation of shear waves and upper soil layers when shear waves cross these porous layers, which cannot conduct and perceive the tensile and shear stresses.

It is established that total usage ofpendulum devices is the main reason of deficit information about destroying seismic wave impulses.

There is experimental conformation of this theory.

Key words: *seismic, waves, impulse, shock, soil, upper, thickness, oscillations, shear, displacement, destructive, buildings, column, layer.*

Сформулировано и основано на конкретных свойствах поверхностной толщи грунта что они являются сильным усилителем разрушительных эффектов сейсмических волн, вызванных быстрым торможением волн в верхних слоях грунта. Этот эффект приводит к интенсивному ускорению верхней массы грунтов, что дает сдвиговые толчки на фундаменты зданий, их колонн и стен.

Смещения от волновых импульсов в верхнем слое грунта затем производит его собственные сдвиговые низкоскоростные колебания. Его параметры представлены в этой статье.

Обнаружено, что специфичный механизм взаимной трансформации поперечных волн и поверхностных слоев грунта когда поперечные волны пересекают эти пористые слои, которые не могут проводить и воспринимать растяжения и сдвиговые напряжения.

Установлено, что всеобщее использование маятниковых приборов является главной причиной дефицита информации о разрушительных сейсмических волнах. Существует экспериментальное подтверждение этой теории.

Ключевые слова: *сейсмические волны, импульс, удар, грунт, верхний, толщина, колебания, сдвиг, смещение, разрушительный, здание, колонна, слой.*

Based on results of our investigations of anomalous shear forms into seismic destructions in columns and walls we have made the conclusion that every strong earthquake must produce destructive impulses carrying by shear waves.

People touch these wave shear impulses like shocks in the soil. They have large soil velocity $V_i > 2$ m/sec, which act on foundations and cut off columns and walls of buildings [1,2,4 - 6].

The destructive shear seismic waves cause the displacement of upper soil thickness, which then begins to oscillate.

Standard pendulum seismic devices [7] fix just these shear soil oscillations. They carry small soil velocity $V_2 < 1$ m/sec, which is no able to cut columns and walls off, and it is not dangerous for buildings.

Here we intend to prove that upper soil thickness has extraordinary and important property, which very much increase destroying abilities of seismic waves.

Thus, we confirm that upper soil thickness, having the depth of 100 - 150 m, must be the strong intensifier of destroying effect of seismic waves, when they cross this thickness under enough steep angles to the soil surface.

The particular case of this special effect for the second shear waves have been described by us in papers [1,2].

Here we at first time intend to give the strictest and common wording of this effect and intend to discover its physical sense.

According to the experimental data, received in [3], seismic waves decrease at ten times their phase velocity, when they run through the upper soil thickness, having the height H equal to 100 -150 m, because it has very big gradient of modulus E and G of longitudinal and shear soil deformation.

When every seismic waves brake themselves and lose their phase velocity C they must intensively increase the soil velocity V, which determine the destroying force of seismic waves for buildings.

This correlation between phase wave velocity C and mass soil velocity V must appear when every seismic wave goes through'every quasi-elastic environment, which intensively decrease its modulus E and G into direction of wave's movement. That correlation can be correct only if the area F of wave's front is constant.

In our case the condition F = constant is real, because the height of specific upper soil thickness $H < 150$ m. It is many times smaller then the lengths of whole run of seismic wave equals to tens of kilometers.

The effect of big increasing of mass soil velocity V because of decreasing wave phase velocity C follows directly from the law of preservation of impulse P-t of the force P for the time t, which must be equal to the quantity of movement of mass m at velocity V: P-t = mV).

For longitudinal wave this law can be written as

P-t = mV = const; m = pFCt, (1)

where m - soil mass, which can be drawn in the movement for the time t; a - wave compressive stress; t - time of action of the wave force P = (Fa); p - soil density.

The law of preservation of impulse (1) can be written for upper and down soil layers of upper thickness in the following form:

(Fo)t = $m_d V_d = m_u V_u$, or p_d F C_d t V_d = p_u F C_u t V_u (2)

From (2) we can find the basic dependence between upper V_u and down V_d velocities into upper thickness:

$$v_u = v_d \frac{\rho_d C_d}{\rho_u C_u}. \quad (3)$$

The same formula can be received from the equilibrium conditions of the soil into the seismic wave:

a = c_d = <y_u = const; $c_d = p_d C_d V_d = o_u = p_u C_u V_u$. (4)

If we take into account doubling of upper soil velocity after reflection from upper soil surface, we should determine the value of velocity V_u by formula

$$v_u = 2v_d \frac{\rho_d C_d}{\rho_u C_u}. \quad (5)$$

According to experimental investigations [3] $\frac{C_d}{C_u} = 10$ and $\frac{\rho_d}{\rho_u} = 2$.

Therefore, upper soil thickness can increase wave soil velocity in forty times. At the same time, waves decrease their phase velocity C in ten times.

That is the issue of strengthening effect of upper soil thickness. This special effect also displays itself in increasing of energy in upper soil layers. We can show that upper soil layers accumulate 20 times more energy U_u then down layers having energy U_d. If we take into account that summary wave energy equals to U = mV^2, then according (2, 3) we find:

The value of energy U is equal to work of the force P = (Fo) multiplied on its way: S = v t.

We can see that way $S_u = V_u$ t of force P = (Fa) into upper soil layers is 20 times more then its way $S_d = V_d$ t into down layers. It means work of force P = (Fa) for the time t produced in upper layers is 20 times more than in down layers.

All formulae (1 - 6) we can also use for shear waves, if we change in them normal stresses c on shear stresses т = GV(C)^л and phase velocity c = <>jEp~^J on shear phase velocity c = <\jGp~^J (G - shear modulus of soil).

The strengthening effect of upper soil thickness became more weak because seismic waves lose part of their energy, when they run through no elastic upper soil layers.

Seismic waves spend part of their energy there for the non-elastic deformations and for the work of friction forces into upper soil. The value of these wastes is proportional to the length of the way S, which was gone by seismic waves, when they cross the feebly compressed and very porous upper soil thickness, having the height equals to approximately 50 m (as we show afterwards).

If waves move along the normal to the soil surface, they run along the shortest way into the porous environment. The length of this way is equal to 50 m. In this case, the wastes of the waves' energy are at minimum and equal approximately to 20 % [5].

Into [1, 2] we analyzed the specific destroying process, which occurs into zones, placed just near the borders of region of seismic destructions, situated at large distance L from epicenter.

If L > 5H_h, (H_h, is depth of hypocenter), direct way of waves from hypocenter to buildings into non-elastic soil increases in more than five times. Because of it, the wastes of energy became equal to 100 % and their destroying effect equals to naught at these zones.

Because of it shear destructions of buildings in these zones can be produced by second shear waves only, which cross upper soil thickness along the normal to the soil surface. These second shear waves are born just under buildings by abyssal longitudinal waves, which run under buildings on the depth of more than 100 m [1, 2].

We found [4 - 6] that the most and a typical form of seismic destructions is the anomalous shears of columns and walls of buildings. On this basis, we made the conclusion that only one possible and real reason of these specific shear destructions must be impulses in shear waves, which produce large horizontal soil velocity V > 2 m/sec causing these shear destructions.

At zones placed near the epicenter, where L < H h, shears of building are caused by the first shear waves.

At middle zones, where H j, < L < 4H h« shears of building are produced by shear and longitudinal waves together.

At far zones, where L > 4H h, shears of columns and walls in buildings can be produced by the second shear waves [1,2].

Into zones, where L < 4H h, longitudinal waves compress building's columns and walls and destroy them together with wave shear stresses, produced by shear waves.

Now in the second part of our article we must explain how seismic shear waves can run through the very porous upper soil, if there waves carry enough large shear stresses т and main tensile stresses o_m^+ = r having value т = pCV more than 0.5 MPa [1,2].

The issue of the problem consists into the next: it is well known that weakly pressed upper soil, in principle, cannot perceive any tensile and shear stresses even at high speed of loading.

At the large depth soil mass is pressed by strong vertical pressure P > 1 MPa and horizontal pressure of 0.2P. Together they produce incline pressing stresses $|o_p"|$ > 0,5 MPa. So long, at this depth H > 50 m soil can perceive without problem the tensile wave stresses $<x_m^+$ < 0.5 MPa < $|cr_p"|$. Besides, soil can perceive shear stresses т at the expense of friction stresses (here the coefficient of friction f in the soil is approximately equal to 1).

When shear waves come into upper soil layers (where H < 50 m), situation principally changes. There tensile wave stresses c_m = т = $GVC\sim^1$ produce incline planes of soil ruptures. These rupture planes dismember the soil environment onto incline stripes, which are pressed by main pressing stresses $|o_p|$ = т.

These stripes incline at the angle of 45 e to soil surface and direct to the side from epicenter. The thickness of pressed soil stripes equals to some meters; their width equals to 50 m • (sin45 e) $^{'l}$ - 70 m; their length can be equal to hundred meters.

After appearance of incline pressed stripes, shear waves can cross very upper soil layers. However, for it they must transform themselves into two new waves: new longitudinal waves and new shear waves, which at the sum give the beginning soil velocity V.

The first new wave is the compressive longitudinal wave running along the incline stripes with the phase velocity $C_1=\sqrt{E}p^{-1}$. It produce soil velocity V i = 0.7V and pressing stresses $|\sigma 1|$ = pV $1(C\ 1)^{-1}$.

The second new wave is the shear wave running along incline stripes. It has phase velocity $C_2=\sqrt{G}p^{-1}$ and carries shear stress $r_2 = pV_2C_2$ and soil velocity V_2 - V ь directed across the stripe. If we summarize V i and V $_2$, we receive the beginning horizontal vector V.

Into pressed incline stripes shear wave stress т $_2$ can be received by the expense friction stress т $_f$ = f« of. The value т f > r, because f = 1. Besides, the main tensile vertical stress a_2^+ = т $_2$, can be covered by pressing stress of first new waves. It is easy to prove that $0.7\ |\sigma_1| > \sigma_2^+ = \tau_2$.

As a result, all tensile stresses disappear into very upper soil thickness. Besides, these new two waves produce the new intensive horizontal pressure, having value $|\ 0.7\ \sigma_1 + \sigma_2^-\ |; |o_2^-| = \tau$.

This new pressure causes the disappearance of ruptures in very upper soil. So long as the upper soil environment becomes continuous again, it has new transformed picture of stresses' field.

All of these stress and soil transformations do not influence on the strengthening effect of upper soil thickness, which has been described earlier.

Above we have described the first and the most dangerous wave process, which is the main reason of seismic buildings' destructions. We can confirm that destructive wave impulses really exist, because they print themselves into anomalous shear destructions of columns and walls [4-6]. People feel these wave impulses like series of soil shocks, which evidently differ from soil oscillations (Fig. 1). At this process, the shear waves cause the displacements of upper soil thickness, which produce its own shear oscillations - that is another second process.

Thus, we confirm that seismic soil oscillations have nothing common to the previous destructive wave process, which only initiate another second oscillation process - the process, where upper soil thickness makes its own shear oscillations (Fig. 1). They have small frequency co, period T =2я $co^{'1}$, and low soil velocity V < 0.8 m/sec, which is not dangerous for columns and walls of buildings.

Let us find formula for frequency co of upper soil thickness, which is displaced at value of A $_0$ by shear waves. The thickness has the depth H, area F and mass m = pHF (p is middle soil density). The center of heaviness of this upper soil mass is placed on the height of approximately 0.4 H from down plane of displaced soil thickness. Because of it, we have the following equation for its own no damping shear oscillations:

$$0.4\frac{\partial^2\Delta(t)}{\partial t^2}m - r\Delta(t) = 0; \quad \frac{\partial^2\Delta(t)}{\partial t^2} = \frac{r}{0.4m}\Delta(t) = \omega^2\Delta(t), \tag{7}$$

where **Δ(t)** – displacement of upper surface of soil thickness; **r** – return shear reaction of displaced thickness if **Δ(t)** = 1; ω – value of own soil thickness frequency; $\omega^2 = \frac{r}{0.4m}$.

If we take into account that **r = F τ; τ = G γ; γ = 1/H,** we can find that $r = \frac{FG}{H}$ (**r** – return shear reaction of displaced thickness if **Δ** = 1); **γ** – according shear deformation; **G** – middle value of soil shear modulus. Having that $r = \frac{FG}{H}$; **m = ρHF;** $\overline{C}_2 = \sqrt{G\rho^{-1}}$; $\omega^2 = \frac{r}{0.4m}$; we can receive the following formula for ω and **T**:

$$\omega^2 = 2.5\frac{r}{m} = \frac{2.5G}{H^2\rho} = 2.5\frac{\overline{C}^2}{H^2}; \quad \omega = \sqrt{2.5}\frac{\overline{C}}{h}; \quad T = \frac{2\pi}{\sqrt{2.5}}\frac{H}{\overline{C}}. \tag{8}$$

where $\overline{C}$ - middle shear wave phase velocity into upper soil thickness. For example, if **H** = 100m and $\overline{C}$ = 500 m/sec [3], T= 0.8 sec.

Finally, we must state the most important problem, which is the main reason of permanent failures of official strategy in building's seismic protection, described in [4 – 6]. This problem is the total using of pendulum seismic devices, which can reflect only harmonic soil oscillations. But this very specific devices, in principle, cannot fix the short seismic impulses (Fig. 1) [7], which are printed into all shear destructions.

Above we stated that the most typical anomalous shear forms of seismic destructions in columns and walls cannot be caused, in principle, by low speed soil vibrations, fixed by standard pendulum devices [4 – 6]. Into [4 – 6] we proved that these extraordinary forms could be caused only by shear wave impulses producing destroying soil velocity **V** > 2 m/sec. However, pendulum devices do not give us necessary information about these destroying impulses [7].

We will really be able to protect our buildings against earthquakes, if only we use some another types of seismic defense, which can exactly reflect short wave impulses [7].

It will permit us to elaborate the new effective strategy of earthquake protection and refuse from existing failure strategy, which contradicts to real form and real facts of seismic destructions [1-7].

The experimental basis and confirmation of above-mentioned theory are the results of experiments conducted Kirghiz State University of Building, Transport and Architecture in 2009.

In these experiments with the help of vibration platform it was modeled the influence of strong seismic oscillations onto models of clay mud houses.

According to data of analysis of real seismic destructions, the real clay mud houses destroy at officially fixed accelerations of 0.2g.

In our experiments, we saw impossibility to destroy these models even at the acceleration of 1.2g, which is six times more than 0.2g. These results confirm our main theoretical postulate: at the earthquakes, buildings, in principle, cannot be destroyed by the official soil oscillations. In reality, buildings are destroyed and go to ruin by seismic waves' impulses, which are unknown yet to the official seismic science.

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