THE INFLUENCE OF THE OVERGROUND AND UNDERGROUND PARTS OF CONSTRUCTION HIGHTS CORRELATION ON THE INTENSITY OF SEISMIC EFFECT

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Approximate solution of the problem of influence of the construction underground part value on the oscillation intensity of this construction during an earthquake is considered. Interchange of ground and underground parts of the construction depends on the conditions of reflection and refraction of approaching seismic waves. One takes into account the fact that horizontal seismic action is transfered as throught horizontal and vertical surfaces. With distance increase from the Earth's surface seismic wave amplitudes are decreased.

To solve this problem in an approximate form the following simplifications are adopted:

a) approach of longitudinal and shear waves to the construction are considered apparently;

b) propagation velocities of longitudinal and shear waves are in relation as $1:\sqrt{3}$;

c) inertial forces inside the construction are summarized, the forces are caused by refracted waves as on horizontal and on vertical planes;

d) wave diffraction is not considered.

In some cases some underground storeys are constructed in a building. Seismic action can be different for the buildings with underground parts and for those without such parts.

Propagation of a plane seismic wave at angle α to the horizon is considered. Displacement vector U_p in sinusoidal longitudinal wave with frequency ω equals

$$\bar{U}_{p_1} = \bar{a}_p \exp\{i\omega[t - (x \sin\alpha + z\cos\alpha) : V_{p_1})] \quad (I)$$

where a_p is amplitude of longitudinal wave, V_{p_1} is velocity of longitudinal wave in ground, $x \sin\alpha + z\cos\alpha$ determins the position of isophasal planes of seismic wave approach at angle α.

Refracted waves propagate in underground part of construction with amplitudes:

$$\bar{u}_{p_2} = B_{pp}\, \bar{a}_p \exp\left[i\omega\left(t - \frac{x \sin\alpha_2 + z\cos\alpha_2}{V_{p_2}}\right)\right] \quad (2)$$

$$\bar{u}_{s_2} = B_{ps}\, \bar{a}_p \exp\left[i\omega\left(t - \frac{x \sin\alpha_2 + z\cos\alpha_2}{V_{s_2}}\right)\right] \quad (3)$$

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I corresponds to ground, 2 corresponds to building, ρ is longitudinal wave, s is shear wave. Refracted coefficients B_{pp} and B_{ps} of longitudinal wave on the boundary ground-building are functions of incident angle of wave α, velocities of wave propagation and density. For fall shear wave refracted coefficients are B_{sp} and B_{ss}.

Inertial forces appear in the boundary layer of the building underground part, the thickness of which equals I. X_x is horizontal force on the vertical surface, X_z is horizontal force on the horizontal surface (foot). These forces are equal to the product of mass and acceleration.

$$X_x = F_x \, h \, \rho_2 \, \bar{a}_p \, \omega^2 (B_{pp} \cos \alpha_2 + B_{ps} \sin \beta_2) \quad (4)$$

$$X_z = F_z \, h \, \rho_2 \, \bar{a}_p \, \omega^2 (B'_{pp} \sin \alpha'_2 + B_{ps} \cos \beta'_2) \quad (5)$$

F_x is squar of vertical surface of underground part of the construction, F_z is squar of horizontal surface, ρ_2 is density, α_2 and β_2 are refracted angles while falling $\bar{a}_p$ wave on the vertical surface at angle α, α'_2 and β'_2 are refracted angles while falling of $\bar{a}_p$ wave on the horizontal surface of construction boundary at angle $90^\circ - \alpha$, h is surface layer of construction equal I, B is refracted coefficient with appropriate indexes.

Summary horizontal force Z_p depends on fall angle of longitudinal wave α and corresponding refracted coefficients

$$Z_p = X_x + X_z \quad (6)$$

Expression (6) can be written in dimensionless form taking into account the fact that during variations of angle α product $h \rho_2 \bar{a}_p \omega^2$ is constant, it simplifys calculations.

Approach to the construction of shear wave with amplitude $\bar{a}_s$ and refracted coefficients B_{ss}, B_{sp}, B'_{ss} and B'_{sp}.

Numerical calculations were made for seven constructions of different types projected for seismic regions in two cases of relation between velocities of wave propagation in construction and ground $V_1 : V_2 = I.3$ and $V_1 : V_2 = 0.4$. Corresponding relation of densities were $\rho_1 : \rho_2 = I.04$ and $\rho_1 : \rho_2 = 0.8$. Various angles of wave approach are considered (α).

In the ground which is basement for constructions oscillation amplitudes decrease with the distant growth from the Earth's surface. Body longitudinal and shear waves approached normally to the Earth's surface, have doubling amplitudes at the cost of reflection from day surface. Exchange waves are absent in this case. Reflected wave has the same amplitude as fall wave $\bar{a}_{PP} = \bar{a}_P$; displacements have the same directions. Summary amplitude on the surface is two times greater as displacement inside medium $\bar{a}_{PP} + \bar{a}_P = 2\bar{a}_P$. This condition changes a little while approaching to the surface of body waves at angle α At the depth equal to the length of half-wave amplitude decreases two fold.

When surface wave propagates the ground particle moves along ellips counter-clockwise in vertical plane passing from source to the point of observations. Variations of the values of displacements from depth H depends on wave length λ. and on σ (Poisson's ground ratio). According to experimental data relations between horizontal displacement $a_{0.1}$ at the depth H = 0.I λ and displacement on the surface a_0 are the following:

$$\frac{a_{0.1}}{a_0} = 0.46 \text{ (when } \sigma = 0.44)$$
$$\frac{a_{0.1}}{a_0} = 0.26 \text{ (when } \sigma = 0.3\text{)} \qquad (7)$$

At the depth H = 0.03 λ

$$\frac{a_{0.03}}{a_0} = 0.77 \text{ (when } \sigma = 0.44)$$
$$\frac{a_{0.03}}{a_0} = 0.74 \text{ (when } \sigma = 0.74) \qquad (8)$$

When grounds are stratified the appearence of standing waves as a result of repeated reflections is possible. In this case for some frequencies specified resonance of oscillation amplitude substantiolly are increased. For instance[I],in region I acceleration records are given. The records were made in a well atdifferent depths during near earthquakes. Relation of maximum accelerations at depth 8 m α_8 and on the surface α_0 is $\alpha_8 : \alpha_0 = 0.45$. In the other cases [2,3] measured accelerations in wells at the depths about IO m and on the surface are in relation as 0.5:0.8.

Calculations for approach angle α of longitudinal and shear waves from 30° to 60° for underground part of the construction of 7 m. It corresponds to two underground storeys of nine-storeyed building in which relation of underground and overground parts correspond to about I:4. For instance, if oscillation amplitude at the depth of 7 m corresponds to 0.7 of amplitude on the surface, intensity of seismic action decreases approximately by IO%. Decreasement of inertial forces in the building can be calculated for concreat conditions depending on the underground part of the building, velocities of wave propagation and elastic construction characteristics.

Literature

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