INFLUENCE OF SOME SOIL PARAMETERS ON THE MODIFYING EFFECT OF LOCAL SOIL CONDITIONS

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Summary

It is well known that the local soil conditions modify the earthquake ground motion. One way to characterize the difference between motion on soil and motion on firm ground is to obtain the amplification spectrum.

The variety of real soil conditions puts very often some problems related to the thickness of the alluvium deposit, the dissipative behaviour of the soils and the interpretation of the results obtained. In this paper are given some results concerning the influence of soil parameters on the amplifying and filtering bedrock motions.

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The analyses of the consequences of varous earthquakes show very clearly that the local geology is the main cause for structural damages in many cases. One way to characterize the modifying effect of local geology is to obtain the amplification spectrum using the steady-state sinusoidal analysis. A simple model consisting of linear, homogeneous, horizontally stratified layers overlying a homogeneous half-space is investigated.

The amplitude amplification spectrum $A(\omega)$ depends on the frequency $\omega$, the layer thickness $H_j$ ($0<j<N$, N-number of the layers), the density $\rho_j$, the viscosity constant $\eta_j$, the shear wave velocity $c_j$ and the impedance ratio $\alpha_j = \gamma_j c_j / \gamma_{j+1} c_{j+1}$ ($\gamma_j = g \rho_j$) [1,2].

The energy-dissipative layered system is of practical interest [4,5]. When the viscous constant $\eta$ is known from experimental data for each layer it is very easy to calculate $A(\omega)$. But very often it is assumed that the damping is a fraction of the critical damping, for example $\lambda = \eta / \eta_{1,cr} = 0,05$. In this case it is necessary to determine $\eta_{1,cr} = 2 \rho c^2 / \omega_1$ where $\omega_1$ is the first natural frequency and $\eta = \lambda \eta_{1,cr}$. The frequency $\omega_1$ can be determined by the approximate formula $\omega_1 = \pi c_{av} / (2 \Sigma H_j)$ where $c_{av} = \Sigma c_j H_j / \Sigma H_j$, or by the first peak of $A(\omega)$ for elastic system. If the damping is of hysteretic type then $\omega \eta / (\rho c^2) = 2\beta$ where $\beta$ is a fraction of critical damping.

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The influence of some factors as the layer thickness, the total depth of the layered system, the shear wave velocity, the impedance ratio, the damping, etc. on the modifying effect of the local geology is stutied by some authors [2,3] assuming a layered system with increasing layer stiffnesses, i.e. $0<\alpha_j<1$. Our investigations concern the more general case when $0<\alpha_j \gtreqless 1$.

For not energy-dissipative layered system with $0<\alpha_j<1$ [2] $1 \leq A(\omega)<\infty$. The case of $A(\omega)=1$ is practically impossible because it means that all $\alpha_j=1$. If some of $\alpha_j>1$, depending on the corresponding impedance ratios and thicknesses, it is posiible for some frequencies $A(\omega)<1$.

For elastic layered system and $0<\alpha_j<1$ the amplification factor at characteristic frequencies $\omega_n$ has an upper bound $1/\alpha_N$ and a lower bound $1/(\alpha_1 \alpha_2 \ldots \alpha_N)$. When some of $\alpha_j>1$ this is not always true and $A(\omega_n)_{max}$ depends on the value of $\alpha_j$ and $H_j$.

Some authors point out that if $\alpha_N$ is sufficiently small all $A(\omega_n)$ will be prominent, but if $\alpha_N$ is large the resonant amplifications are greatly suppressed. This is correct only when it is not a graet difference in $\alpha_1$, $\alpha_2, \ldots \alpha_N$. Fig. 1 and 2 show that even when $\alpha_N$ is very large it is possible to have significant amplification. More important is the ratio $\gamma_{N+1} c_{N+1} / \gamma_1 c_1$.

The values of $\omega_n$ depend on the impedance ratios, the total depth of the system and namelly on the ratio $H_{N-1}/H_N$

The influence of the damping on the $A(\omega)$ values is obvious (Fig. 1,2). For large values of $\omega$ $(\omega>20)$ $A(\omega_n)$ decreases very rapidly. The amplification is slightly sensitive to the various values of $\lambda$ or $\beta$ for each layer.

The modifying effect of local soil conditions depends not only on the physical parameters of the medium but also on some geometric characteristics as the total depth and the ratio between the thickness of two last layers over the bedrock.

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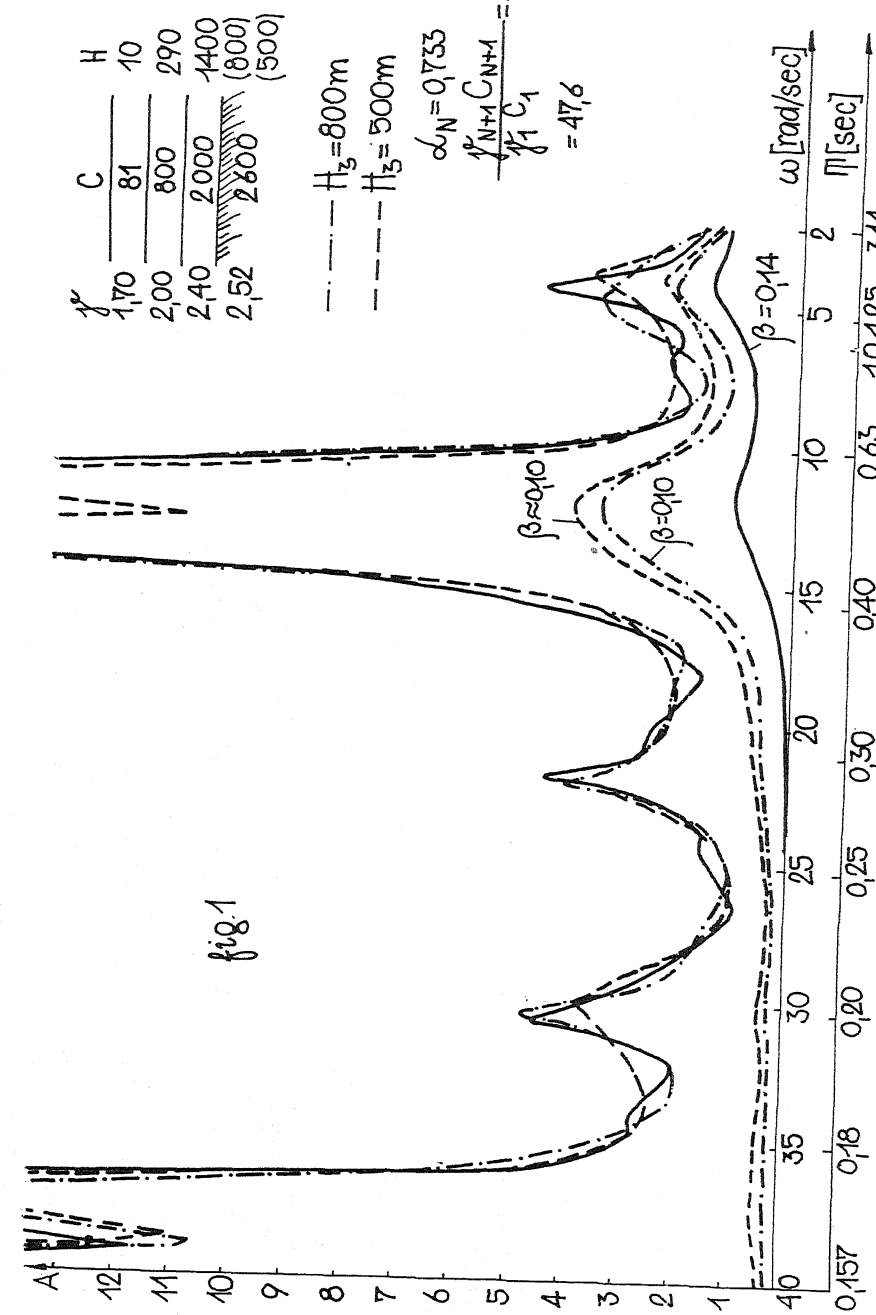
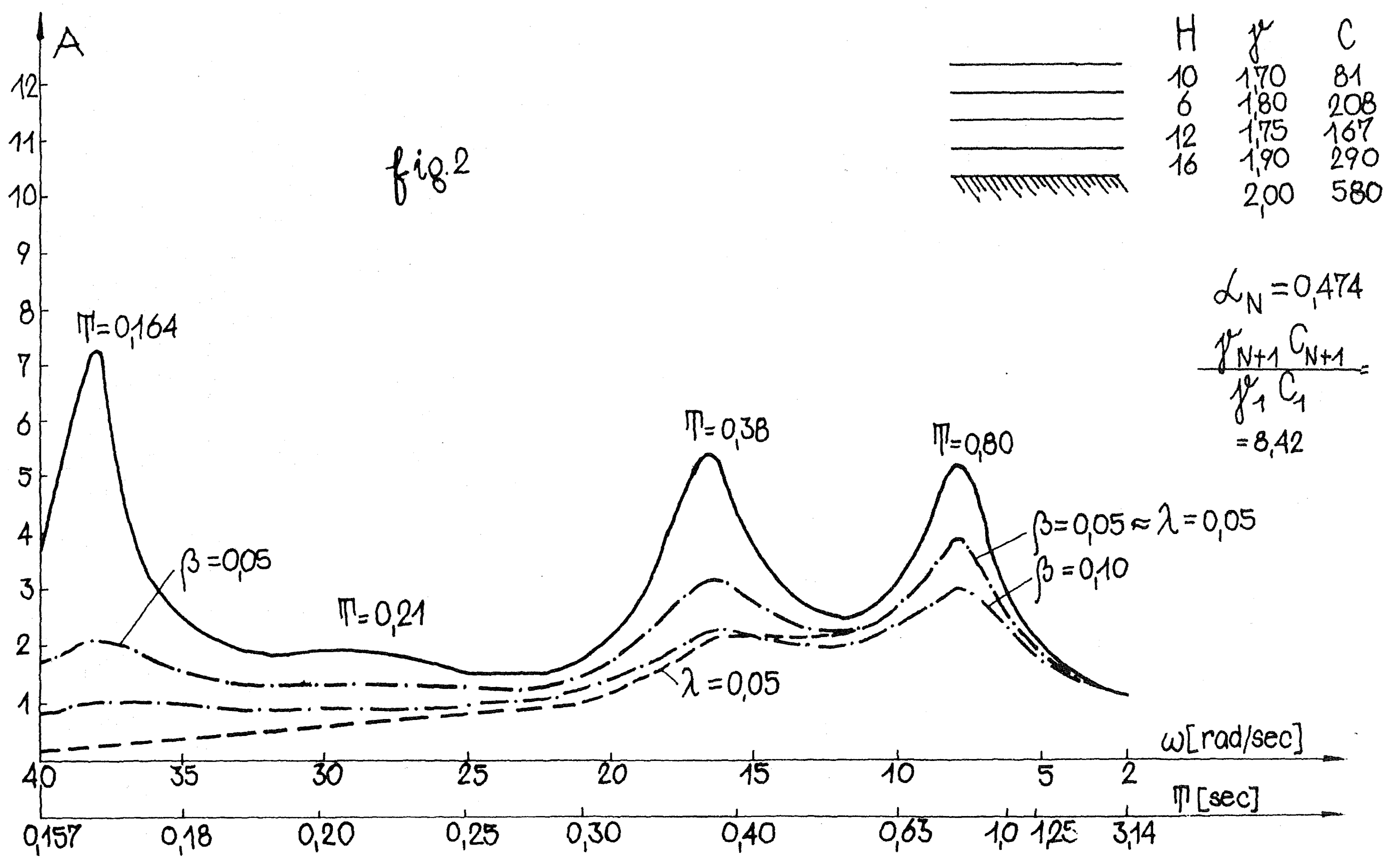


fig.1
A
ω [rad/sec]
T [sec]
γ C H
1,70 81 10
2,00 800 290
2,40 2000 1400
2,52 2600 (800) (500)
H_z = 800m
H_z = 500m
α_N = 0,733
γ_{N+1} C_{N+1} / γ_1 C_1 = 47,6
β = 0,14
β = 0,10
β = 0,10


A
fig.2
H γ C
10 1,70 81
6 1,80 208
12 1,75 167
16 1,90 290
2,00 580
α_N = 0,474
γ_N+1 C_N+1 / γ_1 C_1 = 8,42
T = 0,164
β = 0,05
T = 0,21
T = 0,38
T = 0,80
β = 0,05 ≈ λ = 0,05
β = 0,10
λ = 0,05
ω [rad/sec]
T [sec]
12 11 10 9 8 7 6 5 4 3 2 1
40 35 30 25 20 15 10 5 2
0,157 0,18 0,20 0,25 0,30 0,40 0,63 1,0 1,25 3,14