SOIL AMPLIFICATION FACTOR OF SURFACE WAVES

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SYNOPSIS

The paper presents the investigation of the effect of a horizontaly stratified deposit of soil layers in amplifying surface waves.The amplification spectra are obtained using the wave method of solution and they are given for different layer thiknesses and different rigidity of the rock.The influence of the layer thikness on the phase velocity of surface waves is studied and a critical wave number is determined.The comparison of the amplification spectra of surface waves and those of body waves is shown.

INTRODUCTION

The effect of local soil conditions in modifying the earthquake motions has been established for some time.Most of the work in this area has been concerned with studying the propagation of body waves [1,2,3].Two kinds of amplification factors are known:1.the ratio between the displacements (or accelerations) at the free surface of the layer and the corresponding displacements at the free surface of the rock without soil on top;2.the ratio of the displacements at the top of the layer to the corresponding displacements at the bottom of the layer (when the layers are more than one - the interface between the rock and the last layer).

This paper presents the analysis of the amplification spectra of surface waves propagating in a layer upon a rock. The determination of these factors for one layer as well as for multiple layers is given in [4] and [5].

ANALYSIS OF AMPLIFICATION SPECTRA OF SURFACE WAVES

The amplification factors are determined assuming that a plane harmonic wave propagates in elastic media parallel to the free earth surface;the rock is treated as an elastic half space [4].Using the wave method of solution the expressions of the displacements in matrix form are obtained and then the amplification factors according to the following relations:

$$A_h'(\omega)=\frac{u_s}{u_r^o}\,e^{i(k'-k)x};\qquad A_v'(\omega)=\frac{w_s}{w_r^o}\,e^{i(k'-k)x};$$

$$A_h''(\omega)=\frac{U_s}{u_r}\,e\qquad A_v''(\omega)=\frac{w_s}{w_r}$$

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where: $u_s, w_s, u_r^o, w_r^o, u_r, w_r$ are the displacements components at at the free surface of the layer, free rock surface and interface between the rock and the layer respectively; $\underline{k}$ and $\underline{k}'$ are wave numbers, $k' = \omega/0{,}9194 c_{2,r}$ with Poisson coefficient 0,25 and $c_{2,r}$ - shear wave velocity of the rock.

The values of $\underline{k}$ are obtained by the solution of a real transcendental equation (without damping). In the case of P and S waves the values of their velocities are material parameters but in our case the wave number has to be determined in every particular case because the surface wave velocity depends on the layer thikness. In the analysis of $\underline{k}$ as a function of layer thikness a critical wave number is determined and it shows when the layer could be treated as a waveguide or a half space [5]. This fact leads to the conclusion that the amplifying effect of surface waves could be determined for layers with thikness no more than half wave length.

The amplification spectra of surface waves of a layer with thikness H=20 m., $\rho = 0{,}20$ t.s^2/m^4 and $c_{2,s} = 225$ m/s and a rock with characteristics $\rho = 0{,}20$ t.s^2/m^4 and $c_{2,r} = 1007$ m/s (for x=0) are shown in fig.1 and 2.

It is interesting to show the influence of layer thikness as well as the change of the ratio between the shear modulus of the rock and the layer. This is ilustrated in fig.3 and 4 (only for A_h'). Similar results are obtained for A_h'', A_v' and A_v''. Fig.5 shows the influence of the damping where β is the fraction of critical damping corresponding to body waves The amplification spectra (A_h') of P, S and surface waves are shown in fig.6.

CONCLUSION

The analysis of the results shows that the amplification spectra of surface waves depend on the layer thikness and taking into account the natural periods of structures constructed in Bulgaria soil layers with thikness from 30 m. to 50 m. are more dangerous for buildings. It is evident from fig.6 that for some structures (depending on their natural periods) the soil amplification effect of surface waves is of great importance.

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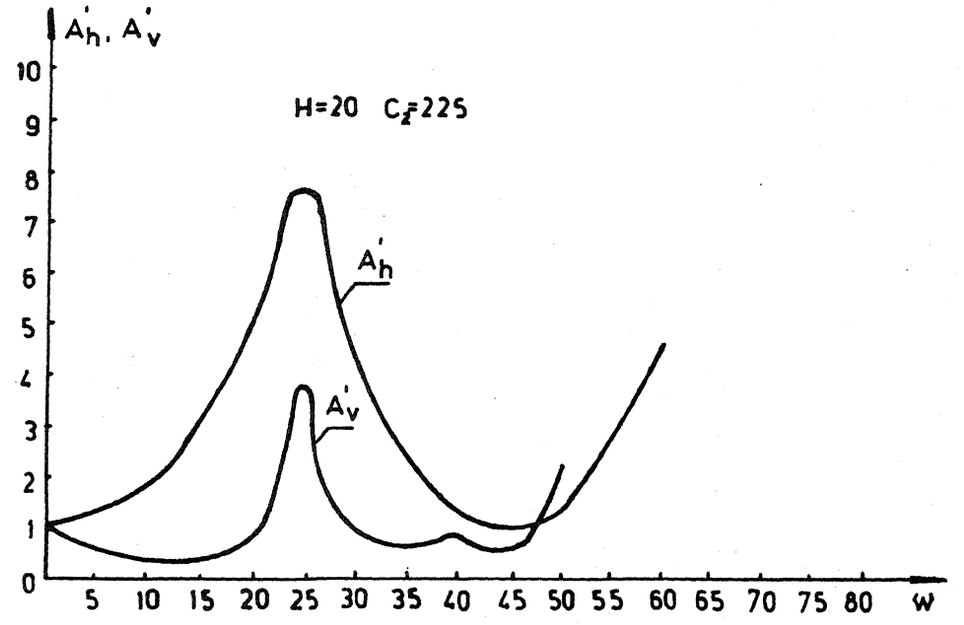
A'h, A'v
H=20 Cz=225
A'h
A'v
0 1 2 3 4 5 6 7 8 9 10
5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 w

fig.1

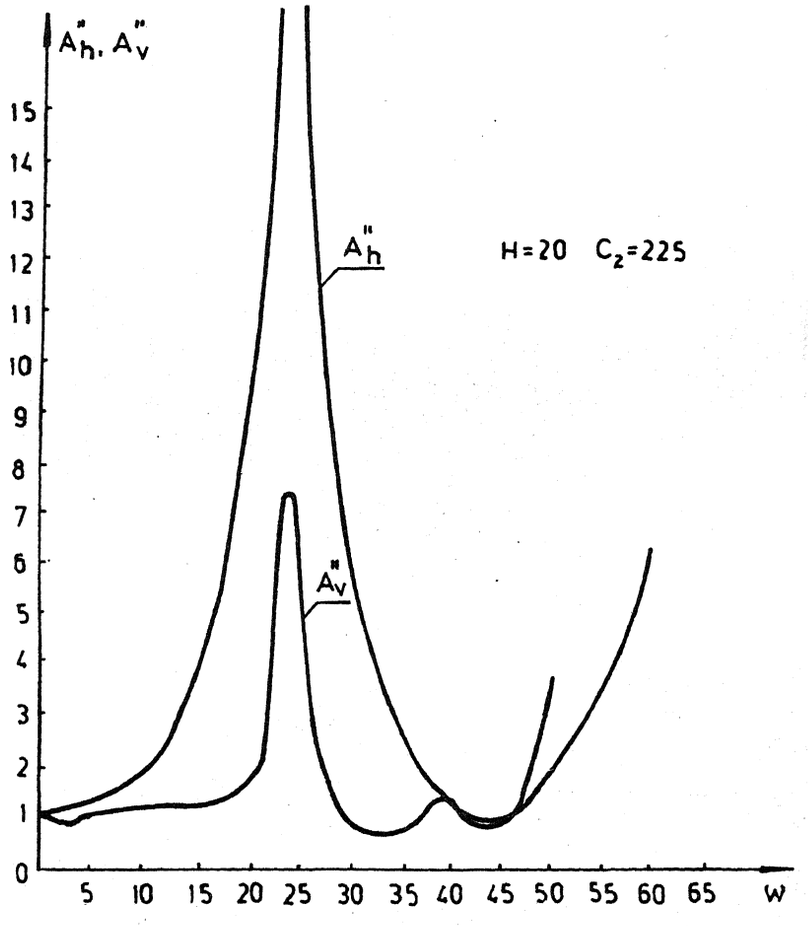
A"h, A"v
A"h
H=20 Cz=225
A"v
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
5 10 15 20 25 30 35 40 45 50 55 60 65 w

fig.2

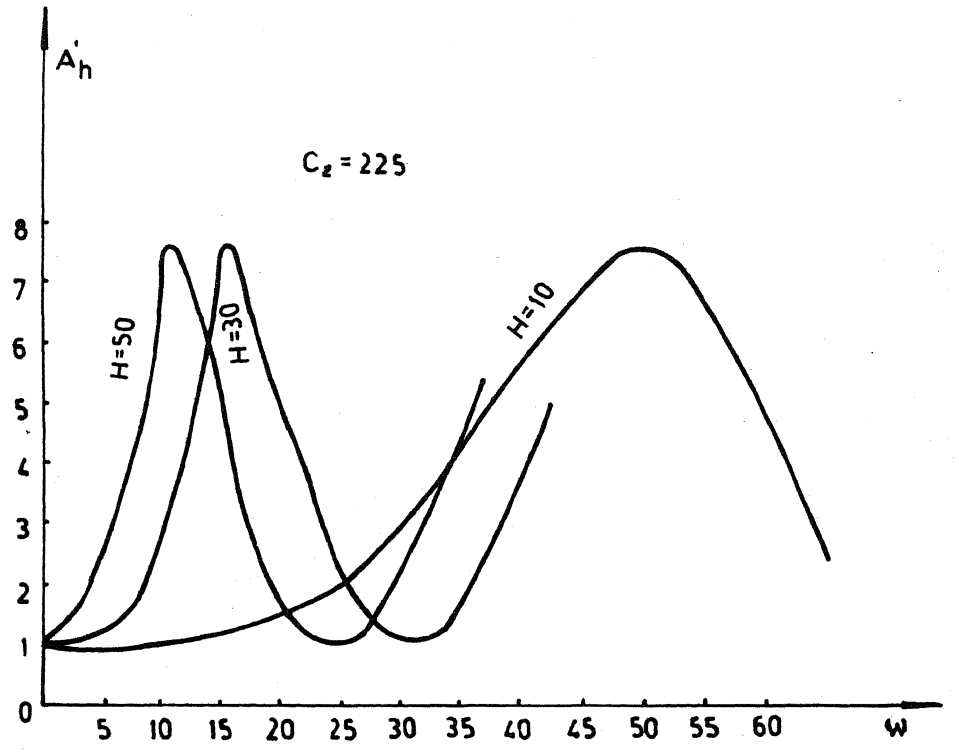
A'h
Cz = 225
H=50
H=30
H=10
0
1
2
3
4
5
6
7
8
5
10
15
20
25
30
35
40
45
50
55
60
w

fig. 3

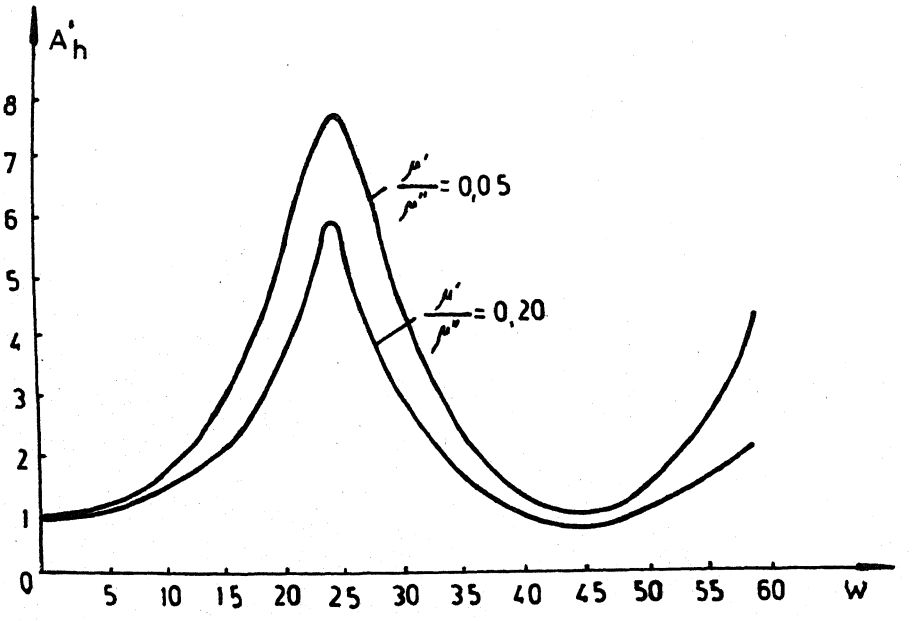
A'h
μ'/μ'' = 0,05
μ'/μ'' = 0,20
0
1
2
3
4
5
6
7
8
5
10
15
20
25
30
35
40
45
50
55
60
w

fig. 4

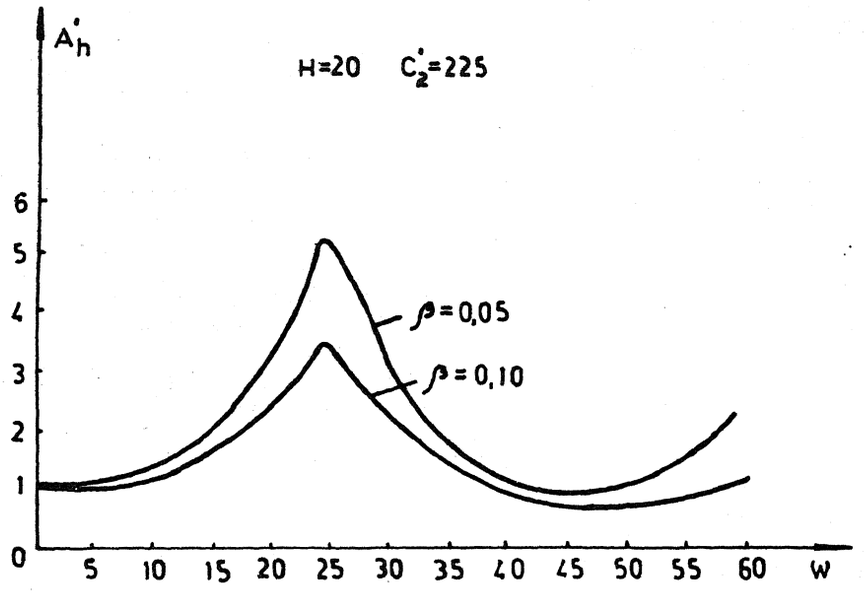
A_h'
H=20 C_2'=225
6
5
4
3
2
1
0
β=0,05
β=0,10
5 10 15 20 25 30 35 40 45 50 55 60 w

fig. 5

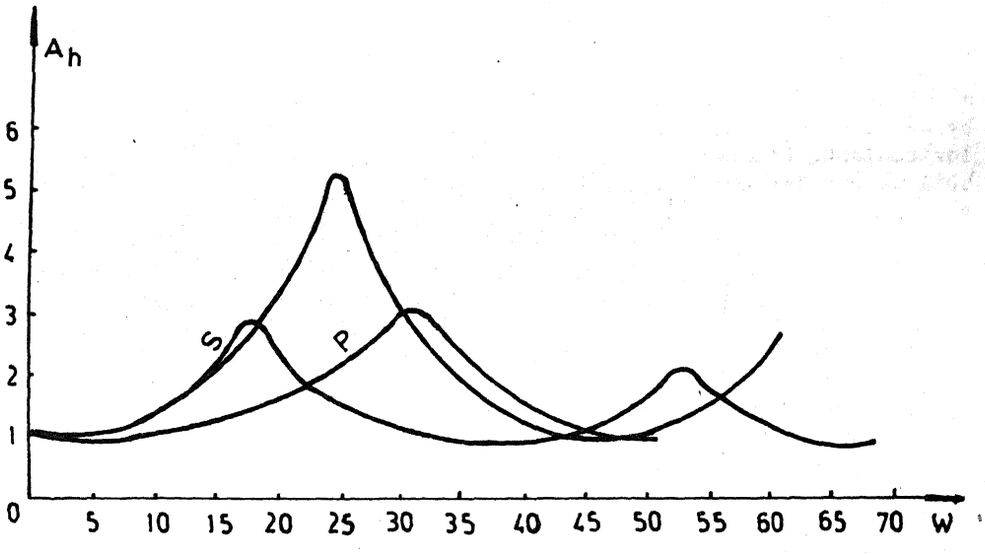
A_h
6
5
4
3
2
1
0
S
P
5 10 15 20 25 30 35 40 45 50 55 60 65 70 w

fig.6