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PROTECTING BUILDINGS AGAINST GROUND-BORNE VIBRATIONS BY MEANS OF ISOLATING MATERIALS

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ABSTRACT
The vibration generated by surface or underground transportation propagate in the ground and penetrate into building through foundation or underground elements such as buried walls (parking for instance). The purpose of this presentation is to report the results of a study carried for the French Government concerning the use of isolating layers between the ground and buried structures. A 2D-Boundary/Finite element program has been developed and employed to stimulate different configurations. Parameters such as the source position, the type and composition of ground, the type, size, thickness and positioning of isolating layers, the influence of the size of the superstructure, the type of buried structures, the type of source spectra have been considered. The determination of a pertinent indicator has also been addressed. The effect of the isolating layers has been best evaluated by computing relative sound pressure levels inside the buildings. It appears that this type of treatment is most effective for surface excitation and it is clearly sensitive to the type of ground considered. Very promising efficiencies (more than 15 dB(A)) can be obtained for the frequent situation of buried parking levels with a vertical treatment facing the excitation and extending only down one or two levels. Measurements on a 1/1 scale test facility will be carried during the year 2000.

1 - INTRODUCTION
The vibrations generated by surface or underground transportation propagate in the ground and penetrate into buildings through their foundations or underground elements such as buried walls (parking places for instance). The purpose of this presentation is to report the results of a study carried for the French Government [1] concerning the use of isolating layers placed between the ground and the buried structures. A 2D-Boundary/Finite element program has been developed and employed to simulate different configurations. Parameters such as the source position, the type and composition of ground, the type, size, thickness and positioning of isolating layers, the influence of the size of the superstructure, the type of buried structures, the type of source spectra have been considered. The determination of a pertinent indicator has also been addressed. The effect of the isolating layers has been best evaluated by computing sound pressure levels inside the buildings.

2 - NUMERICAL ANALYSIS
The computer program MEFISSTO [2,3,4], developed at CSTB, has been used. It is based on a classical 2D Boundary/Finite element approach where the BEM part describes precisely the semi-infinite or stratified ground medium. Any finite part or sub-domain can be either modeled by BEM or FEM. A complex Green function can be considered if one wishes to restrict the meshing only to finite boundaries. The 2D limitation implies that the excitation forces are in fact infinite coherent lines and that the buildings, also, are infinite on a line parallel to the excitation. As a first approximation, this will correspond to the case of a train running close and parallel to a long building.
In [1], a very extensive study can be found, where the variation of many parameters is considered: type of ground, position of excitation, type of foundation, size of underground and surface structures, type and disposition of isolating layers. The analysis can be done directly on the velocity levels in different manners (local values or surface averaged), but due to the complexity of the problem and to the presence

of different wave-types it has been finally chosen to assess the global efficiencies by computing the pressure levels in the upper volumes in an SEA-type manner: the normal plate velocities are used with the plates' radiation loss factors to give radiated powers which are then summed to lead to the pressure values assuming a diffuse pressure field.

Figure 1 shows the situation here considered. A single upper storey (more complex upper buildings have been tested with little influence on the efficiency of isolating layers) and two underground volumes (figuring parking places) are modeled. The ground is an infinite half-space either made of Loess or of Sand and a vertical unit force is applied 6 m before the treated foundation wall either on the surface or 10 into the ground thus figuring a surface or an underground train. A 10 cm-thick elastified polystyrene is used as an isolating layer. It is positioned vertically along one (A) or two (B) levels. Eventually (C) it may be extended to the underside. The excitation force has either a flat spectrum or a typical train spectrum with a peak at 63 Hz. dB(A) efficiencies on the pressure levels are given for both cases respectively as () or [] values. On each graph there are therefore 3 values, for the cases (A), (B), (C) with a flat source spectrum and 3 values for the cases [A], [B], [C] with a typical train force spectrum.

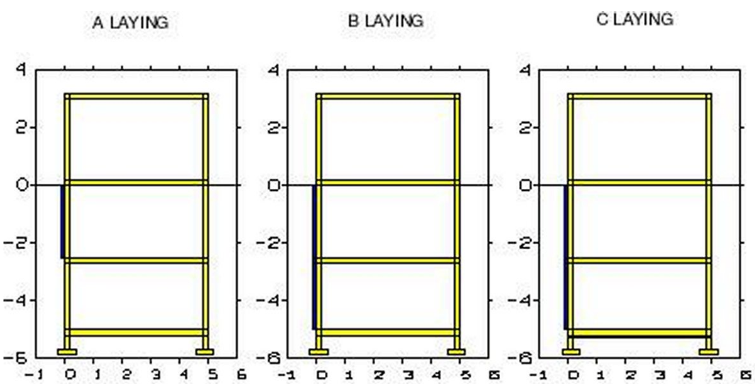

Figure 1: Different layings of isolating materials.

Figure 2 reports the efficiencies of the A, B, C treatments on the pressure level in the upper volume for the two types of ground and the two source positions. The upper values on each graph show the dB(A) efficiencies for the two source spectra as previously mentioned. It can be seen that better efficiencies can be found for a surface excitation. Reductions of more than 10 dB(A) are obtained for loess and for sand even if only one underground level is treated (A treatment). Treating the underside (C treatment) is not necessary but increasing the vertical treatment down to two levels (B treatment) further increases the efficiency. For the underground excitation, the isolating layers are significantly efficient only for a sandy ground. When the source is on the ground surface, Rayleigh waves are mostly generated. They are rapidly attenuated with depth so that most of the energy impinging on the foundations is cut off by the polystyrene, which explains why the addition of a bottom lining is not necessary. On the other hand, when the source is buried, both body and shear waves are generated; they will excite all the underground elements. Even the fullest C-treatment may be insufficient, since the bottom foundations, which can not be treated for stability reasons are then significantly excited.

The ground is usually more complex than a simple half-space, since it may be stratified. Adding a rigid surface, 10 m under the free surface will somewhat be the other extreme from the case already considered. The waves will be trapped between the surface and this rocky bottom, thus amplifying the excitation of the foundations. However in the previous case of surface excitation, and again due to the nature of the Raleigh waves, the efficiency of the proposed treatment was found to be little affected.

An other important point is the validity of this 2D approach. In practice, buildings are not infinite and the lateral underground walls (perpendicular to the line of excitation) will also be excited so that it may be necessary to also treat them. Nevertheless, simple considerations [1] seem to indicate that these lateral contributions could be of limited effect.

3 - CONCLUSION

It appears that the type of treatment proposed is most effective for surface excitations and it is clearly sensitive to the type of ground considered. Very promising efficiencies (more than 10 dB(A)) can be obtained for the frequent situation of buried parking levels with a vertical treatment facing the excitation and extending only down one or two levels. Measurements on a 1/1 scale test facility will be carried during the year 2000.

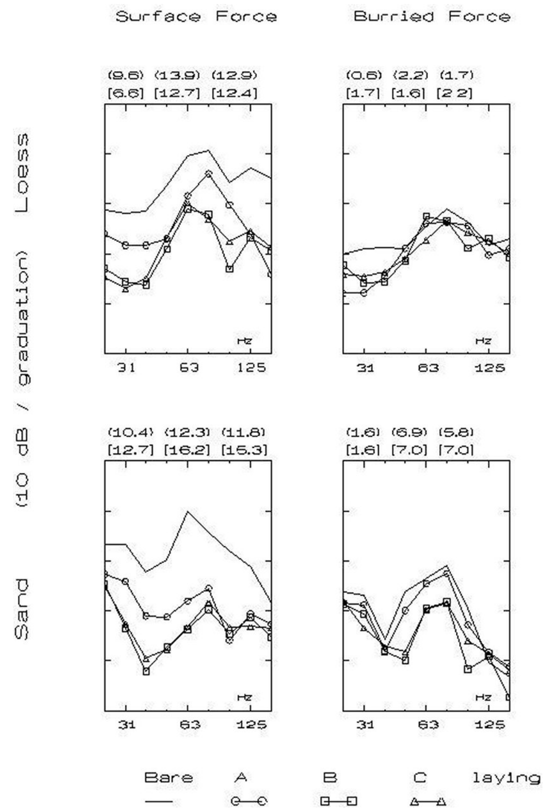

Figure 2: Sound Pressure Levels; effect of isolating layers; 10 dB / decade.

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REFERENCES

1. **P. Jean and al.**, *Protection des immeubles par doublage de fondation*, CSTB, 2000
2. **P. Jean and al.**, Study of the vibrational power injected to a wall by a ground surface wave, *Journal of Sound and Vibration*
3. **P. Jean and al.**, A boundary element program for the study of vibration propagation in the ground, In *Internoise* , pp. 571-576, 1997
4. **P. Jean**, Boundary and finite elements for 2D soil-structure interaction problems, *Acta Acustica*, 1999