Study on Structure and Ground Vibration Reduction Using Wave Barriers

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1. Introduction

Ground vibration induced by seismic waves, traffic, machinery parts can propagate through the surrounding soils to adjacent building structures and make people who lived nearby feel distress. Therefore, the ground vibration reduction has become an important issue in recent years.

The problem of vibration isolation induced by various sources has been the focus of a great deal of research since the 1950s [1]. Generally, vibration countermeasures have been adopted include the construction of open or in-filled trenches, wave impeding barriers (WIB) and etc [2, 3]. In this paper, a method in consideration of wave barriers is used to reduce the ground vibration and the effects of wave barrier depth, width, quantity and materiel are investigated.

2. Parametric study of wave barriers

The problem of passive isolation of horizontal vibration by wave barriers is considered. As shown in Fig. 1, some rectangular barriers (depth Dm, width Wm) of the interval Mm are located at a distance Pm from the vibration source to the first barrier and a distance Qm from the last barrier to the observation point. Properties of soil and wave barriers are shown in Tab. 1.

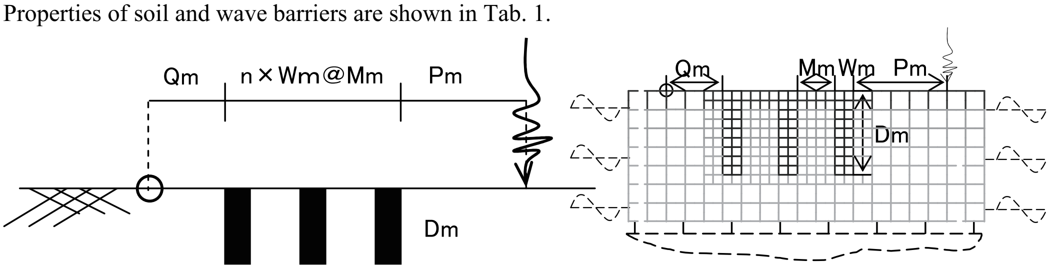

Fig. 1: Schematic model of problem/FEM model of problem

No.	Thickness (M)	Density (t/M^3)	P-wave Vel. (M/s)	S-wave Vel. (M/s)	Damping (%)
1	2	1.6	300	150	2
2	4	1.7	500	300	2
3	24	1.8	1000	500	2
Soft	H	1.5	200	100	2
Hard	H	2.3	4000	2200	2

Tab. 1: Properties of soil model and wave barriers

The vibration of excitation wave propagates through wave barriers from the vibration source to the observation point. Since vibration isolation by wave barriers is primarily achieved by screening of surface waves (Rayleigh wave), the vibration source is be setup in the surface of the soil. Usually, the predominant

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frequency of seismic waves and traffic should be considered. The predominant frequency of seismic waves is mostly from 0.1 to 1 Hz. And the one for traffic is from 15 to 30 Hz [4]. On the other hand, the present soil properties can not be ignored as maximum energy in the frequency which the group velocity of Rayleigh wave is minimized can be transmitted when the vibration propagates in the surface ground. The phase and group velocities of Love wave and Rayleigh wave for soil properties is been shown in Fig. 2.

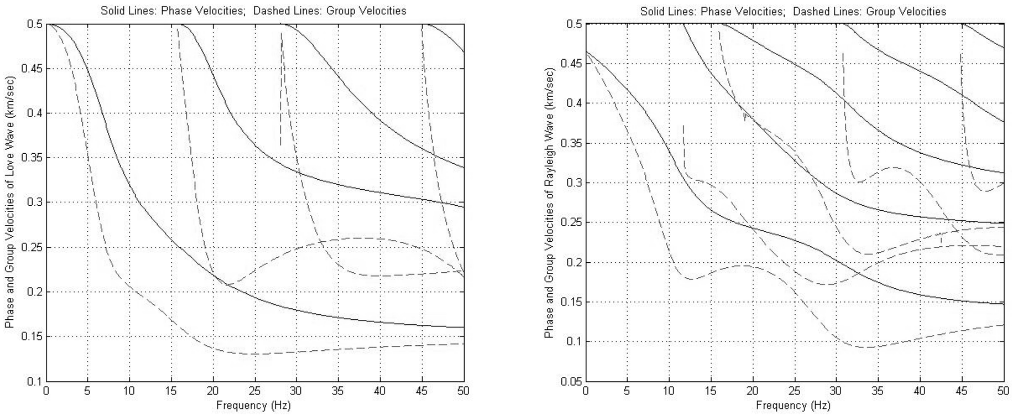

Fig. 2: Phase and group velocities of Love wave and Rayleigh wave

It can be observed that the minimized group velocity of Rayleigh wave is around 12 Hz. Therefore, the frequency around 12 Hz should also be considered. In this case, a Gaussian distribution with mean of 12 Hz and variance of 4 Hz is selected as the assumed input motion.

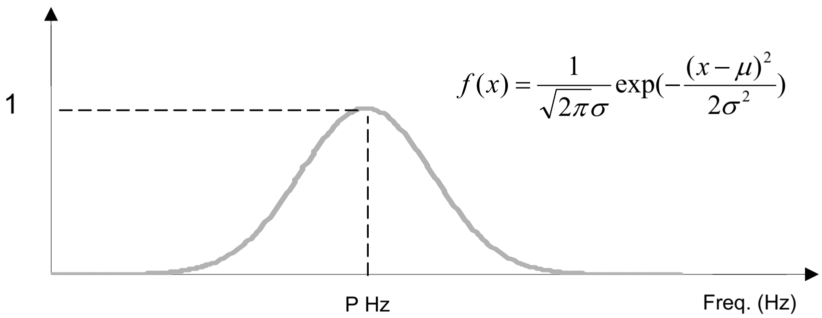

Fig.3: Gaussian variation of the assumed input motion

The acceleration response of observation point will be calculated based on FEM methodology. A parametric investigation is carried out to study the effect of depth, width, quantity, material of wave barriers by comparasion between transfer function of each situation.

3. Results of parametric study

3.1. Effect of wave barrier depth

In this part, the effect of wave barrier depth is investigated. Acceleration transfer functions of observation point are compared in Fig. 4 and properties of wave barrier for simulation are shown in Tab. 2. In Fig. 4, H=0m means the situation of no barrier.

It is obvious that deep wave barrier is more effective than the shallow one. There is a quite big drop between H=5m and H=10m. Considered properties of soil model, the wavelength of surface wave is approximately 8m [5]. When its depth is longer than the wavelength of surface wave, the reduction is obviously effective. A reduction of 50-70% is observed round 20 Hz. On the other hand, the amplification is observed over 30 Hz. It is possible that the soft barrier is used in this case.

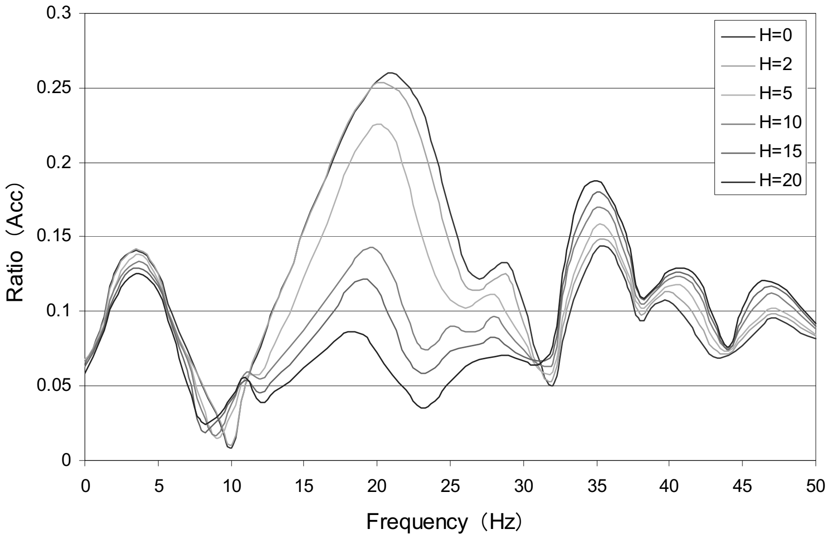

Fig.4: Comparative study of wave barrier depth

Width	Depth	Interval	Quantity	Material
4m	Hm	2m	1	Soft

Tab. 2: Properties of wave barrier

3.2 Effect of wave barrier width

In this part, the effect of wave barrier width is investigated. Acceleration transfer functions of observation point are compared in Fig. 5 and properties of wave barrier for simulation are shown in Tab. 3. In Fig. 5, W=0m means the situation of no barrier.

It is more effective by increasing wave barrier width and the increase of effect is not a quite obvious one such as the depth. But the attenuation zone becomes wider by increasing wave barrier width. The effect is also thought that should be related with the interval of wave barriers when the quantity is over 1.

3.3 Effect of wave barrier quantity

In this part, the effect of wave barrier quantity is investigated. Acceleration transfer functions of observation point are compared in Fig. 6 and properties of wave barrier for simulation are shown in Tab. 4. In Fig. 6, N=0 means the situation of no barrier.

It is shown that although a single wave barrier can be effective, wave barriers arranged in periodic pattern or etc can be getting the better reduction. Comparing with the increase of wave barrier width, the attenuation zone does almost not become wider. It can be seen that the attenuation zone depends on the form of wave barrier but not the quantity.

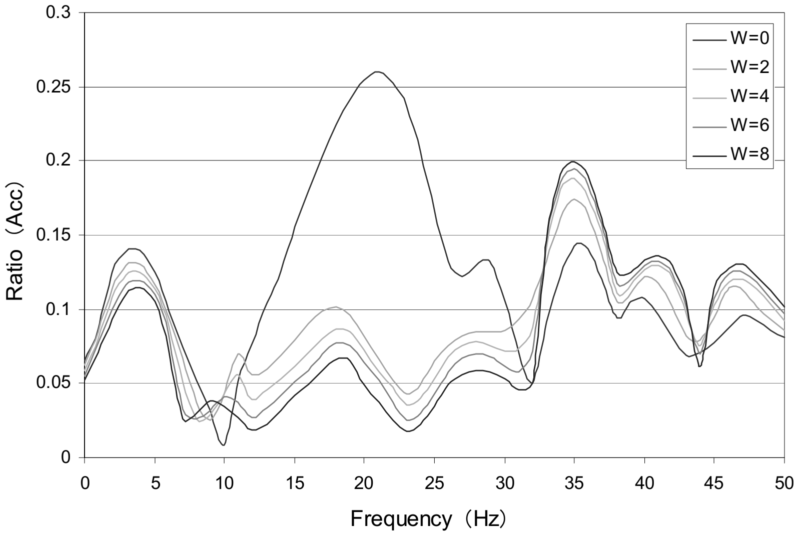

Fig.5: Comparative study of wave barrier width

Width	Depth	Interval	Quantity	Material
Wm	20m	2m	1	Soft

Tab. 3: Properties of wave barrier

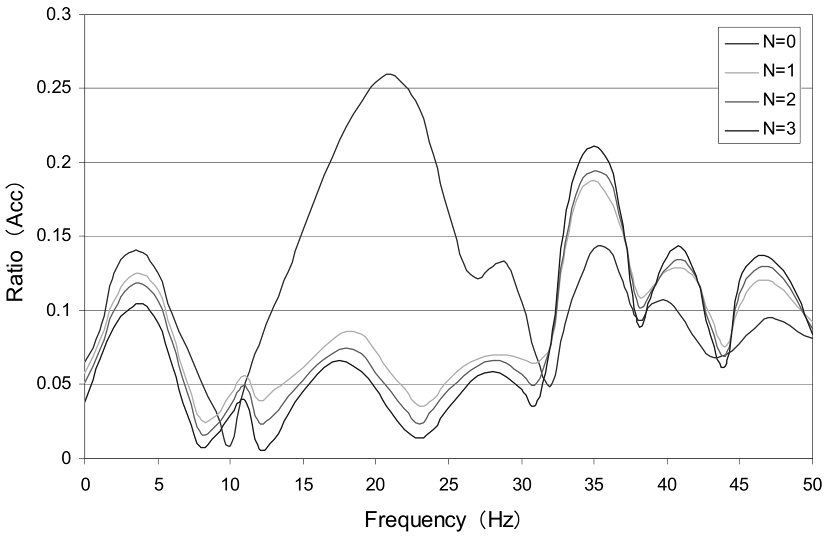

Fig.6: Comparative study of wave barrier quantity

Width	Depth	Interval	Quantity	Material
4m	20m	2m	N	Soft

Tab. 4: Properties of wave barrier

3.4 Effect of wave barrier material

In this part, the effect of wave barrier material is investigated. Acceleration transfer functions of observation point are compared in Fig. 7 and properties of wave barrier for simulation are shown in Tab. 5.

Two materials which soil cement as for the soft wave barrier and concrete as for the hard one are be used in this case. We can see that the soft wave barrier (Low Velocity) is more effective in low domain and the hard wave barrier (High Velocity) is more effective in high domain.

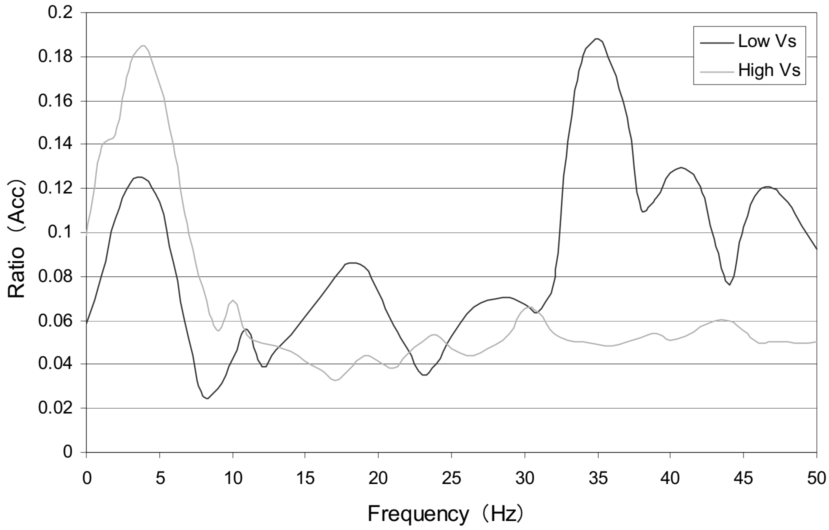

Fig.7: Comparative study of wave barrier material

Width	Depth	Interval	Quantity	Material
4m	20m	2m	1	Soft/Hard

Tab. 5: Properties of wave barrier

4. Conclusion

A FEM method is used for simulating the reduction of vibration by ground propagation using the wave barrier. It is shown that a minimum depth is the guarantee of an effective reduction for the ground vibration. Wave barriers which arranged in layering pattern are more effective than the single one. Different materials can play different roles in the reduction.

5. Reference

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