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ABSTRACT

It is examined by using the structure that a steel pipe pile and a PHC stake were arranged in the central part of the scrap tire. A consideration from full-size field experiment and the model experiment was done by this paper to examine a vibration decline character as propagation route countermeasure method of the ground vibration by the isolation wall which a scrap tire was used for.

1. A FULL-SIZE EXPERIMENT

In this research, it can thing about countermeasure method of a ground vibration caused by construction work, the plant machinery, a means of transportation in of the vibration which shows it in the Figure-1 and that a tire was compressed in the vertical direction and which it gained. That cross section is shown in the Figure-2. Isolation walls are a tire outside diameter Φ 70cm, an outside diameter Φ 36cm of the center stake and the inside diameter Φ 34.6cm with a steel pipe pile with L=3m of the wick material of the central part. And, isolation walls are a tire outside diameter Φ 70cm, an outside diameter Φ30cm of the center stake and the inside diameter Φ 15cm with a PHC stake with L=3.0m of the wick material of the central part. Twenty tires are being used in this experiment. This purpose is the thing that the recycling rate of the scrap tire was thought to rise with expecting improvement in the vibration isolation performance. Leased land does the where a city in Hyogo Prefecture Toyooka City owns it, and the compression type isolation wall of 2 level is laid, and an experiment area makes that laying underground depth GL-3.0m. Through the execution extension of the isolation wall and execution arrangement show details in the Figure-4, a wick material does absurdity with a steel pipe pile in the type L, and a wick material lays the isolation wall of 2 level of 9.8m+6.5m with a PHC stake in a total 13.3m of 9.8m+3.5m in the same way in the type L. The central part of each isolation wall is being filled with sandy soil to dig it in the spot and which occurred. And, it is checked, and the union of parts that a compression type isolation wall is located next to each other is laid in the soil without connect. (Hayakawa et al, 2005, 2007(a),2007(b))

Figure 1. Scrap tire with a steel pipe pile and PHC stake

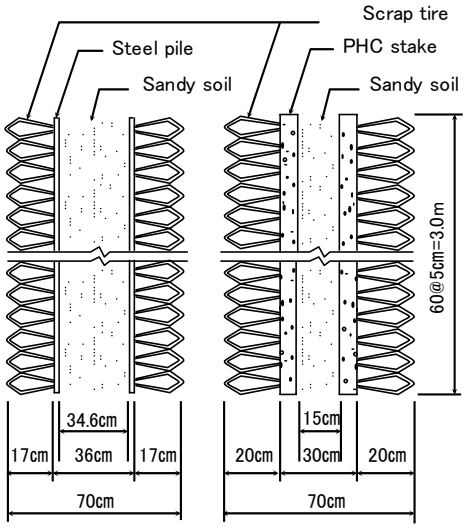


Figure 2. Cross section of scrap tire isolation wall

1.1 The ground conditions

The ground conditions of field is shown in the Figure-3. It is composed of silt and sandy soil, sand gravel and silt from the surface of the earth side to GL-4.0m, and average N value is 17 in about 30 from 2 more than boring investigation. N value is about 8 with a gravel bed from GL-4.0m of that deeper to GL-10.0m. And, it knows that it is GL-22.0m deeper that N value reaches more than 50 along with the public construction around the experiment area in boring investigation. The shear velocity (Vs) of the ground is estimated at Vs=249m/sec when the it becomes Vs=206m/sec and the N value of the lower layer part is made 30 when the N value of the upper layer part is made 17 from the estimated equation $Vs=80N^{1/3}$.

1.2 Excitation method and measurement arrangement and measurement apparatus

Free fall method by heavy weight is adopted, and excitation method examines effect on a decrease in vibration. In other words, a free fall makes it do heavy weight of the mass 300kgf from the drop height H=1m, and excited. The measurement arrangement figure of the full-size experiment is shown in the Figure-4, and the laying underground conditions of the compression type isolation wall are shown in the Figure-1. 2 level of the PHC stake and the steel pipe pile is laid in the same field, and the wick material of the central part arranges a measurement area to the width 34.0m x length 19.5m(=663m^2). Measured point of 13 points of 1 measured line is arranged as 18 line of A-R, and measured line is measured in total in 234 points. A measurement interval makes 13 an interval with 5 with 7 in the interval as 1.0m from measured point from 3 which puts an isolation wall as an interval 1.0m from 5 from measured point 7 of that back 0.75m and 2.0m. A measurement apparatus measured the up and down element (Z direction) of the vibration. Vibration acceleration level with measurement of the surface of the earth side by using five potable vibrometers (VM-52: manufactured by RION Inc.). Moreover, data recorder (LX-10: manufactured by TEAC electronic measurement Inc.) was connected to five picking out and five potable vibrometers, and an acceleration wave form was recorded, and the action of the ground around the isolation wall and the action of the compression type isolation wall were confirmed at the top of the isolation wall and those front and back to measure five points of horizontal elements (Y direction) and five points of up and down elements (Z direction) at the same time.

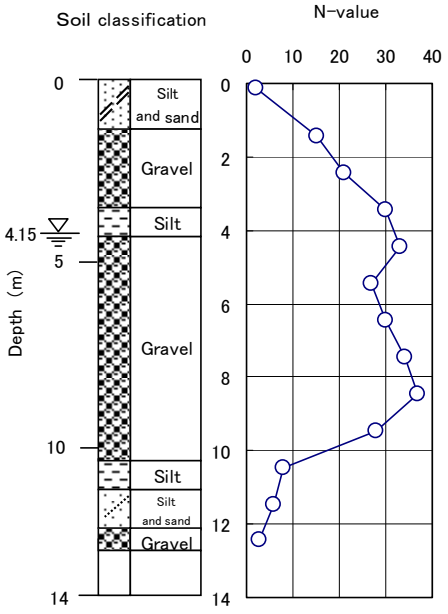


Figure 3. Boring log at test site

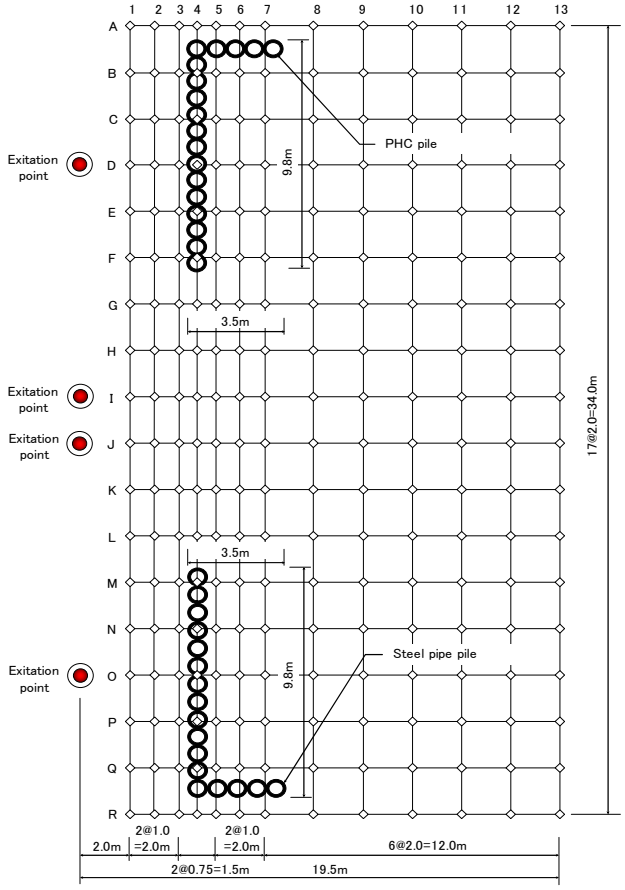


Figure 4. Configuration of scrap tire isolation wall and measurement point

1.3 Measurement condition

Heavy weight was used in the point from isolation wall on the extension wire of the line on the PHC stake side of the center D line of the isolation wall PHC stake and the center O line of the isolation wall steel pipe stake and the natural ground without a countermeasure and the J line on the steel pile stake side or the center of isolation wall 4.75m, and shock excitation was done, and core material measured the maximum value of the vibration acceleration level which occurred at that time as shown in the Figure-4. The wave form of the acceleration was recorded again at the same time. Around one case carries out each 91 measured point (7 line x 13 measured point) 3 times, and around one case carries out 13 measured point (1 line x 13 point) each in excitation in the D line and the O line in the I line which is the natural ground without a countermeasure, and the J line 3 times. Because heavy weight was made to fall about 55 times in each place and it was being carried out and the surface of the earth side became unevenness due to heavy weight drop, the surface of the earth side was done in every drop, and ground surface was smoothed, and a vibration answer in the surface of the earth side was made to become a constant, and heavy weight excitation went to the one by the wick material of the isolation wall through 2 level.

1.4 Vibration decrease action

The wick material of the compression type isolation wall showed the representing values of the vibration decrease action in the surface earth side which a PHC stake (the following type: PHC) in a Figure-5 and a Figure-6 used a steel pile (the following type: steel pipe) for the wick material of the isolation wall. The D line which is the center line of the isolation wall, and the C line which becomes side of the D line and an E line are considered countermeasure data by the isolation wall, and a Figure-5 compares an I line as a natural ground without a countermeasure. A Figure-6 compares a J line in the same way countermeasure data by the isolation wall as a natural ground without a countermeasure. The O line which is the center line of the isolation wall, and that N line located next to each other and the P line. The isolation wall of the point is made the boundary in both types from excitation point 4.75m, and it is greatly being decreased. A fixed vibration acceleration level is almost shown with 4.75m- 4.0m in the isolation wall of the type PHC from excitation wick point, and it shows a tendency to be the same as the distance decline of the natural ground after 14.0m. Moreover, a fixed vibration acceleration level is almost shown with 4.75m-12.0m in the isolation wall of the steel pipe type from excitation point, and it shows a tendency to be the same as the distance decline of the natural ground after 12.0m.

2. THE CONSIDERATION OF EFFECT ON A VIBRATION ISOLATION EFFECT

2.1 Comparison with a result of an examination of previous result

As for the Figure-7, comparison examined a result of an experiment of previous result and this result of an experiment

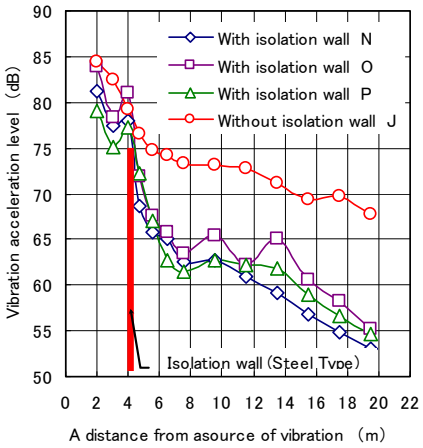


Figure 6. Vibration decrement with the distance

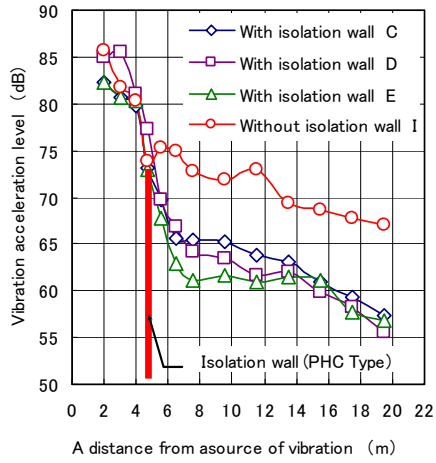


Figure 5. Vibration decrement with the distance

about the result of heavy weight excitation examination. It is being put in order in the relations between the thing R(H/λ) which became a dimension-less in the wavelength (λ) found from shear wave speed (Vs) that 2 case don't make the depth of the wall, the answer frequency of vibration (f) as the way of correcting a difference in the ground conditions, and the acceleration ratio ($\gamma=a/a_0$). In other words, it is shown that it is in the R and γ from the research result about the open trench of previous paper. The result looked for from the experiment-type of the open trench which a Figure-7 is shown in the next type is shown, too. This result of an experiment can get effect on a vibration isolation in a type PHC and a steel pipe type greatly than the last result. Moreover, it is compared in the type PHC, and a steel pipe type shows a little great effect on a decrease in vibration as well as the thing examined from the Figure-7 in the influence by the difference in the wick material. Therefore, it use the tire original form, and it is understood more than the last thing filled with smashed tire and concrete that great effect on a decrease in vibration can get the thing that a clipping tire was compressed in the ready-made stake and which was arranged.

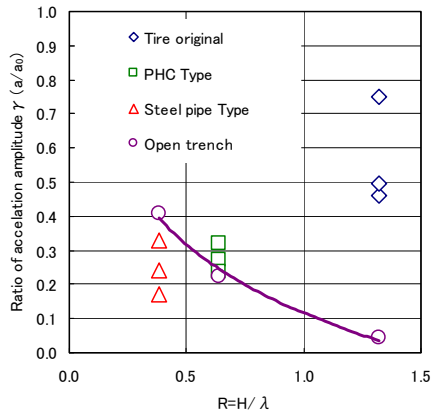


Figure 7. Effect on a decrease in vibration with R

2.2 The verification of effect on a decrease in vibration

Generally, the amplitude of the wave motion which shoots on the isolation wall and an amplitude ratio at the back of the wall are expressed about appraisal method of effect on a decrease in vibration by the ground vibration isolation wall with the wave penetration theory. It is shown in the next type which a wave motion impedance (the propagation speed the density of the medium) was used for.

$$\frac{a}{a_0} = \frac{2\alpha}{\sqrt{(\alpha^2-1)^2 \sin^2 \frac{2\pi}{\lambda} w + 4\alpha^2}} \qquad (1)$$

Here,
a/a_0: an acceleration ratio (by the wave motion penetration theory) before and after the vibration isolation wall, α: wave motion impedance ratio, w: the thickness (m) of medium, f: frequency of vibrations (Hz) and λ: wavelength (m)

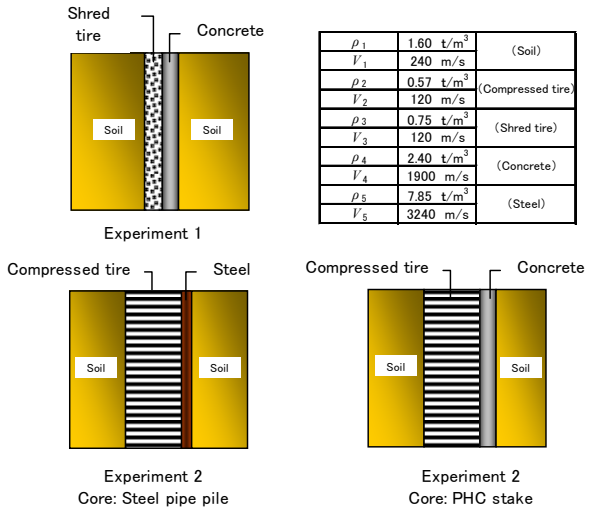


Figure 8. Wave motion penetration model

A Figure-8 showed the wave motion penetration model of both experiments. A form is a circle, and faces the proceeding direction of the wave motion from how to connect every isolation wall being a thing by connection, and the isolation wall being made the target by this research is not the form that quality of medium is the same in the right angle horizontal direction. Therefore, the circle form of the isolation wall was added, and the judgment side of the part of around 1 radius was modeled as uniform section by this modeling. (Hayakawa, 2006), (Woods, 1970)

A Figure-9 compared a calculation by the wave motion penetration theory with the found value of the acceleration ratio before and after the isolation wall in three cases. Found value shows measurement value in the center line (It is shown as a found value 2) of the isolation wall and both sides (It is shown as a found value 1.3.). It is understood that a calculation on the judgment side is compared with found value as shown in this graph and excessively evaluated. A calculation to the whole section model is an underestimate to the found value through it is shown in the same figure, too. The matter that the influence factor concerned with effect on a decrease in vibration by the isolation wall is not only a wave impedance ratio is analogized out of this.

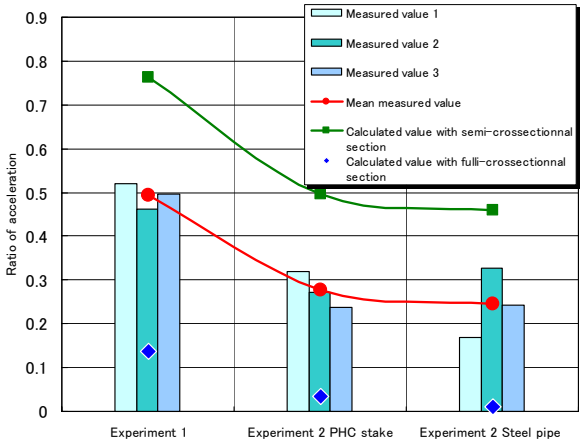


Figure 9. Measured value and calculated value

$$\frac{a'}{a'_0} = \frac{\left(\frac{f}{f_0}\right)^2}{\sqrt{\left\{1-\left(\frac{f}{f_0}\right)^2\right\}^2 + \left(2\zeta\frac{f}{f_0}\right)^2}} \qquad (2)$$

Here,
a'/a'_0: acceleration ratio about the in front of and after the isolation wall, f/f_0: frequency ratio, ζ : damping ratio

A Table-1 is the thing which tightened the damping ratio found from the logarithm decline rate found from the acceleration

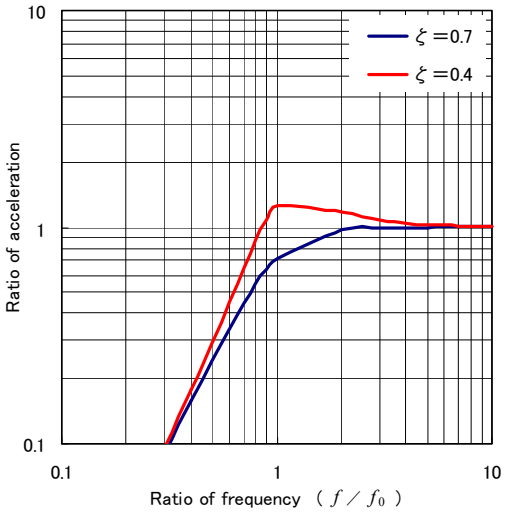


Figure 10. Ratio of frequency

Table 1. Frequency and damping ratio

	Experiment 1	Experiment 2 (PHC stake)	Experiment 3 (Steel pipe)
f (Hz)	36	23	26
f_0 (Hz)	53	33	33
ζ	0.4	0.7	0.7

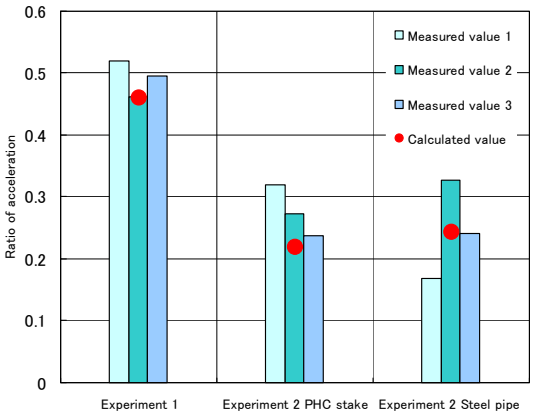


Figure 11. Measured value and calculated value

record observed in the found value of the excellence frequency of vibration before and after the isolation wall in three cases experiment and the top of each isolation wall. A Figure-10 shows relations between the frequency ratio of vibration gained by equation (2) and the acceleration ratio as parameter. It is remarkable in case as less than that, and the frequency of vibrations ratio shows $f/f_0=1$ in peak value as for the acceleration ratio to become small. Moreover, 2 shows peak value by the thing to be equivalent to the latter's result of an experiment in the frequency of vibrations ratio $f/f_0=2$, and shows that an acceleration ratio become small in case as less than that. It is compared in the former result, and the latter result of an experiment relates to this as for effect on a decrease in vibration growing big. An acceleration ratio was calculated by using the excellence frequency of vibrations and the damping ratio from the equation (2) here. The calculation that these values were given to the value found from the wave motion penetration theory to the judgment side model and which was calculated was shown in the Figure-11. It is understood that found value is almost reproduced with these cases together. Therefore, effect on a decrease in the ground vibration of the isolation wall which a scrap tire was used for is considered the thing which concrete of the part of the wick material and effect on a decrease by look difference of the wave motion impedance ratio with the ground by the steel and effect.

3. MODEL EXPERIMENT ABOUT THE SCRAP TIRE VIBRATION ISOLATION WALL

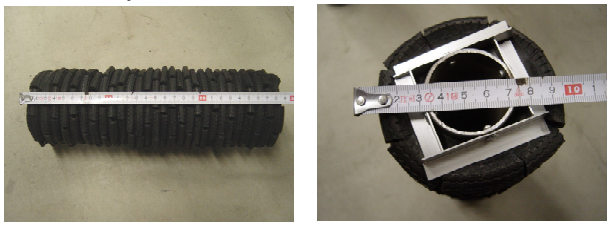
Great enough effect on a decrease in vibration was confirmed in the local experiment by the vibration isolation wall of the actual size which a scrap type tire was used for. However, it can think that it is difficult to make a factor affecting such as the ground condition around isolation wall change freely in the spot experiment. It was made by the way of tightening the model ground to install isolation wall due to rammer drop and strengthening it, and it went to when the effect of the original form pattern isolation wall and the compression type isolation wall was verified for including install of the hollow part in this experiment.

3.1 Experiment outline

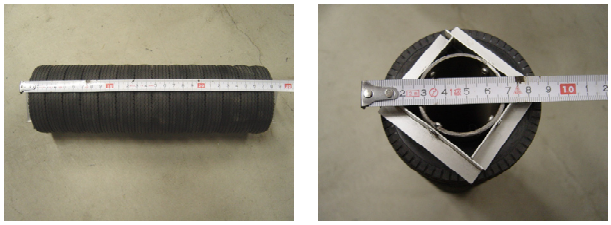
A compression type isolation wall was arranged in the experiment in the model soil layer in Photograph-1. 28 compression mold tires are being used for the outside of the steel pipe. A tire is an outside diameter: 8.5 cm x length: 28cm and 5 stake-shaped things are coupled.

And, the form of the original form pattern isolation wall was shown in the Photograph-2. 14 tires are arranged to the outside of the steel pipe. A tire is an outside diameter: 8.0cm x length: 28cm, and 5 stake-shaped things are coupled.

Photograph-3 shows the condition of isolation wall arranged to model soil layer. A model soil warehouse is width: 60cm x

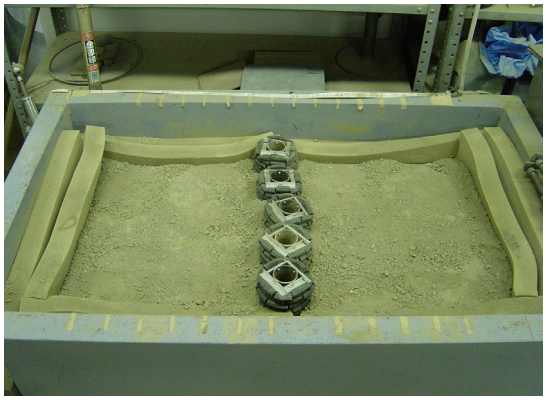


Photograph 1. Compressed tire model



Photograph 2. Original tire model

length: 100cm x depth: 60cm. And urethane is laid in the circumference to prevent the influence of the reflected wave.



Photograph 3. Model soil layer

3.2 Measurement method

A free fall makes top of the surface have the steel ball of 10gr, and goes as excitation method. A miniature acceleration sensor (made by Tokyo-sokushin VP-2007) is being used for the measurement of the vibration acceleration on the surface of the earth side, and it goes for data recorder (made by TEAC LX-10) through the wave form record through the amplifier.

3.3 Result of the measurement

A Figure-12 showed a vibration decrease tendency by the original form pattern isolation wall. The relations of the distance from the acceleration amplitude ratio in each measurement point with the measurement value in the shortest measurement point and excitation point are shown from a position of a steel ball drop.

When a central part is moved to the midair, an acceleration amplitude ratio shows 0.5, and what was filled with the sand become 0.7 in front of isolation wall. And, an acceleration amplitude ratio shows a tendency to growing big from the case of the midair when it is filled with the sand in front of isolation wall. As for this, the amount of reflection of the wave motion is thought the benefit that it increased by a midair part's been filled with the sand. And, both cases show a tendency as for the acceleration amplitude ratio, to be about the same in about 0.2 together behind isolation wall.

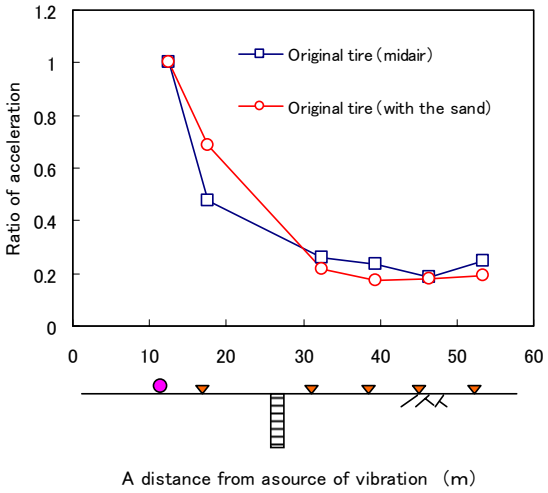


Figure 12. Vibration decrease tendency by the original from pattern isolation wall

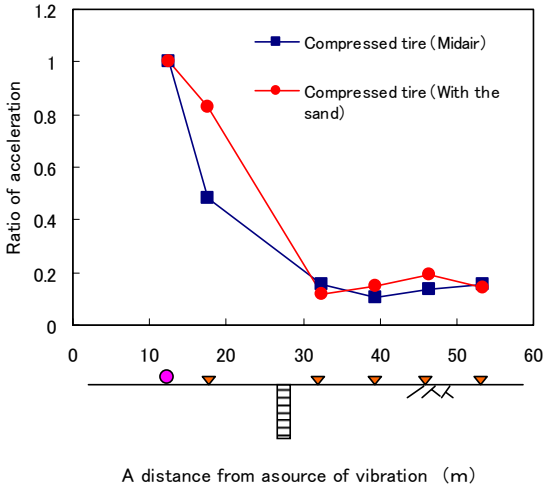


Figure 13. Vibration decrease tendency by the composition type isolation wall

Figure-13 showed effect on a decrease in vibration by the composition type isolation wall. When a central part is moved to the midair, an acceleration amplitude ratio shows 0.5, and what was filled with the sand shows 0.8 in front of isolation wall. And, an acceleration amplitude ratio has been big in front of isolation wall since the case that the one that it was filled with the sand is midair. The reflection of the wave motion in the front of the compression type isolation wall shows a tendency to be big for this tendency though to be the same as case of the original form pattern isolation wall more. An acceleration amplitude ratio becomes about 0.15, and it is compared on the original form pattern isolation wall, and an acceleration amplitude ratio becomes small behind isolation wall.

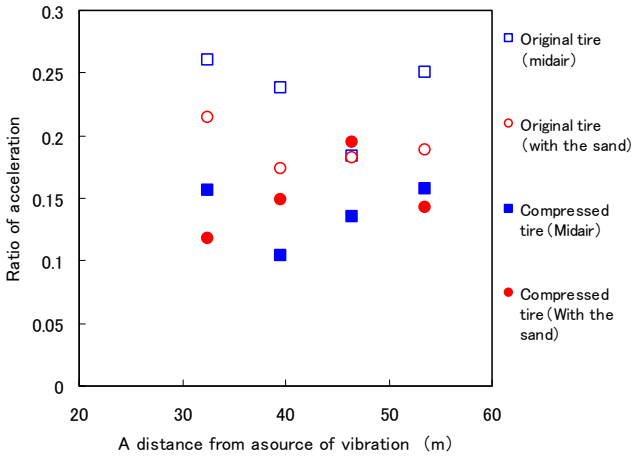


Figure 14. Compared a vibration decrease tendency behind isolation wall

3.4 Vibration decrease tendency behind isolation wall

A Figure-14 compared a vibration decrease tendency behind isolation wall at the case that each midair part wall filled with the sand, and the case of the midair with the original form pattern isolation wall about the compression type isolation wall.

A compression type isolation wall is concerned so that it may be understood from the figure, and a vibration acceleration amplitude ratio is formed small regardless of the existence of filling up to the midair part. A Figure-16 compared effect on a decrease in vibration behind isolation wall with a Figure-15 in the same way.

It is the case that a filling up part was moved to the midair so that it might be understood from now, and a vibration acceleration amplitude ratio becomes small, and compression type isolation wall is a similar result by the place filled with the sand, too.

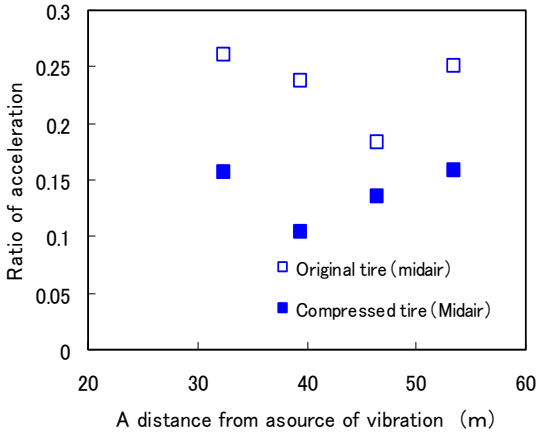


Figure 15. Compared effect on a decrease in vibration behind isolation wall

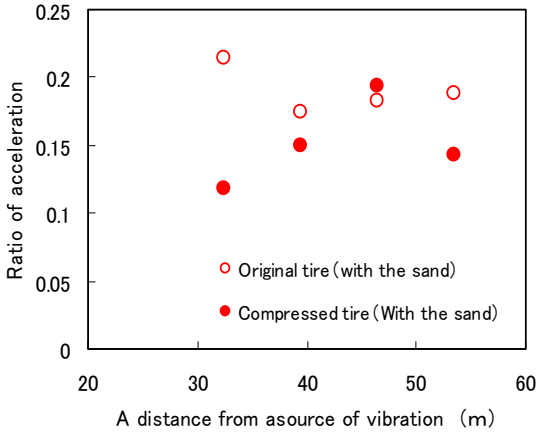


Figure 16. Compared effect on a decrease in vibration behind isolation wall

4. CONCLUSIONS

Effect on a decrease in vibration was compared in the experiment of the actual size which a compression type isolation wall was used for as heavy weight excitation input. It becomes the following when this research result at present is put together.

(1) It became the vibration decrease value of about 5dB -10dB, and the vibration decrease value of 7dB-12dB was shown in the same way in the isolation wall of the type PHC in the 4.75m-16.0m point in the isolation wall of the steel pipe type from excitation point.
(2) The frequency of vibrations stage which could get effect on a decrease was 23Hz-70Hz from the comparison of the acceleration spectrum.
(3) When three results were compared about the acceleration ratio from a result of an experiment with 3 cases, a compression type isolation wall was compared on the isolation wall of the original form use, and it knew that it was as well as the open trench as for effect on a decrease in vibration.
(4) It was understood that effect on a decrease in vibration of such an isolation wall could be experiment by compounding the theory of vibration transmission rate with the wave motion penetration theory. And, as for a decline fixed frequency's influencing the frequency of vibration distribution of the vibration acceleration level.
(5) The compression type isolation wall which the rubber of tires was large in could get an acceleration amplitude ratio small, and it was understood that it was excellent in effect on a decrease in vibration as that result. This conclusion is common to the result of the local experiment which a full-sized scarp tire isolation wall was used for as well.
(6) It can think that effect on a spring by the rubber of isolation wall acts effectively by arranging it. And, it was understood that a big change didn't occur behind isolation wall through effect on reflection of the wave motion in front of isolation wall grew big by filling the midair part of the steel pipe with the sand.

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