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DEVELOPMENT OF CYLINDRICAL NOISE-REDUCTION UNIT

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ABSTRACT
We have been carrying out research and development on a cylindrical noise-reduction unit (hereinafter refereed to as "Noise Reducer") that reduce noise levels without the need for increased height of normal noise barrier. In field tests, it was verified that the noise reducer decrease noise levels by 2.3 dB at maximum and 1.5 dB on average at a measuring point of 20 m from highway. To theoretically elucidate the sound field behind the reducer, numerical analysis was carried out.

1 - INTRODUCTION
In recent years, growing traffic volumes, particularly in the number of large trucks, has led to a steady rise in highway noise levels, and there is increasing pressure to raise the height of existing noise barriers in response. To overcome this situation, efforts have been made to develop a new type of decorative noise abatement device Noise Reducer which achieves noise reduction benefits without increased barrier height and without creating an unsightly road environment for drivers

2 - CONFIGURATION OF NOISE REDUCER

2.1 - 1/5-scale-model experiments
As with the Noise Reducer, a variety of geometry cylindrical, triangular, reverse triangular, rectangular have been subject to scale model testing to study difference in mitigation effect by the geometry. In all cases, mitigation effect was larger than the straight wall type of the noise barriers according to the prior art, and among them, cylindrical geometry proved to be slightly better than the others in mitigation performance.
Further, as with the outside diameter of the cylindrical Noise Reducer, there appeared a tendency in the range of Fresnel number N equal to or larger than 10 that the larger the diameter, the larger the mitigation effect. shown in Table 1.

Fresnel number N range			1<N<10	N>10	N<1
Data count			64	5	69
Case	No. 1	Ref.	0dB	0dB	0dB
Case	No. 2	Cyl.80mm.	2.5	8.3	2.9
Case	No. 3	Cyl.100mm.	4.0	9.6	4.4
Case	No. 4	Cyl.140mm.	3.4	11.3	4.0
Case	No. 5	Triangle.	2.5	5.6	2.7
Case	No. 6	Square.	3.7	8.5	4.0
Case	No. 7	Inv.Tri.	4.0	8.1	4.3

Table 1: Variation between attenuation levels of traditional type and various test cases when Fresnel number N... average values for each range.

2.2 - Field test

The acoustic effects of the cylindrical Noise Reducer were tested on a standard banked stretch of highway. Figure 1 shows the sectional distribution of the amount of attenuation in median noise levels (L50) following installation of the Noise Reducer. While noise reduction of 2.0 dB-2.5 dB was seen in locations relatively close to the highway (up to 15 m from the noise barrier), noise reduction was 1.0 dB or less for locations farther out.

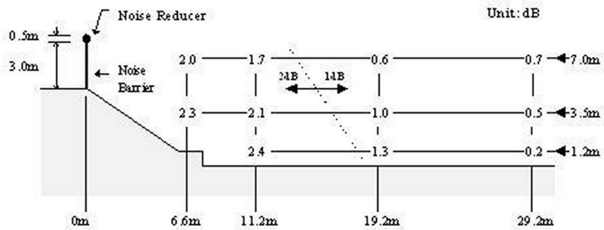

Figure 1: Amounts of noise level (L50) attenuation following installation of the noise reducer.

2.3 - Visually attractive type noise reducer (mushroom-type noise reducer)

A more visually attractive type of Noise Reducer was developed as a means of improving driving scenery in addition to reducing noise levels. Dubbed the "mushroom-type"Noise Reducer, the shape is somewhat rounded, and mounted on the top of the noise barrier it appears to be of monolithic construction with the barrier itself. shown in Figure 2.

Figure 2: Structural drawing of noise reducer.

As expected, installation of the Noise Reducer produced conspicuous results, as maximum noise attenuation of approximately 3 dB was observed closest to the highway. At a measurement point 20 m from the road as well, maximum noise attenuation of 2.3 dB and average attenuation of approximately 1.5 dB were obtained. shown in Table 2.

Distance	Av	S.D	Max.	Min.
5 m	2.0 dB	0.5 dB	2.9 dB	0.9 dB
20 m	1.5 dB	0.5 dB	2.3 dB	0.1 dB

Table 2: Installation effects of mushroom-type noise reducer (averages, standard deviations, maximums, minimums).

3 - THEORETICAL ANALYSIS CONCERNING INSTALLATION EFFECT OF NOISE REDUCER

The Noise Reducer was developed by way of such demonstrative means as scale and full-size model experiments. The boundary element method (based on the Helmholtz's boundary integral equation) was used to analyze the condition of the back surface of a noise barrier provided on the top end with a Noise Reducer at elevated bridges.

Figure 3 shows the comparison between simple straight wall 3 m high and 3.5 m high wall including Noise Reducer; 2 to 3 dB reduction effects appears in the both directions. These measurements almost fully agree with the trend of analytical calculation.

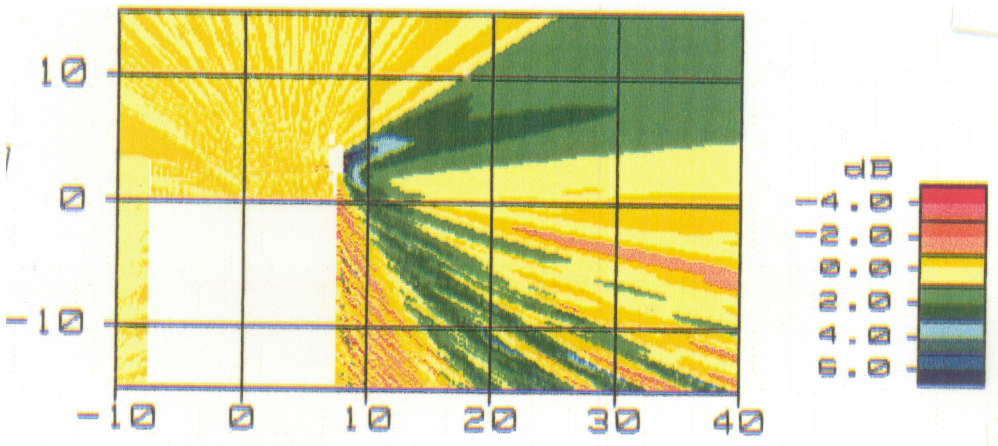

Figure 3: Insertion loss distribution.

4 - PLANTING-TYPE NOISE REDUCER

The planting-type Noise Reducer are formed by slightly enlarging the top portion of the original mushroom type with soft and balanced shape, and planing in the top opening space. It has a more beautiful shape than the mushroom type Figure 4.

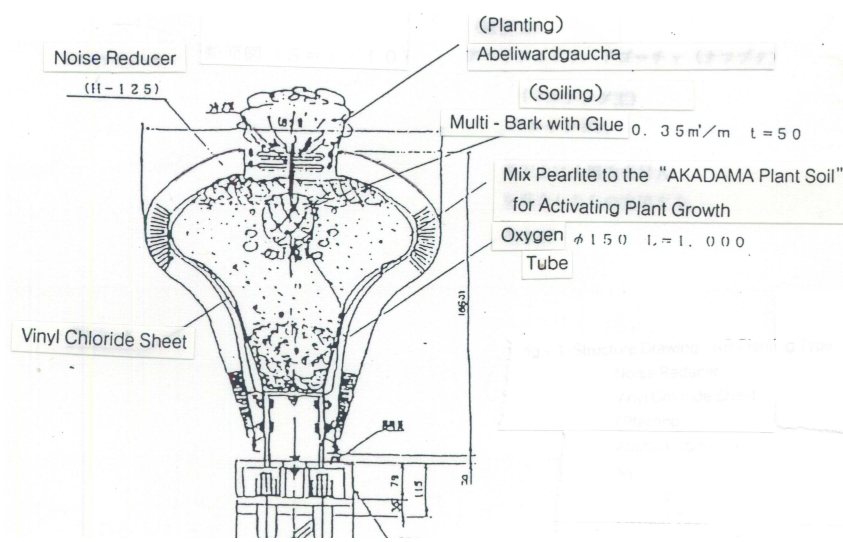

Figure 4: Structure drawing; planting-type.

The conditions for selection of planted trees in the Noise Reducer are as follows
Since it is difficult to sufficiently water trees planted in the reducers, they must be strong for drying.
Since it is difficult to prune away trees planted in the reducers, they must be desirably maintenance free.
Abelia edwardgaucha was selected as it may meet these selection conditions.

4.1 - Field experiment

Planting-type Noise Reducer was installed on balustrade of an overhead bridge in an automobile road. Automobile running tests were carried out before and after installing the Noise Reducer, to investigate into noise mitigation effect. (shown in Figure 5).
Sound pressure differential was determined using the mean value of the noise peak levels of the test runs before and after installation are 3.9 dB, 6.8 dB, and 7.0 dB at 0 m, 10 m and 20 m.

4.2 - Theoretical analysis

In this analysis, a calculation range was set for the measuring section of the overhead bridge subjected to this field measurement survey: First, the sound source was placed on a lane center at "the side of measuring points on the ground level"; and calculated sound pressure level difference before and after installation of Noise Reducer on a guard rail at the above described side.

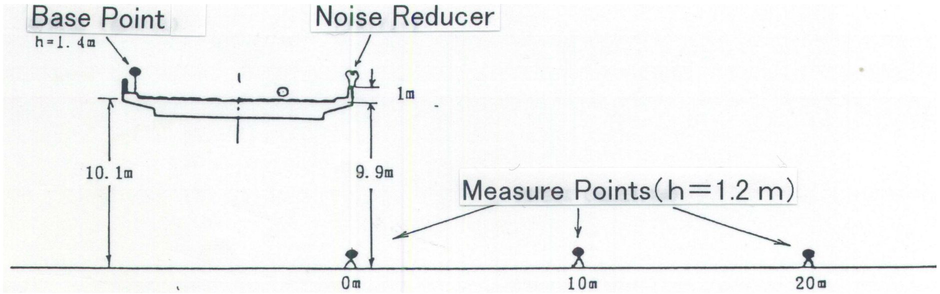

Figure 5: Measuring points in field tests of planting-type noise reducer.

Figure 6 shows not only noise mitigation effect diagonal upwardly but also attenuation effect as much as 2-5 dB diagonal downward. In particular, the attenuation is remarkable in a range 10-20 m apart from the edge of the elevated road where housings are located around.
Comparison between calculations and measurements reveals a general agreement even with a slight difference at 20 m point.

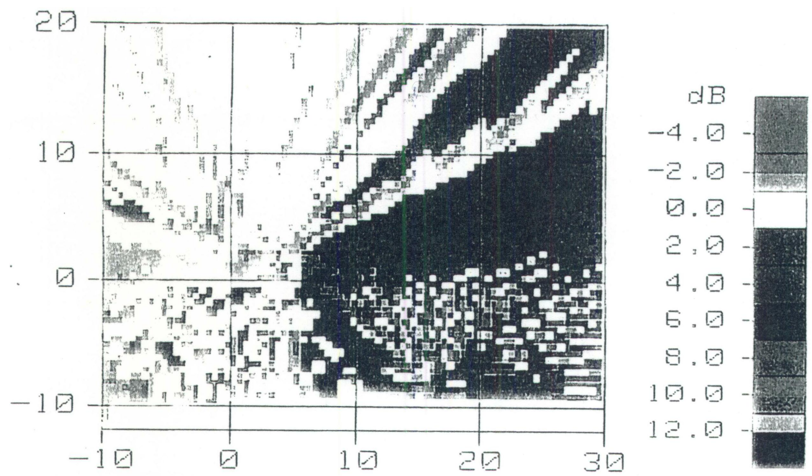

Figure 6: Calculated insertion losses.

5 - SUMMARY

To confirm the installation effect of Noise Reducer, site experiments at an elevated highway bridge and sound field analysis by way of boundary element method were carried out, and the measurements and corresponding calculations were studied from the standpoint of both experiment and theory. The results are summarized as follows

1. In view of actual measurements at site and numerical calculations, it was confirmed that the Noise Reducer had a significant noise mitigation effect, and effective as noise mitigation means, particularly for a place where the height extenuation of existing noise barriers is difficult from various circumstance.
2. Analytical calculations of sound field by way of the boundary element method showed a relatively good agreement with test measurement at site. Therefore, it was proved that numerical calculation by the boundary element method can well represent the condition of sound field at the back of noise barrier.

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