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Reduction of traffic-induced vibration by soilbags ("donow")

Reduction de la vibration des sacs de terre provoquee par la circulation routiere

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ABSTRACT
In this paper, the vibration reduction by soilbags ("donow" in Japanese) is studied experimentally both in laboratory and in a field-testing pit. The experimental results indicate that the vibration produced on the vertically piled soilbags is significantly reduced and the vibration produced on one column of vertically piled soilbags is hardly transmitted into the adjacent column of the vertically piled soilbags even they are in contact each other. When soilbags are piled to construct a vertical barrier in the ground, they can reduce the vibration that is produced on the ground away from the barrier. The paper also introduces two cases of applying soilbags to reinforce truck roads with asphalt pavement and with concrete pavement, respectively. In both of these two cases, the traffic-induced vibration is significantly reduced after the reinforcement with soilbags.

RÉSUMÉ
Dans ce travail, la diminution des vibrations par des " sacs de terre" ("donow" en Japonais) a été étudiée expérimentalement à la fois en laboratoire et par essais in-situ dans des puits. Les résultats obtenus montrent que les vibrations appliquées sur une colonne verticale de "sacs de terre" sont significativement réduites et que les vibrations appliquées sur la colonne de "sacs de terre" sont fortement transmisses à la colonne adjacente de "sacs de terre" même si elles sont en contact entre elles. Lorsque les "sacs de terre" sont entassés verticalement pour construire une barrière dans le sol, ils peuvent réduire les vibrations appliquées dans le sol loin de cette barrière. Ce papier expose également deux cas d'application du renforcement de routes pour camions constituées d'asphalte et de béton. Dans les deux cas, les vibrations induises par la circulation sont fortement réduites après le renforcement avec des "sacs de terre".

1 INTRODUCTION

When subjected to external forces like the dead loads of upper buildings, soilbags usually tend to be flat with the extension of the bags' perimeters and thus tensile forces are produced in the bags. The tensile forces of the bags in turn act on the soils inside the bags, resulting in the increase of their strengths. It is to be noted that soilbags take effect by making use of the applied external forces (Matsuoka and Liu, 2003). Experiments and practices indicated that soilbags could increase significantly the bearing capacities of building foundations if they are properly arranged under the building foundations. Furthermore, soilbags have still the advantages of

- Being environment-friendly due to no use of any cement or chemical agents.
- Being silent during construction.
- No need of special construction equipments, even possibly by manpower.
- Being light with the similar weights as soils.
- Being able to contribute to the recycle of waste materials, as any construction wastes such as concrete, asphalt, tile wastes as well as the granular remains after garbage treatment may be put into bags.
- Having unbelievable high compressive strengths.
- Reducing traffic- or machine-induced vibration.
- Preventing frost heave if soilbags are filled with coarse granular materials.
- Being effective to reinforce waterlogged soft ground.

In this paper, the vibration reduction through soilbags is studied experimentally both in laboratory and in a field-testing pit. Then, we introduce two cases of using soilbags to reinforce truck roads with asphalt pavement and with concrete pavement, respectively, and report the vibration measurement results in these two fields.

2 LABORATORY VIBRATION TESTS ON SOILBAGS

2.1 *Vibration reduction through the vertically piled soilbags*

Figure 1 shows the vibration tests on 5 vertically piled soilbags (Matsuoka et al., 2002a). One soilbag has a width of 40cm and a height of 8cm. The material inside soilbags is No.3 silica sand with a maximum grain size of 3.4mm, an average grain size of 1.2mm and a minimum grain size of 0.3mm. Four acceleration sensors of small strain gauges are respectively set on the interfaces between soilbags. The experimental results show that the input acceleration down to the ground is reduced by 13% (in gal.) through three vertically piled soilbags with a reduction of about half of the corresponding input acceleration for each soilbag ($50\%\times50\%\times50\%\fallingdotseq13\%$). If the same silica sand is put into a paper-made box as shown in Fig.1 (c), the acceleration is reduced only by 57% through the same depth as the three soilbags (8cm×3=24cm). Furthermore, if the same silica sand is piled up without any lateral boundary restrictions as shown in Fig.1 (d), then the acceleration is reduced by 39% through the same depth as the three soilbags (8cm×3=24cm). Among these three cases, soilbags are the most effective to reduce the input acceleration. This is because the vibration energy is absorbed by the compressive and rebounding deformation of soilbags ac companying with the extensive and contractive deformation of the bags under loading and unloading.

2.2 *Vibration reduction through the adjacent piled soilbags*

Figure 2 shows the vibration tests on two columns of vertically piled soilbags that are in contact laterally or separated, respectively (Matsuoka et al., 2002a). Two types f the platen vibrators with vibration frequencies of 60Hz and 6Hz, respectively, are used. Figs. 2 (b) and (d) illustrate that although the two columns of the piled soilbags are separated, some accelerations are measured on the adjacent column of soilbags due to the transmission through the ground. By deducing the magnitudes of those accelerations and considering the ±10gal of the tolerance of the used strain-typed gauges, the accelerations on the adjacent contacting column of the piled soilbags as shown in Figs. 2(a) and (c) are almost zero. This implies that the vibration in the column of the piled soilbags with the vibrator placed on it is hardly transmitted into the adjacent column of the piled soilbags even if those two columns are laterally in contact each other. The fact that the vibration is hardly transmitted laterally into the adjacent column of the piled soilbags is also checked by observing the water fluctuations in the two glass cups that are respectively put on the two columns of the piled soilbags as shown in Fig.2 (a). It is clearly observed that when the vibrator runs, the water level fluctuates significantly in the glass cup placed on the column with the vibrator, whereas the water level is nearly at a standstill in the glass cup placed on the adjacent column without the vibrator. Furthermore, this vibration transmission can be felt by touching the soilbags by hands as well.

3 VIBRATION TESTS ON A FIELD SOILBAG PIT

Figure 3 shows a schematic view of the vibration measurement in a field pit constructed with soilbags (Matsuoka et al., 2002b). One soilbag is 40cm wide, 40cm long and 8cm high. The field pit is 280cm wide, 280cm long and 56cm deep. In the pit, four layers of the vertically piled soilbags, with a total height of 32cm, are first placed, and then a barrier against vibration, consisting of three layers of the overlapped soilbags with a total height of 24cm, is constructed on the four layers at one end of the pit. The widths of the lowest and top layers of the barrier are 160cm and 80cm, respectively. The left part of the pit in front of the soilbag barrier is backfilled with the same soils as used in soilbags, which are excavated in road construction and have the grain size less than 25mm. In the tests, vibration is respectively produced at the central point of the pit surface with two types of vibrators: one is the electrically driven platen vibrator with a mass of 25kg and a frequency of 60Hz; the other is the engine driven platen vibrator with a mass of 60kg and a frequency of 90Hz. The measurement is taken at the points of every 40cm along the measurement line perpendicular to the soilbag barrier against vibration, as shown in Fig. 3(b). The measured vibration levels in dB are plotted against the distances away from the vibration source in Fig.4 for the electrically driven platen vibrator and in Fig.5 for the engine driven platen vibrator. The solid lines with black plots in Figs. 4 and 5 are the distance damping against vibration measured near the field pit. It can be seen from Figs. 4 and 5 that the vibration produced by both the two vibrators is reduced significantly just through the soilbag barrier compared to the distance damping. The average vibration reduction is about 15dB for the electrically driven platen vibrator and about 10dB for the engine driven platen vibrator.

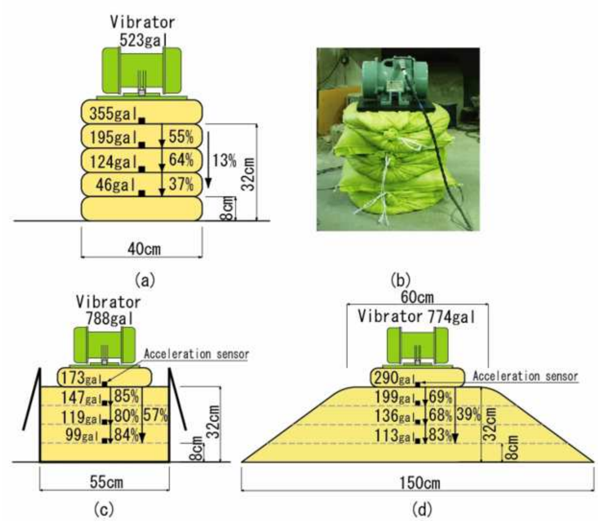

Figure 1. Laboratory vibration tests on vertically piled soilbags to investigate the downward vibration reduction.

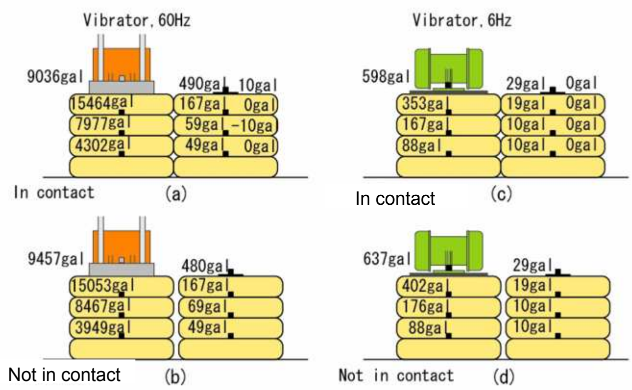

Figure 2. Laboratory vibration tests to investigate the transmission of vibration into the adjacent piled soilbags.

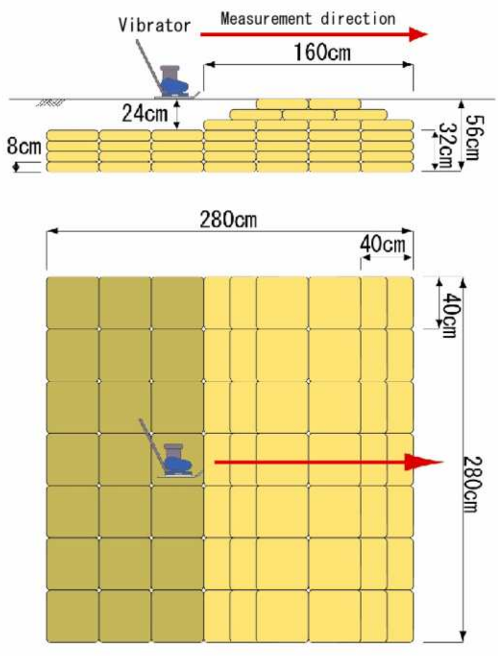

Figure 3. Schematic view of field testing pit constructed with soilbags.

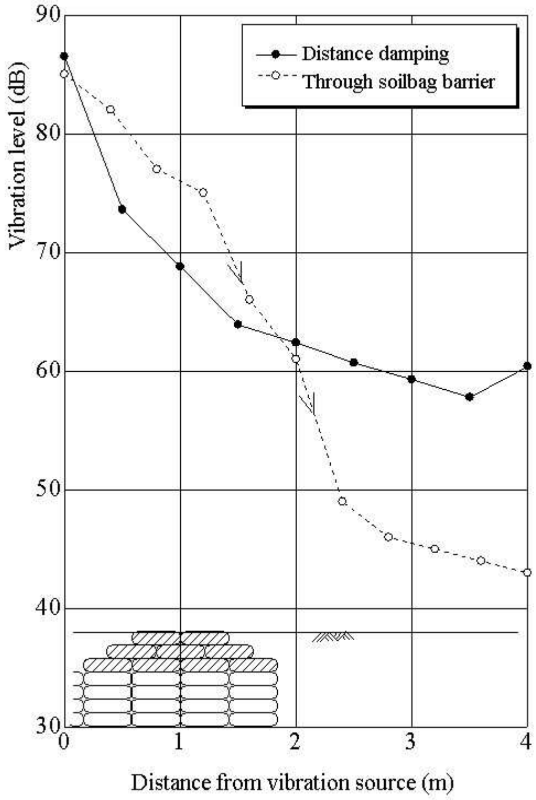

Figure 4. Vibration reduction through the soilbag barrier in the case of electrically driven platen vibrator.

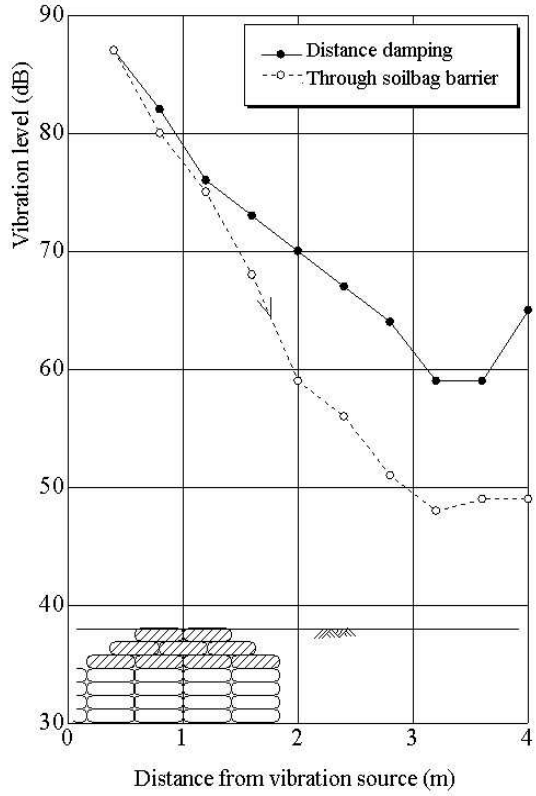

Figure 5. Vibration reduction through the soilbag barrier in the case of engine driven platen vibrator.

4 APPLICATION IN TRUCK ROADS AND THE REDUCTION OF TRAFFIC-INDUCED VIBRATION

Soilbags have already been applied to reinforce truck roads in Nagoya city both with asphalt pavement and with concrete pavement. Here, we report the field vibration measurement in both of these two cases.

Figure 6 shows the placement and compaction of soilbags under a truck road with asphalt pavement. The field is located near the cross of a 20m wide road with heavy traffics. The asphalt pavement has been severely damaged due to the weak roadbed beneath it and the heavy traffics. The traffic-induced vibration on this bad road has troubled the residents significantly. Fig.7 shows the schematic view of the reinforcement with soilbags in this field. Under the asphalt pavement, there are a 27cm thick coarse-grained asphalt concrete, a 15cm thick recycled crushed stone (RC-40) and three layers of soilbags with a total height of about 20cm. The recycled crushed stone is used to protect the underlying soilbags from the high temperature of the asphalt concrete during pavement. To reduce the traffic-induced vibration more effectively, two layers of four soilbags overlapped by three and half soilbags are further placed near the sidewalk. Before and after the reinforcement with soilbags, the vibration measurement was respectively taken at the sidewalk (points P1 to P3) and at the third floor of a steel-framed house (P4), as shown in Fig.7. The measurement results are listed in Table 1, where each data is obtained by averaging the maximum vibration levels measured within 10 minutes. It can be seen from Tab.1 that after the reinforcement, the vibration levels measured at both four measurement points are much less than 60dB, which is the most strictly standardized on the traffic vibration at night. In particular, the residents in the steel-framed house are very happy to feel hardly the vibration after the reinforcement.

Figure 8 shows the schematic view of another truck road field reinforced with soilbags but with concrete pavement. Table 2 summarizes the average maximum vibration levels measured at two ends of the sidewalk (points P1 and P2, shown together in Fig.8) before and after the reinforcement with soilbags. Similarly, the vibration levels are greatly reduced (about 12dB) after the reinforcement. Therefore, both in the case of asphalt pavement and in the case of concrete pavement, the reinforcement with soilbags for truck roads can reduce significantly the traffic-induced vibration. Such vibration reduction effect with soilbags will further be verified through the long-term vibration measurement at the above two fields.

Table 1: Measured vibration levels at the asphalt-paved truck road before and after reinforcement by soilbags

Measurement point	P1	P2	P3	P4
Before reinforcement	67dB	66dB	57dB	65dB
After reinforcement	55dB	54dB	46dB	50dB

Table 2: Measured vibration levels at the concrete-paved truck road before and after reinforcement by soilbags

Measurement point	P1	P2
Before reinforcement	69dB	66dB
After reinforcement	57dB	54dB

Figure 6. Reinforcement for a asphalt-paved truck road with soilbags.

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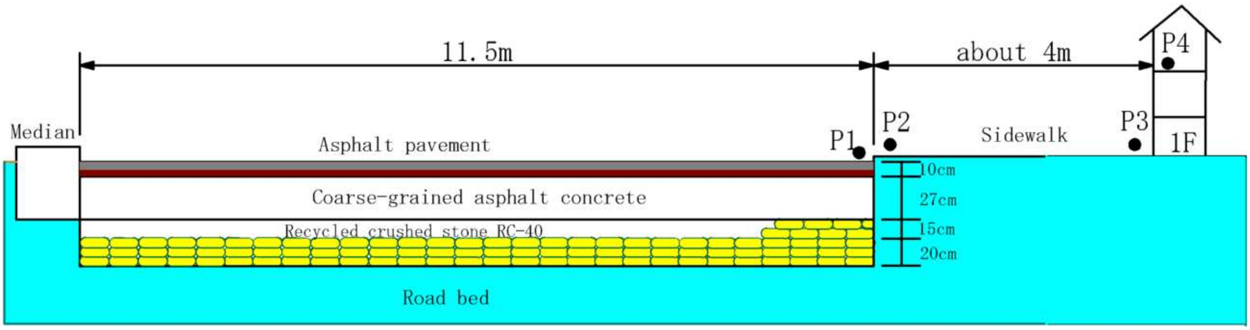

Figure 7. Schematic view of reinforcing the truck road under asphalt pavement with soilbags and the locations of the vibration measurement points.

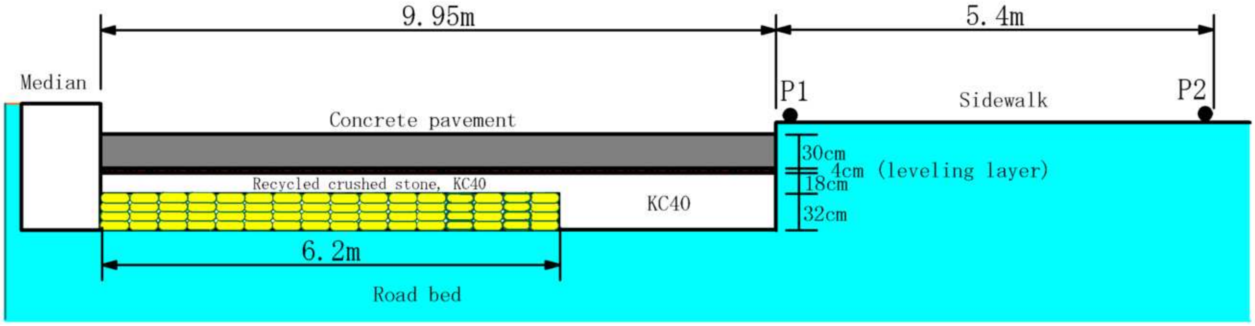

Figure 8. Schematic view of reinforcing the truck road under concrete pavement with soilbags and the locations of the vibration measurement points.

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