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Trial construction of arching structure by using large-sized soilbags

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ABSTRACT: Soil bag has been confirmed to perform excellent due to the restriction effect of the geo-synthetics (of the bag material). From this fact, it comes to an idea if any arch structure could be built with soil bags, instead of the rigid material such as stone or concrete that have been conventionally used. However, it is difficult to build an arch structure of actual scale with the soil bag of an ordinary size. Hence, in order to confirm the feasibility on construction of the actual arch structure and its behavior, an experiment that large size soil bag instead of the ordinary size was used to build an actual size arch structure (R=5m), was conducted. At the final experiment, stress and displacement took place in the arch structure, and the strain worked in the geo-synthetics, were measured, and its feasibility whether it could be constructed as a structure, was confirmed.

1 INTRODUCTION

Arch structures have been used for the structures such as bridges and tunnels for very long time. In order to form the arch, mainly rigid material such as stone and concrete have been used.
Whereas "soil bags", which can be easily made at site, have been used for various purposes in the civil construction. Recently, it is confirmed that improving the quality of the "soil bags" by packing the soil into the geo-synthetics, turned out to be greatly effective by research done by Matsuoka et al. Therefore, the authors considered that the "soil bags" could be used as material for the arch structure, and carried out an experiment of actual size. Here it is described on the evaluation of its constructability and the results of its observation.

2 CONTENTS OF EXPERIMENT

A centre was used in order to construct the arch structure. The centre was set at 50 cm raised position by four hydraulic jacks, which would be able to be removed at last. Time dependent behavior was observed by measurement from the setting of the "soil bags" until the removal of the centre.

2.1 *Figures of the arch and the soil bags*

The arch structure built in the experiment is shown in Figure 1. As for the "soil bags", box-shaped soil bags and wedge-shaped soil bags were used. Filler material used was crushed stone (C-40).

2.2 *Measurement*

In the experiment, earth pressure activated on the arch structure, strain of the geo-synthetics forming the "soil bags", and displacement of the arch structure were measured. The locations of the measurement apparatus are shown in Figure 1.

2.2.1 *Earth pressure cell*

Earth pressure cells were set in the basement of the arch structure (earth pressure cells No.1 and No.2), and at the inside of the 9 th large soil bags from the bottom (earth Pressure cell No.3 and No.4). The earth Pressure cell consisted of four load cells, and it can measure the earth Pressure at the upper and lower faces, and at the inner and outer faces.

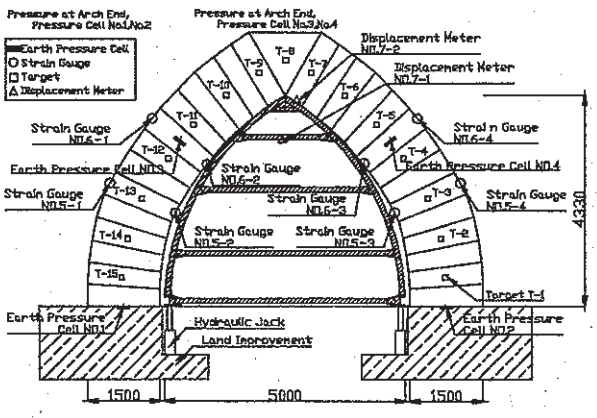


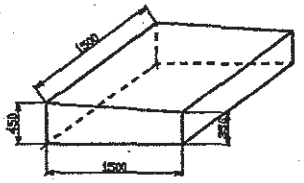
Figure 1. Arch figure and location of measurement apparatus.

2.2.2 *Strain gauge*
Strain gauges were set inside and outside of the arch at the 6 th and 9 th large soil bags from the bottom.

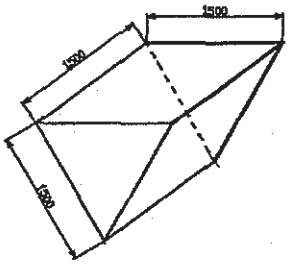
2.2.3 *Displacement seismograph and target*
Displacement seismograph used was of wire-type displacement seismograph. It was set at the centre (displacement seismograph No.7-1) when the centre was settling, and it was set at the 14 th large soil bag from the bottom (displacement seismograph No.7-2) after the centre was removed. In addition, targets were set at the front face of the arch structure, and the displacement of the arch structure was measured by using transits.

3 EXECUTION PROCEDURES OF THE EXPERIMENTS

The execution procedure of the experiment is shown in Figure 3. Pictures during the construction are shown in Figure 4 to Figure 7.



Box-shaped soil bag



Wedge-shaped soil bag

Figure 2. Shape of large soil bag.

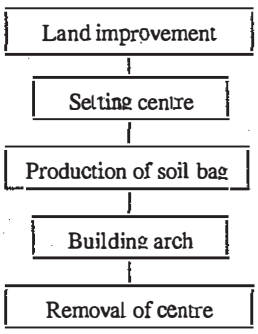


Figure 3. Flow of experiment.

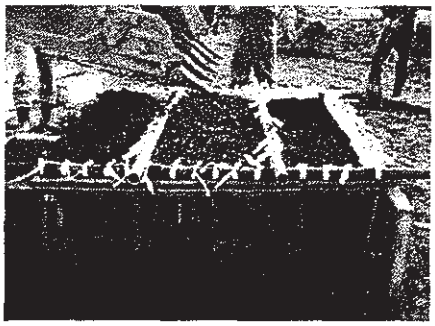


Figure 4. Production of soil bag.

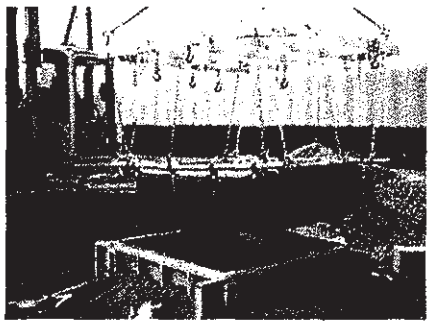


Figure 5. Lifting of soil bag.

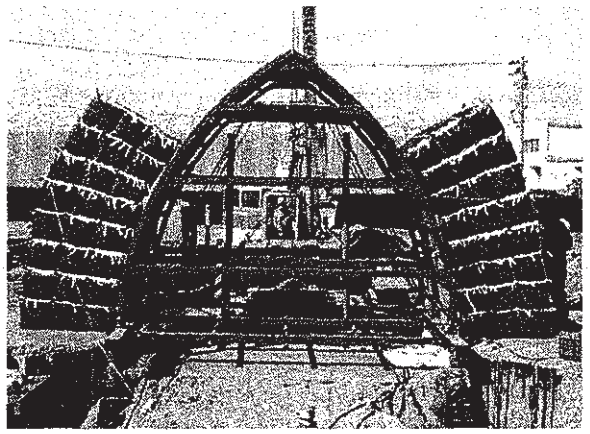


Figure 6. Setting soil bags.

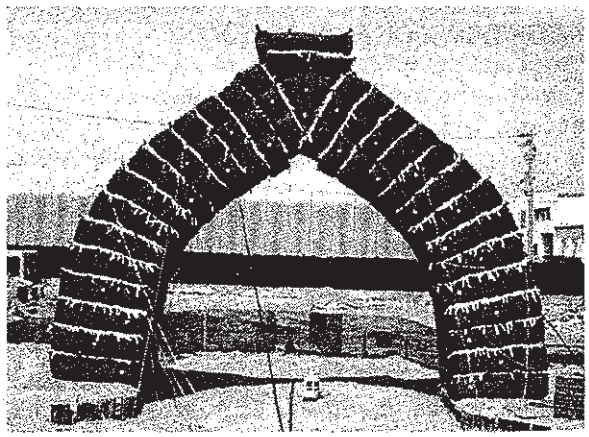


Figure 7. Completion of arch.

Table 1. Characteristics of geo-synthetics.

Item		Characteristics
Material		Polyester
Mesh size	(mm)	7.0 × 7.0
Mass	(g/m^2)	700
Tensile strength	(kN/m)	98.0 × 98.0
Elongation ratio	(%)	22.0 × 22.0

4 MEASUREMENT RESULTS AND DISCUSSIONS

4.1 *Earth pressure*

4.1.1 *Behavior at construction for large soil bags*

Figure 8 show relationships between each earth pressure and time passed while setting large soil bags. The earth pressure inside of the soil bags (earth pressure cells No.3, No.4) increased significantly at 10 th from the bottom. Instead, the earth pressure at 7the end of the arch (earth pressure cells, No.1, No.2) did not shown as much increasing tendency as that shown by the earth pressure inside. This is considered because that the earth pressure cell was embedded in the base ground treated with stabilization, and its set condition became of buried type, and little effect was observed at the end of the arch.

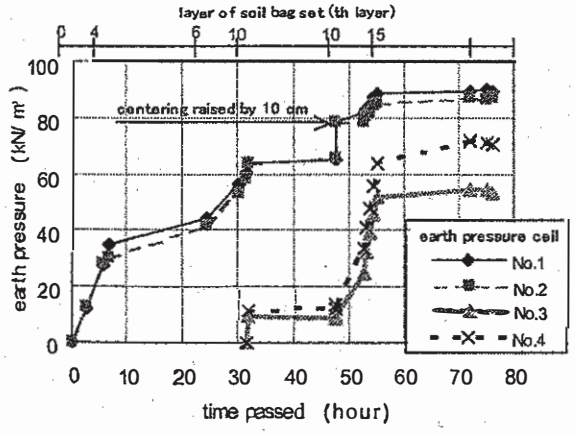


Figure 8. Relationship between earth pressure and time at placing soil bags.

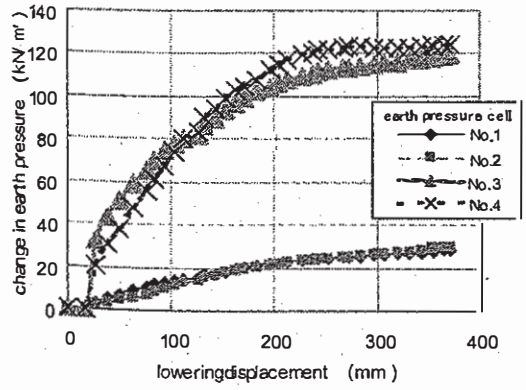


Figure 9. Relationship between earth pressure change and vertical displacement at lowering centre.

4.1.2 *Behavior when centre is lowered*

Figure 9 shows the relationship between the change in earth pressure accompanied with the lowering of the centre, and the vertical displacement at the centre. The earth pressure inside the soil bags (earth pressure cell No.3, No.4) tended to increase significantly with an increase in the vertical displacement. This is considered because that the large soil bags set in the upper part leaned against the centre, and that the earth pressure increased as the centre lowered. Whereas the earth pressure at the end of the arch (earth pressure cells No.1, No.2), shows a tendency of gradual increase. This is also considered to be the same effect of the setting as mentioned above.

4.1.3 *Earth pressure distribution in the section*

Figure 10 shows the relationship between the earth pressures measured by the load cells inside and outside of the panel type earth pressure cells No.2 and No.4, and the time passed. Each earth pressure cell tends to show that the earth pressure generated at the inside is the lager.

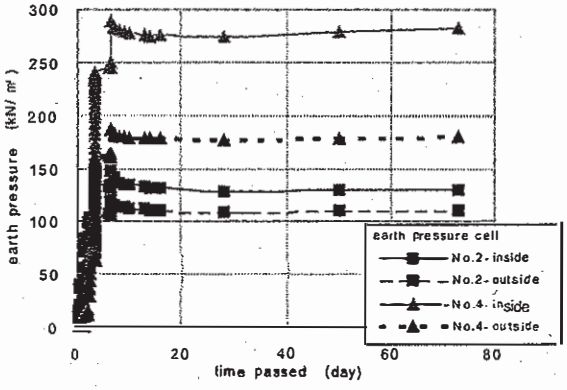


Figure 10. Relationship between earth pressure at inside, outside of arch, and time passed.

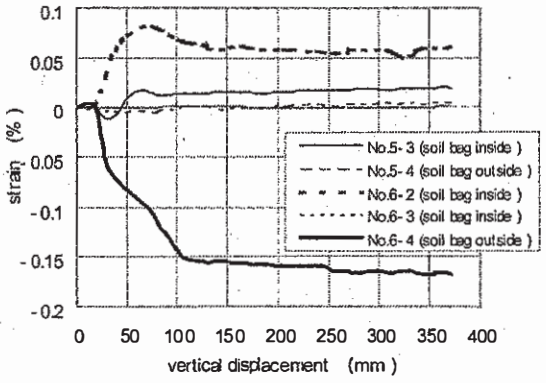


Figure 11. Relationship between strain inside, outside of soil bags, and lowering displacement centre.

4.1.4 *Strain of geo-synthetics*

Figure 11 shows the relationship between the strains at the inside and outside of the arch in the geo-synthetics during the lowering and after the removal of the centre, and the vertical displacement. The strain of the geo-synthetics at the inside of the soil bags is very small and tension (+ symbol: tension) occurs. This is because soil bags are compressed and bended laterally. As seen in Figure 12. From this, stress is confirmed to be concentrated at the inside of the arch, and it is considered that the filler material which would otherwise deform, is constrained by the geo-synthetics.

4.2 *Displacement of the arch structure*

Figure 13 shows the behavior of the arch structure expressed by the measurement of the targets set in the large soil bags. From this Figure, little settlement was observed for the soil bags lower than the 6th bag from the bottom (T-4), whereas a tendency of some settlement was observed in the upper soil bags. The settlement took place after the removal of the centre, was considered to be caused by a phenomenon that interlock (or cohesion) between the neighboring soil bags became strengthened. There was a tendency of settlement observed at any target until about 30 days, but that was observed to cease after that. The magnitude of the settlement in accordance with the lowering of the centre was about 0.4 m as the maximum settlement.

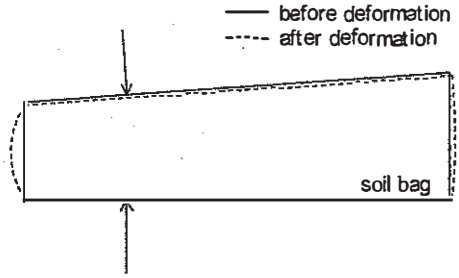


Figure 12. Behavior of soil bag.

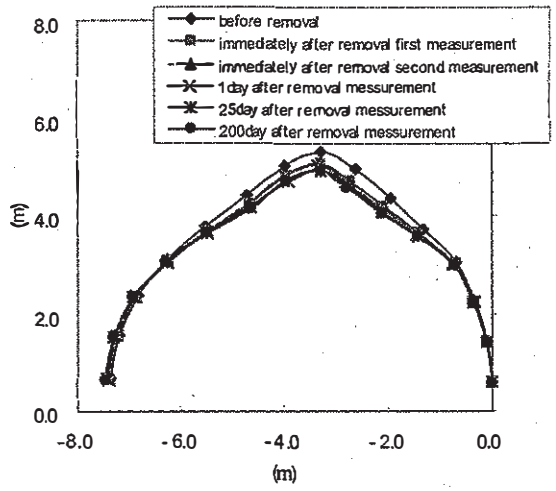


Figure 13. Behavior of soil bag arch.

5 FINAL REMARKS

As stated in Figures 10 and 11 compression stress is consentrated at the inside of arch structure. This means that arch action is constructed at the inside of the structure. The displacement behavior shown in Figure 12 also supports this aspect. If this arch structure was constraimed laterally, more complete arch action would be observed.

From this experiment, the proposed method was found to have some room for improvement in its constructability, but it was confirmed to be able to build it. In addition, the arch structure consisting of the large soil bags using the geo-synthetics, was found necessary to allow some deformation. However in reality, as an arch effect due to the lateral earth pressure and the soil itself is expected, it is considered to be able to build a structure exhibiting little deformation, and high stability.

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