Greening method of shotcrete slope blended on landscape

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This study concerns the protection method and the natural maintenance of aging shotcrete. In Japan, in the high economic growth period in 1960's, a great number of slopes were formed to construct many roads and most slope protection methods were to cover shotcrete on the slope. In recent years, with concerns about the environmental and landscape, the construction of shotcrete is decreasing. However, even now about 7,000,000㎡of shotcrete is laid every year, and it is predicted that the total amount of shotcrete is enormous. Now, about 60 years passes after a great number of shotcrete was laid, and shotcrete have been aging. Therefore, we suggested the method which construct for directly aging shotcrete in the protection method and the greening protection method is considering cost and risk with new construction. We adopt the protection method by rock bolt and rope net. In this study, at first, we establish the vegetation base suitable for growth of plants which can be use together with the protection method. And then, we install many kind of the vegetation base that gave the vegetation on a model shotcrete. Finally, we compared the rates of water retention and vegetation growth.

1. INTRODUCTION

In recent years, with concerns about the environmental and landscape, the construction of shotcrete is decreasing. In Japan, in the high economic growth period in 1960's, a great number of slopes were formed to construct many roads. It is predicted that the total amount of shotcrete is enormous. Now, about 60 years passes after a great number of shotcrete was laid, and shotcrete have been aging. Therefore, we suggested the method which construct for directly aging shotcrete in the protection method and the greening protection method is considering cost and risk with new construction. We adopt the protection method by rock bolt, rope net and pressure plate.

Traditional greening shotcrete let the vegetation bases such as the ground or the planter do planting and clambering or nutating. The problems in this method are that it takes a long time for the shotcrete to be greened and that the greened parts can be patchy. Therefore we thought that we could solve the problems by installing more than one vegetation bases (Figure1) which has planting at the equal distance on a rope net. In this study, we compared plants and the vegetation base suitable for shotcrete substitute for the ground and the planter from test results.

Figure1. Vegetation bases

2. TEST OVERVIEW

In this study, we examined vegetation and the vegetation base in desk examination, water retention test and field. We suggested vegetation and the vegetation base in the desk examination. We examined the water retentivity of the vegetation base which is to be suggested in the water retention test, and we examined whether the adaptation was possible in outdoor environment in the field test. Figure2 shows the flow chart of the study.

(1) Desk examination

In the desk examination, we suggested vegetation and the vegetation base. We suggested Hedera helix, Trachelospemum asiaticum, Euonymus fortune coloratus, Hedera canariensis which are often used for wall surface greening well and have good coating speed. We suggested Akadama soil which has an aggregating structure and has contradiction property of drainage drainage characteristics and water retention characteristic contradicting property at the same time and we also suggested humus soil which can supply nourishment to the soil materials of the vegetation base. We suggested the hemp which is a natural material for storing materials of the vegetation base. We put 4ℓ of soil materials which was made of the hemp containing water retention agent and spread dry reduction materials on the surface to prevent evaporation of the water. We suggested the vegetation base structure as Figure3 and table1. Structure A and structure D used 4ℓ of soil materials, structure B and structure C used 2ℓ them. They had the structure that can save rain water by the rain in the bottom of the vegetation base.

(2) Water retention test

In the water retention test how water retention rate changed in the difference of soil materials was considered. We conducted two types of water retention tests. In the test1, we compared water retention effects of the mixture soil consisting of akadama soil and humus soil suggested in this study to compost which was available in the market and was said to be versatile. In the test2, we examined the most suitable combination ratio of akadama soil and humus soil. Table2 expressed the test condition.

We show below formula for computation of the water retention.

$$water\ \ retention\ \ rate = 7.2 \times 10^{-3} \times Raw - 0.393$$

Here, RAW is numerical value shown by a measuring instrument.

(3) Field test

Figure2 is a model shotcrete. We reproduced a model shotcrete consisting of the board of 1.76m in height and 2.73m in width painted with the mortar and installed a rope net. We put it in two places of north (N) and south (S) direction with slope of 50 degrees. We planted the vegetation on the vegetation base and set up the bases to the rope net.

We measured the water retention rate, growth (height of a plants and cover degree) of the vegetation, the environmental condition (temperature and humidity and amount of rainfall) in each combination. Then, we confirmed the number of the pixels of the greening parts and the whole shotcrete, and we divided the number of the pixels of the greening parts by the number of the pixels of the whole shotcrete, and obtained a cover degree from the digitized photograph image. We measured it in spring season (from April to June) and winter season (from November to January).

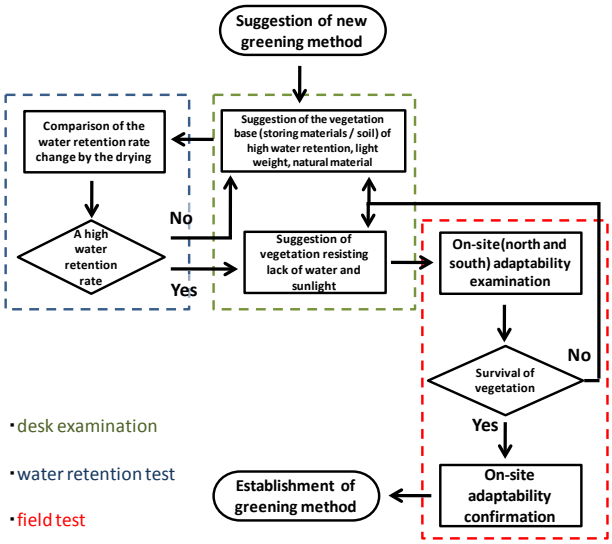

Figure2. Flow chart of the study

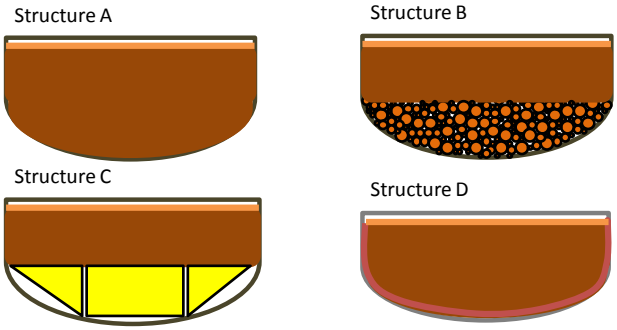

Figure3. Structure of Vegetation base

Figure4. A model shotcrete

Tabel1. Structure of vegetation base

Structure	Soil materials	The weight of soil materials(ℓ)	Vegetation base storing materials
A	40% of akadama soil and 60% of humus soil	4	hemp
B		2	
C		2	
D		4	polyethylene

Tabel2. Test condition

Test condition	
Soil	1.5kg
Water	600mℓ
Temperature	100℃(oven-dried)
Notation system	
Akadama soil	A
Humus soil	H

3. TEST RESULTS

(1) Water retention test

In the test1, we compared a change of the water retention rate in the mixture soil with the general combination rate of 60% of akadama soil and 40% humus soil to versatile compost. Figure5 is the result of test1. The water retention rate fell in the compost about 2 times as much as the mixture soil consisting of akadama soil and humus soil, and the mixture soil was confirmed superior in the water retention effect.

We examined the most suitable combination ratio of akadama soil and humus soil in the test2. Figure6 is the result of test2. When the percentage of akadama soil increased, the water retention rate fell immediately after the measurement started, and the water retention rate drastically fell after the measurement progressed to some extent, when the percentage of the humus soil increased. However, the mixture soil with the ratio of 40% of akadama soil and 60% of humus soil was confirmed superior in the water retention effect.

(2) Field test

Figure7 expressed water retention rate changes according to the vegetation base structures. Water retention rate of structure A one month after the rainfall fell about around 1% whereas water retention rate of structure B - D fell more than 2%. Therefore it is thought that the quantity of soil materials of the structure A was double compared to structure B and structure D, and that in the structure B and structure D, there was no storing rainfall at the bottom of the vegetation base. And, as for structure D, difference of vegetation base was also thought to be the cause.

Figure8 and figure9 shows the water retention rate change of the vegetation base suggested in this study and past study. In the vegetation base suggested in the past, water retention rate increased to 6% at the time of the rain, but, water retention rate maintain around 4% when there was no rain. However, water retention rate of the vegetation base which we suggested newly in this study maintained around 7%, and the vegetation base which we suggested was confirmed superior. Therefore, the vegetation base materials which we suggested newly in this study are confirmed superior with the high water retention effect.

Figure10 shows the result of cover degree measurement. The measurement period was from April 12 to June 14 2010. It is confirmed that the cover degrees increased smoothly in the north direction, but it decreased in the south direction. We show the state of the vegetation in the south direction on the June 14 in figure11-14. It is confirmed that Hedera helix, Trachelospemum asiaticum, Euonymus fortune coloratus dried up in around 2 months. However, it is confirmed that Hedera canariensis grew steadily. Therefore, superiority of Hedera canariensis is confirmed in the vegetation which we suggested.

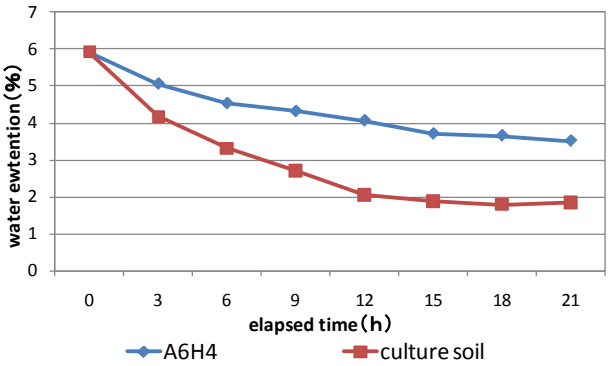

Figure5. The result of test1

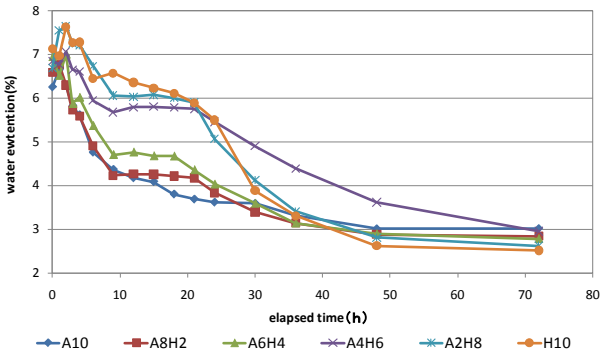

Figure6. The result of test2

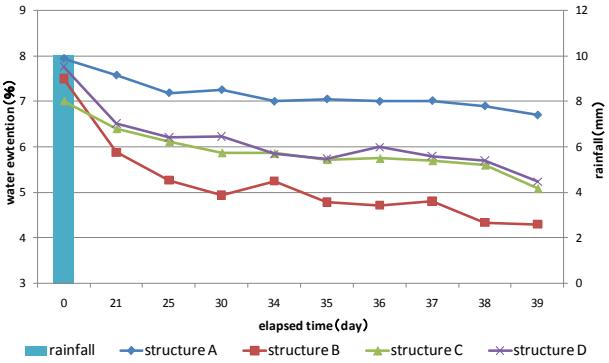

Figure7. The result of water retention rate (Structure of the vegetation base)

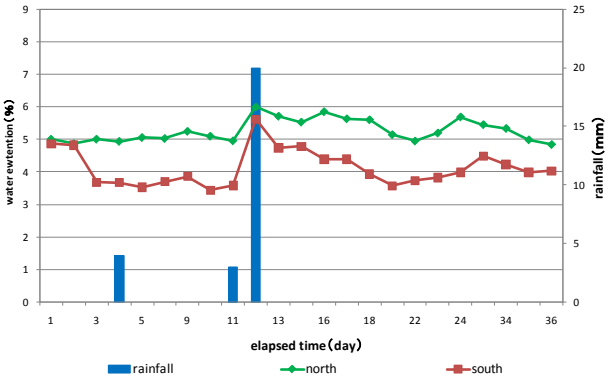

Figure8. The result of water retention rate (In this study)

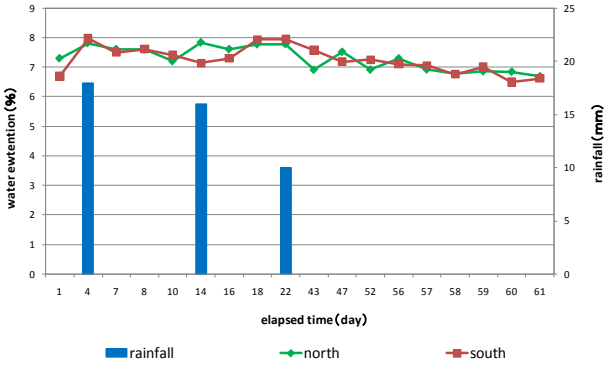

Figure9. The result of water retention rate (In past study)

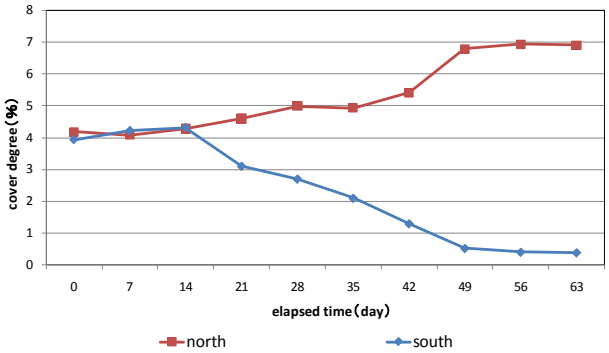

Figure10. The result of cover degree

Hedera helix | Trachelospemum asiaticum | Euonymus fortune coloratus

Figure10. Dried up vegetation

Figure12. Hedera canariensis

4. CONCLUSIONS

We compile below a result provided from this examination.

(1) The superiority of akadama soil and humus soil in water retention test was confirmed in the comparison with the compost.
(2) The superiority of the combination ratio of 40% of akadama soil and 60% of humus soil was identified in the water retention test.
(3) The superiority of structure A was identified in the field test.
(4) The superiority of the vegetation base we suggested was confirmed in the comparison with the vegetation base in the past study in the field test.
(5) The adaptability in the north direction was confirmed in the field test.
(6) The superiority of Hedera canariensis was identified in the field test.

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