The study of greening shotcrete considered the 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.

2. TEST OVERVIEW

(1) Water retention test

We compared how water retention changes in a difference of the bag fiber and quantity of the water retention agent from the result of water retention tests taken place twice. In test 1, we set the quantity of the soil was 450g, and that of the water retention agent were 2% and 4% of the weight of the soil(which were 9g and 18g), and set the initial addition of water was 600ml. We examined how the water retention changed in a water content machine for soil that was kept at 100 degrees Celsius. The test pattern is all 8 pattern, it is ①: h-C-9, ②:h-LC-9 ,③:h-C-18 ,④ : h-LC-18 ,⑤: nw-C-9 , ⑥:nw-LC-9 ,⑦: nw-C-18 ,⑧: nw-LC-18. In test 2, we conducted a examination in 8 patterns as test 1 with the initial water addition of 400ml. We show below formula for computation of the water retention.

$$q = 7.2 \times 10^4 \times Raw - 0.393$$

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

(2) 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 put a plant on the bags with the soil which contained water retention agent (water keep), and installed them on the rope net. We used lightweight compost (LC) and normal compost (C) for the examined soil, nonwoven fabric (nw) and hemp (h) and sponge (sp) for the fiber of the bag, Hedera helix (H) and Trachelospermum asiaticum(T) and Rhacomitrium canesces(R) for the plant, and we installed plants, bags, and composts with combinations on a model shotcrete. The combination is ①:H-nw-C,②:H-nw-LC,③:H- h -C,④:H- h -LC,⑤:T-nw-C,⑥:T-nw-LC,⑦:T- h -C, ⑧:T- h -LC,⑨:H-sp,⑩:R, it is 10 ways of. 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).

3. TEST RESULTS

(1) Water retention test

The water retention fell 3h after the test started with the water retention agent 9g (2%), and 6h with 18g (4%) shown in figure3 From this result, it was proved that the water retention effect increased by adding water retention agents.

Figure4 shows that the water retention fell at the same time with the water retention agent of 9g and 18g, but that the degree of fall is bigger with 9g after 9h. In addition, it was confirmed that the hemp was superior in the water retention effect. The line nothing of Figure4 does not use the water retention agent and the bag. From this result, we understood that the bag and the water retention agent had a great effect for the water retention. However, we did not gain any results for which we could choose the best quantity of the water retention agent.

Figure1. Vegetation bases

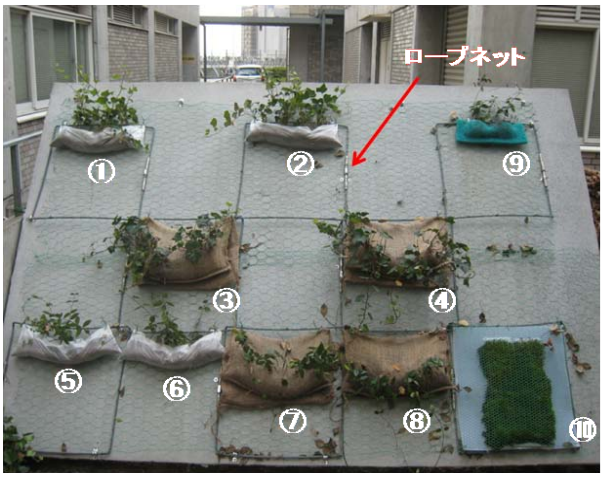

Figure2. A model shotcrete

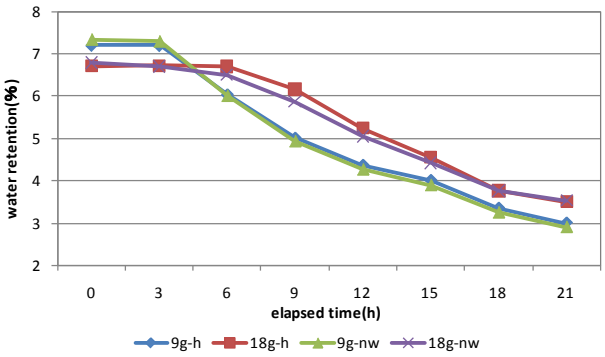

Figure3. As a result of water retention test1

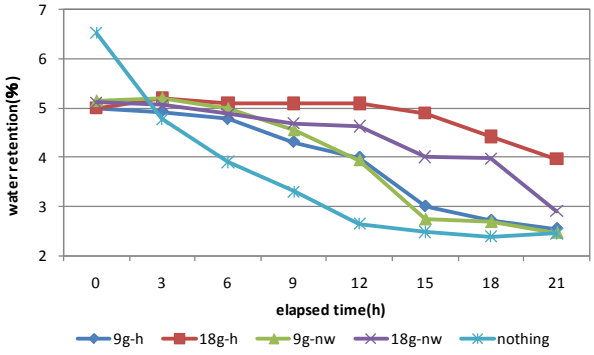

Figure4. As a result of water retention test2

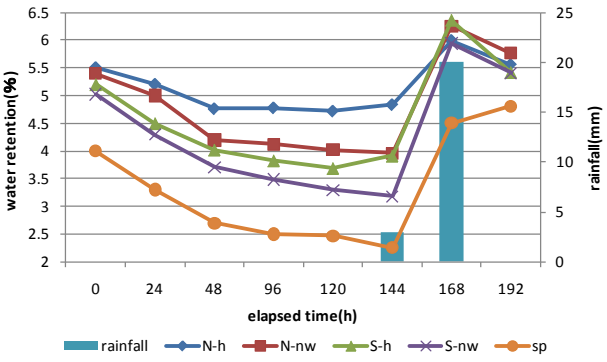

Figure5. Water retention results (Winter season)

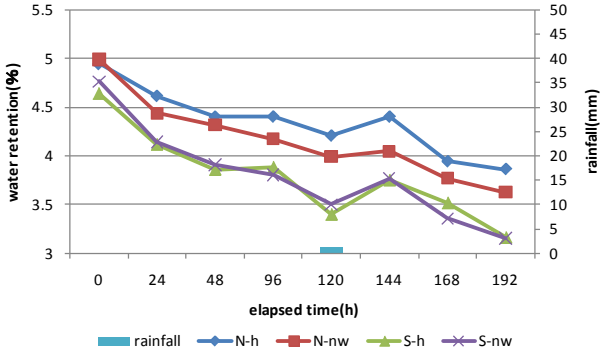

Figure6. Water retention results (Spring season)

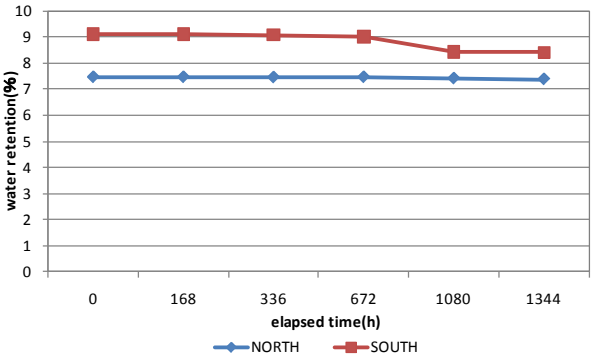

Figure7. Cover degree results (Winter season)

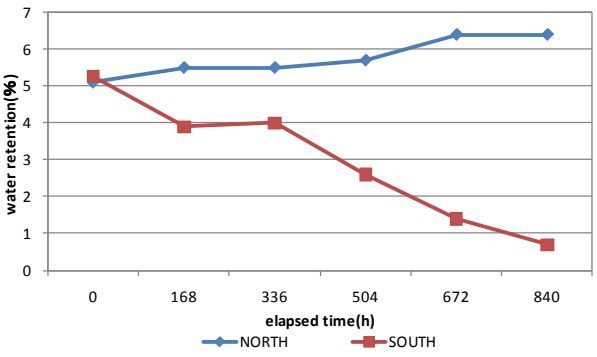

Figure8. Cover degree results (Spring season)

(2) Field test

Figure5 and figure6 expressed water retention rate in each case. The north direction was confirmed superior in the water retention effect. As for the fiber of the bag, the hemp was confirmed superior in the water retention effect. The sponge always showed low values. However, in spring season, we were not able to identify the difference of the superiority in the water retention effect between the nonwoven fabric and the hemp in the south direction. It is thought that the water retention of the hemp fell as much as that of nonwoven fabric, because the hemp was not able to cope with heat.

Figure7 and figure8 are results of the cover degree measurement. The increase of the cover degree facing the north and the south direction was not observed in the winter season as shown in figure7 From this, it is thought that has the growth of the vegetation has for stagnation period in the winter season. From figure8, the cover degrees increased at the north, but the cover degrees decreased at the south in spring season. It is thought that because the vegetation in the south direction died of heat and lack of water, the cover degrees decreased in the south direction. Although the vegetation in the north direction remains little growth indicated in table1, it is thought that cover degrees increased because the number of leaves increased and the leaves grew big with the development of the sprouts as shown in Figure9. Table2 is a breakdown of the cover degree. While the cover degree of Hedera helix increased from 3.63% to 4.85%, that of Trachelospermum asiaticum showed little change from 1.46% to 1.52%. It is because leaf area of the Trachelospermum asiaticum is small in comparison with that of Hedera helix, and coating degree is sparseness.

Figure10 is a photograph of Rhacomitrium canesces in the north and the south direction. As is shown in figure10, there was a change in a color of Rhacomitrium canesces in the north and the south direction after seven months, south Rhacomitrium canesces changed into brown and north, while Rhacomitrium canesces stayed green. This means Rhacomitrium canesces did not die, but turned into the state of suspended animation. However, the color of Rhacomitrium canesces became green from brown with the rainfall and recovered from the suspended animation.

Figure9. The growth of the sprout

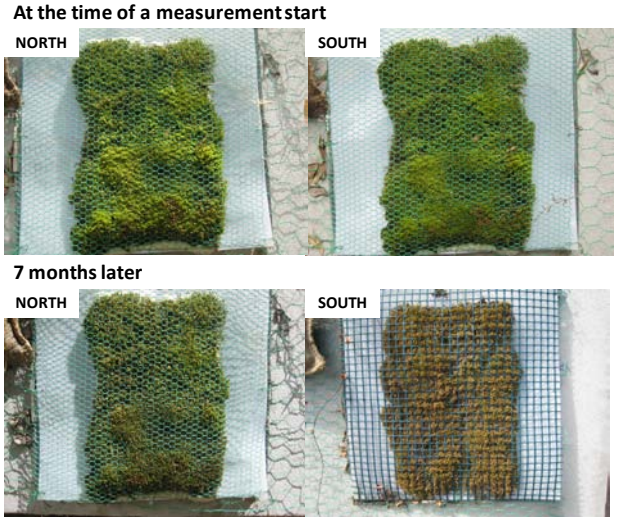

Figure10. A change of Rhacomitrium canesces

Table1. Growth of the vegetation

direction	elapsed time(h)	length of the plant(cm)							
		①	②	③	④	⑤	⑥	⑦	⑧
north	0	45	25	41	35	34	27	34	37
	840	51	26	43	45	40	30	38	44
south	0	26	30	41	36	53	33	68	46
	840	24	26	42	35	52	31	67	49

Table2. A breakdown of the cover degree

	cover degree(%)	
elapsed time(h)	Hedera helix	Trachelospermum asiaticum
0	3.63	1.46
840	4.85	1.52

4. CONCLUSIONS

We compile below a result provided from this examination.

(1) From this result, it was proved that the water retention effect increased by adding water retention agents.
(2) We did not gain any results for which we could choose the best quantity of the water retention agent.
(3) As for the fiber of the bag, the hemp was confirmed superior in the water retention effect from water retention test and field test.
(4) The north direction was confirmed superior in the water retention effect.
(5) In spring season, we confirmed a lot of death of vegetation in the direction for the south.
(6) In the direction for the north, it was not seen increase of the cover degree in the winter season by the cover degree measurement, but increase of the cover degree was confirmed in spring season.
(7) While the cover degree of Hedera helix increased from 3.63% to 4.85%, that of Trachelospermum asiaticum showed little change from 1.46% to 1.52%.
(8) About Rhacomitrium canesces, the recovery from apparent death was confirmed by the rain.

5. VIEW IN THE FUTURE

We understood that the vegetation base which we suggested in this study was weak in the south direction from test result. It seems that the cause is the durability of the water retention effect did not work in the heat and quantity of the soil. Therefore it seems that the problem is improved by thinking about durability of the water retention effect, the effective uptake of the rainwater, the choice of the quantity of the soil which is necessary for growth of the vegetation and the maintenance of the water retention effect. In addition, about the vegetation, we understood that the coating degree of the Trachelospermum asiaticum was sparseness. This is thought to be the cause why greening becomes patchy. Therefore, it is necessary to introduce new vegetation with the characteristic that a coating state is dense, and choose the other vegetation which is suitable for greening shotcrete.

REFERENCES

Kameyama, S. (2002): Vegetation investigation for creation plans in a green environmental design. pp.105.