SLOPE BENCHING AND SHRUB AND TREE RESTORATION AS AN AVALANCHE COUNTERMEASURE ALONG A ROAD

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Abstract

This paper reports the results of avalanche prevention by slope benching including restoration of on-slope shrub and tree vegetation that enhances avalanche prevention effect. The slope benching was conducted in 1993 to prevent snowslide on a mountain slope along a road under construction in northwestern Hokkaido Prefecture, Japan. The annual snow depth reaches 3 m around there. The slope is 330 m long. The elevation difference between the roadside and the mountain ridge is about 200 m. The slope area is 1.6 ha. To prevent soil erosion, a water channel was dug on each bench. Neither steel nor concrete was used in the benching work.

Before the benching, most of the slope surface was covered with chishima-zasa (Sasa kurilensis: a short, thin bamboo) and scattered trees. Avalanche debris including roots from uprooted trees was observed at the end of down slope almost every year. The debris accumulation is caused when the smooth stems and leaves of the hardy wintering chishima-zasa fall and cause the snow accumulated on the slope to glide easily. After the benching, which structurally mitigated snow glide, the bench surface became covered with shrubs and trees over time. Sakhalin spruce were planted on a part of the slope for growth comparison with the natural replacement vegetation. Four observation plots were established on the slope in 1998 to measure plant growth rates. Each plot was 3 m x 1 m. The results of the benching work follow:

1: No avalanche was observed after the benching.

2: Shrubs and trees recovered, with particularly predominant growth of Japanese mountain birch.

3: Eight years after the benching, the mean height of Japanese mountain birches scattered in the four observation plots on the slope was between 5 cm and 270 cm. Several Japanese mountain alder grew taller than 4 m.

4: Naturally regenerated trees grew better than the planted plants.

The benches are now completely covered with natural shrubs and trees. The benched slope can no longer be distinguished from its surroundings. We achieved avalanche prevention using an eco-friendly measure. This paper reports effects of experimental slope benching as a countermeasure to avalanche, and tree growth on the slope that have been observed from 1993 to 2001.

1. Introduction

Snow sheds or avalanche prevention posts are common measures to protect roads from avalanche in Japan. Avalanche control fences also are commonly used[1). In the early 1990s, an environmentally friendly avalanche countermeasure started to be investigated for roads in the Experimental Forest of Hokkaido University, which is in a snowy region. Avalanche prevention trials led by forestry experts that benched the slope by bulldozer had been successful in one of the Experimental Forests of Hokkaido University[2)] . The slope benching work also aimed at restoring vegetation that would enhance avalanche prevention effects. In snowy regions, compacted spring snow can be utilized as a scaffold for a bulldozer to bench a slope. To generally apply the successful result of such avalanche-prevention trial to protection of roads from snow slide, its examination from the standpoint of cost-effectiveness and safety was required.

The test site of this report was in the Uryu Experimental Forest of Hokkaido University, where road construction was underway. The Hokkaido Development Bureau (currently the Hokkaido Regional Development Bureau; Ministry of Land, Infrastructure and Transport) and the Forest Research Station of Hokkaido University jointly tested a countermeasure against avalanche. The test project focused on ecological consciousness, and the goals included not only prevention of avalanche but ecological improvement of the roadside environment. The onsite ditch was designed in consideration of wildlife, and fruit trees that would provide fruit for wildlife were planted to protect the slope. Because the test site was in the Experimental Forest of Hokkaido University, it was possible to use a mountain slope from the roadside to its snow slide-prone peak.

From the standpoint of ecology and cost, slope benching is clearly superior as an avalanche countermeasure compared with countermeasures of structures made of concrete or steel. The remaining issue was whether it would work safely.

It was difficult to conduct a test on a slope by a road in use, because safety as an avalanche countermeasure was not 100% guaranteed. The test was conducted on a mountain slope in the Experimental Forest of Hokkaido University where snow slide would scarcely damage vehicles or people, because the road by the slope was under construction and was not trafficable. There was enough time to identify how the slope benching could prevent avalanche and how vegetation growth on the slope enhanced the effects of the benching.

2. Outline of the test slope-benching

The test site of the benching work was a 1.6-ha, U-shaped slope 430 to 620 m above the sea level. Its mean gradient was 30° . The slope length from mountain ridge to road is 330 m. Most of the slope surface was covered with *chishima-zasa* (*Sasa kurilensis*: a short, thin bamboo) and scattered trees. The maximum snow depth reaches 3 m around there. Before the slope benching, avalanche debris was observed at the slope foot almost every year. Photo 1 shows the slope looking upward to the ridge from the roadside at the end of snow cover season. The slope was conventionally a snow slide track and remaining snow and avalanche debris can be seen in the center of the photo. A closer look at the debris is shown in Photo 2. Soils and gravels mixed with branches and some large roots of uprooted trees were seen.

In 1993, benches 4 to 5 m wide were created using bulldozers and power shovels, with the aim of stopping the snow glide that had led to avalanche on the slope.

Photo 1: the slope before the benching work

Photo 2: avalanche debris at the foot of the slope

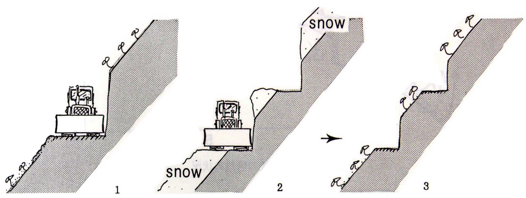

Figure 1: Slope benching using remaining snow as a scaffold for a bulldozer

Photo 3: distant view of the slope bench

Photo 4: close view from * in Fig. 3

Photo 5: look of photo 4 eight years later

The slope benches were created using the compacted spring snow as the scaffold for bulldozers, which enabled bench creation by the least cutting of the original slope. It also is beneficial for faster vegetation growth because less slope cutting facilitates leaving organisms undisturbed on the surface. What should be noted is that slope benching work on snow needs to be conducted with caution so as not to trigger snow slide. The slope benching work is outlined in Figure 1. On part of the benched slope in 1993, 37 Sakhalin spruce of about 1.5 m in height were planted. The shaded portions of sections A , B and C in Figure 2 are slope benched in 1994. A distant view and a close view of the benched slope are shown in Photo 3 and Photo 4, respectively. Sections A, B, and C are seen from right to left in Photo 3 and Photo 4.

3. Growth of vegetation

Figure 3 shows details of slope sections A, B and C, which were benched in 1993. Photo 4 was taken looking up the section B at the intersection (* mark) of the access path from section A to section B in 1993.

Photo 5 and Photo 6 show the same place eight years later. They were taken at plot No. 4 and plot No. 3 on June 21, 2001. The slope previously bared by the benching work is covered abundantly with trees taller than human height. The trees growth progressed all over the benches, and broadleaf trees have developed in line into the chishima-zasa field.

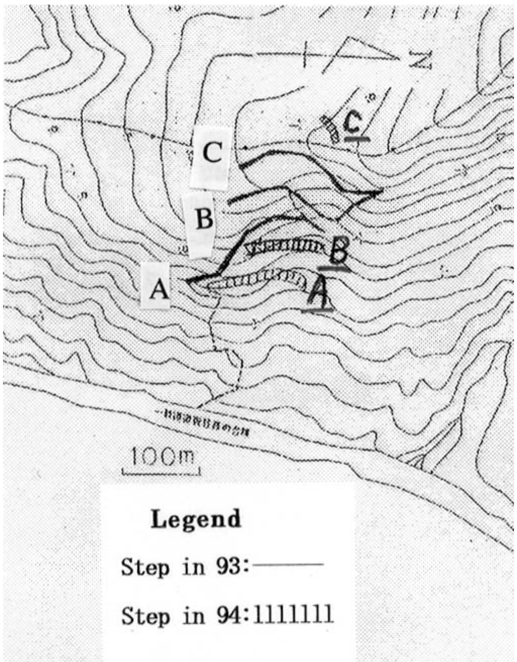

Figure 2: Slope area benched in 1993, 1994

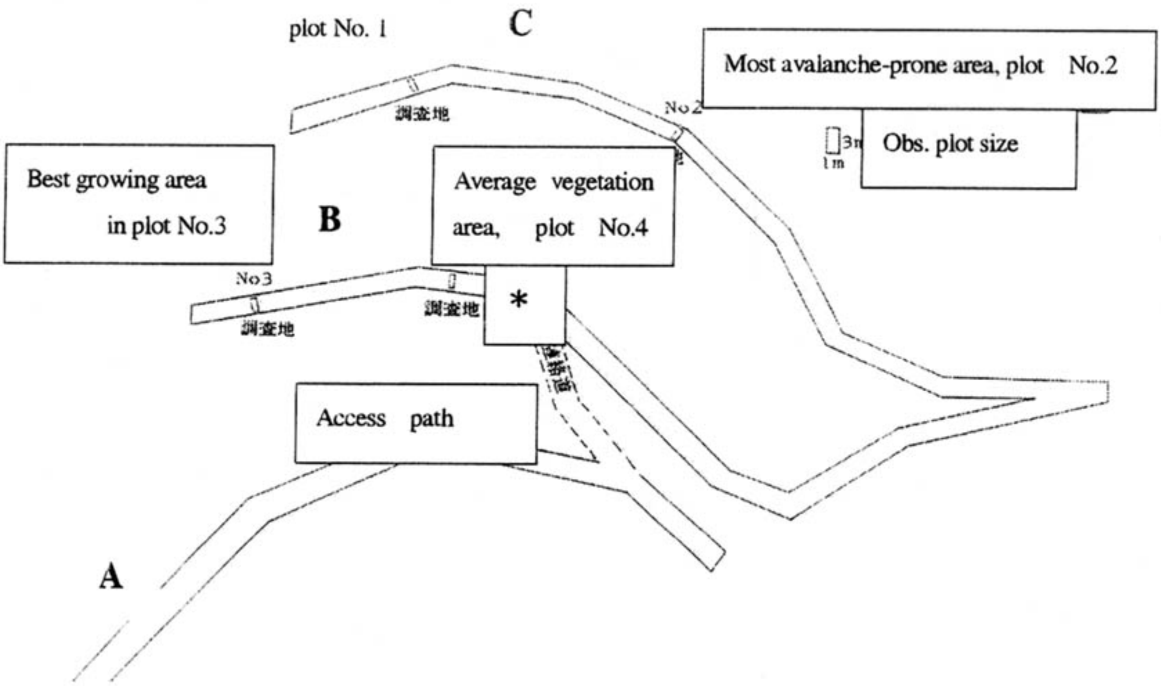

Figure 3: Natural regeneration observation plots in section A,B, and C on steps in 1993

The broadleaf trees also are advancing toward the slope that lies at right angle to the slope where a streak of broadleaf trees are seen. The slope was previously covered mostly with chishima-zasa because frequent snow slide had hindered growth of plants other than chishima-zasa. The tree height was measured at the four plots in Figure 3. Each plot was 1m x 3m. Figure 4 shows the growth of naturally grown Japanese mountain birch from 1997 to 2000 at the four plots. Measurements of the tree height were conducted every October. Not only Japanese mountain birch, but also some 3- to 4-m-tall Japanese mountain alder are growing on the benches.

Trees that grow steadily annually enhance the anti-snow-slide effect of the benches. Figure 4 shows that Japanese mountain birch grows fastest. The growth of trees will differ by location. Table 1 shows the growth rate difference among Japanese mountain birch by location.

Difference of tree growth rate by location is given in Table 1. The tree growth in plot 3 is greatest, and natural regeneration of vegetation is progressing there. The growth in plot 4 is average.

Photo 6, look of photo 3 eight years later

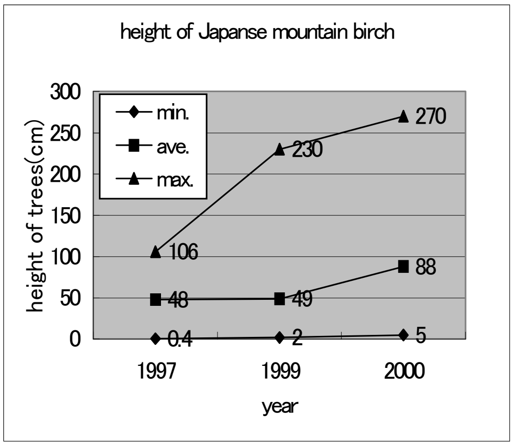

Figure 4: Minimum, average, and maximum height (unit: cm) of Japanese mountain birch from 1997 to 2000.

Plot No.	Number of Japanese mountain birch 1997	2000	Height of trees (cm) (min.- max.) 1997	2000
No.1	19	36	8 (5-125)	34
No.2	41	12	4 (25-101)	56
No.3	107	28	33 (65-270)	112
No.4	191	65	17 (40-230)	102

Table 1 Japanese mountain birch growth on the slope bench created in 1993

The area involving plot 2 was the most difficult place for vegetation to grow because of frequent snow slides. Although the tree growth rate in the plot is slower than that in other plots, the trees are growing steadily and they will form a fine woods.

4. Plantation of Sakhalin spruce

In 1994, 37 nine-year-old Sakhalin spruce were planted on the slope that includes the four observation plots, and their growth rate has been observed. Future vegetation by natural regeneration on the benched slope was expected to be mostly deciduous trees represented by birches. Therefore Sakhalin spruce, conifers, were planted because the ideal onsite forest structure was mixture of deciduous trees and conifers.

Their planting was beyond the aim of snow slide prevention but it was important to restore the mountain forest. Forest diversity is necessary for natural environment restoration as well as for ensuring a healthy forest that will be a hardier avalanche-prevention measure. The tree height was measured in October 1999 and 2000 as well as in June 2001. Figure 5 shows the tree height increase. As of 2001, six trees had died; however, most of them keep growing although their branches were partly bent by snow weight and some look barely alive in the snowy environment.

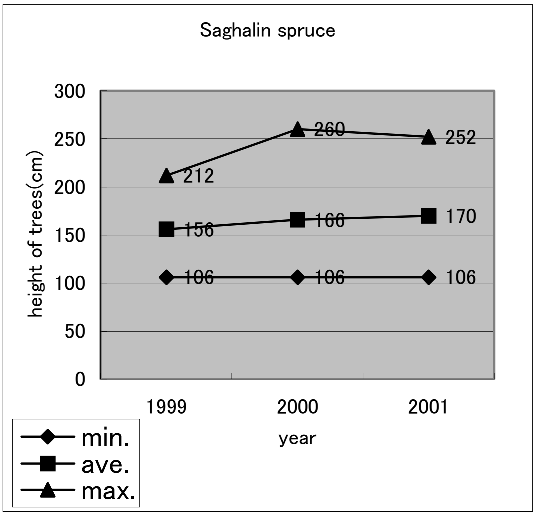

Figure 5: Growth of Sakhalin spruce

5. Conclusion

Avalanche prevention by benching and restoring on-slope shrub and tree vegetation was tested on a roadside slope in cold, snowy northwest Hokkaido, Japan. The slope had been snowslide prone because of its U shape and former cover of hardy wintering *chishima-zasa* which, falls and causes the snow accumulated on the slope to glide easily. During the eight years since slope benching, no snowslide has occurred at the site despite extraordinarily heavy snowfall in some years.

The slope that was cut by bulldozer blade to be bared immediately after slope benching is now completely covered with shrubs and trees 2 to 3 m high

Even if you look up the slope, whose elevation difference from the road is 200 m, it is becoming difficult to identify traces of the slope benching work. Slope benching costs much less than other anti-avalanche countermeasures including structures made of concrete or steel. It also is eco-friendly because slope benching is effective in restoring vegetation on the slope so as to prevent destruction of the mountain environment by avalanche.

6. Acknowledgements

We would like to express our appreciation to the engineers of Uryu experimental station of Hokkaido University for their support for a series of field observations.

7. References

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2) Eishi Fujito, Katsuaki Nonaka(in Japanese), Step formation on the slope by using snow cover, The annual Rep. of the forest research station of Hokkaido university Vol.4, pp.52-55,(1986)