RESEARCH OF ANTI-FREEZING FOR THE BUDDHIST IMAGE CARVED ON TUFF CLIFF BY CLOSING SHELTER

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Introduction

The Buddhist images carved on natural cliff tend to be deteriorated by climate change such as freezing, crystallization and growing epiphytes because they are always exposure to outdoor. For example, in Usuki stone Buddha, which is located in Oita prefecture (Fig. 1), its surface was damaged by big chill every few years.

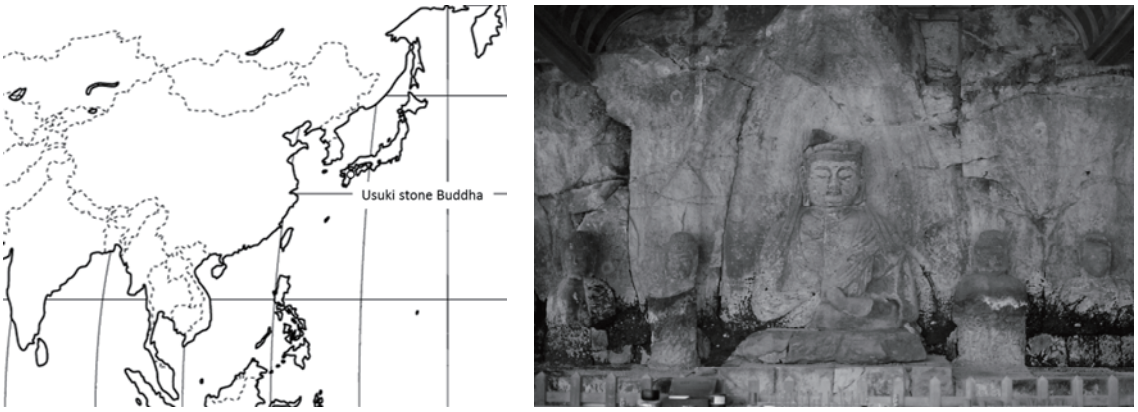

Fig. 1: The Usuki stone Buddha (Left: location, Right: the Buddhist images)

In the Usuki stone Buddha, it has been continued the researches to clarify what causes the deterioration and plan the next conservation project. From the meteorological observation, it was confirmed that freezing has affected the biggest deterioration phenomena. So we took some measures against the freezing.

In this paper, it has reported the conservation effect of shelter in the Usuki stone Buddha and the field test for anti-freezing of stone surface by closing shelter.

Classification of shelter type in the Usuki stone Buddha

In Japan, the shelter has often constructed at the Buddhist images carved on natural cliff for conservation themselves, especially they have been prevented from rain and inflow. The Usuki stone Buddha also has been constructed the shelter with wide roof about twenty years ago (Fig. 2). At first, the shelter of Usuki stone Buddha was compared with one of other Buddhist images by using "ventilation rate (the ratio of aperture area to volume in the shelter)" in order to confirm its conservation ability. Each shelters were classified under four

types from the viewpoint of whether its side wall were installed or not and how width of each roofs.

Fig. 2: Shelter of the Usuki stone Buddha (Hoki second cluster)

Table 1 shows the ventilation rate and monthly mean value of diurnal range between outdoor and indoor on August. If the shelter was closed, temperature change in the shelter was smaller than the others. However, it was observed that temperature change was small like a closed shelter in the Usuki stone Buddha although its side walls were not installed.

Table 1: Ventilation rate of each shelter types

(* Diurnal range was monthly mean value on August, 2005)

	$S(m^2)$	$V(m^3)$	$VR(m^{-1})$	diurnal range (outdoor)*	diurnal range (indoor)*
without side wall (usuki)	103.1	593	0.174	8.3	4.3
without side wall (small roof)	25.9	155	0.156	5.2	3.8
with side wall	13.8	137	0.101	8.3	4.4
Closed	7.2	223	0.032	7.9	3.1

It was estimated that the reason why temperature change was small was low impact of sunshine and radiation cooling because of wide roof in the Usuki stone Buddha. And it was also estimated that freezing was caused not by radiation cooling but advection of cold air.

Anti-freezing method in the Usuki stone Buddha

1. Heating on the Buddha surface

To prevent the Buddha surface from freezing, the heat lump was installed at Hoki second cluster and observed the temperature change on its surface by thermal images. Fig. 3 shows the change of temperature distribution because of heat lump irradiation. When it was turn on the heat lump, the surface temperature on the knee of main image was increased from 4.5 to 6.5 degree of Celsius. So it was confirmed that heat lump was effective on this site.

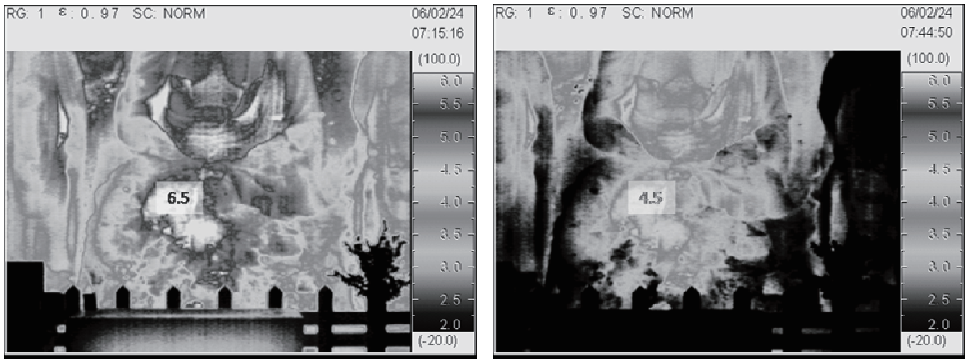

Fig. 3: Change of temperature distribution by heat lump

2. Control the cold wind

Heat lump was effective to prevent the Buddha surface from freezing, but it might help the vegetation growth. So the polyester curtain was installed each entrance of shelter and it was closed during the nighttime when it was cold (Fig. 4). And temperature and air current in the shelter was measured.

Fig. 4: The method to control a cold wind

Fig. 5 shows the change of temperature and wind speed. It notes that the polyester curtain was closed from the evening of 15th to the morning of 16th, January 2008. The left graph shows that the temperature when curtain closed was 3 degree centigrade higher than it opened. And wind speed was also decreased because of curtain. From this result, the polyester curtain was effective to control the cold wind.

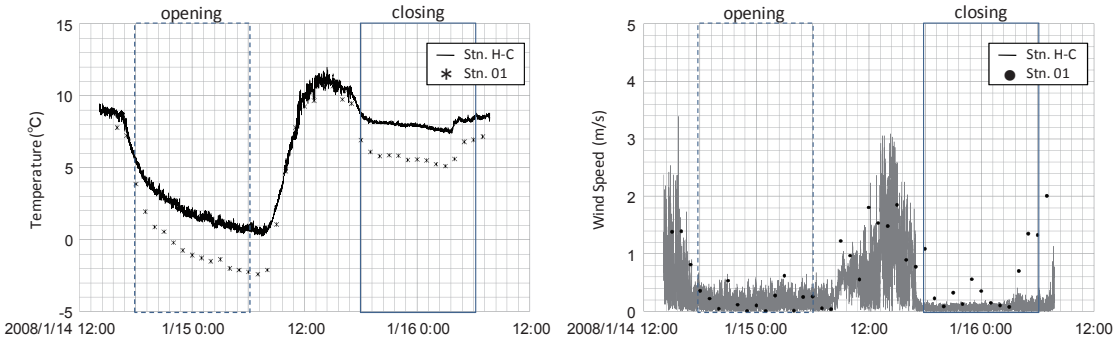

Fig. 5: Change of temperature and wind speed in the shelter

Results

The shelter was originally constructed in order to prevent the Buddhist image carved on natural cliff. From the investigation, it was confirmed that shelter was effective to control its environment and the risk of freezing has still remained because of cold air inflow.

Then, it was conducted two kinds of field test: heating on the surface and closing shelter. From the result, it was confirmed that closing shelter only when the cold weather predicted was effective and reasonable in the Usuki stone Buddha.

References

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