Field Experiment of Ice Dome Spanning 20~30 Meters

Tsutomu Kokawa
Department of Architecture, School of Art and Technology
Hokkaido Tokai University, Asahikawa, Hokkaido, Japan

ABSTRACT

Aiming at the realization of a large ice shell to be used for a variety of architectural facilities in winter, experimental studies of ice domes spanning 20~30 m have been carried out at Tomamu since 1999. Two field studies of a 20-m-span ice dome (17-m base diameter and 6.5-m height) were developed in 1999~00. These test domes showed a high structural efficiency, so in the winter of 2001 the experimentation was taken a step further by carrying out a field study focusing on both the construction and creep test of a 30-m-span ice dome (25-m base diameter and 9.2-m height). Based on the findings from these studies, it can be concluded that the application of an ice dome spanning 20~30 m should be feasible.

OUTLINE OF CONSTRUCTION METHOD

The kamakura and igloo are classic snow-ice structures, but it seems that these structure have neither construction rationality nor structural efficiency in the case of a large span. A kamakura is a traditional Japanese snow hut where children play house during the New Year holidays; it is formed by scooping out snow from a small mound of snow. An igloo is a snow hut built by arranging snow blocks hemispherically. In contrast, the ice shell is constructed by following a simple, quick and economical method:

1. building up the 3-dimensional formwork by inflating a 2-dimensional membrane bag covered with ropes anchored to the snow-ice foundation.
2. covering the membrane with a thin snow-ice sherbet layer (1 cm) by blowing the milled snow with a rotary snowblower, spraying water with a high-pressure adjustable nozzle, then letting it freeze naturally where temperatures remain at −10° C.
3. repeating the application of snow and water until the desired shell thickness (1/100th of the span) is reached, then removing the bag and ropes for reuse.

The ice quality of the completed dome can be judged satisfactory if there is sufficient outward transmission of light from the lighted interior.

FIELD TEST OF 20-M-SPAN ICE DOME

Theoretically, the use of an ice dome with a span between 20 and 30 m is feasible. However, the actual proof test of an ice dome this large had not been done before, except for the field experiment of a 20-m-span ice dome in 1985 (Kokawa and Murakami, 1986); more work was necessary to demonstrate its structural reliability for use as an architectural structure. Thus, with an eye