Fourth Workshop on
Hydraulic of River Ice
Montreal, June 19-20, 1986

Quatrième atelier sur
l'Hydraulique des glaces
Montréal, 19-20 juin 1986

MANAGEMENT OF RIVER ICE COVER FOR OUTDOOR ACTIVITIES

L. Jolicoeur[1] Ls.-A. Gagnon[1] and Claude Vincent[2]

1 Groupe-Conseil Roche Ltée
2535, boul. Laurier,
Sainte-Foy, Qué.
G1V 4M3

2 Service de la gérance
Ville de Québec
Hôtel de Ville
2, rue des Jardins
Québec, Qué.
G1R 2S9

ABSTRACT

This paper deals with the management of natural ice cover for winter outdoor activities.

The main aspects of a good operation are presented to achieve a safe use of the ice cover area and to extend the length of the period of activities. These aspects include gathering of data, knowledge of the formation and growth of an ice cover, operation and survey.

A safe and efficient management of a natural ice cover should be based on an operation manual particular to the river.

RESUME

Cet article traite de la gestion d'un couvert de glace pour la tenue d'activités hivernales de plein air.

Nous présentons les principaux éléments d'une bonne gestion permettant l'utilisation sécuritaire de la surface glacée et une période d'utilisation prolongée: recueil de données, connaissance de la formation d'un couvert de glace, croissance de la glace, opération et surveillance.

Enfin nous croyons que tous les éléments d'une bonne gestion doivent se retrouver dans un manuel d'opération propre à chaque cours d'eau.

GENERAL

In the Province of Quebec and in Canada most of the towns are crossed by a river. River ice covers represent a great interest for winter outdoor activities. Nevertheless only a few towns are using the ice cover ressource and unfortunately the usable period is very short because of difficult wheather conditions (snow fall, warm temperature and rain) and poor management.

The most common winter activities on rivers are fishing like at Ste-Anne de la Pérade on Ste-Anne river

and skating like on Rideau river in Ottawa and St-Charles River in Quebec city. Those two places will hold our attention because of a past survey of Rideau river during "Winterlude" and the existing operation manual of the St-Charles river ice cover prepared by C. Vincent.

This paper is more an operational and management guide for outdoor activities on ice than a theoritical overview of the bearing capacity of ice covers.

1° DATA

The first step is to gather the following data:

- hydraulic regime of river (stability of the ice cover);
- bathymetry of river;
- climatic informations;
- dangerous spots where the ice could be thinner (bridges, river bends, overflow pipes, river inlet and outlet);
- ice thicknesses.

2° KNOWLEDGE OF FORMATION AND IDENTIFICATION OF AN ICE COVER AND OF ITS BEARING CAPACITY

The person responsible for the survey of the ice cover should have this basic knowledge. For the formation and identification of an ice cover we will refer the reader to the book Ice Mechanics (Michel (1978)) in which it is described at length.

We must know that there is several kinds of ice and that a standard river ice cover is made with a snow ice layer over a columnar ice layer. For our needs we will need only two categories: clear ice (columnar ice) and white ice (snow ice).

The bearing capacity of a natural ice cover depends mainly on its thickness, on the uniaxial tensile strength of the ice at the bottom layer and on the load geometry. In view of the many factors that affect the bearing capacity of ice, and that cannot be taken into account readily in the computations, it has been usual to assume a very simple formula of the type:

$$P = C\ h^2 \qquad (1)$$

where P : bearing capacity in kg

C : constant determined from experience and the conditions of the ice cover

Values used in Canada for fresh water ice vary from 3,5 to 7 x 10^4

h : effective thickness of ice in meters.

0,1 m of snow ice = 0,05 m of clear ice.

If a water layer is present within the ice cover, only the thickness of the upper layer of ice should be used to determine the effective thickness.

The cracks that are more than 2 mm in width could be classified as wet or dry cracks. Dry cracks are formed only in the upper part of the ice cover and do not affect bearing capacity. A wet crack is one in which water can be observed when it is formed and for this wet crack the capacity of the ice is that of a semi-inifinite plate and is thus reduced by half.

The presence of snow is a supplementary load. If it is uniformly distributed it does not engender a bending moment in the ice cover. As soon as a track is made on the ice through the snow, snow banks on the

sides produce stresses that may even crack longitudinally the ice road.

If the average air temperature is higher than -4°C a safe practice is to reduce the admissible loads by 50 percent and if the maximum air temperature exceeds 4°C it is recommanded to suspend operations. The capacity should also be reduced for a period following a sudden drop in air temperature. This effect has not been properly investigated but may be due to induced thermal stress that will open up cracks on the upper part of the ice cover. Combined with cracks formed by vehicles on the lower part of the ice, this may increase the risk of failure.

Speed of vehicles should be kept lower than 10 to 25 km/hre (depending on the ice thickness) to avoid the problem of resonance of the water underneath with the ice cover which could be then seriously overstressed.

Then with the simple formula and the reduction factors, tables could be made in which we will obtain an admissible load for a given effective thickness.

3° GROWTH OF ICE COVER

The two principal means for increasing the ice thickness are the clearing of snow and watering.

The snow act as insulation and decreases the ice growth so it should be cleared. The watering is made as for any outside skating-rink, by small layers to avoid formation of false ice. This last method should be used especially for the dangerous places where the ice is thinner and seldom controls the use of all the ice surface.

4° OPERATION AND SURVEY

To ensure safe operation, an adequate survey should be done and strict security rules should be respected. The first step is the preparation of an operation manual with sketches of river sections indicating the dangerous spots.

- Preparation of ice cover

This is the most critical part because the load of the machinery is directly governed by the ice thickness and we are at the beginning of the winter. For example for the use of a Ski-Dozer and of a Junior Blower we need an effective ice thickness respectively of 200 mm and 400 mm.

During the preparation period, continuous measurements of ice thickness, of ice movements (with a theodolite), of air temperature and continuous survey of cracks should be achieved. Those measurements and survey should be made each day.

The snow is cleared on the ice so that the snow banks on the side should not be higher than the ice thickness. The snow is cleared only for the necessary width for future activities.

Each day the cracks are to be filled with snow and water and the ice cover watered.

- Outdoor activities

During this period it is less critical because loads produced by skaters or others are far below the capacity of the ice cover.

The same survey and operation is done during this time except that the measurements of ice thickness and ice movements could be spaced at higher interval if temperature variations are not too sudden.

The public safety should be assured by the continuous presence of a skating patrol with radios.

5° BREAK UP

At the time of break up, the ice in the section used for outdoor activities is thicker and stronger than the ice in the lower and upper parts of the river. This phenomena could cause ice jam.

Jolicoeur, Michel and Labbé (1984) have presented a simple method of preventing ice jams by cutting trenches in an ice cover. Without presence of snow on the

ice cover the trenching can be done easily. With this method flooding will be prevent.

6° CONCLUSION

The use of natural river ice cover for winter outdoor activities should always be managed with the help of an extensive field survey program and strict operation procedures. The personnel in charge shall have a good formation for the surveys and ice cover inspection.

It is also mandatory to monitor on a chart or map the ice thickness along the concerned area, local ice defects, cracks and temperature variations. This data should be recorded overall the winter season. The interpretation of the map or chart shall be supervised daily by the manager who should have thorough experience with the ice formation phenomena and with ice bearing capacity.

REFERENCES

- Deugo, D., (1973), Ice control on the Rideau river, Ottawa. Seminar on Ice Jams in Canada, Alberta, Technical memorandum No. 107, p 155-157.

- Gagnon Ls.-A. and Michel B. (1979), Load-bearing capacity of ice plates. Proceedings of Workshop on the bearing capacity of ice cover, N.R.C.C., Winnipeg.

- Jolicoeur L, Michel, B. and Labbé J. (1984), Cutting trenches in an ice cover to prevent ice jams. Proceedings of Workshop on hydraulics of river ice, University of New Brunswick, Fredericton, New Brunswick, p 127-136.

- Meneley, W.A. (1974), Blackstrap Lake ice cover parking lot. Canadian Geotechnical Journal, No. II, p 490-508.

- Michel, B. (1971), Winter regime of lakes and rivers. U.S. Army Corps of Engineers, Monograph III - B1a, 130 p.

. Michel, B. (1978), Ice mechanics. Les Presses de l'Université Laval, 500 p.

. Vincent, Claude (1982), Cahier des normes d'échantillonnage et d'opération. Document interne, Ville de Québec, 40 p.