Abrasion of Concrete Structures by Ice

Usure par la glace de structures en béton

Widerstand von Beton gegen Abrasion durch Eis

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1 INTRODUCTION

In arctic sea regions a concrete sea structure in subjected to heavy mechanical loads near the water level due to the moving ice sheet. Moving ice sheets load protruding aggregate stones, and the loads are considerably greater than the compressive strength of ice as determined in uniaxial compressive tests. This is due to the triaxial compression stress in the ice surrounding the stone surface.

Also, recurrent freeze-thaw cycles in the concrete wetted by waves and the tide expose the concrete to damage if it has not been designed to resist recurrent freezing in marine conditions. Temperature changes that exceed the approximate value $\Delta T = 40$ °C also deteriorate the bond between the cement stone and the stones and increase cracking in the cement stone between the aggregate stones.

This paper deals with the abrasion problem. The abrasion depth and resistance of concrete in arctic sea conditions can in practice be determined by calculations and laboratory tests.

2 ABRASION STUDIES

In a Finnish study the determination of abrasion of concrete in arctic offshore structures was based on four different methods:

- laboratory tests
- tests with an icebreaker
- abrasion studies on Finnish lighthouses
- computer calculations.

An abrasion machine was developed for laboratory use. The abrasion resistance of different concretes can be studied with the abrasion machine so that the concrete will have under gone cyclic freezing-thawing tests before the abrasion tests.

The abrasion resistance of similar concrete mixes was also studied at sea with an icebreaker. In icebreaker tests the specimens were fastened onto the bow of the

icebreaker at water level. The abrasion of the concrete specimens was measured at the end of the tests.

The abrasion of Finnish lighthouses was measured at four lighthouses in the Gulf of Bothnia.

The abrasion and fracture of the concrete were also studied with computer calculations. The ice pressures against small areas such as aggregate particles that are protruding from the surface of a concrete structure were measured with laboratory tests. Also the bond strength between aggregate particles and cement stone was measured in tests. These values were needed in the computer calculations. On the basis of the calculations, using the calculation model, the abrasion of concrete was estimated as the function of ice sheet movement.

3 COMPARISON OF TEST RESULTS AND COMPUTER CALCULATIONS

In Fig. 1 a comparison of the abrasion (max. and min. values) of concrete is presented as the function of the compressive strength of concrete in laboratory abrasion tests during 10 minutes, in icebreaker tests, for ice field movements of 40 km, 100 km and 1000 km according to the abrasion calculations and in Finnish lighthouses during one year.

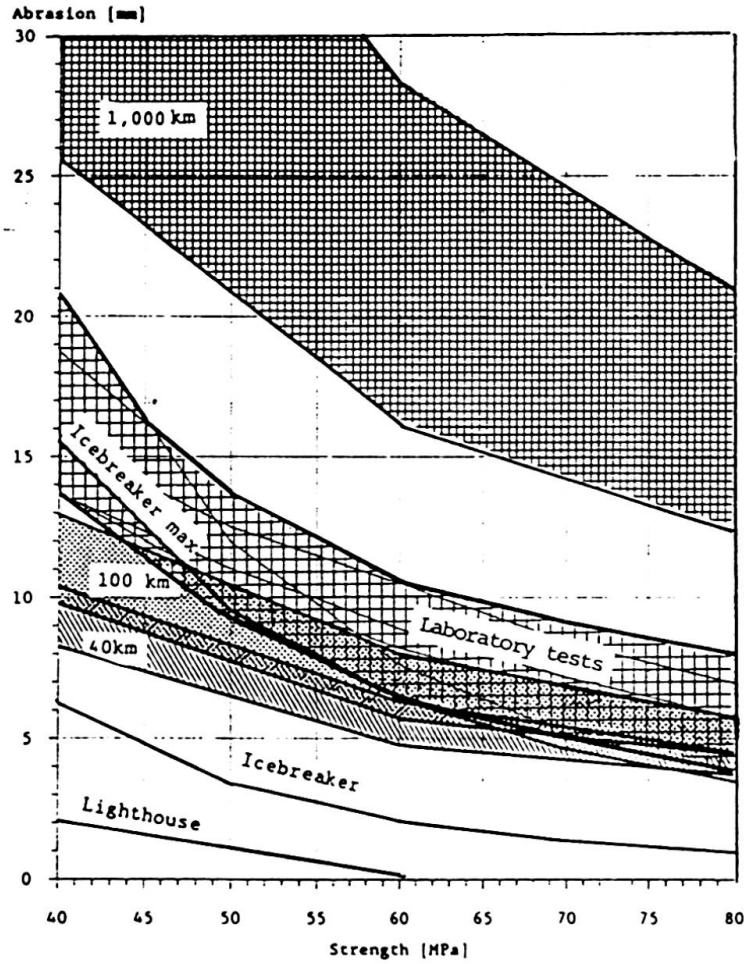

Fig. 1. Abrasion of concrete as the function of compressive strength.

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