Cracks in fast ice and their impact on ice transport operations

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ABSTRACT

A certain number of cracks of various origins are present during the organization of work and movement on the fast ice. During sea level fluctuations, the tidal cracks appear parallel to the coast or encircling ice formations, with grounded icebergs and grounded hummocks. Rather broad cracks form during fast ice movements. The abrupt changes of air temperature, cleaning of ice surface from thick snow layer can be accompanied by thermal cracks. The cracks of technogenic origin appear during loading of ice, hydrostatic disequilibrium of snow-ice cover and other impacts on ice from the side of vessels and vehicles. Some cracks are dangerous for vehicles and people because of reduced ice-load bearing capacity, while a large number of visually observable cracks allow to cross them without any restrictions. The experience of ice-technological work performance and cargo transportation along fast ice in case of cracks presence in the ice cover is summarized in the report. To estimate the degree of ice strength decrease after cracks congelation in the ice basin of the Krylov Research Centre in Saint-Petersburg, a set of laboratory experiments was performed to estimate the ice bending strength of the congealed cracks and unbroken ice under the conditions of various water salinity and ice formed from it. The estimations of ice breccias strength relative to the strength of unbroken ice of primary structure were obtained.

KEYWORDS: fast ice, ice cracks, ice roads, flexural strength of ice.

INTRODUCTION

Fast ice is a form of stationary ice, nevertheless it faces dynamic impacts, which result in deformations of ice cover and forming cracks. Tide cracks, which occur due to vertical movements of ice cover during sea level fluctuations, represent a characteristic feature of the sea fast ice. Besides tide cracks, in fast ice there are cracks formed as a result of horizontal shears, thermodynamic processes in ice cover, natural and anthropogenic loads on ice cover.

Regardless of the nature and origin of cracks they exert a negative influence on the use of fast ice as a platform for transport operations due to violation of ice cover integrity and reduction of its capacity. Most of emergency situations associated with sinking vehicles under ice occurs in the area of cracks. In practice of ice engineering there are various methods of ice strengthening in the area of cracks to prevent emergencies, however in order to select an appropriate method of providing safety a certain experience of hydrometeorological and engineering support of ice works is required. There could be several dozens of cracks of different nature along a linear kilometer of a road laid on fast ice, and the attempts of ice reinforcement at each of them can lead to large obstacles in organization of ice traffic, especially at continuous changes of a scheme of cracks: forming the new ones and re-freezing the old ones. Therefore, defining a necessary and sufficient set of measures to provide safety a certain experience of hydrometeorological and engineering support of ice works is required. There could be several dozens of cracks of different nature along a linear kilometer of a road laid on fast ice, and the attempts of ice reinforcement at each of them can lead to large obstacles in organization of ice traffic, especially at continuous changes of a scheme of cracks: forming the new ones and re-freezing the old ones. Therefore, defining a necessary and sufficient set of measures to provide safety of men and vehicles in the area of a crack is an insurance of effective use of fast ice as a foundation for traffic of vehicles.

THE NATURE AND FEATURES OF CRACKS IN FAST ICE

One should start considering cracks in fast ice with tide cracks – a permanent feature of the fast ice, formed in water areas, which are characterized by water level fluctuations. Tide cracks occur everywhere, where there is a transition from grounded ice to floating ice. Tide cracks, which separate the foot of fast ice from its main part go along the coastline. Often, we deal with not a single tide crack along the coast but a system of parallel cracks with inter-distance ranging from several meters to dozens and even hundreds of meters. Tide cracks also form along large hummock ridges and barriers attached to the soil. These ridges form on a boundary of fast ice of autumn formation and younger fast ice of winter formation at the depth 5-6 m