

PAPER REF: 6511

RESEARCH OF ICE BEHAVIOR AT BLASTING EMULSION EXPLOSIVE

Maxim Yu. Orlov^(*), Gennady N. Bogomolov, Yulia N. Orlova

Tomsk State University, Tomsk, Russia

Tomsk Polytechnic University, Russia

^(*)Email: orloff_m@mail.ru

ABSTRACT

The behavior of the ice cover at blasting emulsion explosive was studied. Full-scale experiments on blasting the river needle ice were carried out. The objects of the study were the snow-covered ice cover, bar ice, sandwich structure ice and needle ice. Russian emulsion explosive Emulast AS-FP was used. The behavior of the ice at the underwater explosion was simulated by means of lagrangian numerical method. The research results obtained as videos, photos, graphics and tables, and configurations of a system "Ice - Explosive - Water".

Keywords: ice destruction, explosive, full-scale test, UNDEX, numerical modelling.

INTRODUCTION

Nowadays, a research of the behavior of certain natural materials is relevant. This is due to the development of the northern territories, the extraction of natural resources in the Far North, etc. Currently, many scientists are studying the behavior of geological materials under dynamic loads (Pernas-Snchez, 2016). It is known that many natural materials under certain conditions have a common mechanism of failure. Ice is a little known natural material. Now the modern failure concept of the ice is beginning to develop (Carney, 2006). This is due to the complex structure of the ice, the presence of phase transitions during deformation, unique plastic properties, etc. There are over 16 types of ice and the latter type of ice has an extraterrestrial origin. In the United States was resumed the research program "SCICEX" which there is a collection of scientific data by the ships of the Navy. The existing experimental data on dynamic loading of ice is not consistent with each other due to the complex structure of ice. Experimental data on explosive loading of ice were not found (Orlov, 2015).

In the Research Institute of Applied Mathematics and Mechanics at Tomsk State University has developed a new physical mathematical model of ice behavior under the shock and explosive loads. Numerical method for calculating shock and explosive loading of various natural materials was modified. Innovation consists of the improved algorithm for calculating the contact surfaces by blasting explosives of different masses. For the development of a numerical method requires reliable experimental data on the processes of destruction the ice with explosive conditions (Orlova, 2014).

The current research presents the results of experimental and theoretical studies of freshwater ice at underwater explosion (UNDEX). For the full-scale experimental mobile laboratory "Explosive destruction of natural materials" was organized. The objective of mobilab is snap-analysis of the behavior of natural materials under explosive. Theoretical studies carried out by numerical method (Glazyrin, 2008).

RESULTS AND CONCLUSIONS

Figure 1a shows a blast lane in the ice cover of the needle after blasting 12 kg of emulsion explosives (TNT equivalent of 10 kg). Ice thickness was approximately 70 cm. The ice edge had stepped shape. Within a radius of 5 meters of ice fragments of varying sizes were found. Figure 1b shows the profile of the free surface velocity at blasting 4 kg of emulsion explosives (TNT equivalent of 3.3 kg). It is seen that the free surface velocity was 105 m/s at 0,25 μ s. The process of destruction of ice accompanied by mainline cracks in the area “Ice - Water - Explosive”.

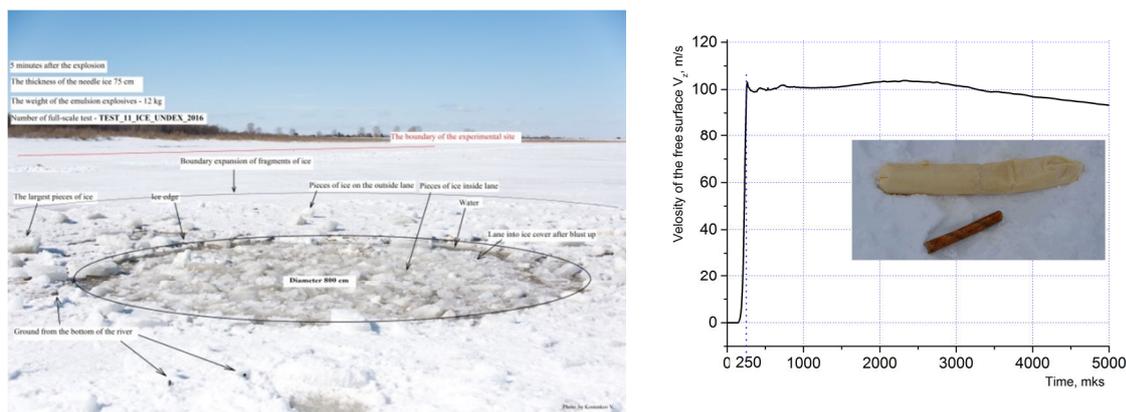


Fig. 1 - The experimental and numerical results: blast lane and velocity profile

Thus, full-scale experiments blasting the river ice allowed to obtain diameter lane. Numerical modeling has allowed to make a quantitative assessment of the process of destruction of ice under the detonation products.

ACKNOWLEDGMENTS

The work was supported by the Ministry of Education Russia (Project Code 1567, № 2014/223) and RFBR 16-38-00515. The authors wish to thanks chief engineer “KuzbasSpetsVzryv” company Alex. Sadochin.

REFERENCES

- [1]-Pernas-Snchez J, Artero-Guerrero J, Varas D, Lypez-Puente J. Experimental analysis of ice sphere impacts on unidirectional carbon/epoxy laminates. *International Journal of Impact Engineering*. 2016, 96, p. 1-10.
- [2]-Carney K, Benson D, DuBois P, Lee R. A phenomenological high strain rate model with failure for ice. *International Journal of Solids and Structures*. 2006, 43, p. 7820-7839.
- [3]-Orlov M, Orlova Yu, Tolkachev V. Mobile laboratory “Explosive destruction of natural materials”: Investigation of the behavior of ice and limestone under explosive loading. *Journal of Physics: Conference Series*. 2015, 653, 012038.
- [4]-Orlova Yu. Complex theoretical and experimental study of the behavior of ice under shock and explosive loading. Abstract of dissertation for the degree of physical and mathematical sciences, Tomsk, 2014, p.26.
- [5]-Glazyrin V, Orlov Yu, Orlov M. The destruction of the ice under shock and explosive loading. *Computational technologies*. 2008, 13, 1, p. 425-432.