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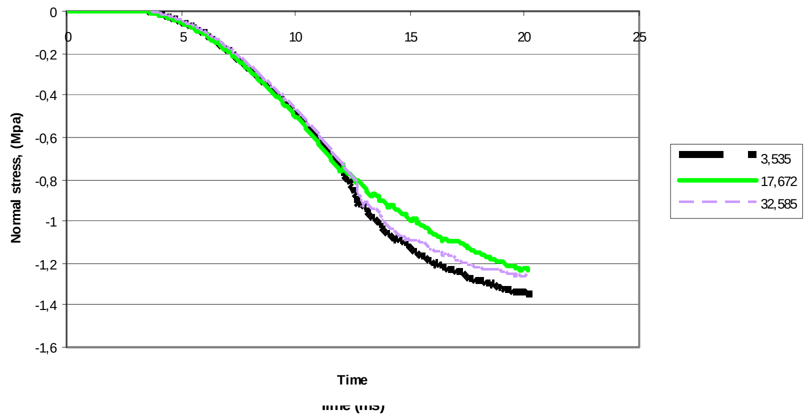
A NUMERICAL SIMULATION OF AN INTERACTION PROCESS BETWEEN AN ICE FLOE AND THE CIRCULAR PILE

The problem of ice/offshore structures interaction has not been solved yet. Three loads surveys [1-3] show, that the action estimations made by different experts or Companies for the same ice conditions and structures has a scatter more than10 times. One of important factors in this problem is influence of the ice properties on the load value. In particular the Russian Code SNiP 2.06.04-82* predicts that the lower is the ice velocity the lower is the ice load.

ab



c

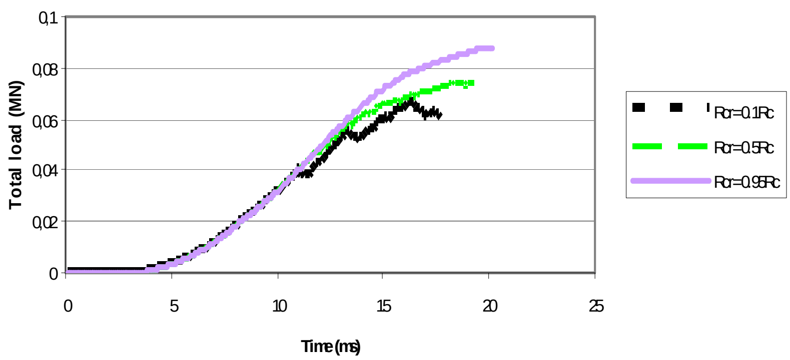


Fig. 1.

The base of this assertion is the fact that at low velocity the ice behaves as the ductile medium. Experiments with the ice samples show that the ductile samples have the lower ice strength. But the nowadays full scale observations show that the maximal action on structures corresponds namely to the low velocity, when the ice yields. Some laboratory tests [4] show that the reason of this phenomenon is the difference in value of the ice/structure contact area at low and high ice speeds.

This problem was investigated on the base of the 2D numerical program developed similarly to the program published in [5]. The finite difference method of integration of the main equations of the solid mechanics was used. The ice was considered as the Coulomb-Mohr medium which transits to the Tresca medium at some conditions. The transition from the ductile to the brittle ice properties was regulated by change of the ice residual strength and the angle of internal friction. Practically the Tresca law was used during the ductile behavior whereas an angle of internal friction of the order 25-30^o and the low residual strength characterized the brittle behavior.

Some results of the simulation are shown in Figures 1 a,b,c. The normal to the structure surface stress variation in the same time period in three points of the front side of the structure (points of the ice/structure contact area located at angles from the direction of the ice motion 3.5^o, 17.7^o and 32.6^o) are shown in Figures 1a (ductile material) and 1b (brittle material). One can see that initially the pressure distribution for both materials coincides, but when the failure starts the difference of distribution for the ductile and brittle material is very significant. If in ductile material pressure distributed evenly over the contact area, in brittle material we have zones with the stress concentration and zones with very low pressure.

The total load in time change for the three different media (ductile, intermediate and brittle) is demonstrated in figure 1c. This figure shows as well that if during the elastic deformation the loads on the structure coincide, then after the failure beginning the difference between the loads exist and the maximal load corresponds to the ductile ice behavior. This result entirely contradicts to the recommendations of the SNiP 2.06.04-82*.

Results of the full scale physical experiment conducted in Norway (Spitsbergen) confirmed qualitatively results of the numerical simulation.

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