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LABORATORY INVESTIGATION OF SEA ICE MECHANICAL PROPERTIES

Laboratory investigation of sea ice properties was performed in summer autumn 2003. it contained Uniaxial compression tests, salinity and density measurements, crystallography analysis. Several cores were compressed at temperatures close to the melting point (-1.9°C). The reason for that was to perform compression test in conditions close to natural. The results showed that unconfined strength at high temperatures –2 …-5°C decreases in comparison with recommended –10 …-15°C. Nevertheless, predicted change of failure mode has never occurred. All the samples showed brittle response at strain rate 10^{-3} s^{-1}.

During the last years, the arctic regions have become of a greater interest due to significant hydrocarbon fields discovered with a high probability of finding new resources. Development and exploration of oil and gas takes place in the Cook Inlet, the Beaufort Sea, Grand Banks, the Barents Sea, Sakhalin and some other regions. Operation in the Arctic has met many problems connected with the severe conditions of the region including remoteness, low temperature, dark season and presence of sea ice.

Ice induced loads on offshore structures are considered to be a design criteria of vital importance for offshore structures in the Arctic. For estimation of the loads mechanical parameters are needed. These are salinity and density (porosity), strength, modulus of elasticity and they are not well known. This makes it necessary to conduct laboratory research. Nevertheless, interpretation of the results obtained in the laboratory is complicated due to the nature of the material.

During the summer autumn 2003 a set of laboratory tests, including Uniaxial Compression Tests (UCT), salinity and density measurements and crystallography analysis, was performed. Core samples for the lab works were taken in the sea ice in the Barents Sea and Van Mijenfjord in the spring of 2003.

UCT was performed in a cold lab of UNIS. In order to obtain maximum strength response in the environment of the lab (-15…-22°C) strain rate was constantly set at 10^{-3} s^{-1}. The samples were shaped according to IAHR guidelines for testing ice and had a form of a cylinder 175 mm high with diameter of 70 mm (Schwartz et al, 1981). By the end of the laboratory season it was suggested to check strength of ice in warm temperatures. It was supposed that relatively warm ice (-2…-5°C which is close to its natural condition) would perform lower strength. More detailed description of tests is given in Vernyayev et al, 2003. Table 1 shows a summary of ice samples compressed at the temperature range mentioned above. The ice sorted for compression at high temperatures was sampled in the Van Mijenfjord level ice in order to reduce depth dependencies.

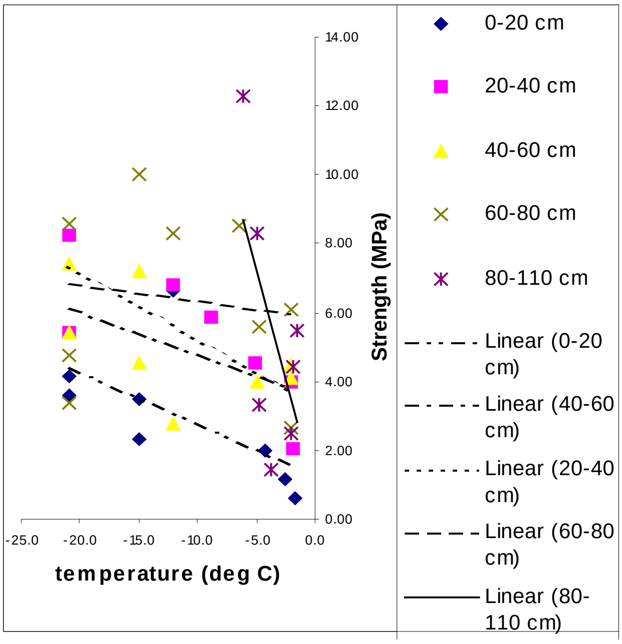
Table 1

Summary of warm ice UCT results

Ice temperature, (-°C)	1 …3	3 …7	7 …13	13 …15	21
Average strength, (MPa)	3.41	5.55	6.09	5.50	5.67
Standard deviation	1.74	3.53	2.04	3.11	1.97
Amount	11	9	5	5	9

At temperature range –7 …-13°C average unconfined strength appears to be at maximum values. Figure 1 shows that rising of temperature up to the melting point decreases strength of samples. In average it drops down 30 %. A trend line representing the bottom layer of ice has a steep angle. That shows a tendency of a skeleton layer of sea ice to be especially sensitive to temperatures regarding unconfined strength.

Nevertheless, all the samples have performed brittle failure while it was expected to be ductile (Høyland et al., 2003; Kamalov et al., 2003, Valkonen et al., 2003). Figure 2 illustrates the cracks developed through the sample.



igure 2. Temperature dependence in relation to layers o ce. Linear trend line calculates the least squares for a lin

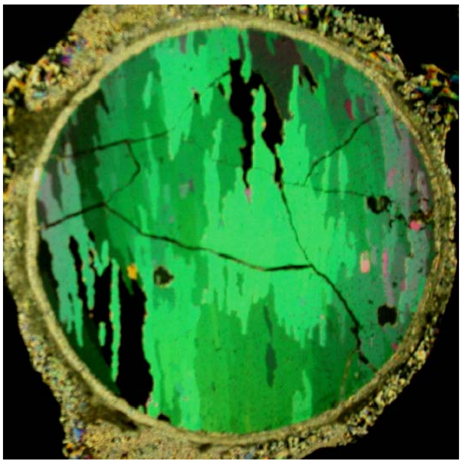


Figure 3. Thin sections of compressed sample's cross-section. Blue arrow shows a crack nucleated along the crystal's surface

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