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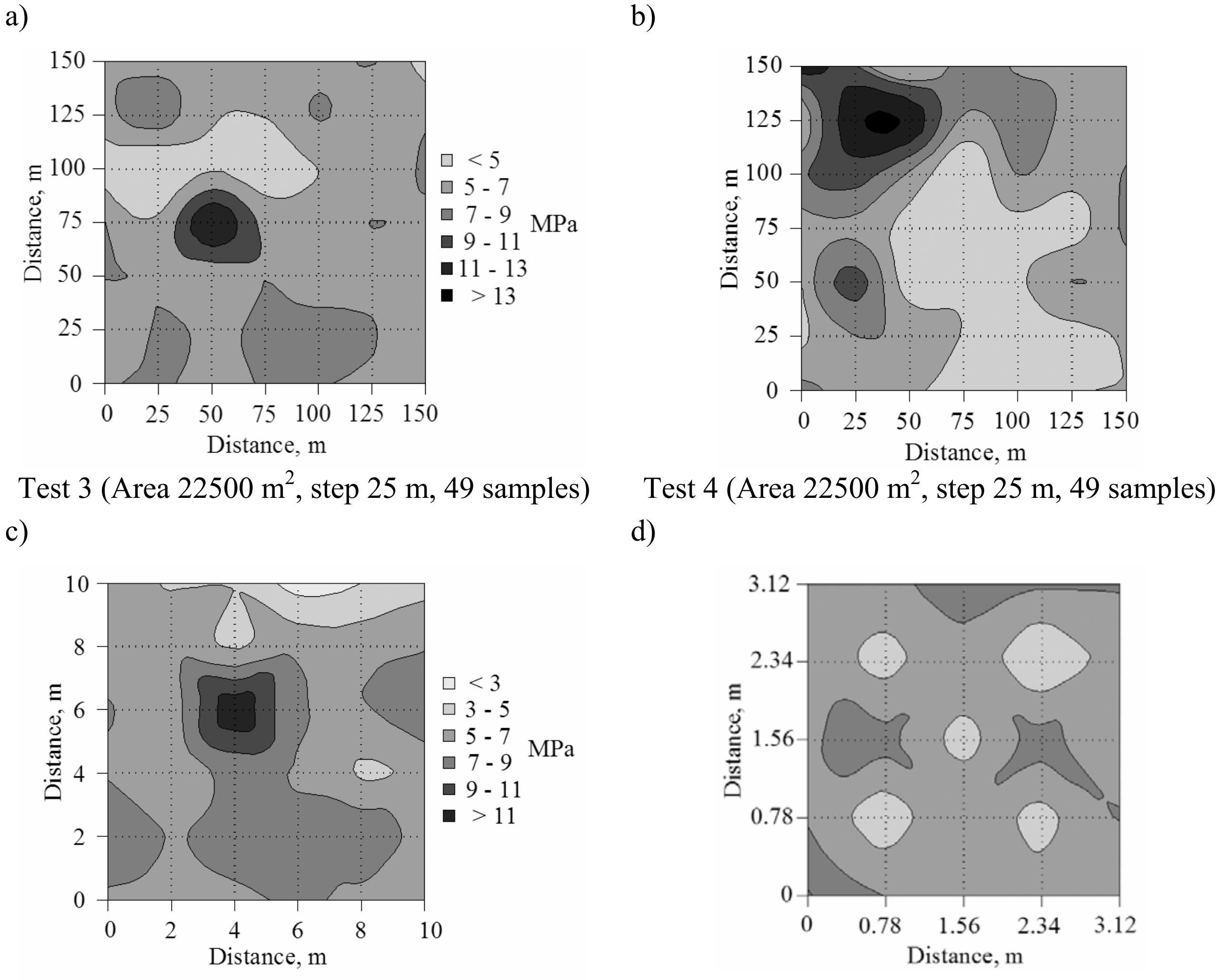
IN-SITU UNIAXIAL COMPRESSION TESTS OF LEVEL ICE

For the Arctic region the ice forces in most cases determine the design load for the offshore structures. The geometry, type of the ice features and its properties: thickness and strength are the most important factors that affect the ice load. The ice strength changes significantly in space and time. Its basically governed by the development of the temperature, the salinity and the porosity. Thus a considerable variation of ice strength data from different field experiments has been reported. Usually the ice load is determined based on Korzhavin's method (SNiP,1996 and API,1995). The uniaxial compression strength is multiplied by several coefficients describing both the structure and the ice field. Therefore a correct evaluation of the ice strength has a great importance for design ice load analysis.

Several field programs of ice strength evaluation through uniaxial compression tests were carried out in the landfast level ice both in the Van Mijenfjorden and in the Adventfjorden on Svalbard, Norway in 2004 and 2005. The spatial variation of the ice properties such as strength, temperature, salinity, density has been measured. The vertical ice cores reaching from 30 to 50 cm depth were compressed during Test 1, Test 4 and Test 3. The cores from 5 to 25 cm depth were taken and compessed for Test 2. It is known that the ice strength depends significantly on temperature (T) and salinity (S). For the testing in-situ, it is importaint to minimize the time between sampling and testing so that T and S don't change. For the current study the ice cores were compressed directly on the site using portable compression equipment. The compression tests were done less than 10 minutes after ice core was sampled from the parent ice. The present paper deals with the spatial heterogeneity of the ice strength for the different tests areas.

Table 1. Ice properties over considered test areas.

Test no.	T_{air}, ºC	σ_{ice}, MPa			T_{ice}, ºC			S_{ice}, ppt		
		min	max	mean	min	max	mean	min	max	mean
1	-2	4.90	8.89	6.40	-5.1	-3.5	-4.5	-	-	-
2	-15	3.60	8.05	6.18	-5.6	-2.9	-4.0	5.1	7.8	6.8
4	-6	3.23	10.71	6.28	-3.4	-2.3	-3.0	-	-	-
3	-18	2.97	12.64	6.35	-12.5	-5.7	-8.5	4.3	6.6	5.1



Test 3 (Area 22500 m^2, step 25 m, 49 samples)   Test 4 (Area 22500 m^2, step 25 m, 49 samples)

Test 1 (Area 100 m^2, step 2 m, 36 samples)   Test 2 (Area 10 m^2, step 0.78 m, 25 samples)

Fig. 1. The absolute ice strength distribution over areas (Sampling sites are points of intersections)

The ice properties data for the current test programs are summarized in Table 1 and the maps of the absolute ice strength distribution over considered test areas are shown in Fig. 1.

Three different test areas with length of 150 m, 10 m and 3.12 m were shown. The ice strength variability for 22500 m^2 areas was estimated in terms of coefficient of variation about 19.4 % for Test 3 and 35.8% for Test 4. The variability is equal to 26.8% and to 19.6% for 100 m^2 area (Test 1) and for 10 m^2 (Test 2) correspondingly. The character of the ice strength fluctuations doesn't change with reduction of the size of the area from 22500 m^2 to 10 m^2. The local spots characterized by the maximum values of the ice strength were observed in all cases as shown in Fig. 1. The ice properties and air temperature were similar for both Test 3 and Test 1. The size of area for Test 1 is 200 times less than for Test 3 but the estimated strength variability corresponds to the same level. For 10 m^2 test area there is no expressive spots of the local strength maximum, but the variability itself is still high. This is result of colder air temperature effect and presence of snow.

Test 3 and 4 were done at Sveabukta in the Van Mijenfjorden in the 2004 and 2005 spring seasons. The mean values of the ice strength over these areas were 6.28 MPa and 6.35 MPa for Test 3 and Test 4. But the ice strength distribution from Test 3, which was carried out at the end of April, is more homogenous than from Test 4 that was conducted at the middle of March. It probably results from the temperature variation of the compressed ice and air conditions during testing. The air temperature during Test 3 was –6ºC and the compressed ice samples was quite warm and have uniform temperature around –3ºC. For Test 4 the air temperature was –18ºC. The ice itself was colder and its temperature changes from –5.7ºC to –12.5ºC. The high temperature variation for the ice cores from the same depth could result from the physical explanation for example of presence of snow. From the other point of view the air temperature was colder than the ice temperature. Thus some ice cores may be cooled down slightly prior compression and this may increased the strength of the our samples and as a result extend the ice strength variability.

The experimental studies of the strength variability in relation to the different test areas was done for a certain depth of the landfast level ice. The analysis lead to the following conclusions:

- Similar character of the strength fluctuations was observed for areas larger than 10 m^2.
- The degree of ice strength variability for a certain depth was about 20% for sufficiently stable ice temperature. In case of ice temperature variation the heterogeneity increased to 35%.