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COMPARATIVE ANALYSIS OF ICE LOADS OBTAINED FROM MEDIUM-SCALE EXPERIMENT AND EXISTING METHODS OF ICE LOAD ESTIMATION

There are exist many formulae to estimate ice force on a vertical structure. However calculated ice forces from these formulae have a wide variety. Main reason why those are surviving may be caused by a lack of reliable data. Comparison of 19 different methods of ice load estimation with value of ice load obtained from test was made. The conclusion that most of the existing equation formulae could overestimate an ice load and could be applied only in case of similar conditions, which they were derived from.

Over the years, a variety of different methods have been developed to predict ice loads on offshore structures. Most ice loads predictions methods were based on several fundamental approaches. Some of them were based on theoretical considerations; some of them on numerical analysis and some were based on experimental results. For one's turn experimental results were obtained from small-, medium-, full-scale investigations. Because of different backgrounds, the resulted or calculated ice forces (loads) are naturally quite different.

In this paper comparative analysis of data obtained from artificial ice - structure interaction experiment (Moslet et al, 2004) and some of existing methods of ice load estimation are mentioned.

This work was done to show that rate of our knowledge is still on level of not clear ice – structure interaction process understanding. It can be created empirical equation for ice load estimation based on "constant" coefficients, but at the moment cannot be created solution, which would contain all the factors, affecting the ice loads on structures.

The artificial ice – structure interaction experiment was done in Van Mijenfjorden spring 2003 season. The purpose of this experiment was to improve our understanding of ice-structure interaction process. Difficulties correspond to arctic conditions and purposes of experiment itself made unrealizable conformity to modeling laws (Timco 1984).

The experiment modeled ice – circular structure interaction. Since the execution of a full-scale experiment is too expensive, the experimental plant was miniaturized to medium-scale range, as a circular structure was represented tube of low diameter, fixed on the bottom of fiord. Since forces, which take place in a full-scale sea ice structure interaction are high, a fresh grown thin ice floe was used for the experiment. The tube was supplied with load panel that contain four load cells. The ice floe pulling force was provided with a winch that was fixed behind the "structure". Force measurements were made during the test. Also were done lab investigations of ice properties to define strength, salinity and density of the ice. As thin section tests showed that the structure of the ice was grained, but some samples showed a grain-columnar structure that is correspond to S2 sea ice.

For the estimation of possible ice force acting on the vertical "structure" were chosen different methods, some of them were based on full-scale data, some of them on theoretical consideration, some on lab investigations and some combining several approaches. As well as empirical and theoretical solutions, equations suggested with existing codes were used to estimate ice load. Most of these equations contain empirical coefficients of unexplainable nature.

Cause of not scaled but just minimized of experimental plant, in equations were used real values of all the parameters, such a width of the structure, ice thickness, compression strength of ice, indentation speed.

The ice loads calculated with existing methods are shown on fig.1 in comparison with ice load obtained from the test.

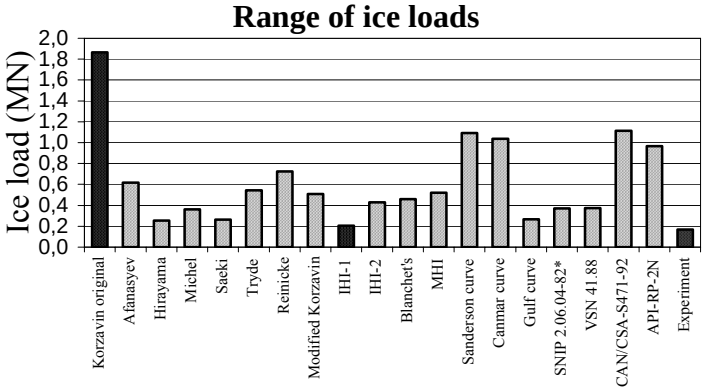

Figure 1. Correlation between ice loads obtained from experiment and value of ice load calculated with different methods

The fig.1 is the clear illustration of the wide range of variation that can be found from existing methods of ice load estimation where the highest overestimation shows Korzavin's original equation. It is almost 10 times higher than test value of ice load, most accurate result, overestimating less than 20%, shows IHI-1 equation proposed by Kato (1992) combining the results from ice tank experiment and the numerical experiment. The overestimation of ice load with existing codes can be explained as excessive caution of designers. Using of uniaxial compression strength in other equations is not justified since during an ice – structure interaction ice does not have a simple "strength". Also using of "independent constants" such an indentation, shape or contact factor, which are not necessarily constant or independent (Sanderson 1984) in some methods can explain inaccuracy of estimation. The full-scale data that is being used as a basis for ice load prediction has been obtained over a period of about 10 years, mostly in one geographical area, and only on few structures.

Although it is difficult to say anything decisive from a single comparison done here, it can be concluded that estimated equations can be applyed only to event of ice structure interaction process with similar conditions which they were derived from, since most of them based on specific tests and approaches and do not explain mechanism of ice-structure interaction. The dependences between ice load and thickness of ice, ice load and indentation speed are still not clear since all the equations suggested different ratios of these parameters.

However to conclude anything more decisive, more data need to be analyzed.

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