Seasonal Variations in the Occurrence of Ice Induced Vibration of a Bottom Fixed Structure

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ABSTRACT

Norströmsgrund lighthouse full-scale data from the winter 2002/2003 shows that ice induced vibrations of a vertical sided offshore structure is occurring more frequently from mid-March and later, than earlier in the winter. Metrological data is used to calculate the ice growth and it is found that the occurrence of ice induced vibrations may correspond with the stop in ice growth. Direct measurements of ice temperature in the surrounding ice cover indicate that the temperature profile in the ice cover changes from a linear shape to a C-shape between 28 February and 10 March. The major observations of ice induced vibrations were done from 10 March and later. Then intense vibrations were detected after a time period with air temperatures in the range of 0ºC to +10ºC. Ice induced vibrations were also corresponding with occurrence of global ice drift observed from satellite images.

KEY WORDS: Ice loads; Static; Dynamic, ISO/DIS 19906.

INTRODUCTION

Ice induced vibrations of vertical faced structures in ice-covered waters has been a known challenge since the first observations of the phenomenon in Cook Inlet Alaska by Peyton (1968). From that time, ice induced vibrations has been observed at full scale structures in Bohai Bay (China), Gulf of Bothnia (Sweden and Finland), Beaufort Sea (USA and Canada), Caspian Sea (Kazakhstan) and Sakhalin Island (Russia).

Large steps towards an explanation of the ice induced vibration phenomenon were taken after four decades of research by the latest issue of the ISO code for arctic offshore structures (ISO 19906-2010). Continuing work are ongoing by DNV and others to refine the proposed design guidelines in ISO 19906-2010.

During the four decades of research on ice induced vibrations, most attention has been devoted to the in-depth physical (mechanical) description of ice-structure interaction. Sophisticated models have been proposed by Mättänen (2001), Sodhi (1995), Kärnä (2008) and several others.

Most models proposed to date have been addressing the importance of the strain rate effects. Sea ice is a material that exists close to its melting point. It is well known that the crushing behaviour at low strain rate is ductile, while the behaviour is more brittle at high strain rates. Bjerkås and Skiple (2005) showed, based on full scale data, that the current ice temperature may have influence on the occurrence of ice induced vibrations. Vibrations seemed to be more frequent for high temperatures than for lower temperatures.

Continuous recordings of ice induced response with corresponding loads and environmental conditions have been a challenge in several measuring programs. Therefore, limited information is available on the seasonal variation of the occurrence of ice induced vibrations.

One of the more extensive measuring programs to date is the LOLEIF/STRICE initiative running from 1998 to 2003. The lighthouse Norströmsgrund (Fig. 1 and Fig. 2) was instrumented extensively by the LOLEIF/STRICE team and manned from mid February to late April for four winters to collect full scale data (Schwarz and Jochmann, 2001).