Ice Induced Vibrations – Observations of a Full Scale Lock-in Event

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ABSTRACT

A full scale event with frequency locked-in ice loads is presented in this work. Data collected at the Norströmsgrund lighthouse in Gulf of Bothnia during the STRICE project consists of several events with lock-in like ice loads. The 180 seconds long event presented in this work occurred 30 March 2003 and was one of the harshest during the entire measuring program 1999-2003. Physical conditions related to ice thickness, drift speed and ice temperature have been reported earlier to play a key role in the occurrence of lock-in like ice loads. This study reports some new features related to ice loads and response. Overall 190 cycles at the fundamental mode was found. The peak load represents an effective pressure of 1.3 MPa with an average load amplitude of 58 % of the peak load. Focus in the study was the triggering of locked-in ice loads. It was found that spatial synchronization of local loads was the reason for triggering. The synchronization could be caused by different physical phenomena where the drift speed, ice thickness and ice temperature is of substantial importance. As well, temporal fluctuations of loads were studied within the event. Together with oscillations at the structural fundamental frequency, a process fluctuating at a 5 sec period was found. However, no clear explanation for the 5sec build-ups was found. At last the end of the event was studied. Stop in lock-in like ice loading was in this case, limited by an in-plane collapse and further flooding of the ice sheet.

KEY WORDS:  Ice loads; Static; Dynamic, ISO 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).

One of the more extensive measuring programs to date is the LOLEIF/STRICE initiative running from 1998 to 2003. The lighthouse Norströmsgrund 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).

Norströmsgrund lighthouse (Fig. 2) was deployed in 1971 about 60 km offshore Luleå in Sweden (Fig. 1). Bottom fixed lighthouses were replacing ships in navigation channels in the 1930ties and 1940ties in Sweden and Finland. An extensive work was performed both in laboratories and in the field to establish design ice loads for the new bottom fixed lighthouses (Frost, 1946). The Norströmsgrund design was based on several failures of structures along the Swedish coast. Hence, the design ice load for structures in the Northern Gulf of Bothnia was upgraded from 2.0 MN/m to 2.2 MN/m before Norströmsgrund was designed (Erntsons and Kjelgren, 1969).

From the 40 years in service, it has been well known that Norströmsgrund lighthouse has experienced ice induced vibrations. Some minor cracks in the massive structure have been observed, while the global serviceability of the structure has survived (Bjerkås et al, 2010).

Fig. 1 Location of the Norströmsgrund lighthouse offshore Sweden.