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Response of an Armoured Riser to Wave and Ice Actions and to Impacts from Ice Blocks

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A finite element model of a riser protected from ice impacts by an armour is described. The riser is connected to a tanker via a turret arrangement. A steep-wave configuration at the 300-m water depth is then considered. Numerical simulations are performed to study the influence of the armour on the response of the riser, and to monitor forces and deformations in the riser. Responses are computed to different sea-states, to surge motions of the surface vessel due to drifting ice, and to impacts of ice blocks on the riser armour. The simulation results confirm the workability of the concepts, and the integrity of the riser is preserved. Forces predicted from simulations on the armour top during ice impacts are of the same magnitude (close to 500 kN) as forces generated during 100-year storms.

INTRODUCTION

Arctic offshore activities have been ongoing for many years but have been rather limited. Most experiences related to oil and gas production have concerned exploration operations and little in the way of production activities has taken place. Although technical and safety challenges are significant, the principal deterrent to Arctic production has been one of production economics. Export of the produced hydrocarbons remains a challenge in the Arctic offshore. Shipping and pipelining are 2 possible alternatives for the export of the produced hydrocarbons; Gudmestad and Løset (2004) conclude that shipping often can be an attractive solution.

Different Arctic offshore offloading concepts have been presented in the literature. A tanker may load directly from the production platform (Malyutin et al., 2003) or from a narrower loading tower (Gudmestad et al., 1999). These concepts may suffer from high collision risks between tanker and structure in variable ice-drift conditions (Bonnemaire, 2006). A tanker can moor on the loading hose via a Single Anchor Loading (SAL) system (APL, 2003), but effective ice management from icebreakers should protect this system in heavy ice conditions. Finally an adaptation of the Submerged Turret Loading (STL) system for Arctic conditions was proposed, where an armour protects the riser against possible damages from impacting ice blocks; a detailed description of the concepts is available in Bonnemaire et al. (2003). Two different designs are considered, depending on the water depth (Fig. 1).

The armour should be strong enough to protect the riser against ice impacts, and it should also cope with year-round environmental conditions. Present technology could, for instance, be used at Shtokmanovskoye Field in the central Barents Sea to export stable condensate. The possible presence of icebergs (Zubakin et al., 2004) will favour a solution featuring the ability to disconnect. While the maximum extension of the ice edge varies a lot in the central Barents Sea (Løset et al., 1997), ice can still be expected from December to May (Løset et al., 1999). Level ice can reach a thickness of 1.5 m, and the consolidated part of ice ridges, a thickness of 3 m (Malyutin et al., 2003). Ice ridges can be expected to be as deep as in the Pechora Sea, i.e. 12 to 18 m. The significant wave height of the 100-year storm is estimated at 11 m.

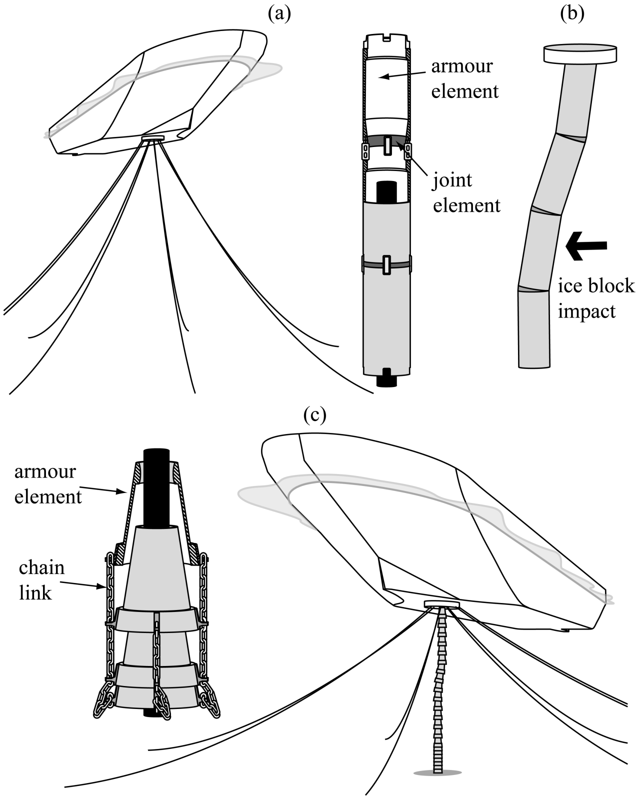

Fig. 1 Sketches of riser armour concept; (a) deeper water (>50 m) version, overall view and armour details; (b) armour deflection under force generated by impacting ice block; and (c) shallow water version (reference to Norwegian patents no. 316283 and 316465)

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