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Design of Hebron Gravity Based Structure for Iceberg Impact

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ABSTRACT

This paper presents a methodology to estimate iceberg impact loading, as well as analyses and design of exterior walls of the Hebron Gravity Based Structure (GBS) to resist the 10,000-year return period iceberg impact loading. The iceberg impact load on the GBS was calculated using a probabilistic analysis including Type II uncertainty analysis with a logic tree. When subjected to the 10,000-year iceberg impact, the Hebron GBS is designed to be highly utilized, that is, the concrete and rebar are stressed to their specified strength (consistent with the Accidental Limit State check). This was done by allowing internal redistribution of elastic forces by using Non-Linear Finite Element Analyses (NLFEA), which resulted in an optimized reinforcement design, safer construction and reduced overall cost of the GBS structure.

KEY WORDS: Hebron; Gravity Based Structure; Iceberg; Impact; Logic Tree; Non-Linear Finite Element Analyses.

INTRODUCTION

The base of the Hebron oil drilling, production and storage platform (Fig.1) is a concrete Gravity Based Structure (Fig. 2), which will be installed in approximately 93 meters water depth on the Grand Banks offshore Newfoundland, Canada. It will be located at the Jeanne d'Arc Basin, 340 km offshore of St. John's, close to the existing Terra Nova and Hibernia platforms. The GBS (~130,000 m^3 of concrete) consists of a base, a caisson and a shaft. The caisson houses seven oil storage cells to store approximately 1.2 million barrels of crude oil. Each storage cell is protected against icebergs by an exterior reinforced concrete wall (ice wall). The top of shaft elevation is 121.82 m (where El. 0 is at the seabed). The base diameter is 129.5 m.

Many icebergs drift into the area where the Hebron platform will be installed and could impact the platform. The International Ice Patrol's website archive of icebergs drifting south of latitude 48° N dating back to 1900's shows annual iceberg counts ranging from zero to more than 2000. As such, it was essential to design the Hebron platform to resist iceberg impacts.

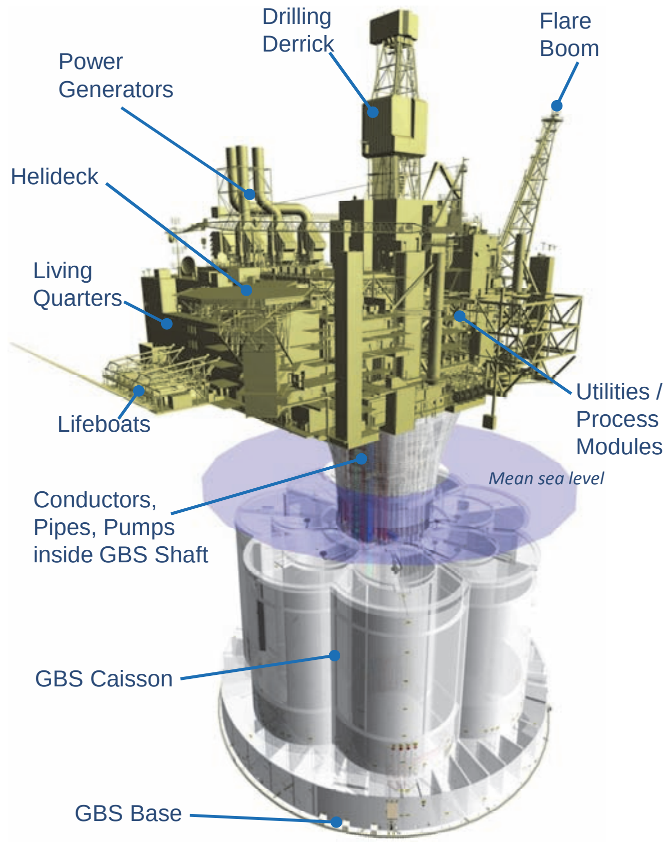

Fig.1 Hebron Oil Drilling, Production, and Storage Platform

LOADING

Iceberg impact was considered at two return periods: 100-year and 10,000-year. The load generated at the first return period is an Extreme-Level Ice Event (ELIE) while the second is considered Abnormal-Level Ice Event (ALIE) event, a very rare event per ISO 19906. It should be noted that a 10,000-year event corresponds to an annual probability of exceedance of 10^{-4}.