Full-scale compression capacity test of an offshore power cable

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ABSTRACT

Umbilicals and power cables may be subjected to compressive loads (negative tension) during installation and/or service. This may lead to local buckling of cable components and possibly overall torsion instabilities. Qualifying the cable to allow some compression will increase range of use and significantly increase the weather window for installation.

This paper describes a full-scale test designed to trigger lateral buckling failure in the cable cross-section of a static power cable. The main purpose of the test was to estimate the compression capacity of the cable and gain a better understanding of local buckling phenomena for power cables in compression.

INTRODUCTION

Umbilicals and power cables are normally installed at a relatively low tension level. This increase the risk of the cables to be subjected to compressive loads during both installation and operation, typically due to vessel motions and current loads. Compressive loads in the cross section may lead to local buckling of components and possibly overall torsion instabilities, which may be catastrophic for the structural and electrical integrity of the cable.

A possible failure mode for the cable's tensile armour wires subjected to compressive loads is radial buckling. Normally this is prevented by using high strength tape around the tensile armour wires. If the radial movement is sufficiently restrained the wires are forced to move laterally and lateral buckling of the wires may occur. A mechanism triggering lateral buckling in power cables have been found to be compressive loads in combination with cyclic bending.

During the recent years, the attention to umbilicals and power cables subjected to compressive loads has increased. API Specification 17E/ ISO-13628-5, ref. [1], do not provide specific guidance with respect to levels of compression, nor does it discuss how buckling develops and possible consequences. Common industry practice accepts some compression based on experience and judgment. However, nearly every field development project involving a dynamic umbilical or cable has to determine how much compressive loads the umbilical or cable can withstand without losing its structural integrity.

A better understanding of the behavior of the cable in compression, as well as to ascertain a safe level of acceptable compression is requested by the industry. This topic was an important part of the joint industry project (JIP) "*Joint Industry Project on Stress and Fatigue Analysis of Umbilicals and Power Cables - Phase III*", where both analytical methods, numerical methods and test methods were described. Related to the JIP, a dynamic test rig for full-scale testing of cables subjected to combined compression and bending loads was designed and built. NKT HV Cables AB (former ABB HV Cables AB) provided a static power cable which was tested in the dynamic rig as part of the JIP. The main purpose of the full-scale test was to gain a better understanding of local buckling phenomena for umbilicals and power cables in compression.

Normally, the load program is designed to simulate installation or operational conditions, as described in [2]. In the current test, the load program was developed to gradually increase the applied load until lateral buckling failure in the cable cross section occurs.

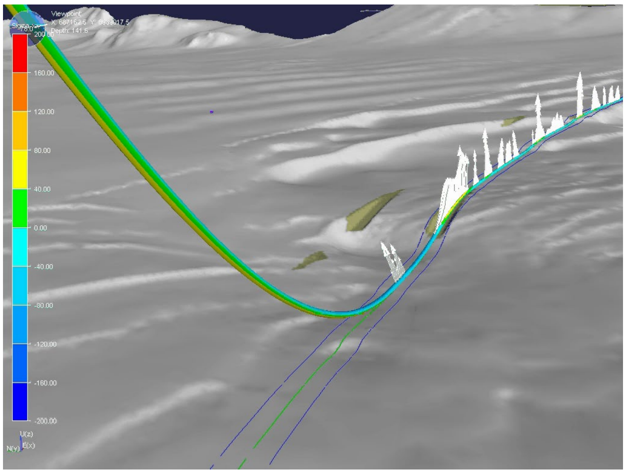

Fig. 1: Cable forces at touch down

TEST SAMPLE

The compression test was performed on a HVAC submarine cable with 3x300mm^2 solid copper conductors. The three power cores are helically wound together with three polymeric fillers over which two armour layer has been applied with opposing lay direction. The cable design is torsional balanced. The armour wires are embedded in bitumen and the outer serving consists of polypropylene yarn. An illustration of the cable design is shown in Fig. 2.

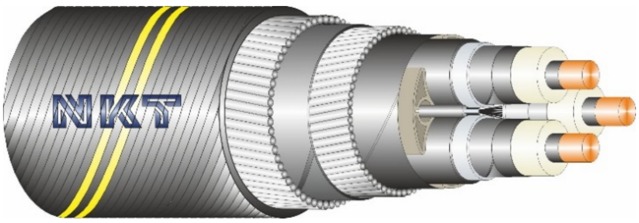

Fig. 2: Tested cable design

The length of the test specimen was 8 m. The sample was prepared by installation of three lubricated high strength steel wire ropes through the cable sample in the axial direction. Each wire was installed in one of the three fillers utilizing the space normally used for optical fibres. Previous testing, ref. [2], used a smaller wire, with 30 kN minimum breaking load, installed in the centre of the cable. The available space in the centre of the cable between the three cores is limited which restricts the outer diameter and strength of the wire. The current setup, with installation in