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Geohazard Assessment in a Deepwater Subsea Development — A Contractor's Perspective

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Abstract

The offshore industry is moving to deeper water, along or in the proximity of the continental slopes. In such environments the geo-hazard assessment for offshore installations is crucial engineering activity. It requires, since the early stage of the project, a sequence of dedicated engineering tasks, including: identification of the potential failure modes of the seabed soils and relevant triggering mechanisms; definition of the probability of occurrence for each failure mode that might interfere with seafloor infrastructures; analysis of the structural response to loads or imposed displacements, and relevant integrity check. Infrastructures dedicated to offshore exploration, production and transportation of hydrocarbons, are designed to meet very stringent safety targets. In this paper reference is made to offshore pipelines transporting hydrocarbons over long distances, crossing seabeds affected by geohazards. For these strategic infrastructures, reliability-based limit state design guidelines currently in force, require that both geohazard specific load effects and pipeline strength capacity are well described in terms of relevant parameters and modelling. Particularly uncertainty measures influencing load occurrence and relevant effects must be known with a suitable degree of confidence to allow rationally based decision on pipeline routing and protection measures, where and if any. Working with theoretical superposition of tails of probabilistic distributions of load and capacity, as required in the probabilistic design or in the calibration of partial safety Factors for Loads and Resistance in the relevant Design formats (LRFD), requires care and good reference basis for comparison. Structural reliability based design, targeting a failure probability of 10^{-4} or 10^{-6} per year, can hardly be based on load occurrence and relevant effects characterized by a large (greater than 0.3) coefficient of variation (load roughness). This is the case for infrastructures along the continental slopes affected by geohazards. Evidence of uncertainty is given by the engineering models dealing with the load transfer capacity from a typical plastic mass (soil and water) flow, running downhill, e.g. triggered by an earthquake, and impacting on a pipeline resting on the seabed, whether free spanning or partially embedded.

Introduction

Geohazard is a typical issue of deep waters projects. The continental slopes are geologically complex areas characterised by steeply sloping seabed, irregular bathymetry and locally abundant sediments. Thick layers of soft sediment likely under or normally consolidated, resting on the flanks of the continental slope, often subjected to seismic activity may give rise to global or local instability of the superficial sediments that may develop into downhill slumping and even plastic flows running over kms. Evidence of such events may be found processing the seabed 3D morphology as currently achievable from dedicated survey adopting state of the art equipment. Examples of seabottom 3D view can be seen in Figures 1 and 2 showing how continental slopes may look, with deeply incised branched canyon systems in late development patterns and shallow canyon systems in early development ones, respectively.

Seabed features are deep canyons or fracture/deep and steep slits approximately running along the steepest descent lines not necessarily associated to seismic faults, isolated or sequence of steps/terrace or slumps along the slope or roughness at the toe, seismic faults and even mud volcanoes. Subsea field development including structures and flowlines ending with plets and jumpers, as well as export pipelines and umbilicals, are often to be routed across such features. Mitigation measures and relocation/rerouting may be required to be developed during design for both operation and installation, as well as purpose developed inspection programmes generally reliability based.