Offshore & Dredging Engineering

Technische Universiteit Delft

UNDEX Impact assessment; the effects of underwater explosions on pipeline integrity.

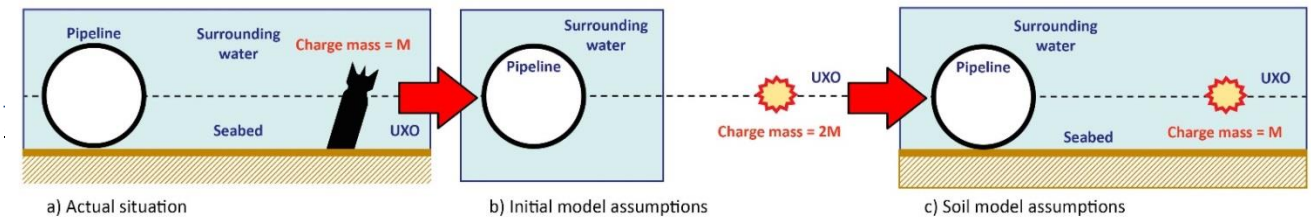
Sometimes a subsea pipeline is planned in an area that, in the past, was a theatre of war or a dumping area used for explosives. During the route survey of proposed pipeline routes, these explosives can be found close to or even in the pipeline corridor. The presence of these unexploded mines, bombs or torpedoes on the seabed (unexploded ordnances, or UXOs) forms a potential hazard for subsea pipelines and other structures. When finding such UXOs, proper safety measures should be taken to make sure the risk of damage to the underwater structures and the environment is acceptable. When proposing a pipeline route, all unacceptable UXOs in the pipeline corridor should be mitigated. They should either be removed, set off in a controlled explosion, or a re-route with a safe standoff distance should be considered.

To create an appropriate mitigation plan, it is important to understand the effects of an underwater explosion (UNDEX) on a subsea pipeline. To gain a better understanding of these effects it is important to investigate the explosion event itself, the pressure wave propagation and the loading on the pipeline. The UNDEX event is well described in literature and empirical formulas describing the pressure over time for a point with a distance R from the charge exist. These formulas can be used to describe the pressure wave acting on the pipeline.

To assess the effect of this pressure wave on the pipeline, a finite element model is created in ABAQUS. As a first approximation of the problem, the pipeline is assumed to be floating in the water. To incorporate the effects of the seabed on this model, the charge weight is doubled, assuming a full reflection of the pressure wave at the seabed. In this simplified version the structural pipe model is surrounded by an acoustic domain that mimics the behaviour of the surrounding water. The pressure wave created by the underwater explosion propagates through this acoustic domain, and the acoustic domain interacts with the structure.

The model is created for a total of 16 different load cases, for a stand-off distance between the charge and the pipeline of 5-10-20 or 50 m, and a charge weight of 25-50-100 or 300 kg equivalent TNT weight. Comparing the results of the shock wave peak at the pipeline with the theoretical values calculated with formulas from literature it can be concluded that the shockwave propagation through the acoustic domain is comparable with that seen in experiments.
Doubling the charge weight is assumed to be a conservative approach for taking the seabed into account. However the presence of the seabed has an effect on the creation of the shock wave, the wave propagation and the loading of the pipeline. The soil will absorb a part of the energy of the UNDEX event, but some of the energy will be reflected. This will not only make the peak pressure higher, but will also change the shape of the pressure profile.

A second ABAQUS model is created which consists of the structural pipe model, the acoustic fluid domain and a solid elastic model for the soil. This model is compared to the initial model where the pipeline was surrounded by the acoustic domain. From this comparison we see that the distribution of the pressure over time changes. The peak pressure is lower, but the decay of the pressure is more gradual. Due to this the force acts on the pipeline for a longer time, changing the reaction of the pipeline. Therefore the simplification by incorporating the seabed as doubling the weight of the charge might sometimes not be conservative. It is advised to further investigate this effect.



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