Using ABAQUS for reliability analysis by directional simulation

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Abstract: *Monte Carlo reliability calculations for high-reliability systems are very computationally expensive. Variance reduction techniques optimize this process greatly and directional simulation is one such technique. Directional simulation is particularly valuable for high reliability systems where the failure surface is highly curved or dislocated. Subsea pipe-in-pipe structures in certain classes represent such a system and Abaqus is ideally equipped to solve this structural problem, which involves contact with friction, buckling, plasticity and fabrication imperfections amongst other phenomena. The pipe-in-pipe structure is non-linear in normal service. The directional simulation algorithms were programmed in VB and Excel. In addition, the VB software generated the Abaqus input files to define a unique model for each combination of parameters to populate the design space/failure surface. The tool also generated the Python scripts required to launch and post-process the Abaqus runs automatically within the directional simulation algorithm. The parameter selection was intelligent to the extent that the algorithm used the available results to cluster runs in the regions of the failure surface that required the best definition. This paper will demonstrate the techniques used and show how the tools were validated on a known-reliability structure. The process of arriving at a probability-of-failure value for a structure (with properties that are random variables) that behaves non-linearly under operating loads will be described.*

Symbols:		
	F	*Load, force*
	S	*Stress*
	D	*Subscript for demand variable*
	R	*Subscript for resistance variable, reliability*
	t	*thickness, with subscripts f for flange and w for web*

Keywords: *Buckling, Design Optimization, Failure, Pipes, Pipeline, Plasticity, Probabilistic Design, Safety, Python Scripting, Shell Structures, Reliability, Directional Simulation.*

1. Introduction

1.1 Subsea pipe-in-pipe structures

In the early days of offshore oil and gas production, fixed platforms were sited directly above the subsurface hydrocarbon reservoirs and the fluids were transported nominally vertically from the

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