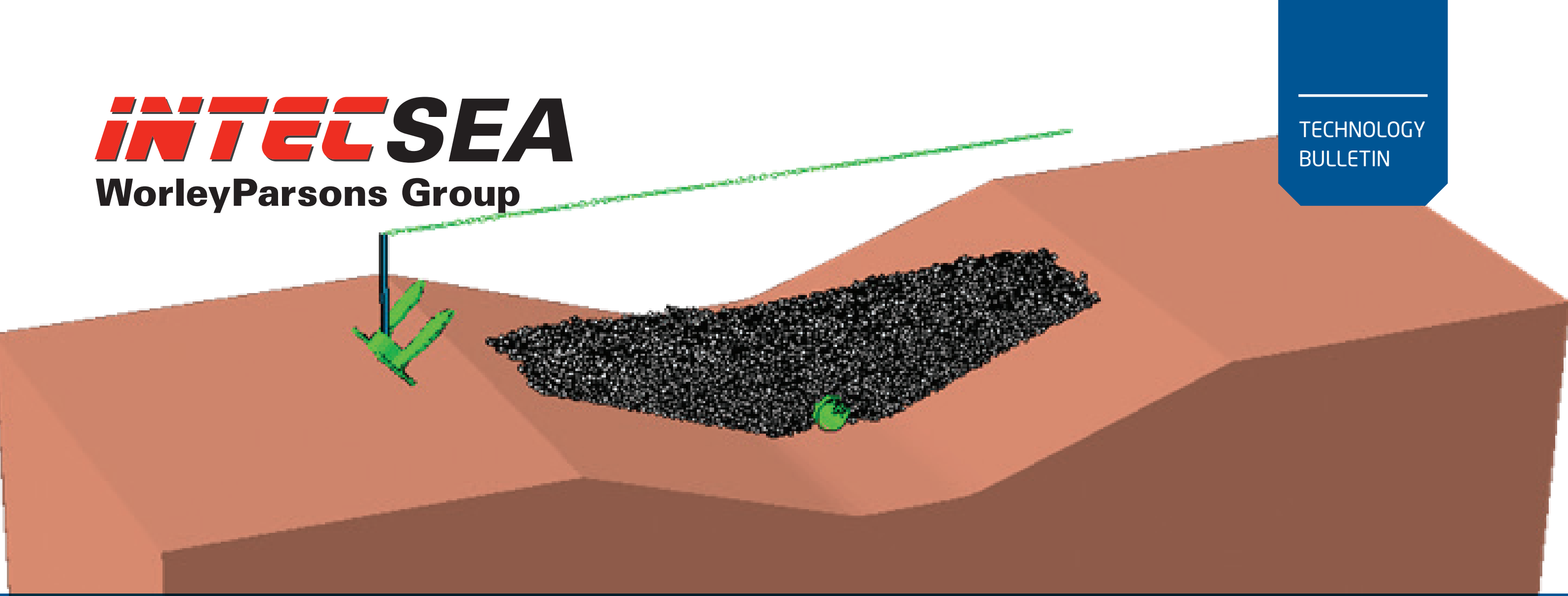
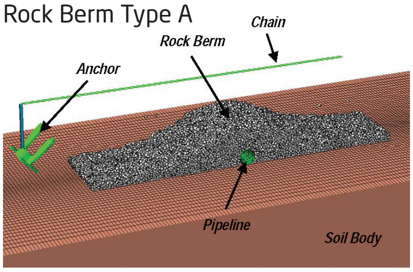
INTECSEA
WorleyParsons Group

TECHNOLOGY BULLETIN



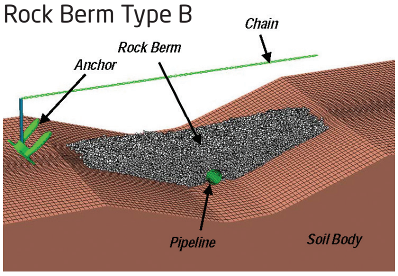
Anchor Drop and Drag Simulation for Pipeline Rock Berm Protection

Rock Berm Type A



Pipeline Laid on Seabed

Rock Berm Type B



Pipeline Laid on Trench Bottom Center

Customer Benefits

- Cost Effective and Rapid tool for pipeline protection optimization
- Substantial potential construction cost savings
- Potential design and construction schedule reduction
- Faster and lower cost than physical testing
- Clear visualisation of interaction mechanisms, not always obvious in physical tests
- Better understanding of damage risks for both planned and existing pipelines, cables and umbilicals

Introduction

Offshore pipelines located near harbour areas or in shipping lanes are at increased risk of impact damage from anchor and other dropped objects. These pipelines are typically buried or protected with rock armour berms. The design of these protection rock berms has been traditionally based on physical model testing since there is no analytical solution available to resolve the complex interactions between anchor, anchor chain, rock armour, seabed soil and pipeline. However, this kind of model testing can be very costly and time-consuming.

Recent advances in numerical analysis technology have been exploited by INTECSEA specialists, who have developed an effective, validated numerical prediction tool, using ABAQUS finite element software. Good agreement has been shown between this numerical model and physical model testing.

Compared to the costly physical model testing, this numerical model allows rapid and detailed sensitivity studies on various rock berm configurations and allows optimized rock berm with appreciable savings on overall project cost and schedule. Typical rock berm types and modelling details are shown below.

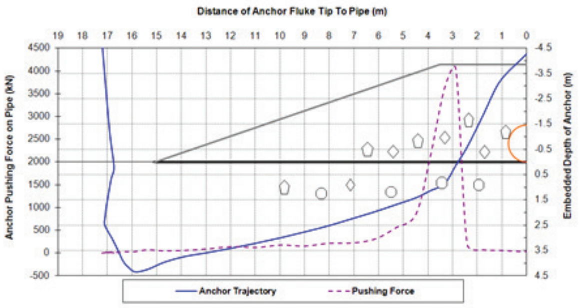
Pipeline OD (inch)	Anchor Weight (tonnes)	Trench Size					Rock Information	
		Trench Depth (m)	Trench Bottom Width (m)	Trench Top Width (m)	Rock Cover Thickness (m)	Slope (V : H)	Size D_{50} (mm)	Numbers in FEA simulation
32	5.0	2 ~ 6	2	2 ~ 10	0.5 ~ 3	1 : 0.33 ~ 1 : 1	330 ~ 380	1000 ~ 6500
48	20.4	3.86	5	28.2	2.4	1 : 3	320 ~ 420	20000 ~ 25000

Anchor, chain, pipeline and rocks are modelled as rigid bodies while soil is modelled as deformable body.

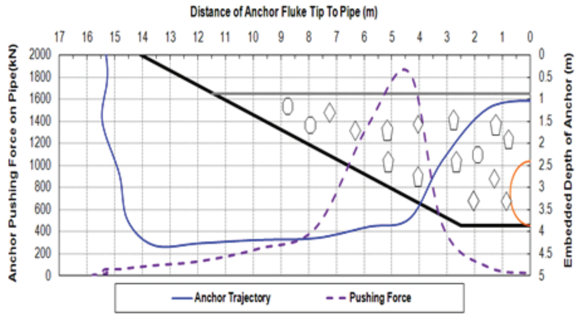
Anchor Trajectory and Pushing Force

A minimum clearance of 300mm between anchor and pipeline needs to be achieved when the anchor is dragged across the armour rock as per common industry practice. Pipeline equivalent stress induced by anchor pushing force also needs to be checked. These results are shown in the following curves.

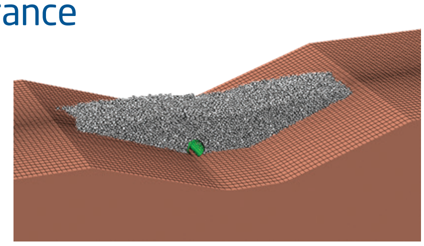
FEA Result- Case 1



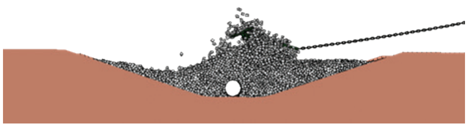
FEA Result- Case 2



Critical Case by Considering Lay Tolerance



Pipeline Laid at Trench Bottom Edge



Anchor Passing Through Rock Berm and Deflected by Rocks

Publications

OMAE 2010-20098: Optimization Study Of Pipeline Rock Armour Protection Design Based On Finite Element Analysis
L.Wang, H. Chia

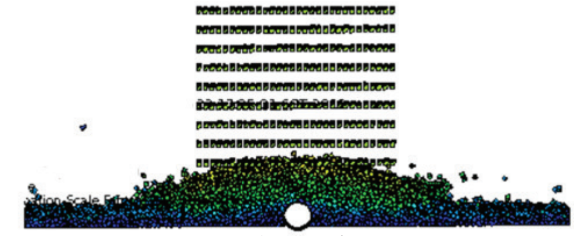
ISOPE 2009: Validation of Rock Berm Cover Design for Offshore LNG Pipeline in Hong Kong
C. Gaudin, M.M. Landon, V. Pedersen, C.H. Kiat, W. Leqin

OMAE 2009-80130: FEA-Based Study Of Pipeline Protection From Anchors
L. Wang, H. Chia, J. Wei, Q. Chen

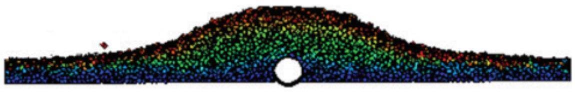
Rock Dumping Simulation

This simulation is to generate rock berm by random dumping process and is a prerequisite analysis for anchor drop and drag simulation.

Rock Berm Type A (25650 rocks)

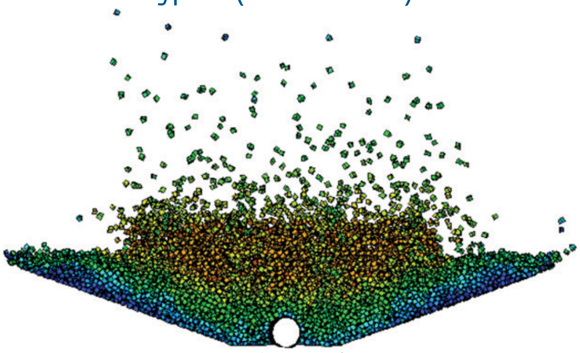


Rocks Dumping

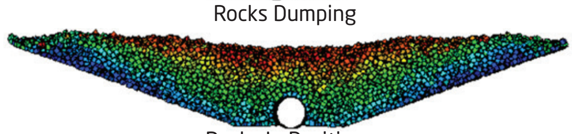


Rocks In Position

Rock Berm Type B (24320 rocks)

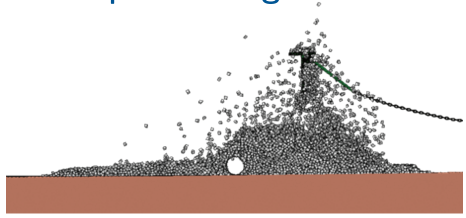


Rocks Dumping

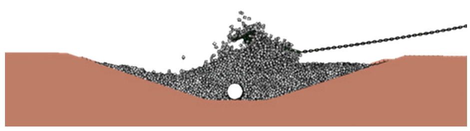


Rocks In Position

Anchor Drop and Drag Simulation



Anchor Passing Through Rock Berm and Deflected by Rocks



Anchor Passing Through Rock Berm and Deflected by Rocks

For more information, contact:
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