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The Effects of an Unstable Seabed on Subsea Pipelines

SUT Student Evening

Andrew Enfield Kirk
October 14th 2010

Motivation behind research

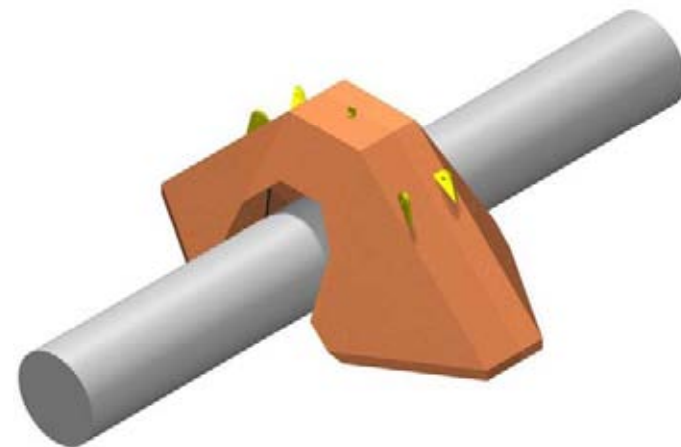


1988: VERITEC RP E305 (old code) assumes the during extreme conditions the seabed below a pipeline remains stable

1996: Andrew Palmer tells us it is not – scour, liquefaction

2007: DNV-RP-F109 (new code) agrees, but doesn't tell us what to do

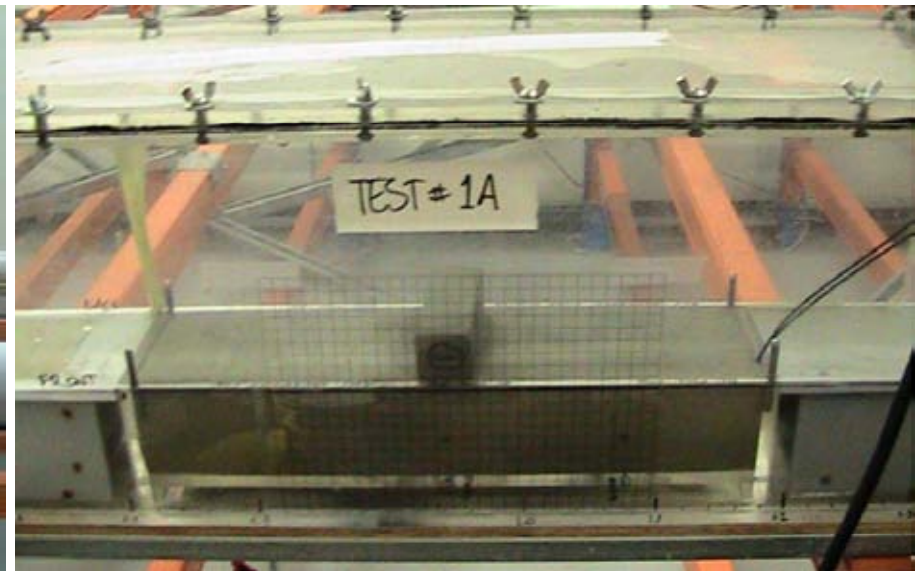
2010-20??: Many projects offshore NW Australia rely on subsea pipelines. Keeping these stable using secondary stabilisation is very expensive...



Objectives



- (i) model typical NWS conditions, observe pipe-soil-fluid interactions
- (ii) review the DNV approach to stability design and comment on its applicability to pipelines on the NWS





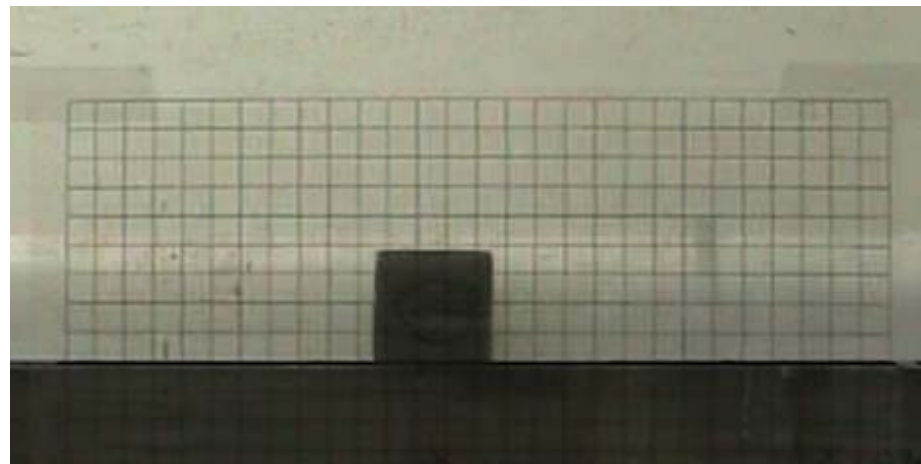
Methods

Wave only action, scaled to match typical NWS wave period and near seabed water particle velocities...

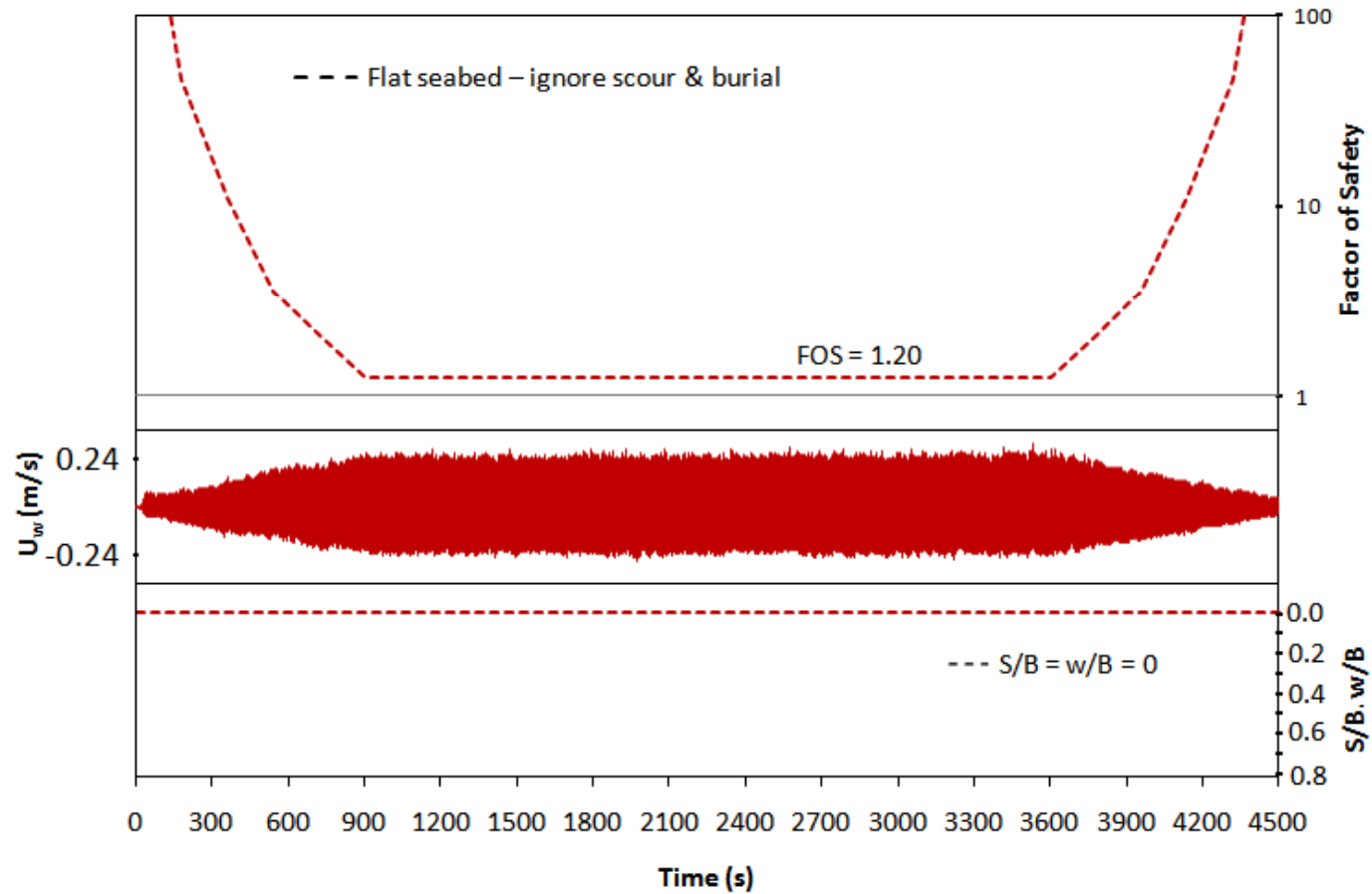
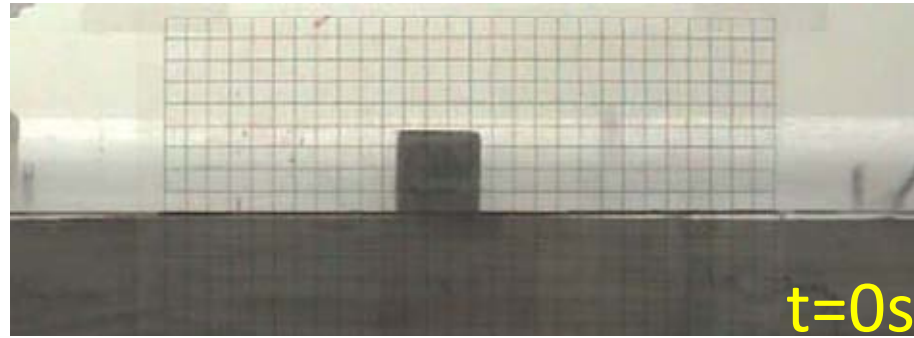
$$Fr = \frac{U_w}{\sqrt{gD}} \quad KC = \frac{U_w T}{B}$$

		MODEL	PROTOTYPE
Wave period	T (s)	3.5	14
Orbital velocity	U_w (m/s)	0.15 - 0.32	0.60 - 1.30
Pipe width	B (m)	0.03, 0.04	0.50-0.66
Pipe specific gravity	SG	1.2	1.5 1.8

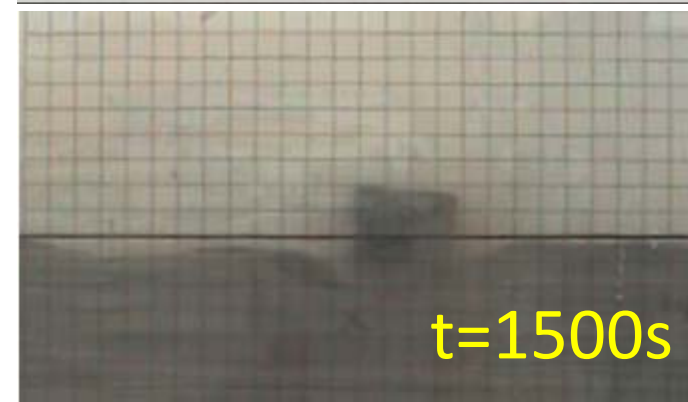
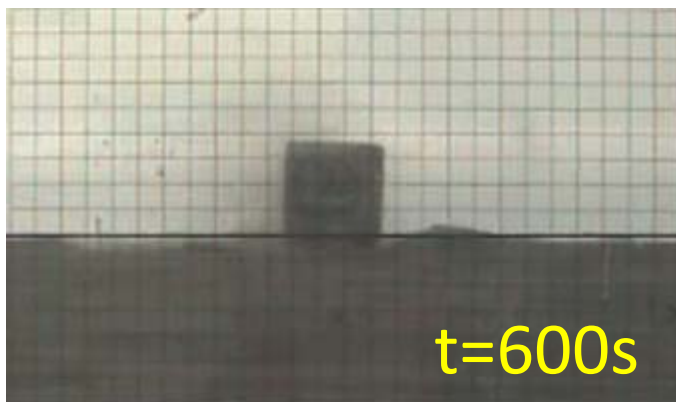
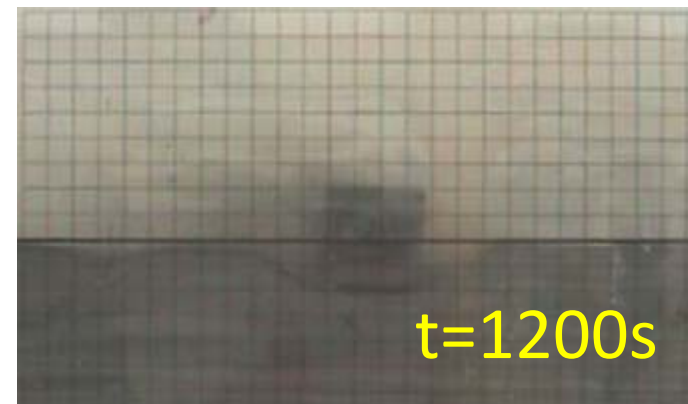
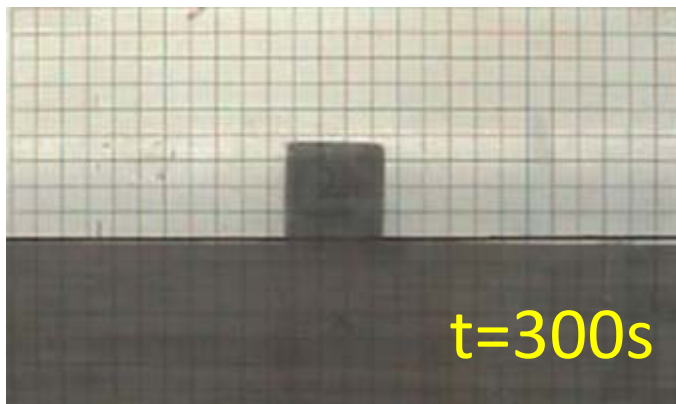
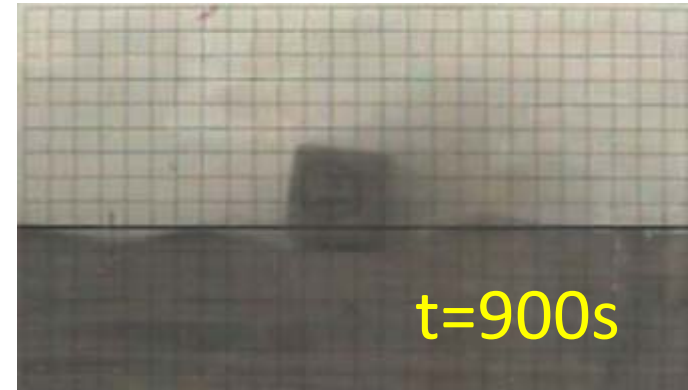
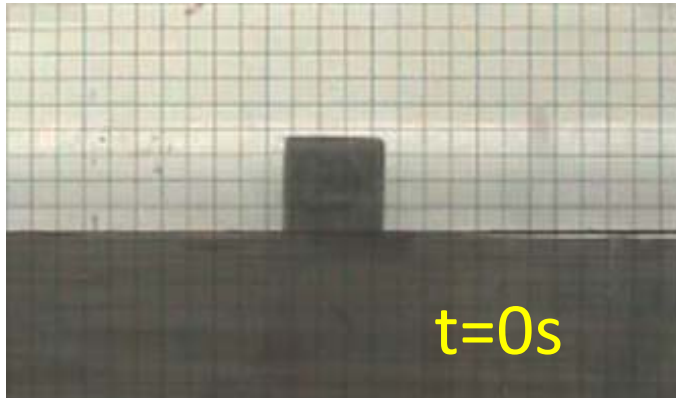
SQUARE “pipeline”?!



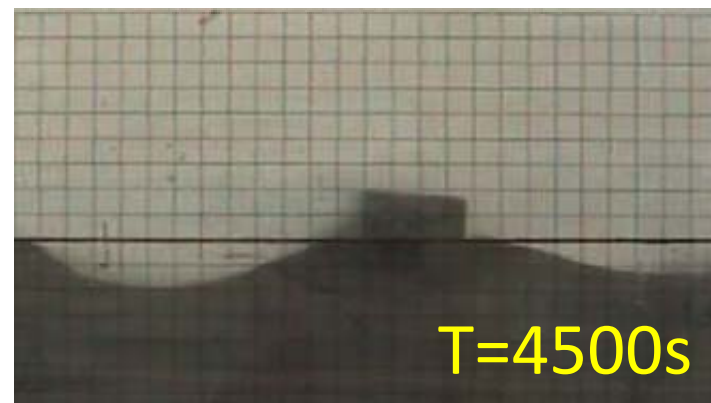
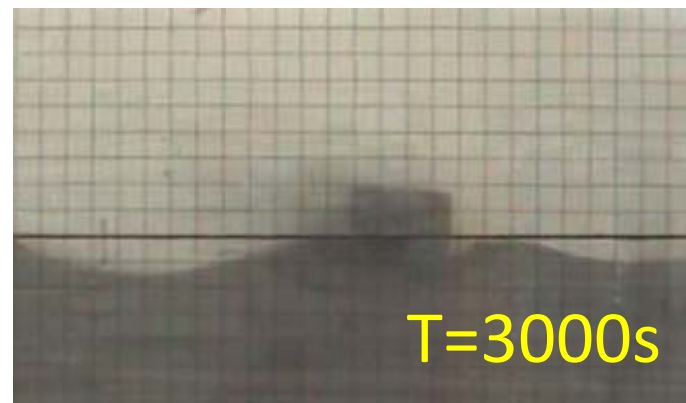
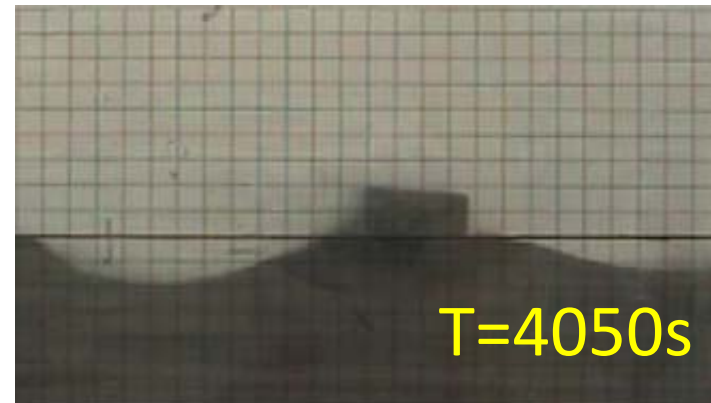
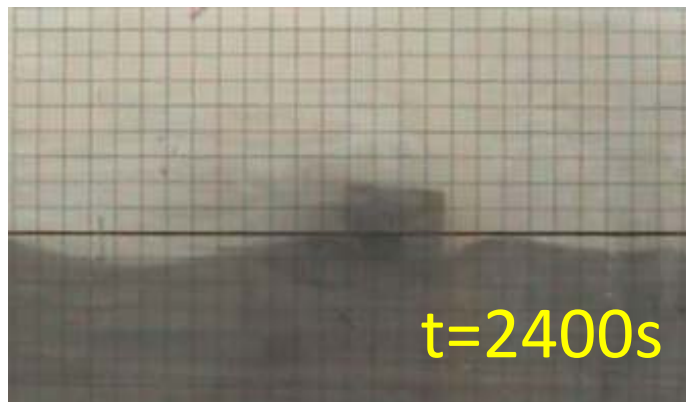
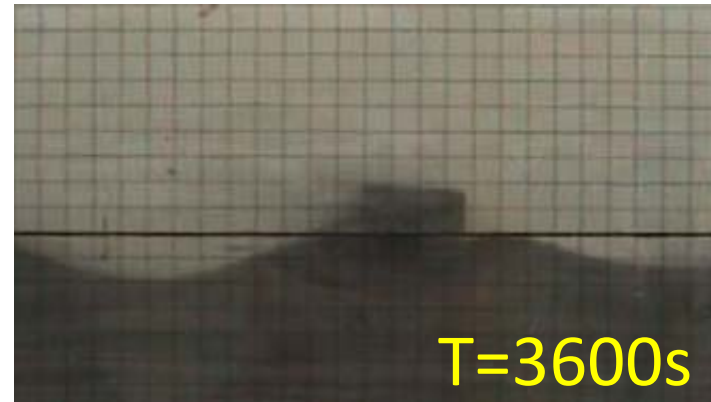
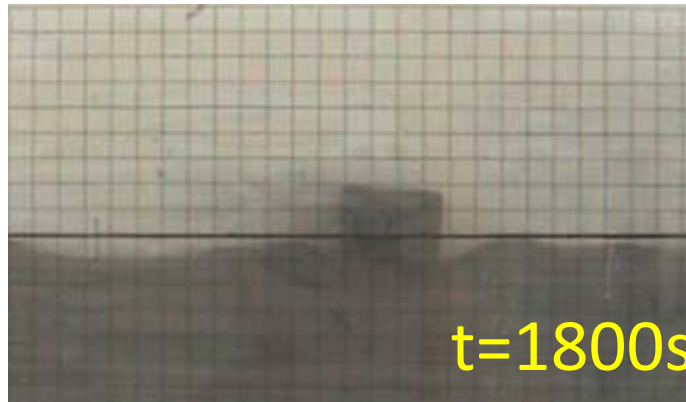
Pipe stability on a stable seabed



What happens?!

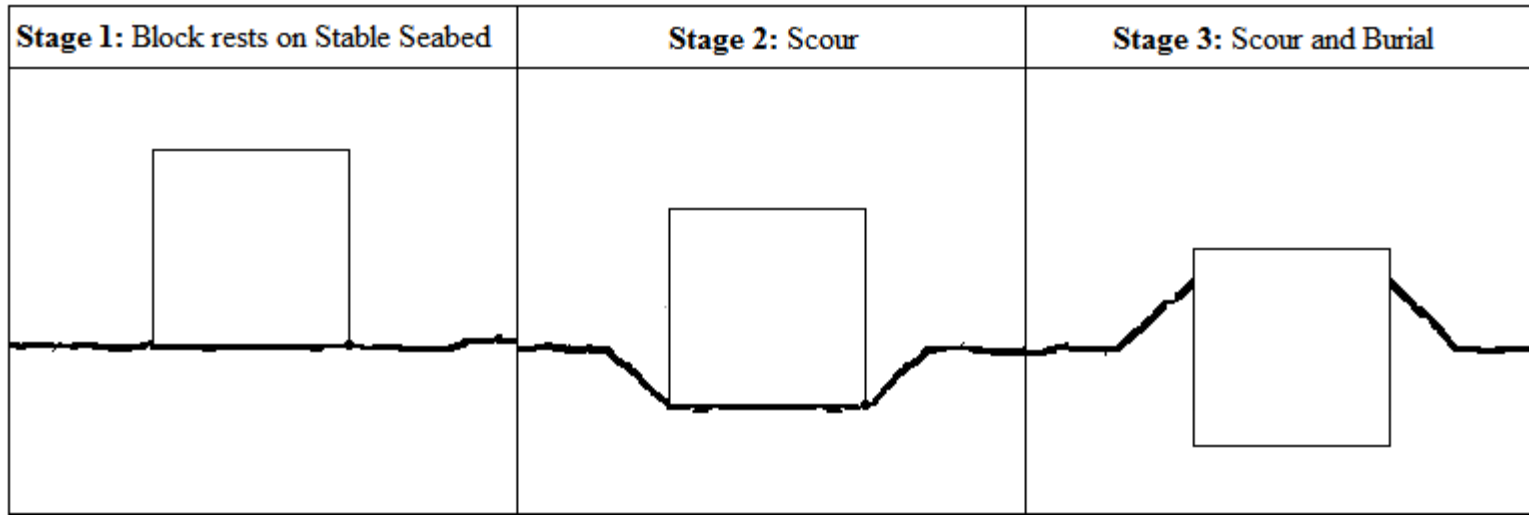


What happens?!





Forces acting on a stable pipe



Numerical model

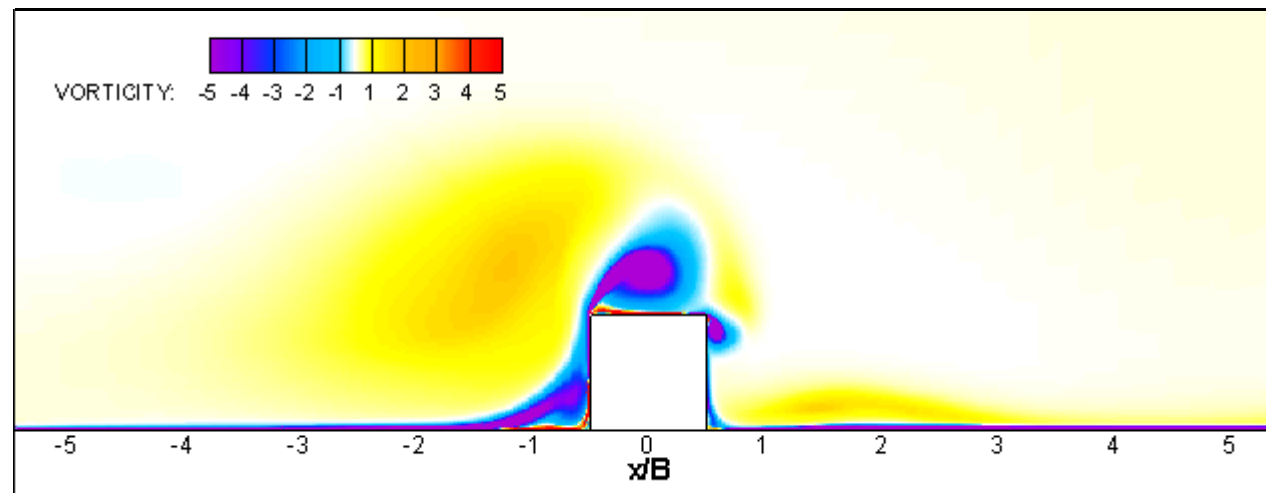
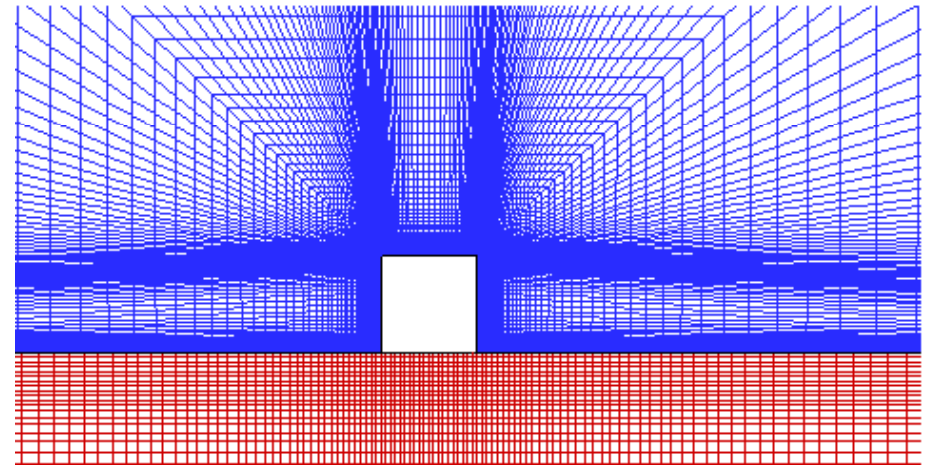


Flow above seabed:

Reynolds-Averaged Navier-Stokes equations

Flow through seabed:

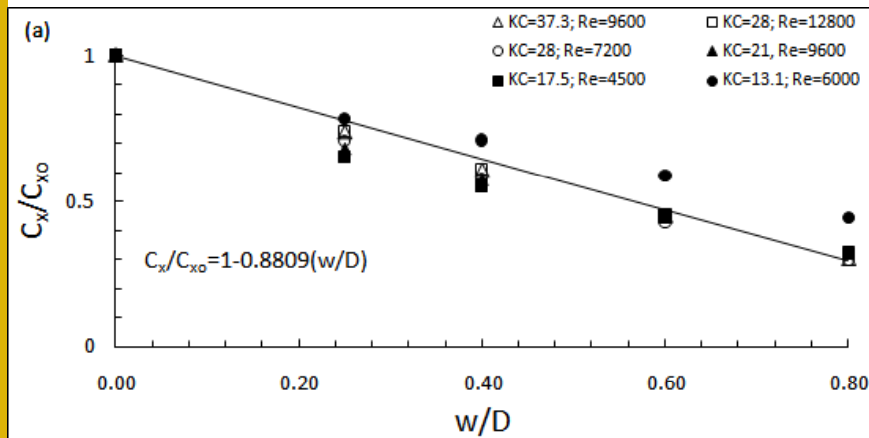
Darcy's law



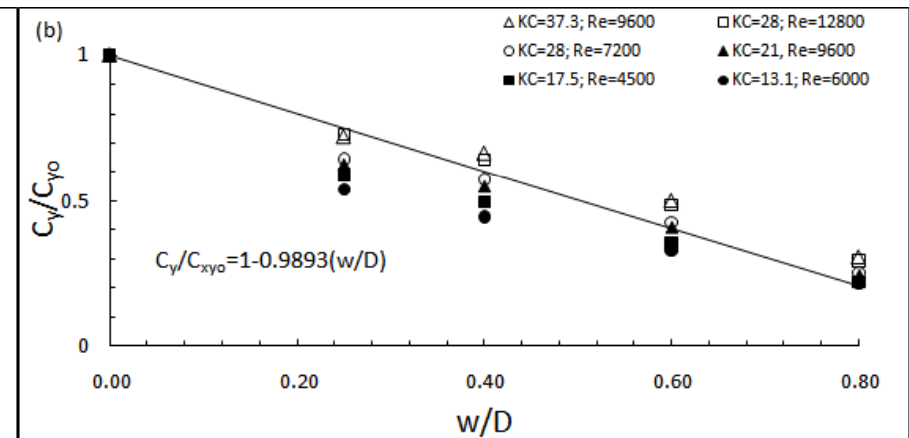
Reduction in hydrodynamic loading



Inline forces

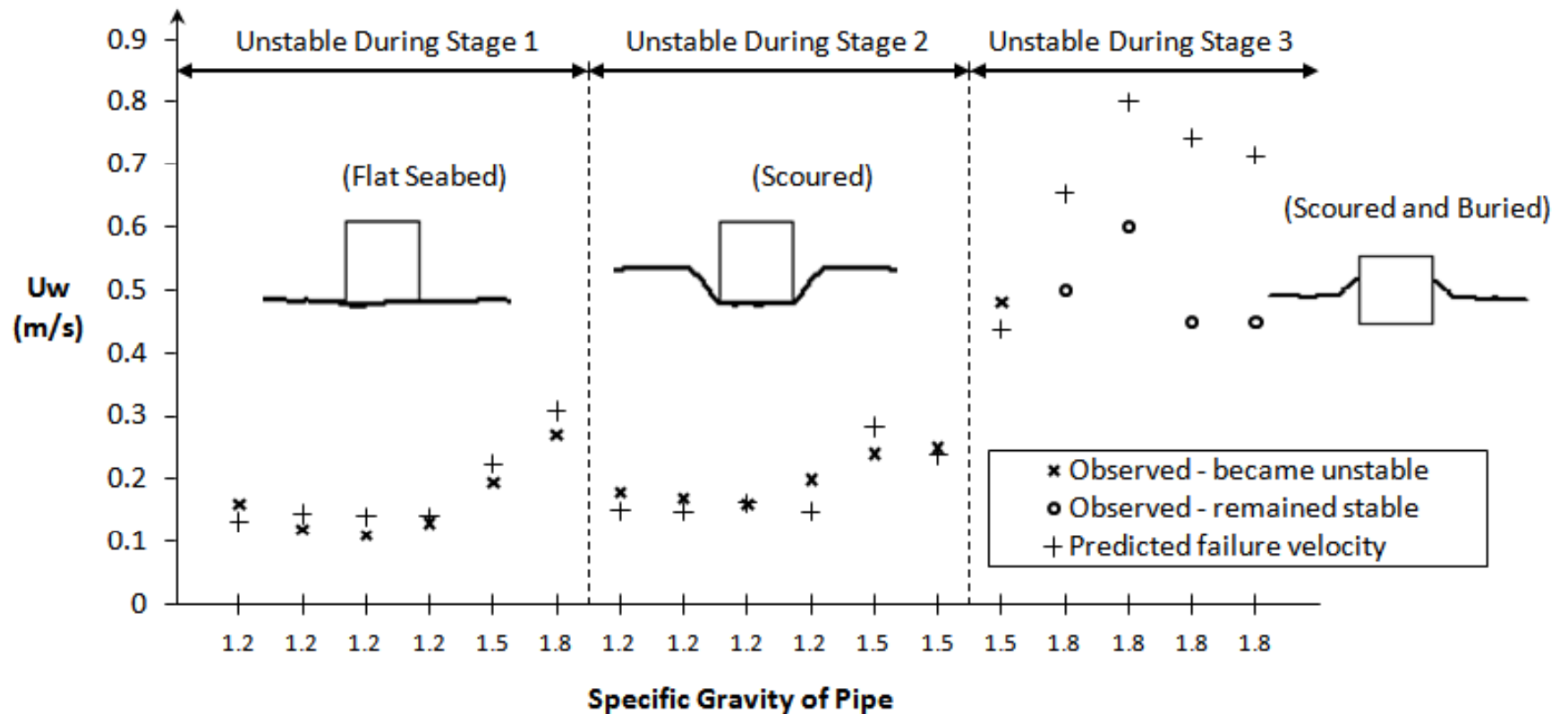


Vertical forces



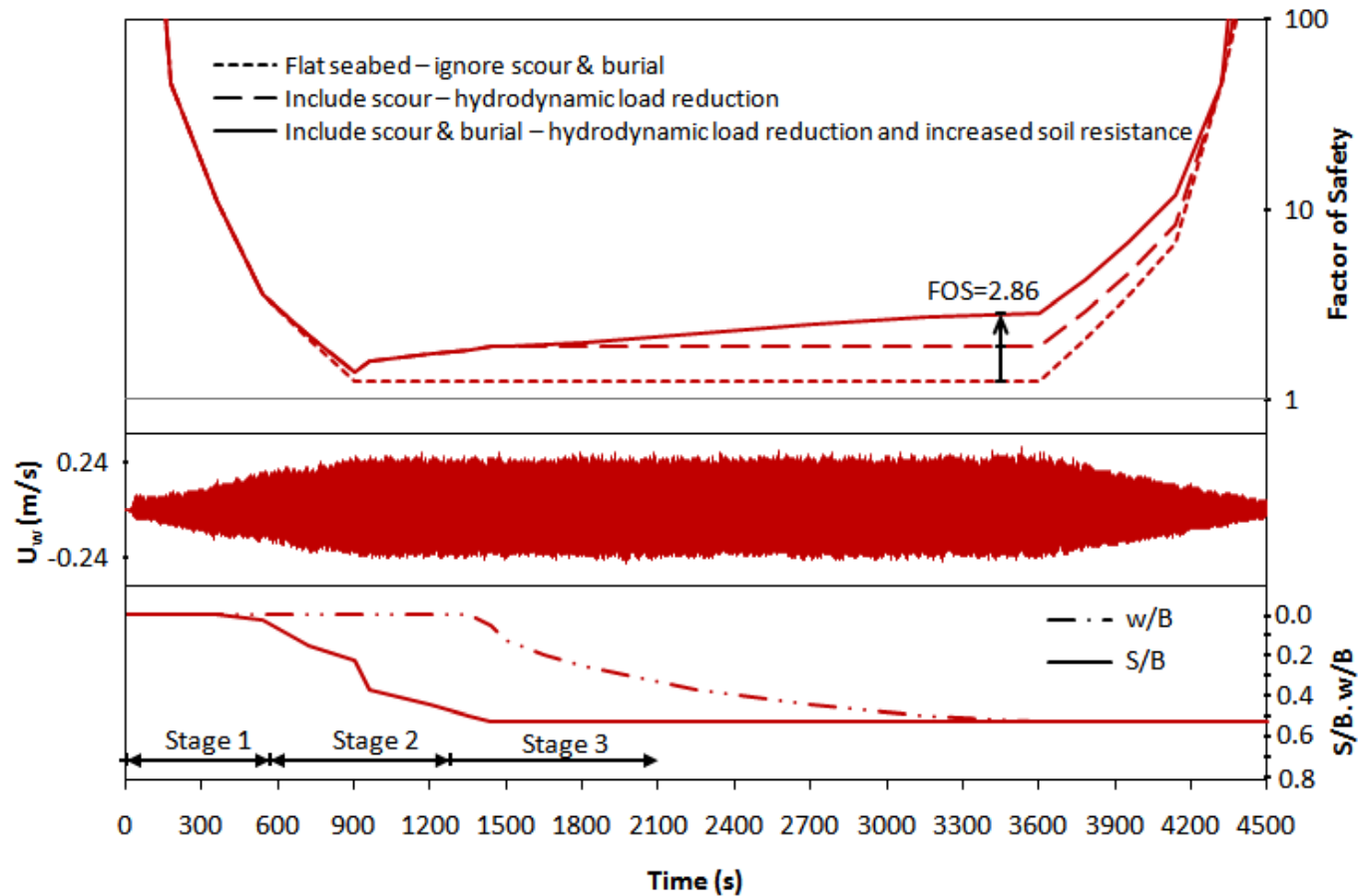
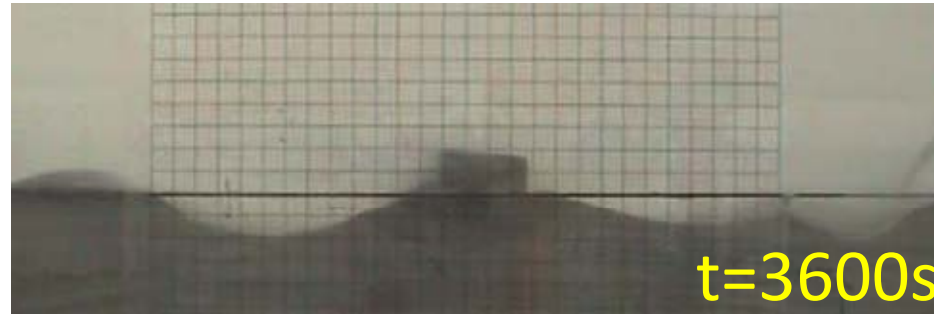


Validation of assumptions

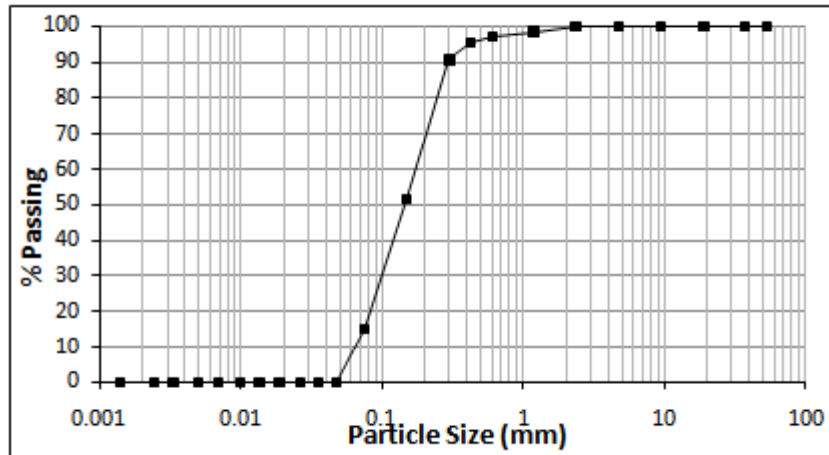




Results – include scour & burial

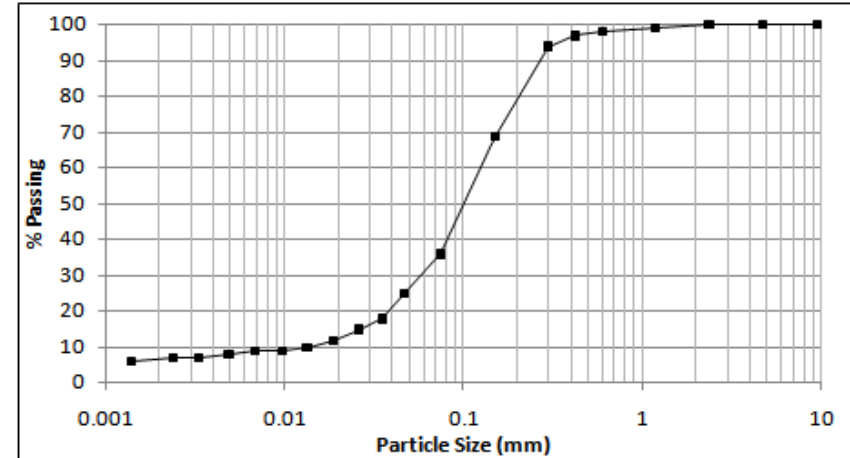


What affects seabed instability?



$d_{50} = 147\mu\text{m}$
 $\% < 75\ \mu\text{m} = 0$

Scour and burial
Backfill comprised LARGE grains



$d_{50} = 107\mu\text{m}$
 $\% < 75\ \mu\text{m} = 36\%$

Almost no scour
No burial

No buildup of pore pressure and therefore no liquefaction



Conclusions

Amount of scour/burial will depend on fines content

The soil did not liquefy – self burial possibly a sediment transport problem, not a geotechnical one

Seabed instability can lead to a significant increase in pipeline stability

Therefore ignoring seabed instability implies conservative (and therefore costly) pipeline stability design

A rational approach would acknowledge seabed instability and allow for reduction in hydrodynamic loads and an increase in soil resistance



Thank you...

..and thanks to my supervisors :

Prof. Dave White
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