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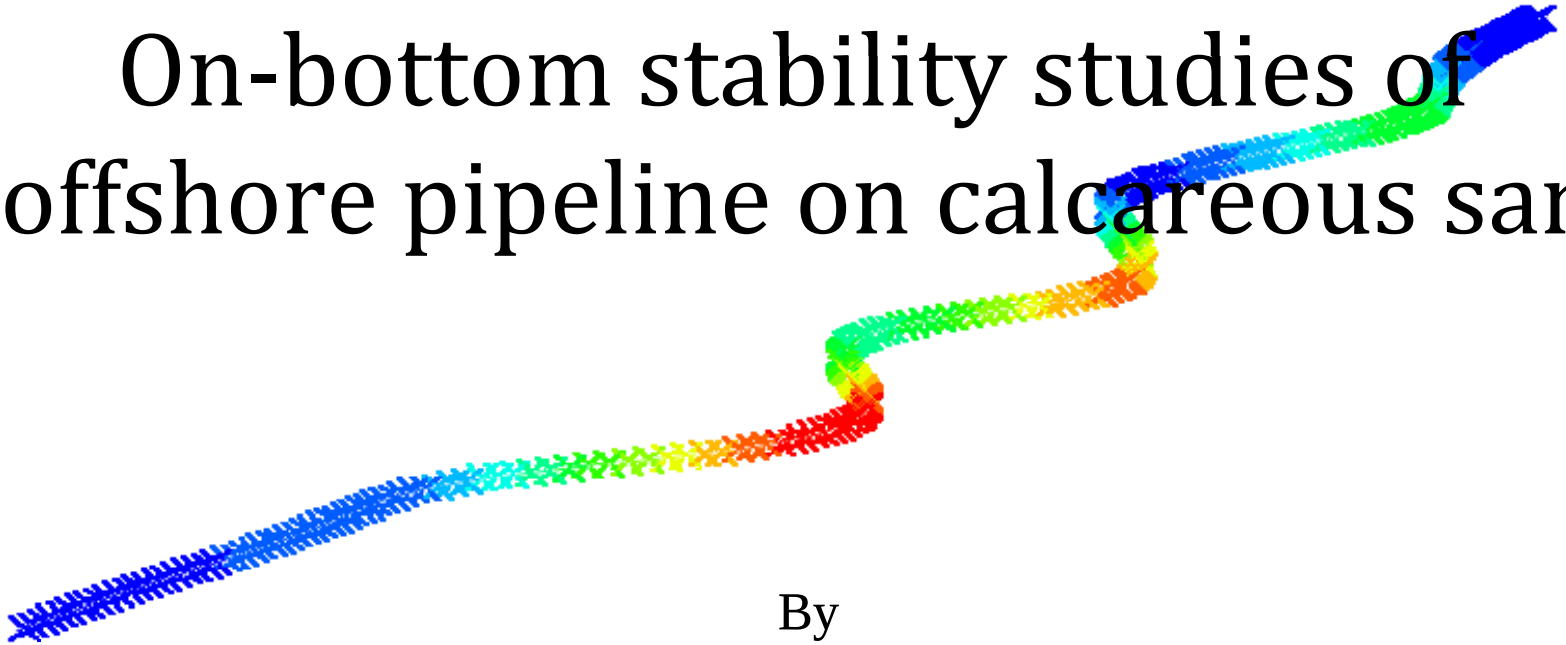
On-bottom stability studies of offshore pipeline on calcareous sand



By

SHIVANANJEGOWDA

Content

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Why stability?

Current Practice

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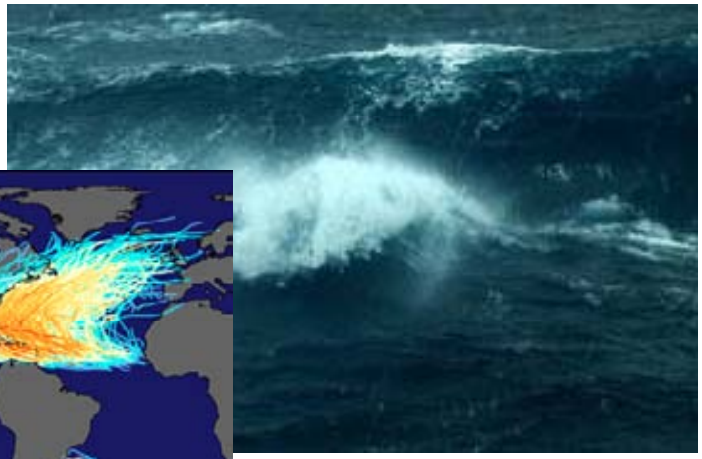
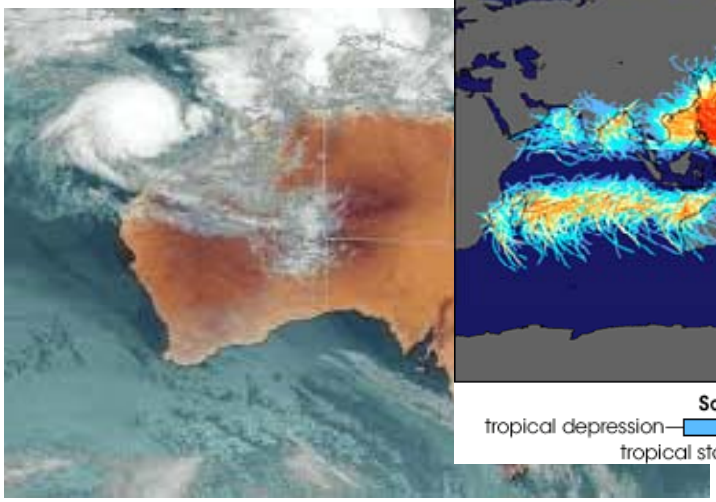
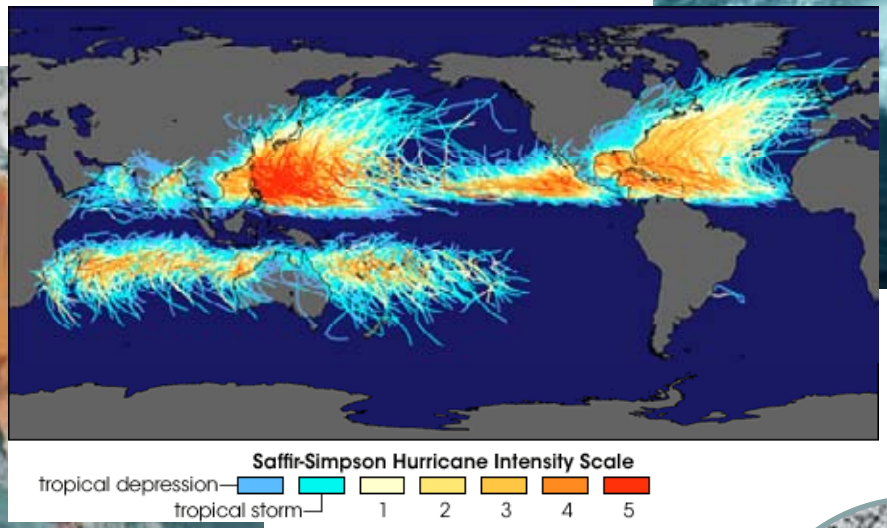
Conclusion

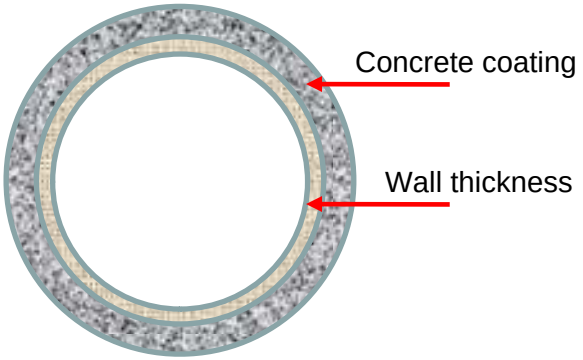
Why Stability?

- Varying sea states





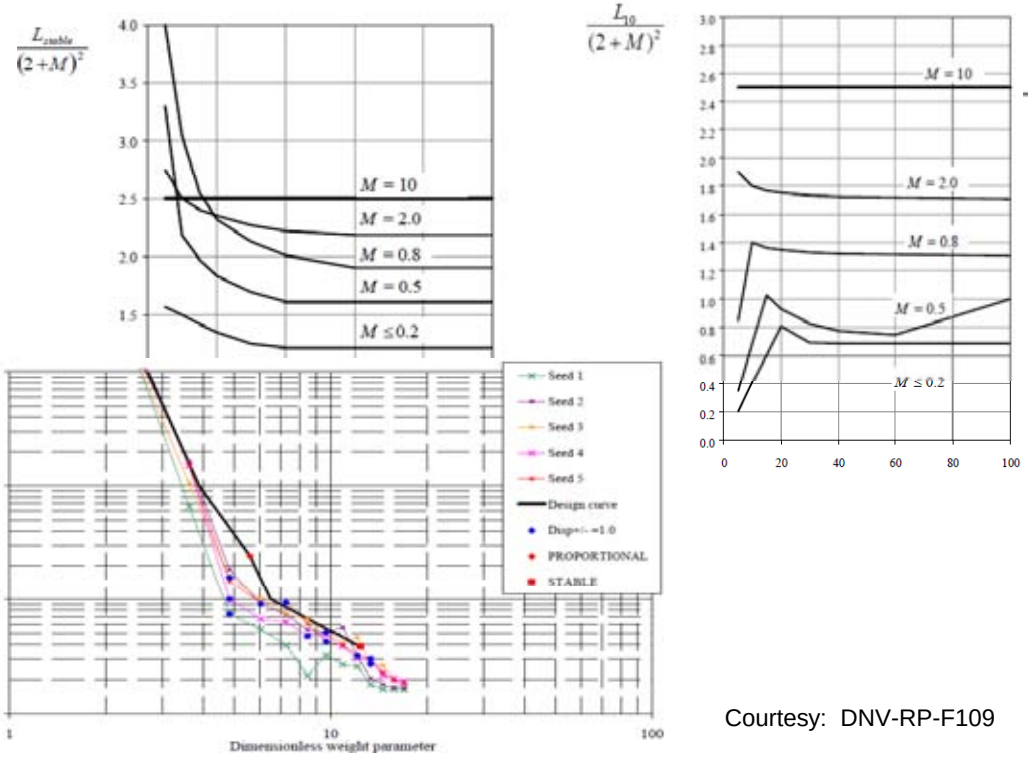




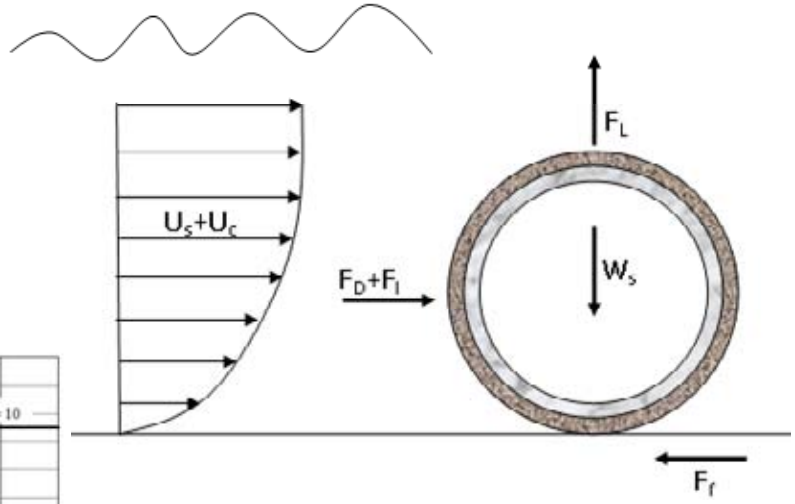
- Varying soil properties

Current Stability method

- Absolute static analyses
- Generalized stability curves
- Dynamic analyses



Courtesy: DNV-RP-F109



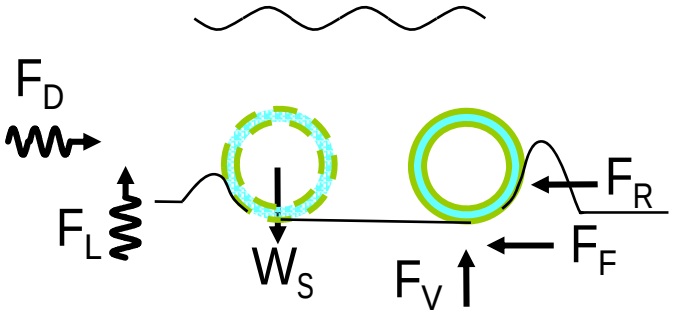
Sliding condition

$F_H=F_D+F_I$

If $F_H > F_f$ Sliding occurs

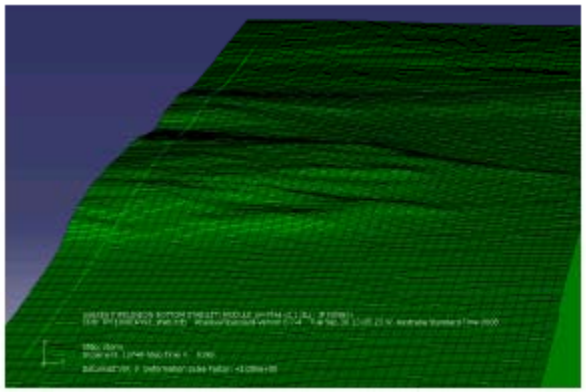
Current Dynamic Practice

- PRCI(AGA) pipeline(2002)
- PONDUS
- SIMSTAB(2009)
  - Empirical model

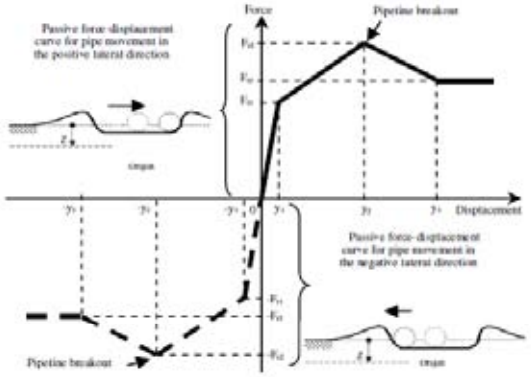


Courtesy: Brennodden&et.al

  - FE approach



courtesy: JP Kenny

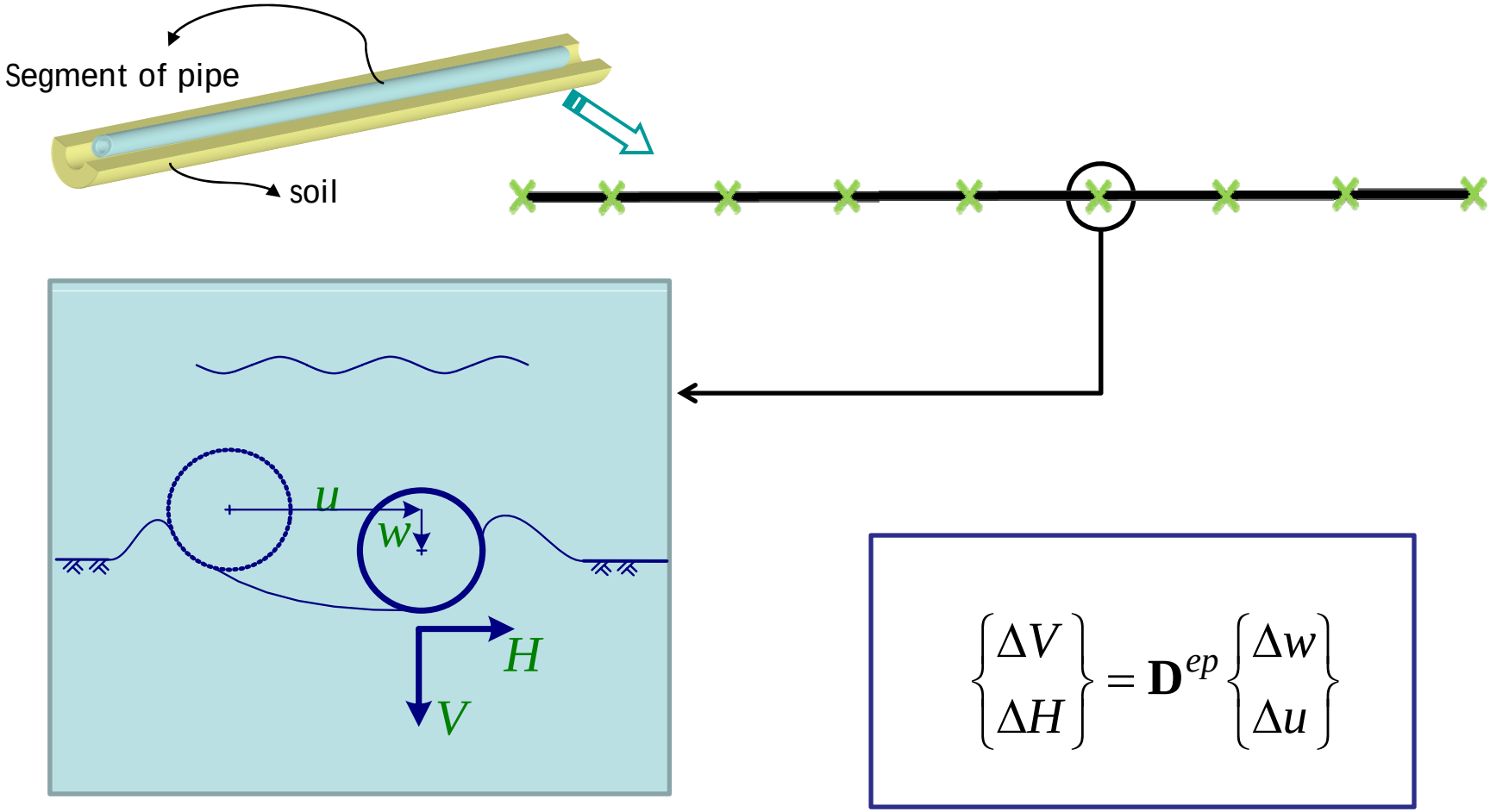


Courtesy: Verley & sotberg, JP Kenny

Better, more reliable and economic design

Time Domain analysis (MacroElement approach)

Methodology



$$\begin{Bmatrix} \Delta V \\ \Delta H \end{Bmatrix} = \mathbf{D}^{ep} \begin{Bmatrix} \Delta w \\ \Delta u \end{Bmatrix}$$

MacroElement Approach

PIPE-SOIL model

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State of art model developed from centrifuge test, *Zhang & Randolph* 2001,*Tian & Cassidy* 2008;

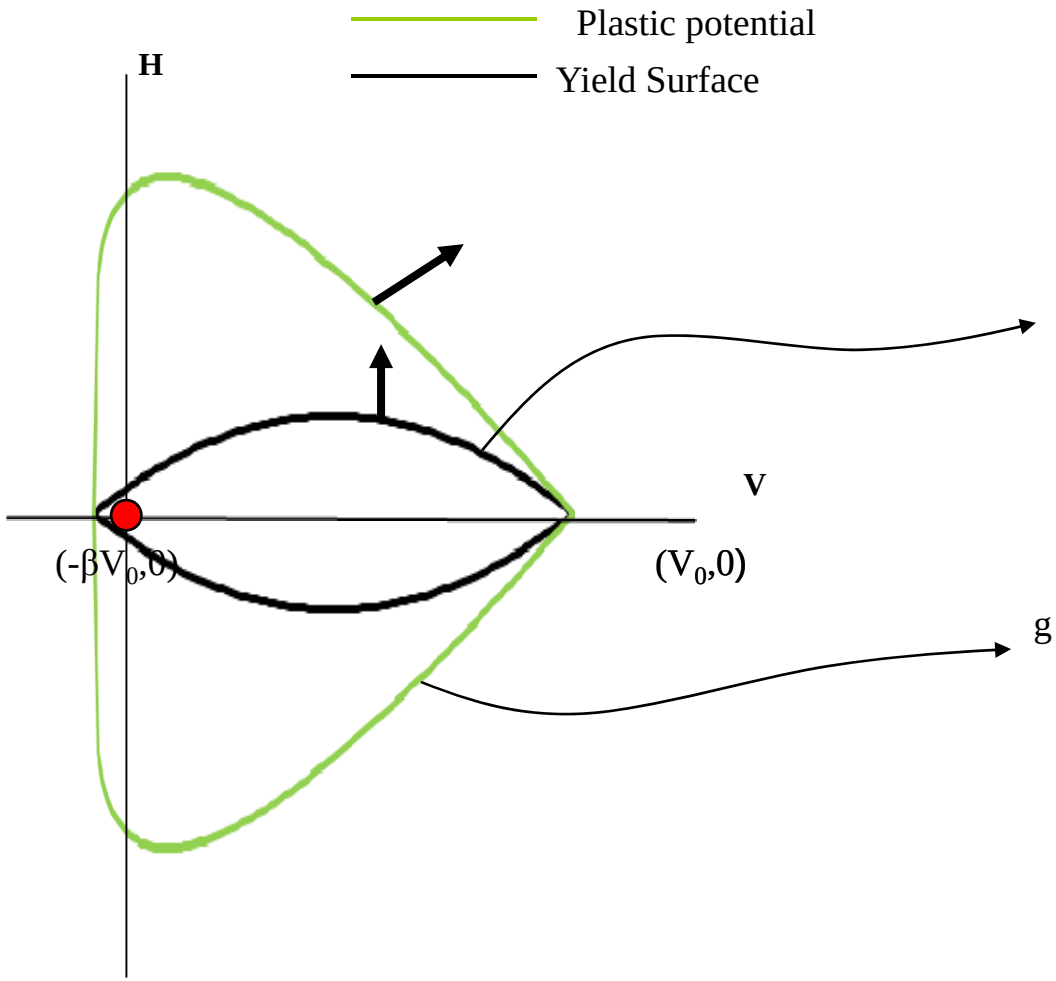
Formulation based on sound plasticity theory

a) Bounding surface

b) Flow rule

c) Hardening law

d) Elastic behaviour



- Bounding surface

$$f = |H| - \mu\left(\frac{V}{V_0} + \beta\right)(V_0 - V) = 0$$

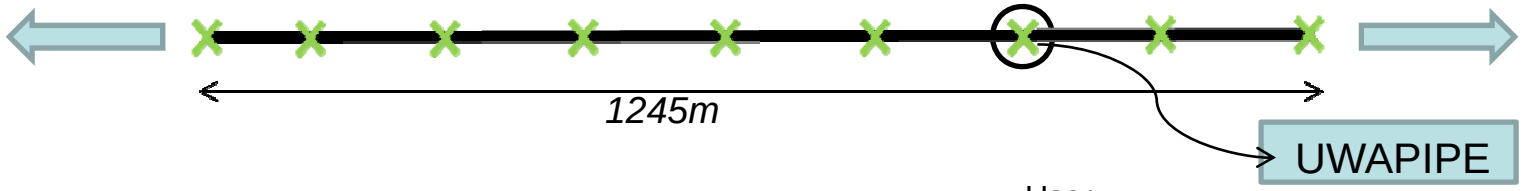
- Flow rule

$$g = |H| - \mu_t\left(\frac{V}{V_0} + \beta\right)^m (V_0 - V) = 0$$

- Hardening Law

$$\Delta V_o = \frac{k_{ve} k_{vp}}{k_{ve} - k_{vp}} \Delta w^p \qquad \mu = \mu_0 + k \frac{w^p}{D}$$

Implementation



UWAPIPE

Pipe –Discretized as beam element

ABAQUS INPUT FILE

User subroutine

Hydrodynamic loads

User subroutine

Pipe-Soil model(UWAPIPE)

Load applied in 2 steps

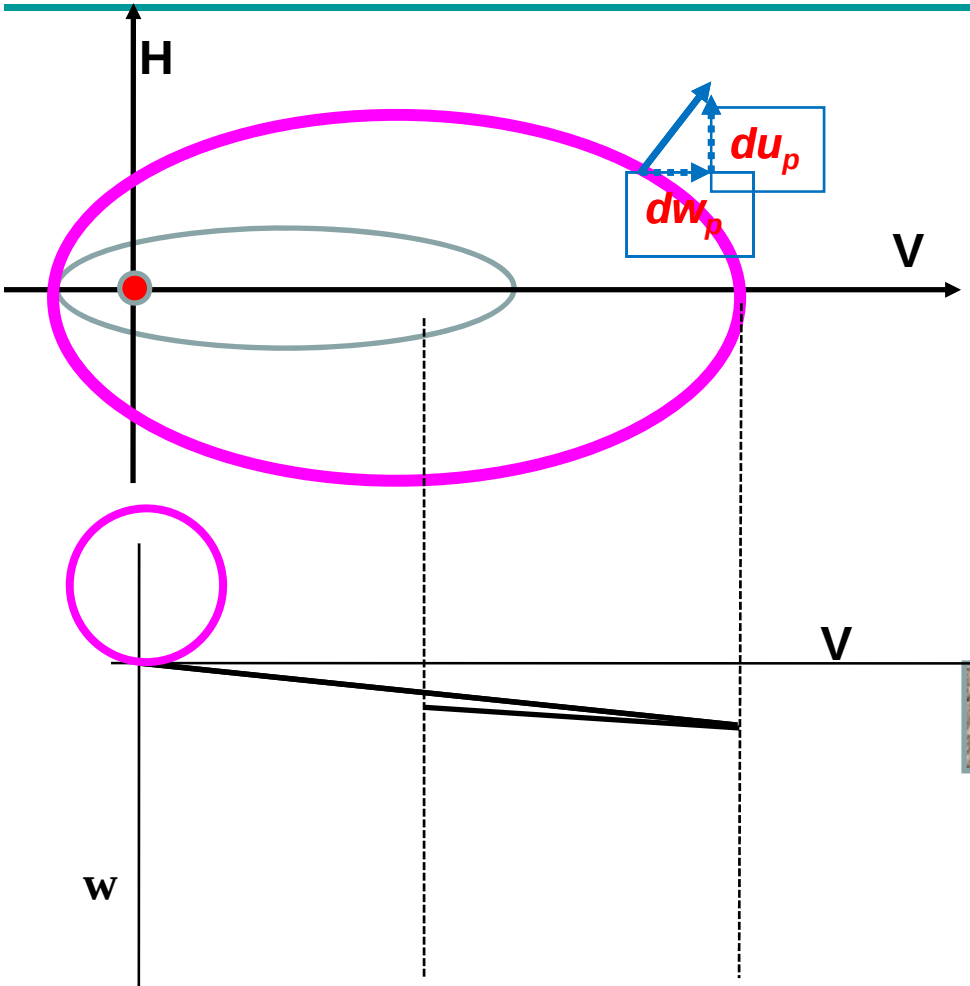
Loads generated for storm duration

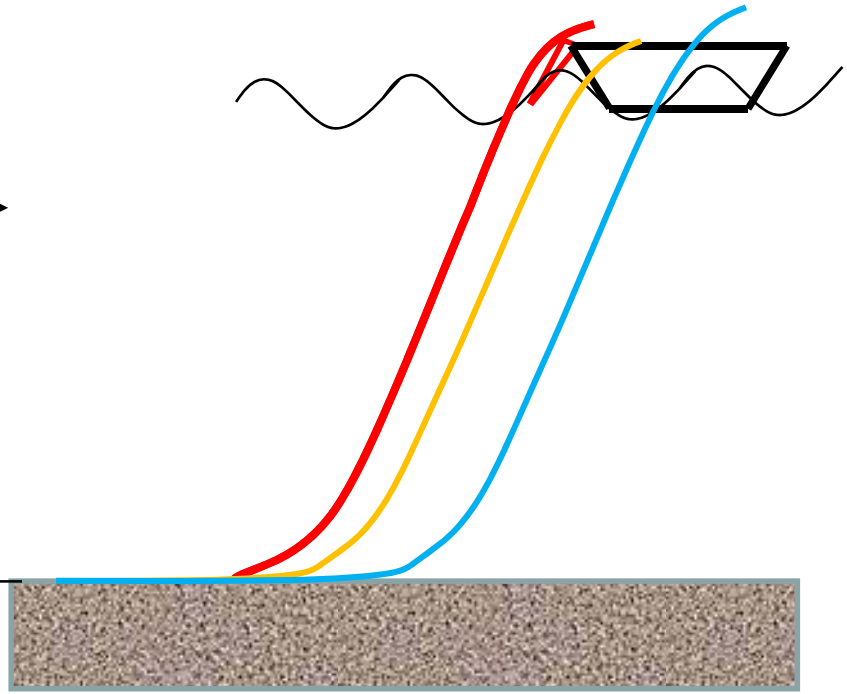
FE Program(ABAQUS)

Structural property
D -1m
t - 0.03m
BeamElem -B31H

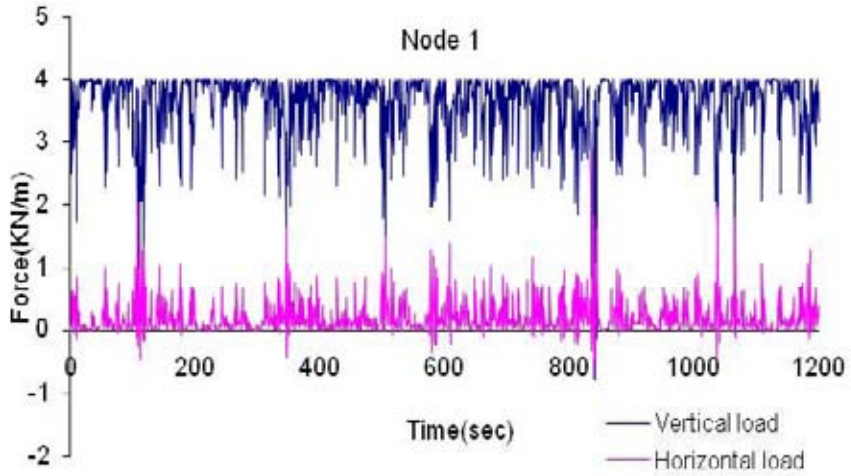
Post processing of data

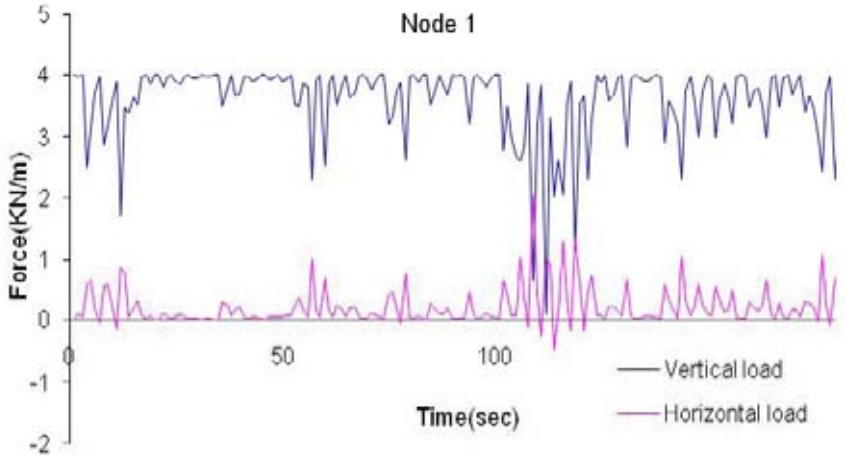
Installation settlement(step1)

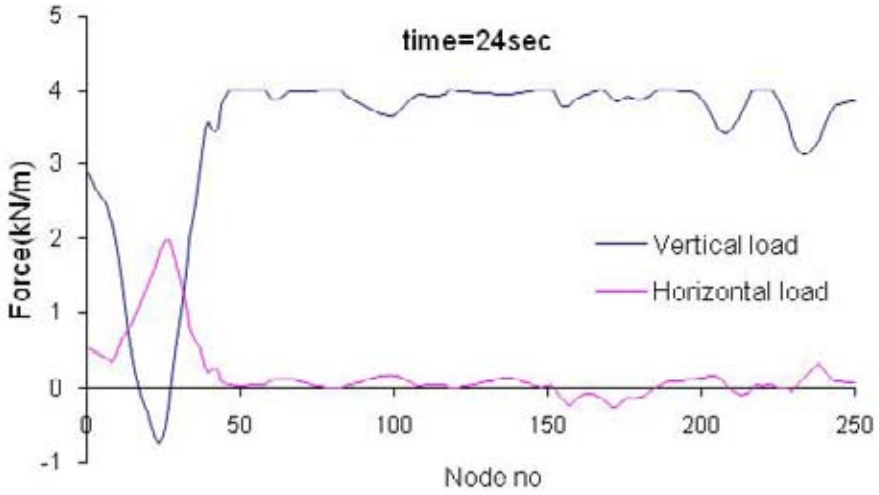


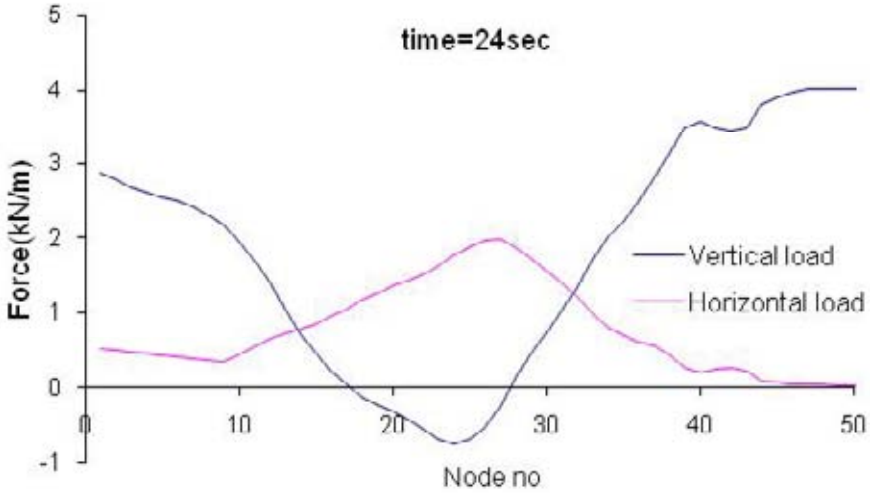


Wave Load(step 2)

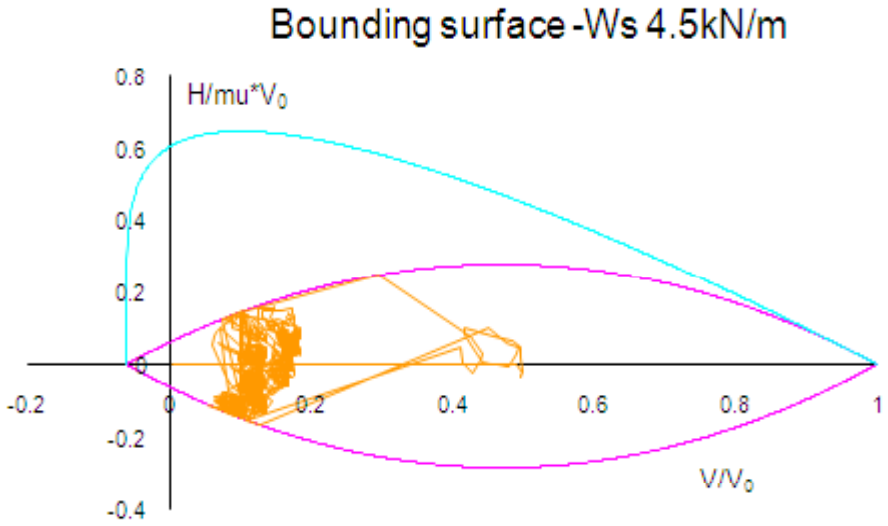


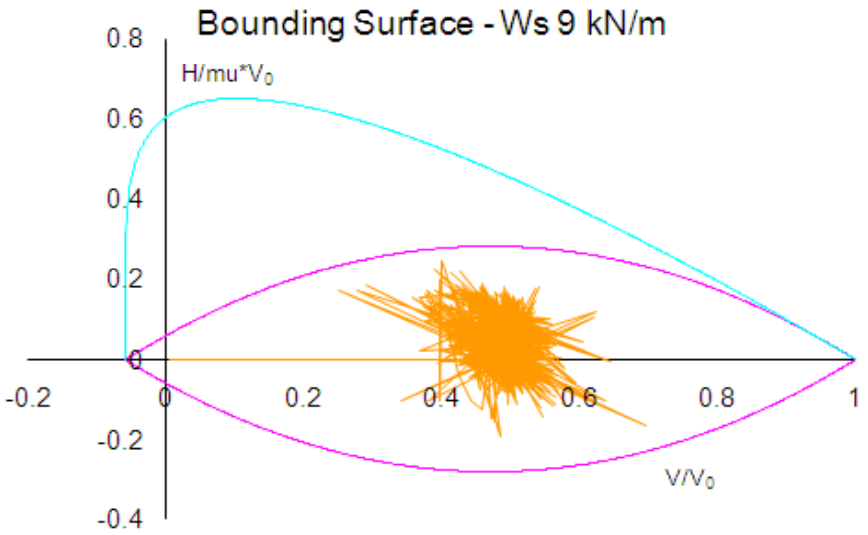






Pipe-Soil reaction

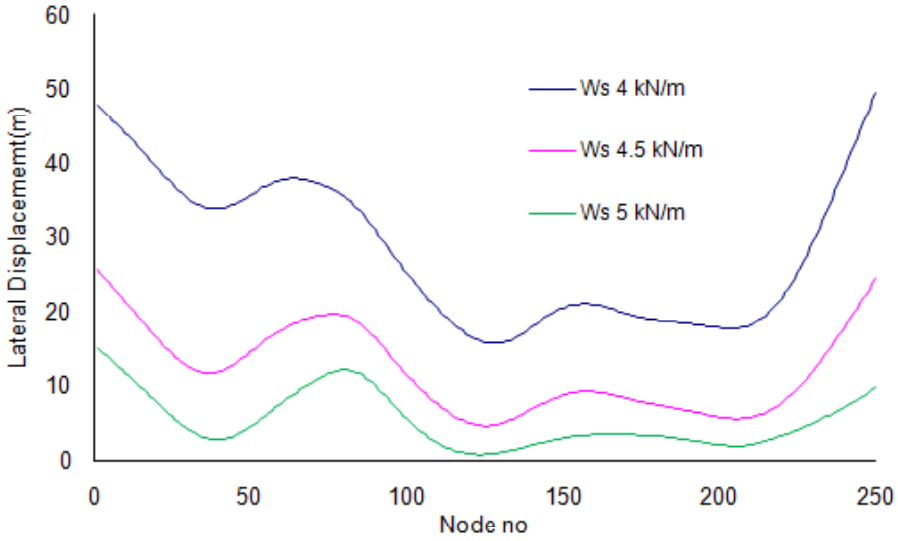


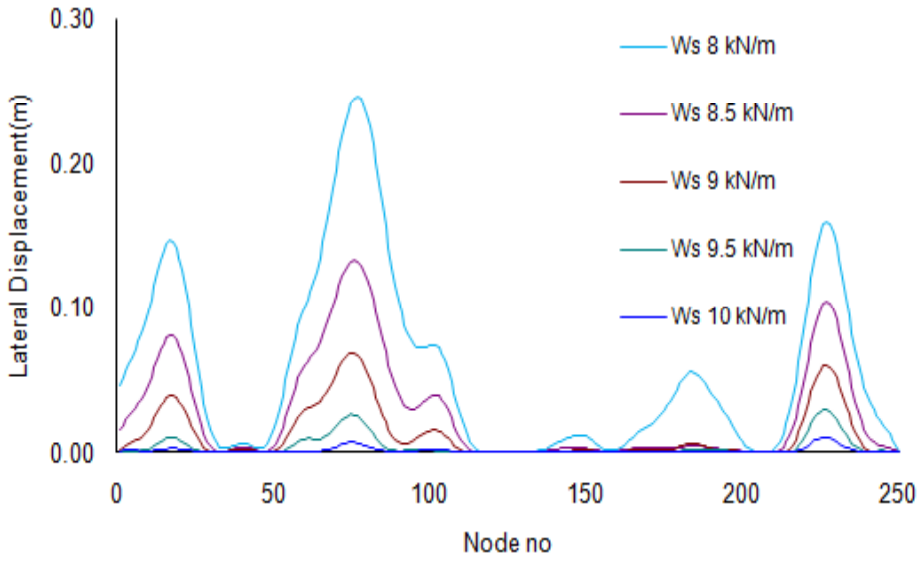


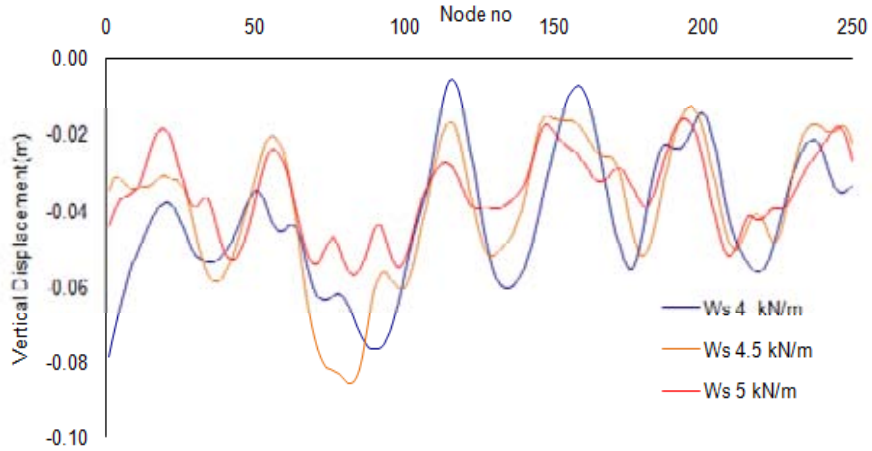
Captures complete pipe-soil reaction in V-H space

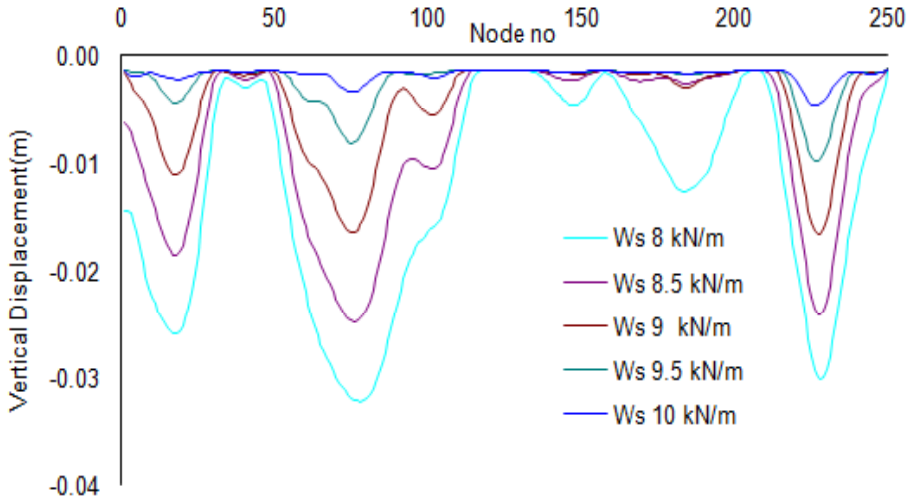
Elasto-plastic response

Displacement

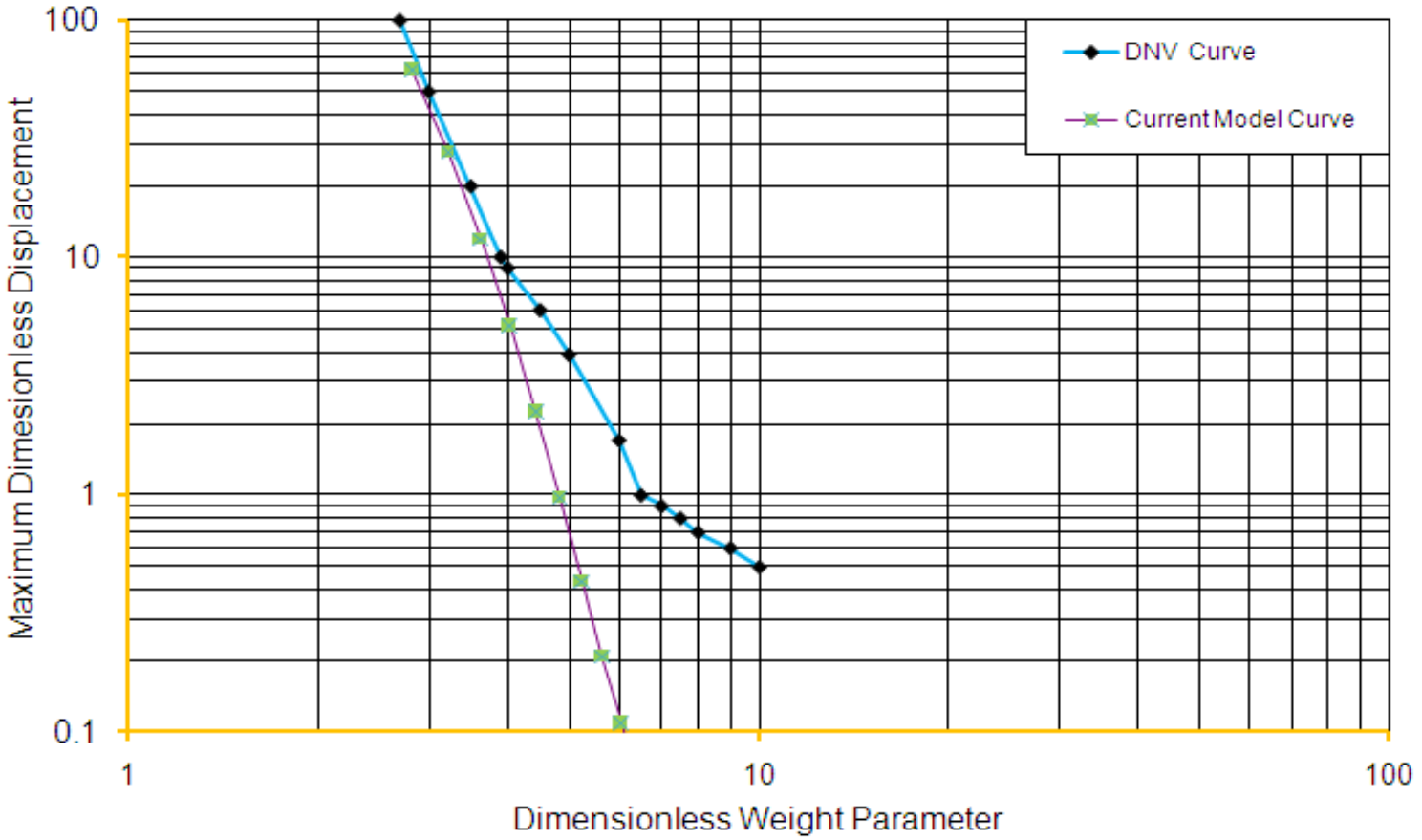








Dynamic Displacement Curve



Computation Example

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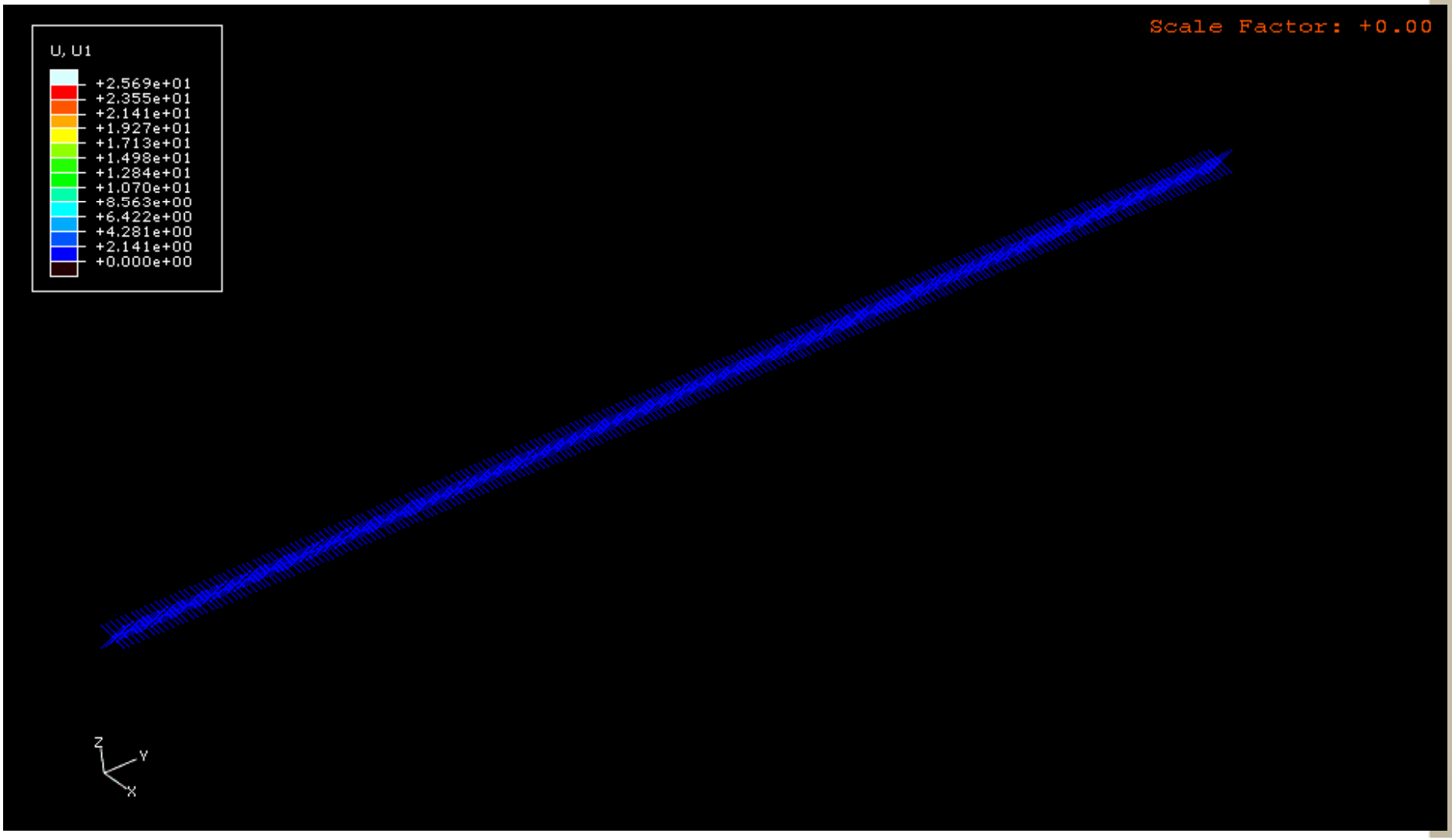
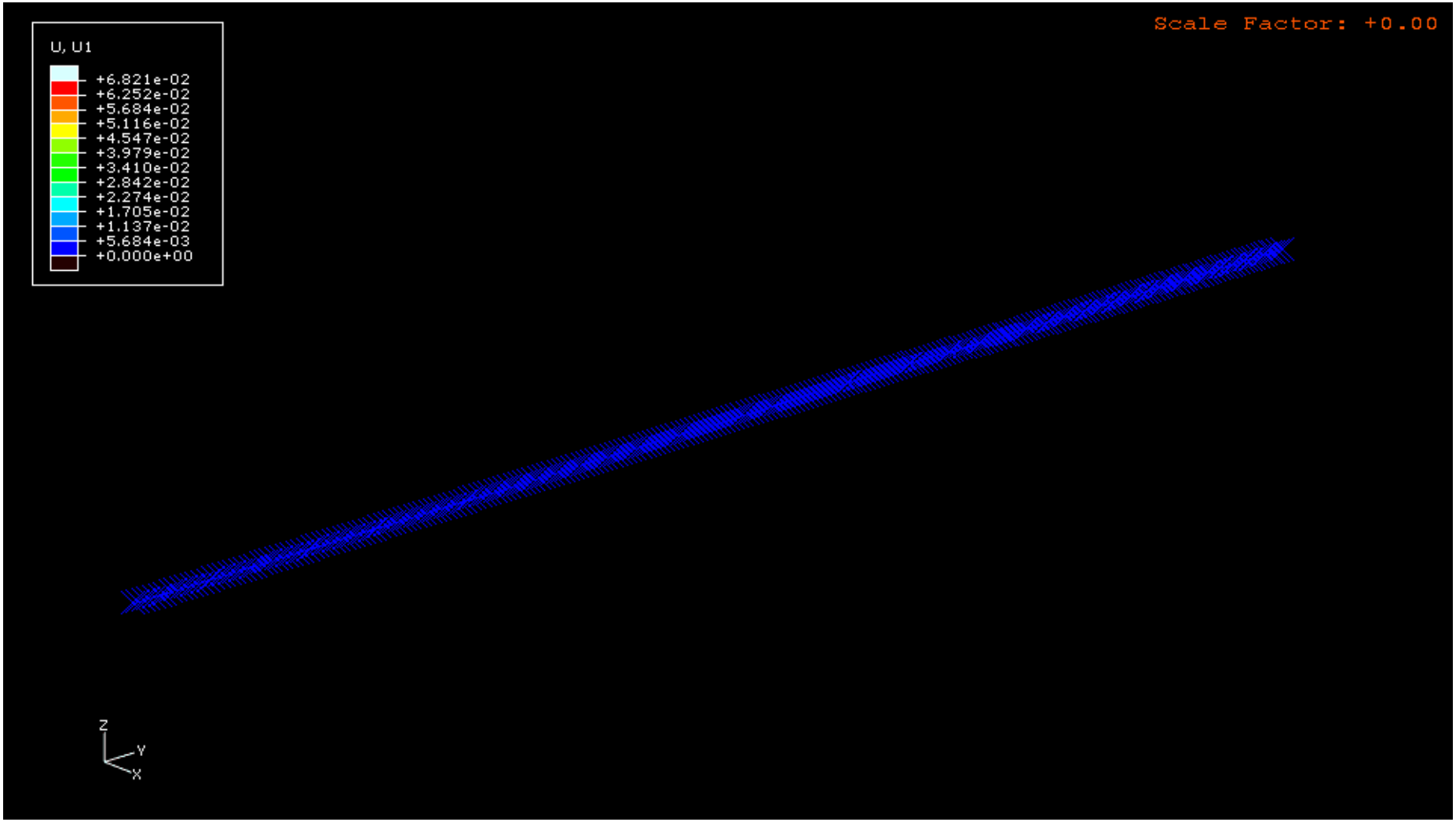
Submerged Weight 4.5kN/m



Submerged Weight 9kN/m



6.Conclusion

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Complete pipeline response under complex hydrodynamic loading is captured

Correct assessment of stability

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Apache Energy Ltd

THANK YOU

ANY QUESTIONS?