VORTEX INDUCED VIBRATIONS

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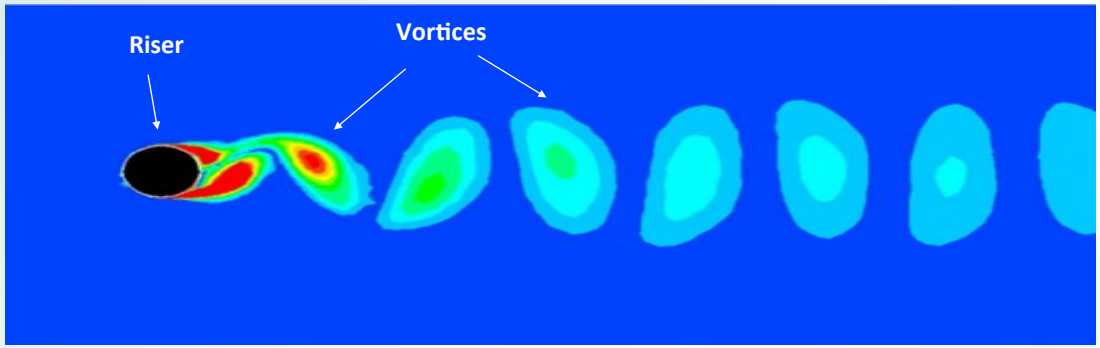
INTRODUCTION

Slender marine structures such as marine cables, pipelines and risers may be set in oscillation by a constant current. The excitation is caused by vortices that are shed alternatingly from either side of the structure hence the name vortex induced vibration (VIV) [1]. Deepwater risers are particularly susceptible to fatigue damage caused by VIVs

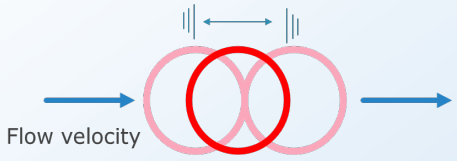


MECHANISM OF VIVS

Vortices (plural of vortex) form in the wake of a fluid flowing around a body, like a cylinder. Vortex shedding occurs when the vortices become detached from the cylinder at high fluid velocities or high Reynolds number. The shedding of these vortices characterizes a turbulent flow and is responsible for VIVs.

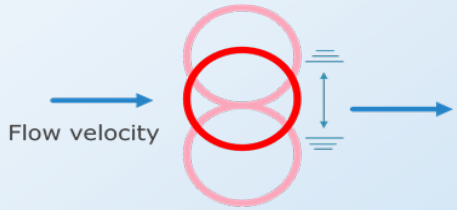
The changing flow patterns cause fluctuating drag and lift force on the riser. These fluctuating loads causes the riser to oscillate. Vortices are shed at a frequency proportional to the velocity of the current flowing past the riser. Large amplitude vibrations occur when the shedding frequency is close or equal to the natural frequency of the riser or cable. There are formulas that can be used to calculate the vortex shedding frequency as well as the natural frequency of the pipe.

FORMS OF VIVS



In-Line VIV

Inline VIVs occur at much slower flow velocities and by implication, vortex shedding frequency, compared to cross-flow VIVs. Also, the riser moves in the same direction (in-line) as flow in this form of VIV.



Cross-Flow VIV

In cross flow VIVs, the riser moves in a direction perpendicular to current flow. Also, cross-flow VIVs occur at much higher flow velocities

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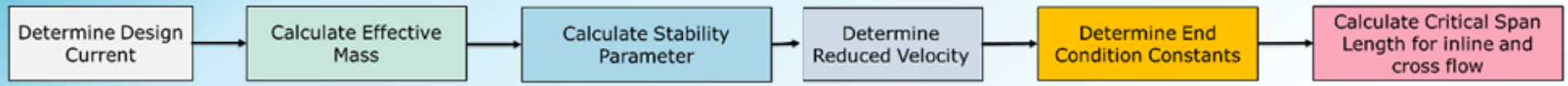
VIV ANALYSIS

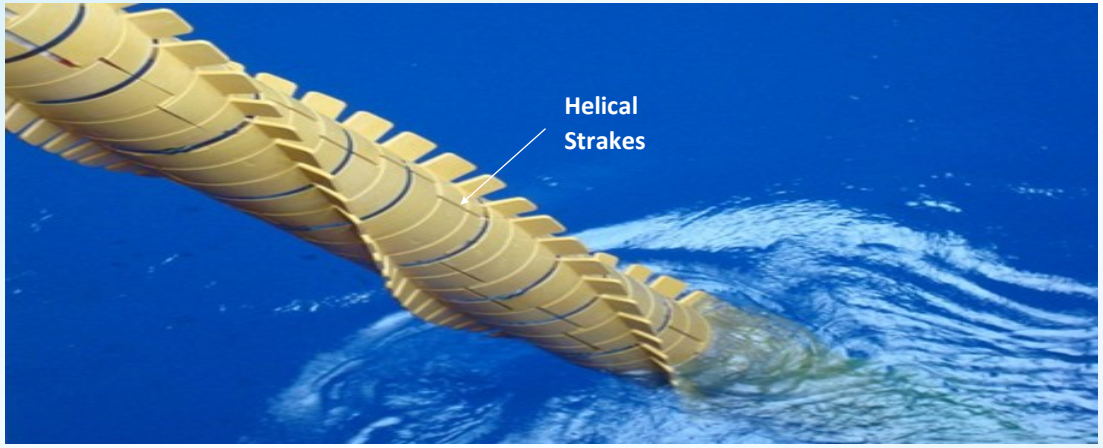


Span analysis design steps for Rigid/Clamped Risers

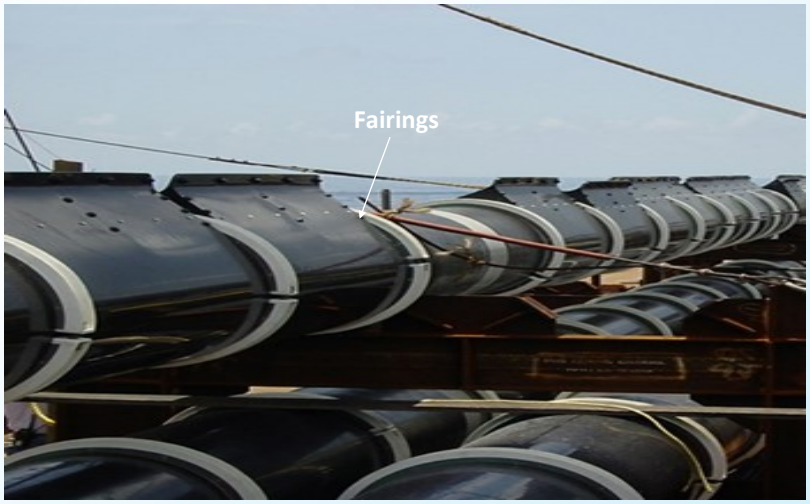
In order to have a safe design, proper VIV analysis is to be carried out. For rigid, clamped risers, a span analysis is carried out. For Steel catenary risers, more advanced numerical techniques are used. Software that may be required to carry out a proper analysis are **Shear 7**, **VIVANA.**

VIV IMPLICATIONS AND MITIGATION

VIV is probably the single most important design issue for steel catenary risers, particularly for high current locations. High frequency vibration of the riser due to vortex shedding leads to high frequency cyclic stresses which can result in high rates of fatigue damage.



However, if the analyses indicate dangerous vibration levels, mitigation measures can be employed that disrupt the formation of vortices around the riser thereby reducing the vibrations caused by vortex shedding. Note that mitigation measures like helical strakes or fairings increases project costs hence they should be used as a last resort.



CODES AND STANDARDS

The following codes and texts may be referenced for VIV calculation guidelines

* DNVGL-RP-C205 – Environmental Conditions and Loads
* DNVGL-RP-F105 – Free Spanning Pipelines
* Subsea Pipeline and Risers
* Offshore Pipelines
* Other relevant technical papers

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