Introduction to VIV and SHEAR7

Prior to undertaking this tutorial, a basic overview of VIV is recommended. Such an overview can be obtained from introductory texts to the subject like:

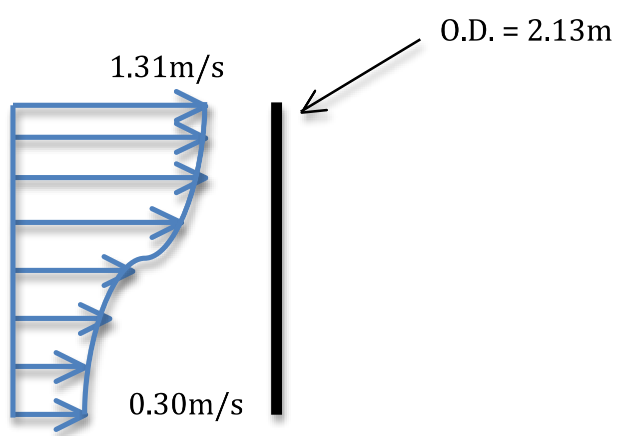
Flow-induced vibration by Blevins, R.D. 1990. Published by: Van Nostrand Reinhold Co., Inc. New York, NY (USA); ISBN: 0-442-20651-8

Note that this tutorial is provided for academic and teaching purposes only.
The tutorial makes use of the on-line free demo version of SHEAR7 at www.shear7.com
Where the logo shear7 appears throughout the tutorial is where the online demo can be run.

This tutorial contains the following parts:

Part i	*Shedding Frequencies, Natural Frequencies & Bandwidths*
Part ii	*Lift curves, Amplitudes of Response & VIV suppression (this is covered in the training course, and not yet provided on-line)*

Part i. Shedding Frequencies, Natural Frequencies & Bandwidths

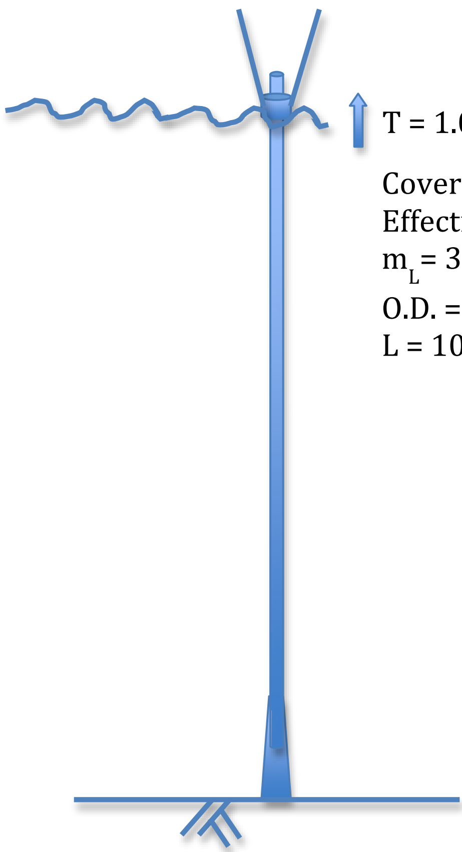


Vortex shedding frequency, f_{shed}, is determined from the following equation:

$$f_{shed} = St.\frac{U}{D}$$

where St is the Strouhal number, which for offshore risers is taken as a constant value of 0.18. *U* is the velocity and *D* is the cylinder diameter. What are the maximum and minimum Shedding (Strouhal) frequencies expected in the above steady state velocity profile?

→ shear7 Go to the online demo version. The default SI units "Drilling Riser with Buoyancy" case has the values already pre-filled out for the above example. Scroll down to the bottom of the demo and click on 'execute'. The results page will show summary graphs of input current and responses. At the bottom of the results page there is a standard Shear7 output file (.out) to scroll through. You also have the option of mailing yourself the .out file or the .plt (plot) file. Scroll down to Section 7 of the .out file on-line and see what are the highest and lowest Strouhal frequencies reported.



T = 1.0E6 N

Covered with buoyancy
Effectively Neutrally Buoyant
m_L = 3415 kg/m [in air plus contents]
O.D. = 2.136 m
L = 1000 m

The above figure shows a Top Tensioned Riser (TTR). For such long tensioned structures the dynamic behavior can be represented through simple tensioned string theory.
The speed of lateral wave propagation, *c*, in a string with tension T, and mass per unit length m_L is given by:

$$c = \text{sqrt}\,(T / m_L)$$

The first natural frequency (Mode 1) is the time taken for a travelling wave to make a return trip along the string.

Time = Dist / Vel
= 2L / c
= 2L /sqrt(T/m_L)

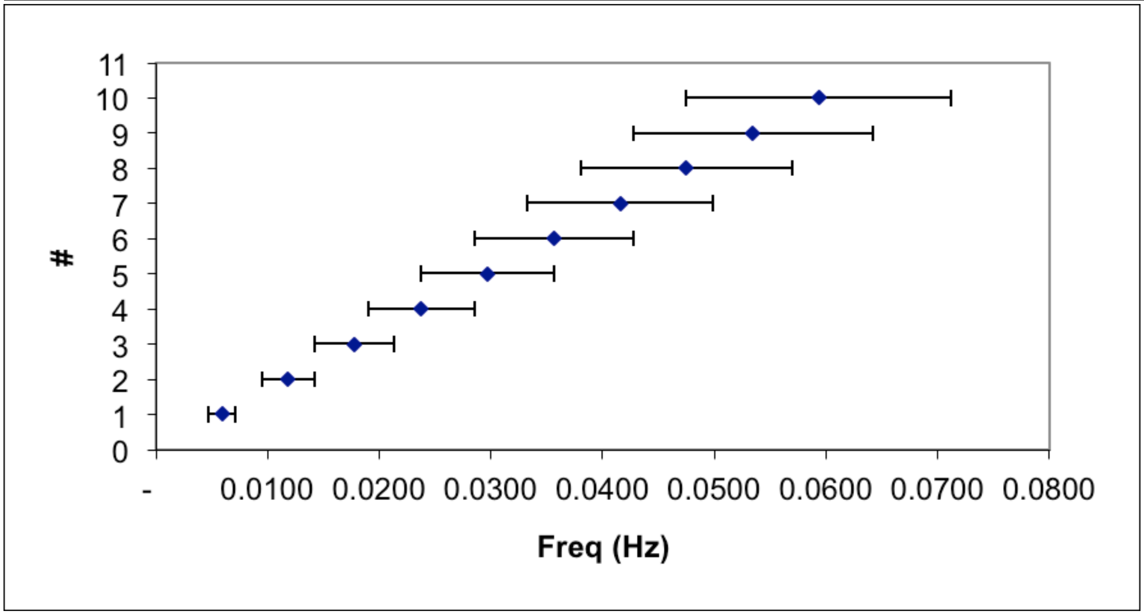
Freq = 1 / Period
= (1/2L)*sqrt(T/m_L)

In the case of a submerged riser, the mass per unit length is the inertial mass per unit length of the riser, which is given as:
m_L = m_{a+c} mass per unit length in air with contents + added mass per unit length

A reasonable approximation is to take an added mass coefficient of Ca = 1.0
So that:
Added mass per unit length = rho(water)*OD^2*PI/4*Ca
A simple approximation then becomes:
f_n=(n/2L)*sqrt(T/(m_{a+c}+rho(water)*D^2*PI/4*Ca)

	Nat. Freq Hz
f1	0.0059
f2	0.0119
f3	0.0178
f4	0.0238
f5	0.0297
f6	0.0357
f7	0.0416
f8	0.0475
f9	0.0535
f10	0.0594

Construct the natural frequencies for the above riser given the simplified formula above.
A demo is provided below.



The natural frequency and the shedding frequency both have the ability to vary such that they can 'lock-in' together. In water the natural frequency varies through a changing added mass.
An approximation is that 'lock-in' can occur in a uniform flow condition within a bandwidth of +/-20% of the central natural frequency.
The plot above has thus been provided with +/-20% error bars to show regions of lock-in.
Once above Mode 3, there is continual overlap such that there are always modes available to be locked-in.

→ Load the default SI units "Drilling Riser with Buoyancy" demo version on-line and change the following:
Length = 1000m
Inertia (inertia(m**4)) = 0.0001 (this makes the effect of EI, or bending stiffness insignificant)
Submerged Weight (sbmg wt(N/m))= 0.0
Scroll through the .out file and see at the bottom of the table of modes under Section 2.2 , how many potentially excited modes are there? This is a function of the number of modes available and the range of excitation frequencies available from the current.

→ Revise the previous run and make it uniform flow conditions by changing the current profile under Block 3 to 0.065 m/s for each entry.
Now how many potentially excited modes are there (under section 2.2 of the .out file)? Also check under sections 5., 6., & 7. in the .out file which shows a summary of the excitation frequencies, taking into account bandwidths and the natural frequency .