A Numerical Investigation of TBA.....!!!1

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Contents

Chapter 1

Governing parameters of fluid-elastic galloping

1.1 Introduction

This chapter contains the formulation of non dimensional governing parameters namely, the combined mass-stiffness Π_1 and the combined mass-damping Π_2 and the results and discussion demonstrating the influence of them. These parameters are formulated by obtaining the relevant time-scales of the system followed by non-dimesnionlising the governing QSS oscillator equation.

A comparison of Quasi-steady state data presented using the classical VIV parameters and the newly formulated Π_1 and $\Pi_2$is presented and it is concluded that $\Pi_2$provides a better collapse for velocity amplitude and mean power compared the classical reduced velocity (U^*) particularly because unlike U^*, Π_2 does not include a frequency component in it. This is followed by the presentation of QSS data and discussion on the influence of Π_1 and Π_2 on power, which concludes that the power transfer is a primary function of Π_2 and a weak function of Π_1.

Following this, a comparison of the QSS data with Direct Numerical Simulations (DNS) is presented. This reveals that the power transfer of the DNS data is strongly influenced by both Π_1 and Π_2. Further analysis reveals that there is a good agreement between QSS and DNS for velocity and power at substantially high $\Pi_1\dot{\mathrm{A}}$s Π_1 decreases, the deviation (between QSS simulations and DNS) increases. Power spectral analysis of the DNS data shows a significant response at the vortex shedding at low Π_1. The relative strength was found out to be an inverse function of Π_1, which provides a clear explanation for the deviation between QSS simulations and DNS data at low Π_1. This is primarily due to the influence of vortex shedding where this effect is not accounted in the QSS model.

1.2 Formulation of the non-dimensionalised parameters Π_1 and Π_2

The natural time scales of the system could be obtained by linearising the quasi-steady equation of motion. (Eq: ****KJ: equation of motion *****) and finding the eigenvalues. The non-linear terms of the forcing function are truncated and the equation of motion could be expressed as,

$$m\ddot{y}+c\dot{y}+ky=\frac{1}{2}\rho U^2\mathcal{A}a_1\left(\frac{\dot{y}}{U}\right), \tag{1.1}$$

After combining the $\dot{y}$ terms and solving for eigenvalues the following solutions for the eigenvalues could be obtained.

$$\lambda_{1,2}=-\frac{1}{2}\frac{c-\frac{1}{2}\rho U\mathcal{A}a_1}{m}\pm\frac{1}{2}\sqrt{\left[\frac{c-\frac{1}{2}\rho U\mathcal{A}a_1}{(m)}\right]^2-4\frac{k}{m}}. \tag{1.2}$$

Galloping essentially occurs at low frequencies therefore it can be assumed that the spring is relevantly weak and therefore, $k\to 0$. Hence a single non-zero eigenvalue remains which is,

$$\lambda=-\frac{c-\frac{1}{2}\rho U\mathcal{A}a_1}{m}. \tag{1.3}$$

Further, if it is assumed that the mechanical damping is weaker than the fluid dynamic forces on the body the non zero eigenvalue could be further simplified to,

$$\lambda=\frac{\frac{1}{2}\rho U\mathcal{A}a_1}{m}. \tag{1.4}$$

In this representation λ represents the inverse time scale of the motion of the body due to the effect of long-time fluid dynamic forces (or forced due to the induced velocity). This term could also be re-written and λ could be expressed as

$$\lambda = \frac{a_1}{m^*}\frac{U}{D} \tag{1.5}$$

This form clearly shows the significant parameters that influences the inverse time scale. $\partial C_Y/\partial \alpha$