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# Experimental Investigation of Vortex-Induced Vibration in Two-Dimensions

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## ABSTRACT

Measurements are made of vortex-induced vibration of an elastically supported circular cylinder in water with reduced velocity ($U/f_nD$) from 2 to 12, damping factors from 0.2% to 20% of critical damping, mass ratios ($m/\rho D^2$) from 2.8 to 17, and transverse, inline, and combined inline and transverse motions with up to 1.49 diameters amplitude. Effects of mass ratio, damping, and strakes are investigated.

## INTRODUCTION

It is well known that vortices are periodically shed by a cylinder in a cross flow. Vortex shedding induces vibration of elastic cylinders and cylinder motion affects the shedding process. Ten reviews of vortex-induced forces and vortex-induced vibration are Gabbai and Benaroya (2005), Williamson and Govardhan (2004), Norberg (2003), Sarpkaya (1979, 2004), Khalak and Williamson (1999), Griffin and Hall (1991), Blevins (1990), Bearman (1984), King (1977), and Leinhard (1966). Recent experimental papers include Jeon and Gharib (2004), Flemming and Williamson (2005), Dahl, Hover, and Triantafyllou (2006), Laneville (2006), Klamo (2006), Dipankar, Sengupta and Talla, (2007), Carberry and Sheridan (2007), Prasanth and Mittal (2008).

A test program of vortex-induced vibration of elastically supported circular cylinders was made with reduced velocity ($U/f_nD$) from 2 to 12, damping factors from 0.2 to 20%, mass ratios from 2.8 to 17 and transverse, inline, and combined inline and transverse motion.

## DESCRIPTION OF TESTS

Tests were conducted on an aluminum cylinder with 2.5 inch (6.35 cm) outside diameter in the stratified flow channel at the Scripps Institution of Oceanography. Its surface was sanded with 220 grit sand paper to give a average roughness of approximately 30 micro inch (Ra) roughness, $k/D$ = 10 x$10^{-5}$. The cylinder pierces the water surface and extends 44.3 inch (1.125 m) into the flow, ending 2 mm (0.08 inch) above the channel bottom. The relatively long 17.8 diameter span in water minimizes the influence of surface effects on the results (Chaplin and Subbiah, 1998, p. 254). The Reynolds number is 75,000 at 1.25 m/s (4.1 ft/s).

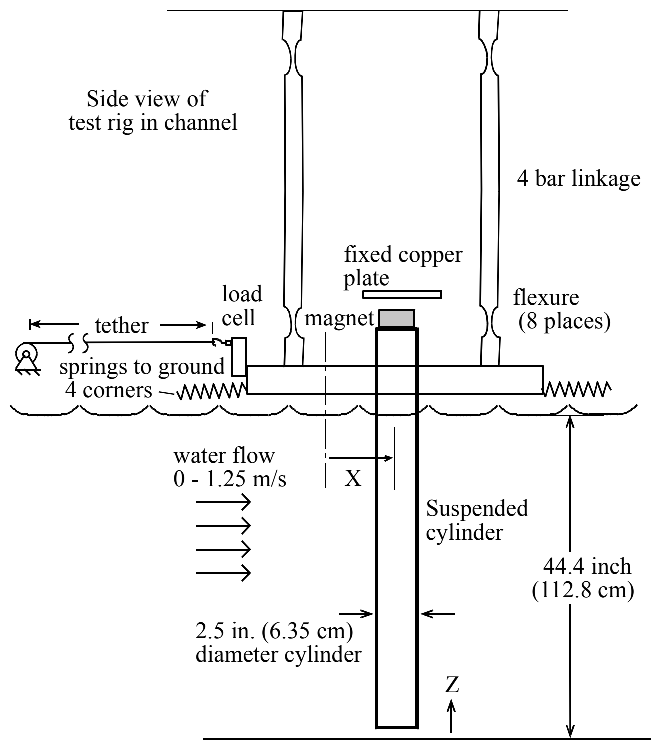


Figure 1: Test cylinder and experimental apparatus. Y out of plane.

The objective of the experimental design was to replicate, as far as practical, an ideal two dimensional spring-supported rigid cylinder that displaces perpendicular to its axis. As shown in Fig. 1 the cylinder is mounted to a square frame that is suspended by 4 parallel bars from an overhead platform. Flexures at the ends of the bars allow 4 diameters of elastic inline ($x$) and transverse ($y$) motion while maintaining the cylinder vertical and perpendicular to the water surface. Lateral ( $x$ and $y$) stiffness is controlled by coil springs at the corners of the frame. As the cylinder displaces laterally ($x$ or $y$) 2.5 inch (1 diameter) the suspended frame moves vertically ($z$) 0.048 inch (1.2 mm), 1.9% of cylinder diameter and 0.1 % of the submerged span. The small vertical ($z$) motion is felt to have negligible effect.