Abstract

Fluid flow around cylinders is a fundamental phenomenon in engineering, impacting fields such as hydrodynamics, aerodynamics, and structural design. Cylindrical structures, especially those with polygonal cross-sections, are present in diverse applications including pipelines, suspension bridges, offshore platforms, and heat exchangers. These cylinders cause flow disturbances, leading to changes in velocity, pressure, and resulting hydrodynamic forces. The interaction between the flow and cylinder geometry significantly affects the system's performance and safety, with improper management of these forces leading to structural failures, as seen in historical incidents like the collapse of the Tacoma Narrows Bridge. Thus, understanding the hydrodynamic behaviour of cylinders and their interactions is crucial for optimizing design, improving efficiency, and preventing catastrophic failures.

The investigations on two-dimensional steady potential flow over single and multiple cylinders is carried out to evaluate flow parameters and hydrodynamic interaction effects. Using complex variable approach, the generalized solutions to study the effect of shapes, size, corner radius and orientation angle, and to study hydrodynamic interaction between two circular cylinders, between circular and polygonal cylinder, and between two polygonal shaped cylinders is presented. The polygonal shaped geometries with finite corner radii are obtained using hypotrochoidal mapping function. The complex potential functions are derived using Milne-Thompson circle theorem along with hypotrochoidal mapping. The uniform and non-uniform flow conditions are arrived at, by taking infinite and finite distance of vortex (or doublet) from the cylinder, respectively.

To investigate the hydrodynamic interaction between two circular cylinders, the annular area between two concentric circles is mapped conformally using bilinear transformation. The complex potential function in terms of Laurent series is used for the doublet trapped in an annulus in ζ-plane and mapped to the ξ-plane around two circles. For the study of hydrodynamic interaction between polygonal and circular cylinder, and between two polygonal cylinders the composite conformal map is developed by unique combination of bilinear and hypotrochoidal transformation. The mathematical formulas to get velocity and pressure fields around the cylinders are obtained by taking differentiation of complex potential function and mapping function. The equations for

hydrodynamic forces between the cylinders are developed using Blasius theorem. The numerical results are obtained and presented to show the effects of shape, corner radii, orientation angle, flow angle, and center-to-center distance on the flow around single polygonal cylinder and the hydrodynamic interaction between polygonal cylinders. The comparison of some of the results obtained using present method is done with the results obtained from commercial CFD software package and results from the available literature.