# YOKOHAMA NATIONAL UNIVERSITY

**Master Thesis**

# Investigation of Aerodynamic Properties of Shape Modified Cable by Illumination Cable

イルミネーションケーブルによって形状変化した橋梁ケーブル空力特性の調査


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# ABSTRACT

The cable is an essential component and plays an important role in long-span bridges. Therefore, the change of aerodynamic properties of the cable effect on the aerodynamic stability of the cable and even long-span bridges. There are many aerodynamic phenomena occurring in relation to cables caused by the shape modification of cable. Many studies were done with cables modification by rain-water rivulet and snow-accretion related to Wake Galloping, Wind-Induced Vibration, so on. One of the reasons lead to modification of cables is the attachment of illuminations to cables, however, is not conducted yet. The objectives of this research are to investigate the effect of the illumination attaches to cables on aerodynamic properties under wind action and to compare the effect of shapes of illuminations on cables.

Numerical Simulation implements available CFD code in OpenFOAM toolbox and applies Large Eddy Simulation (LES) with WALE model and Pimple algorithm to conduct flow around the single cable and modified cable by the different dimension and location of the illumination attachment to the cable. Large Eddy Simulation captures the vortices structure meanwhile Finite Volume Method is used to discretizing fluid domain. The numerical results are verified and validated with Close Circuit Wind Tunnel Experiment data. And, Den Hartog's quasi-steady method is also applied to evaluate the aerodynamic galloping stability of stay cables.

Base on the successful modeling of the single cable case, and the result of verification and validation of a modified cable, three modified cases were carried out employing similar mesh and setting. The study uses the *Gmsh* application to generate O-type domain and meshing of the model. And, based on the result of the simulation, the force coefficients, vortex shedding frequency, static force, velocity profile and Strouhal number are obtained at sub-critical Reynolds number. Differences between the three cases were compared with a single cable, the force coefficients change when the angle of wind attack increase from 0 degrees to 180 degrees, the value of drag coefficient reaches the biggest when the angle of wind attack is around 90 degrees. Besides, vector fields, flow patterns, and pressure distribution around cable are also plotted in cases. From the current research and the related literature, it shows that the change of angle of wind attack and dimension of illumination lead to the changing of the aerodynamic galloping stability of cable-stayed.

Conclusion, the results of the research shows that when changing the angle of wind attack and shape of illumination lead to changing the aerodynamic force coefficients, vortex shedding frequency, and Strouhal number. In addition, the flow of downstream increases turbulence and result in the change of aerodynamic characteristics.

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# NOMENCLATURE

| | |
|---|---|
| $\nu$ | : Kinematic viscosity |
| $\rho$ | : Density of air |
| $\mu$ | : Dynamic viscosity |
| $C_\mu$ | : Constant in turbulence model |
| $\nu_t$ | : Kinematic turbulent viscosity |
| CFD | : Computational Fluid Dynamics |
| LES | : Large Eddy Simulation |
| PISO | : Pressure Implicit with Splitting of Operator |
| SIMPLE | : Semi-Implicit Method for Pressure-Linked Equations |
| Re | : Reynolds number |
| DNS | : Direct Numerical Simulation |
| RANS | : Reynolds Average Navier-Stock |
| FVM | : Finite Volume Method |
| U | : Velocity |
| Fig. | : Figure |
| Eq. | : Equation |
| SI | : International System of Units |
| NS | : Numerical Simulation |
| WTE | : Wind Tunnel Experiment |

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