Vibration	Aerodynamic Measures for Rain Vibration	Other Equipment
Self-Excitation		

Object Machine

Inclined cable (Figure 1) of Cable-stayed bridge

Observed Phenomena

It was reported that abnormal vibrations occurred on the cables of a cable-stayed bridge due to wind from a specific direction at the time of precipitation. Also, observation of an actual bridge has revealed that rain falling on the cables fall down while forming a rivulet at a point where the wind load and the gravity counterbalance. Thus, on an assumption that the existence of a rivulet has an influence on the detachment point of waterflow from the cable surface, a laboratory test was conducted to reproduce this phenomenon; a piece of wire was pasted up on the cable to represent a rivulet formed on the cable, and measurement was made to determine the relationship between the wire position and the vibration amplitude. As a result, it was observed that the wire attached at a position 85° from the stagnation point caused the largest vibration amplitude (Figure 2).

Cause Estimation

Since the vibration amplitude varies to a great extent depending on the attached wire position, it is assumed that the vibration occurs due to the reason similar to that of galloping vibration that depends on the cross-sectional shape.

Analysis and Data Processing

Visualization of the flow with titanium tetrachloride applied on the surface of the inclined cables has proven that detachment of flow occurs within the range of 75° to 80° from the stagnation point. Thus, it is understood that when the wire is located on the downstream side of the detachment point, an aerodynamic instability occurs, resulting in the generation of vibrations with a large amplitude. However, if the wire is attached at a position 75° from the stagnation point, the amplitude remains small. This leads us to consider that, irrespective of changes in the angle-of-attack associated with cable vibrations, the detachment point of flow on the cable surface is fixed at the wire position (Figure 3).

Countermeasures and Results

Considering the fact that fixation of the detachment point of flow on the cables offers a damping effect, cable cross sections were made to have polygonal shapes (hexagonal, octagonal, decagonal shapes) that are expected to have a similar effect to winds from all directions, and then measurement was conducted of the response characteristics for inclined angles to the wind, with the results that have verified the damping effect (Figure 4). Furthermore, an experiment using artificial rain using tap water has proven that no abnormal vibration occurs (Figure 5).

Lesson

Attachment of rain that changes the cross-sectional shape may induce the occurrence of vibration.

References

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T. Kinoshita et al:5th Int. Conf. FIV, 1991, p395-399

Keywords

Rain vibration, cable-stayed bridge, aerodynamic stability, inclined cable, polygonal cross section

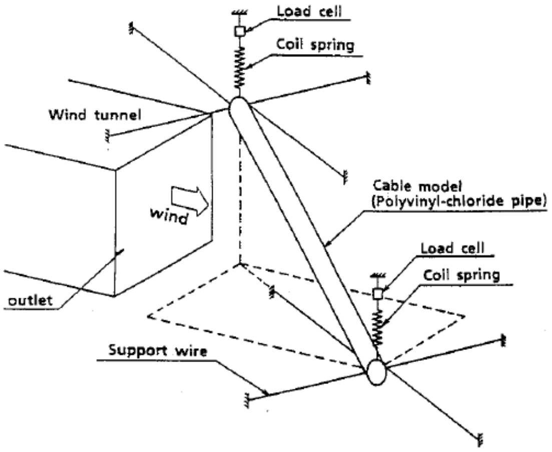


Figure 1 Experimental set-up of inclined cable.

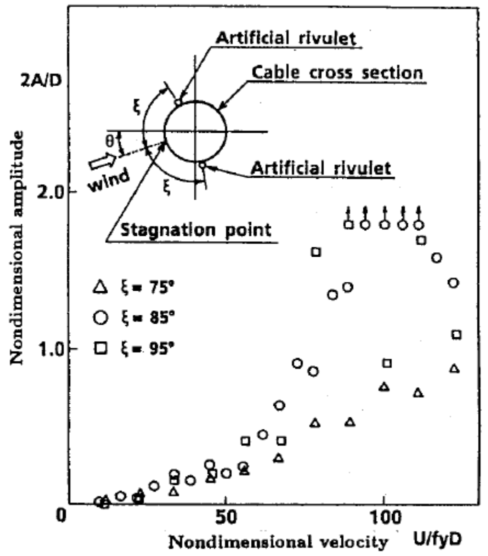


Figure 2 Relationship between wind velocity and oscillation amplitude of inclined cable with artificial rivulet attached at angle ξ=75°, 85° or 95° from stagnation point.

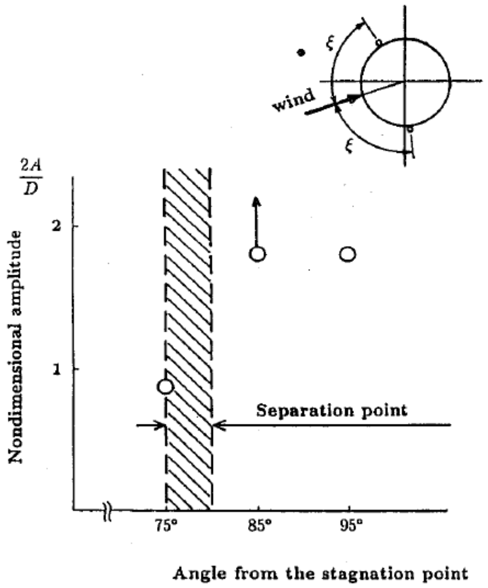
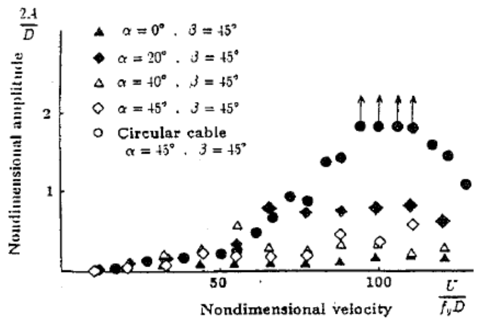
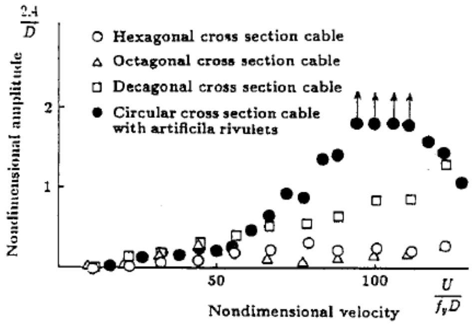


Figure 3 Relationship between position of artificial rivulet, maximun oscilation amplitude and separation point.



a. Velocity and amplitude diagram of octagonal cable on various holizontal angle β. (α=45°) (corner hanging)



b. Velocity and amplitude diagram of various poligonal cable with the same inclination as circular cable (α=45°, β=45°). (face hanging)

Figure 4 Relationship between wind velocity and oscilation amplitude about inclined polygonal cable.

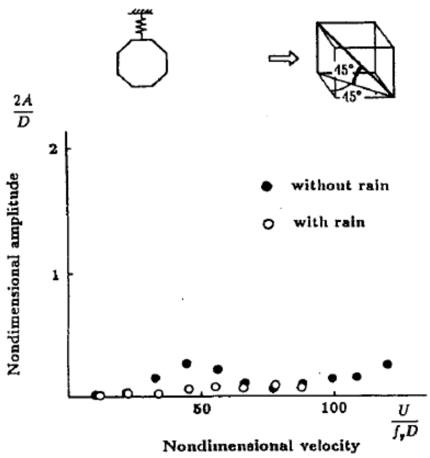


Figure 5 Effect of raindrop about inclined octagonal cable.