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(都市イノベーション学府 Graduate School of Urban Innovation)

論 文 要 旨
Summary of Dissertation

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専 攻 Department	Department of Urban Innovation
氏 名 Name	PHAN DUC TAM
論文題目 Title	Stabilizing effects of flap countermeasures for vortex-induced vibration of a box girder bridge
和訳または英訳 Translation (J->E, or E->J)	ある橋梁箱桁の渦励振に対するフラップの安定化メカニズム

The construction of long-span bridges faces a significant challenge in mitigating the impact of wind forces, which can induce self-induced oscillations and potentially lead to structural failure. Box girders, commonly employed in these bridges, possess low damping and flexibility, rendering them susceptible to aerodynamic instability and wind-induced vibrations. Notable examples of bridges affected by vortex-induced vibrations (VIV) include the Shin Minato, Akashi-Kaikyo, and Tozaki bridges. To address these challenges, aerodynamic solutions have been developed to enhance the stability, safety, and durability of bridge girders. Flaps, fairings, wind noses, deflectors, and spoilers are among the attachments employed to control flow at the leading edge of box girders, thus boosting aerodynamic stability against VIV.

The effectiveness of flaps as a countermeasure against VIV in bridge girders has been successfully demonstrated in the Fujito-Hinoura, Tozaki, Shi-Kizugawa, Kamome, Eisai, and Meiko-Nishi bridges. Further research has expanded upon this concept, exploring additional methods to control VIV. For instance, tests conducted on the Trans-Tokyo Bay Bridge evaluated the efficiency of fairings, double flaps, and skirts in reducing wind-induced vibrations.

Wind tunnel tests play a pivotal role in studying the aerodynamic behavior of long-span bridge sections and evaluating various countermeasures for improved wind resistance. In the case of the Shin Minato Bridge, which encountered vortex-induced vibration issues, Katsuchi conducted tests that revealed the addition of a flap to the bridge's cross-section effectively reduced vibrational amplitude. However, the specific mechanism underlying vibration control remained unclear, prompting the use of Particle Image Velocimetry (PIV) measurements to gain a better understanding of flow structure changes around the bridge girder with and without flaps.

PIV experiments conducted in wind tunnels, examining the flow field around bridge girders, provide crucial insights into bridge aerodynamics and the impact of flap countermeasures on structural stability. By enabling high-resolution, non-intrusive fluid flow analysis, PIV allows researchers to study the interaction between flow and structure, shedding light on the influence of flap countermeasures. The outcomes of these tests contribute to the refinement of flap countermeasure designs and the enhancement of overall bridge aerodynamic stability. PIV has also proven effective in assessing the aerodynamic strength of twin-box girders and investigating the flutter performance of box girders.

The study also emphasizes the significant role of Computational Fluid Dynamics (CFD) in analyzing fluid behavior, particularly in wind engineering. Through CFD simulations, detailed data on pressure, velocity, and turbulence in flow fields around bridges can be obtained, enabling a deeper understanding of complex flow patterns. A

practical application of CFD includes investigating the influence of flaps on the wind flow over box girder sections on bridges. The study employed the Unsteady Reynolds-Averaged Navier-Stokes (URANS) technique and a k-Omega SST turbulence model.

The study aims to clarify the stabilizing mechanisms of flap countermeasures for vortex-induced vibration stability. To achieve this objective, the researchers utilized Particle Image Velocimetry (PIV) measurements to visualize the flow structures in three distinct areas of the bridge, including the local gap, the entire flow field, and the leeward side of the box girder. The study also used various computational fluid dynamics (CFD) analyses, such as static and dynamic simulations, to investigate the aerodynamic coefficients and flow fields around the bridge girder. Based on the PIV tests and CFD simulation, the results show that the flap promoted the separated shear layer to detach from the girder. In contrast, the gap flow between the flap and the girder tended to compensate for the negative pressure behind the flap and above the girder. Consequently, a vortex street formed behind the flap, and vortex convection was also observed above the girder. In addition, the gap flow between the leeward flap and the girder puts energy into vortices behind the deck, preventing interaction with vortices from the upper surface, and disrupting vortex-shedding formation in the wake region. Besides, the gap flow between the flap and the girder changes flow behavior above the girder surface and in the wake region, resulting in changes in pressure distribution, and generating force acting on the bridge. The findings of this study could improve our understanding of box girder bridges' aerodynamic behavior, particularly concerning the impact of flap measures on their stability.

4,000 字以内

Must not exceed 4,000 Japanese characters or 1,600 words.