Proceedings of the 11th World Congress on New Technologies (NewTech'25)
Paris, France - August, 2025
Paper No. ICCEIA 161
DOI: 10.11159/icceia25.161

A Comparative Study of the Influence of Cable Modeling Approaches on the Global Dynamic Behavior of Cable-Stayed Bridges

Thanawat Visessin[1], Koravith Tiprak[2], Eiichi Sasaki[3]
[1]Institute of Science Tokyo
[1]2-12-1, Ookayama, Meguro-kuTokyo 152-8550, Japan
visessin.t.aa@m.titech.ac.jp; tiprak.k.6fd4@m.isct.ac.jp
[2]2-12-1, Ookayama, Meguro-kuTokyo 152-8550, Japan
sasaki.e.ab@m.titech.ac.jp

Extended Abstract

In practical cable-stayed bridge design, each cable is typically modeled as a single tension-only truss element, with a reduced stiffness to account for sagging effects. Although this approach is simple and widely accepted, it may be inadequate for model-based Structural Health Monitoring (SHM), which typically demands a highly accurate Finite Element Model (FEM) to reliably assess current structural conditions and detect hidden damages **[1]**. This limitation arises because the simplified modeling, although often conservative, can lead to inaccuracies in estimating the cable's self-equilibrated shape, force distribution, and the resulting dynamic response over the bridge's lifespan. As such the difference between model assumptions and actual measurement data accumulates consequences in terms of safety and reliability.

To investigate the influence of simplified cable modeling on simulation accuracy and to support the development of a digital twin paradigm, this study selects the Bhumibol Bridge, a major long-span cable-stayed bridge in Bangkok, Thailand. In service for over 20 years. The bridge features a 326 m main span, pylons with a height of 152 m, and 96 stay cables arranged vertically in parallel. A FEM is developed using original design drawings and calculation reports. Multiple cable modeling scenarios are then formulated to evaluate their impact on the structural response through comparative analysis. These scenarios include the conventional simplified approach, using a single tension-only truss element per cable, as well as refined models incorporating 10, 50, and 100 elements per cable to simulate cable behavior more accurately. Furthermore, for each cable discretization case, different considerations of cable sag effects are introduced. These are implemented by adjusting the Young's modulus (E) to represent different levels of sag-induced stiffness reduction, including cases where sag is neglected, partially accounted for via reduced E values, and fully considered using effective modulus formulas **[2,3]**, which incorporate cable self-weight and geometric nonlinearities. The cable tension required for the effective modulus calculation is approximated based on measured natural frequencies obtained from in-situ free vibration tests of the cables. Subsequently, to evaluate and compare the accuracy of each modeling scenario, the simulated fundamental frequencies and mode shapes are validated against experimental data obtained from free vibration tests. These measurements were collected using accelerometers strategically installed on selected pylons and girders of the bridge.

This research clarifies the finite element modeling framework, enabling more accurate simulations of cable dynamics and, consequently, more reliable predictions of global structural responses. The updated cable geometries derived under various modeling assumptions show that element discretization and realistic stiffness modeling, including sag effects, are key to improving simulation accuracy. The findings highlight the importance of optimized element discretization and stiffness modeling in reproducing the real cable behavior, especially in long-span structures. This modeling will provide valuable insight for bridge designers and structural engineers to enhance the predictive ability of FEMs used in cable-stayed bridge analysis, particularly in SHM and maintenance planning. By connecting the gap between the simulated and the true structural response, the developed approach can lead to more reliable and safer infrastructure. Moreover, these validated models present a robust foundation for further investigations into bridge rehabilitation, active control systems, and comprehensive condition assessment.

References

[1] K. Tiprak, K. Takeya, and E. Sasaki, "Integrated neural networks–Particle Swarm Optimization for probabilistic finite element model updating: application to a prestressed concrete girder bridge," Structure and Infrastructure Engineering, pp. 1–35, 2024.

[2] H. Ernst, "Der E-modul von Seilen unter Berücksichtigung des Durchhanges," *Der Bauingenieur*, vol. 40, 1965.

[3] G. Y. Xia and C. S. Cai, "Equivalent stiffness method for nonlinear analysis of stay cables," *Structural Engineering and Mechanics*, vol. 39, no. 5, pp. 661–667, 2011.