Effect of matrices for Stability/Sustainability(Bridge Problem)

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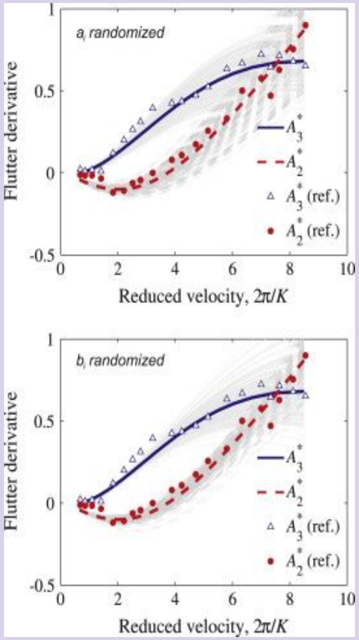
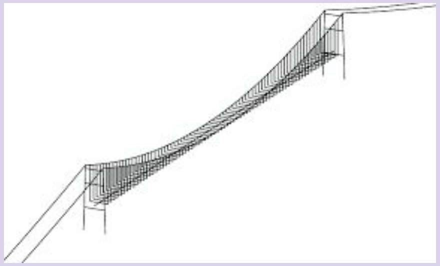
Introduction

Understanding the dynamics of a physical system often requires the solution of an eigenvalue problem or modal analysis. In many studies of dynamic systems, only inertia, viscous damping, gyroscopic, stiffness and circulatory forces are of importance, and such systems can be modeled using linear, time invariant equations of motion. More generally, a broader class of dynamic systems may be described with linear, time invariant state space formulations. The corresponding eigenvalue problems are of the form of matrix linear or quadratic polynomials in the eigenvalue, for which well-established and efficient solution techniques exist.



The study of bridge flutter has attracted the attention of researchers and designers for many decades due to the susceptibility to flutter induced catastrophic structural failure. In line with the technological developments in long-span bridge design and construction,more and more sophisticated models for predicting the onset of flutter are necessary. Among these models, the use of probability-based analysis to study flutter occurrence has been often considered.

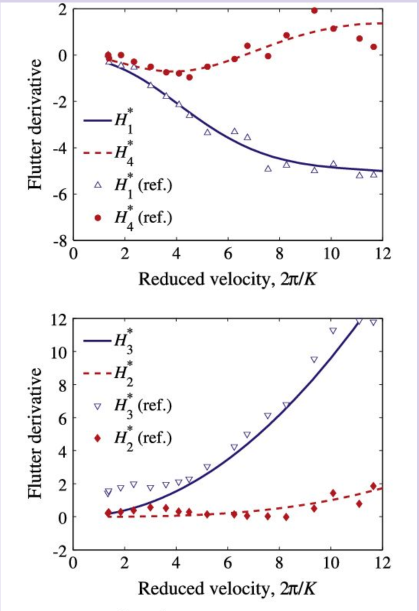


Measured flutter derivatives of bridge deck

Applications to flutter of bridges

During vibrations of multi degree of freedom mechanical systems, such as airfoils or decks of long span bridges, significant self-excited aerodynamic forces can be induced. These forces are motion dependent, i.e. they are proportional to accelerations velocities and displacements of the system.

The aerodynamic forces modify system matrices and influence its eigenvalues and eigenvectors. In particular, they may render the system unstable and cause ever increasing,divergent oscillations in the flutter phenomena. The early developments in analytical flutter analysis were focused on finding the critical wind speed and oscillation frequency when flutter develops . However, dynamic properties and responses of systems for wind velocities below the critical flutter condition are also of interest. For example, in analysis and design of long-span bridges it is useful to establish changes in the structure's modal properties for wind speed varying in a certain range, which can be useful in studies of buffeting response.



Tacoma bridge collapse - Case study

A main theory for why this bridge collapsed is based on natural frequencies and resonance. The resonance is the natural vibration that bridge experiences. In other words, whenever the bridge moves, it oscillates according to a formula that is unique to itself. It just so happens that with this bridge, the natural frequency was close to the surrounding winds which caused the bridge to oscillate so violently that it caused its own destruction. Based on the system of equations the bridge was modeled after the natural frequency is the Eigenvalue of the smallest magnitude of oscillation. For that reason Eigenvalues are heavily relied upon by engineers to help prevent disasters. Because the Eigenvector does not change direction the value remains true for when the oscillation intensifies.

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