Over the past thirty years, an increase in the construction of cable-stayed bridges led to an increase in the observance of wind-induced stay cable vibrations, including “rain-wind” vibrations. Rain-wind vibrations are characterized by large amplitude, low frequency oscillations of the cables that can be damaging to the cables and their anchors to the deck and tower. The exciting mechanism of these oscillations is not yet completely understood, with researchers looking at both aerodynamic interaction between the wind and the cable [1, 2] and structural dynamic interaction between deck and the cable [3]. Laboratory phenomena model experiments were conducted as well (Figure 1) [11].

Parametric excitation as a result of deck motion has also been studied [4-6]. Development of verified nonlinear transient simulations of deck-excited motion of sagging inclined stay cables is progressing [7-9]. Non-linear modal interaction behavior has been identified in transient simulation results for cases of 2D inclined, 2D sagging-inclined, and 3D sagging-inclined cables for an excitation range defining the frequency response of the third mode parametric region. Analytical verification of simulation results is possible for non-inclined sagging cables; solutions are being developed for non-planar motion of inclined sagging cables [10]. Interaction of in-plane and out-of-plane motion was briefly considered with a typical result seen in Figure 2. In-plane response occurred at the input frequency, while out-of-plane response contained two different frequency components. Transient simulations were run with in-plane (in the plane of the sag) harmonic excitation representing deck motion and a small out-of-plane initial impulse disturbance to initiate out-of-plane response representing wind action transverse to the deck.

This effort is focused on providing the next step in verification of nonlinear simulations A sagging laboratory cable is excited harmonically at the base. Measured responses both in the plane of the sag and out-of-plane are compared to simulation results. The 115.75” uncoated galvanized steel wire rope, similar to the stranded steel wires bundled inside a typical stay cable, is seen in Figure 1. This cable was tested previously [11], but corresponding attempts to develop a correlated model of the response failed. Figure 3 (left and right) present selected results of the previous experiments. In this experiment, the mount at the truss also included a hard-rubber damper to study the effect of boundary condition modification. An input with constant frequency of 9.0 Hz was slowly increased in amplitude. Note that experimentally identified frequencies for the second and third in-plane modes were respectively 5.1 and 6.8 Hz.
In this effort, the series of experiments previously conducted are repeated, with results compared to those from a three-dimensional nonlinear finite element simulation of the sagging inclined cable. Damping, a critical factor in the response, is also identified experimentally for incorporation in the simulations.

Figure 3. Left: Pseudo Phase-Plane Portraits and Poincare Maps of the Laboratory Cable Experiment with In-plane Base Excitation: base input (upper left), top truss boundary (upper right), in-plane response (lower left) and out-of-plane response (lower right); Right: In-Plane vs. Out-of-Plane Response [11].

REFERENCES: