Design of experimental apparatus for real-time wind-tunnel hybrid simulation of bridge decks

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ABSTRACT

Due to the challenges in numerical simulation of wind-structure interaction, the dynamic response of long-span bridges subjected to wind loads has been primarily evaluated through wind tunnel tests. The wind-tunnel tests, especially aeroelastic tests, require calibration of springs, masses, and the damping properties of an experimental specimen which takes considerable time and efforts. In hybrid simulation, where a numerical model and a physical specimen are tightly integrated, a component that is difficult to be represented with a numerical model is represented experimentally, while the rest of the structural system is represented numerically. In this paper, designs of experimental apparatus for real-time wind-tunnel hybrid simulation are presented for section model tests of bridge decks. The experimental apparatus for section model tests, which consists of four linear motors, is for aeroelastic tests of section model of a long-span bridge. The rational on the selection of the design configurations is discussed which is followed by configuration of the experimental setup and a potential strategy for running real-time hybrid simulation.

Figure 1 shows details of load transfer mechanism. Linear motors are selected instead of rotary motors and linear actuators, which convert the rotatory motion to a linear motion. Because linear motors directly drive the motion, we can avoid potential issue of backlash or friction that present in the linear actuators. The position feedback of the linear motor is from a high-resolution (5 μm) magnetic encoder. The controller, PD-35P, has servo update rate of 62.5 micro second which is far smaller than typical servo update rate (1 millisecond) of a controller for hydraulic actuators. A stiffener will be attached to the guide rail to minimize the elastic deformation of the load transfer element. Between the moving part of the linear motor and the guide rail are locking sleeve bearing carriage and inline ball joint linkage. These components allow relative rotation between the guide rail and the moving part of the linear motor, and slight change of length between two linear motors when torsional motion is imposed. One of the locking sleeve bearings in each side will be always locked. Two bi-axial load cells are attached between the guiderail and

the specimen mounting plate to measure three components of forces (i.e. vertical, torsional, and along-wind directional forces).

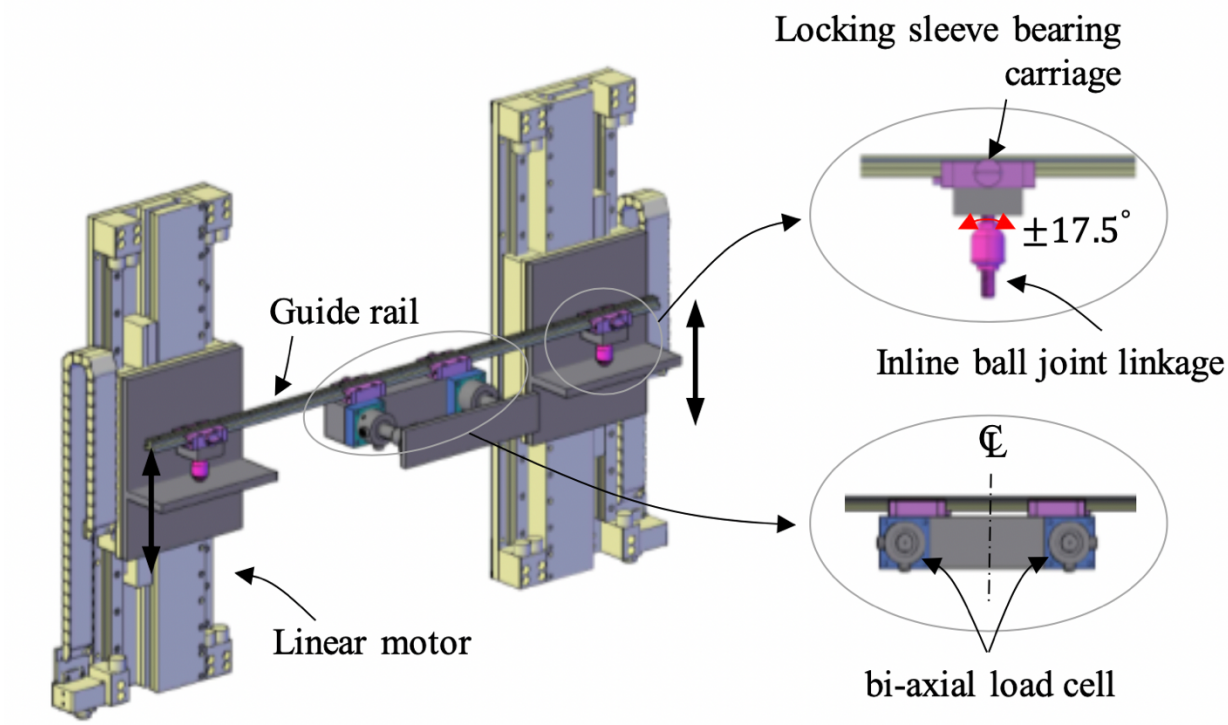

Figure 1. Design of hybrid simulation experimental apparatus for a section model of a bridge deck

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