Bearing solutions for large horizontal forces

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Summary

There are two main general bearing arrangements that are applied where transverse horizontal loads on a bridge deck must be resisted, which are discussed in this paper: a guided-sliding and a free-sliding bearing, paired up on one axis (the standard bearing setup for bridges); and a pair of free-sliding bearings designed for vertical loads, and a second pair of free-sliding bearings designed for horizontal loads on a so-called shear key (or wind shoe), or directly on a pylon. Their respective applicabilities, advantages, and limitations are discussed, with special emphasis on cable-supported bridges. For a shear key setup, restraint becomes a central design issue, affecting the installation, exchange and life-cycle cost of the bearings. Causes of restraint loads on such bearings, and solutions such as preloading systems, are discussed. Two case studies, from current major projects, are presented.

Keywords: bearing, shear key, wind shoe, restraint, disc spring, hydraulic, Forth, Queensferry, Bosphorus.

1. Introduction

Bearings in a structure (e.g. a bridge) transfer loads whilst allowing displacements and rotations. Transverse horizontal loads in bridges may be resisted in one of several ways, the most important of which are described below.

1.1 Standard setup (bearing axes aligned vertically)

The standard bearing setup at each axis of a multi-span bridge is a pair of bearings, one free-sliding and one guided-sliding. For typical horizontal forces up to, this is generally the simplest and most economical solution. But for larger horizontal forces of approximately 10 MN or more, the superstructure material becomes significant in this regard; for steel superstructures, this standard setup remains in most cases the first choice, until forces reach an extreme level of approximately 20 MN. Such high forces lead to significant practical disadvantages, such as:

- sliding plate thickness (needed to resist the bending and shear introduced by the guide bar (see Fig. 4) exceeds the available raw material thickness, resulting in custom cast steel;
- bearing weight exceeds container capacity, resulting in flat rack shipping or assembly on site; and
- bearing tilt, depending on the ratio of horizontal force to minimum coexistent vertical load.

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