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ECONOMIC APPROACH TO DAMPING TRAIL-STYLE FOOTBRIDGES

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Summary

Trail-style bridges located in remote locations are often not assessed for their dynamic performance. These bridges are characterized as Class IV in Setra, defined as a "seldom used footbridge, built to link sparsely populated areas." Organizations like *Bridges to Prosperity (B2P)* and *Bridging the Gap Africa* have been doing excellent work to link remote communities and bridge major obstacles in the developing world.

Trail-style bridges, due to their construction methods and lightweight nature, can exhibit a lively response under footfall. The vertical and lateral motion can potentially be disturbing to certain users, particularly where the bridge crosses a high ravine or spans over a rushing river.

This paper discusses the potential use of Stockbridge dampers as a measure to reduce the buildup of motion under pedestrian footfall for this class of footbridge. A proposed method is provided for 1) defining the damper frequency, 2) determining the mass of dampers, and 3) estimating the level of supplemental damping achieved.

Utilizing Stockbridge dampers may prove very useful for remote trail-style bridges, in additional to urban bridges by offering the designer an economic, non-mechanical solution for adding supplemental damping to control vibration levels.

Stockbridge dampers may also be used for retrofitting bridges that users find uncomfortable due to excessive motion.

Keywords: damping; trail-style bridges; dynamics; stockbridge; tuned mass damper; passive damping; suspension bridge; comfort; accelerations; economical; low maintenance

1. Introduction

Slender, lightweight footbridges in remote locations are often designed without specific consideration given to user comfort and acceleration levels arising from pedestrian-induced vibrations. These footbridges are typically cable supported structures with a focus on economy, such as those delivered by organizations like *Bridges to Prosperity (B2P)* and *Bridging the Gap Africa*. SETRA provides a bridge categorization system where Class IV bridges (like trail bridges in remote locations) are not held to any comfort criteria. Additionally, long-span bridges of this type often exhibit low levels of structural damping and frequencies of vibration within the range susceptible to excitation by pedestrians walking across the bridge.

Trail-style bridges are sometimes built within urban contexts such as a public park or college campus. In these cases, the bridges may become excited by users, either unintentionally or intentionally.

For the MEC Bridge being constructed on a campus in Mississippi, USA, the owner desired a trail-style bridge with a certain liveliness controlled to reasonable levels. Stockbridge dampers are proposed along the underside of the MEC bridge deck to provide supplemental damping.

2. Description of Stockbridge Dampers

Stockbridge dampers are a form of Tuned Mass Damper (TMD) that has traditionally been used on electrical transmission lines to reduce the Aeolian vibration of the lines caused by vortex shedding. They were invented in the 1920s by George H. Stockbridge, who was an engineer for Southern California Edison. The basic form of the damper is a dumbbell-shaped device consisting of two masses at the ends of a short length of "messenger" cable. A clamp at the center of the cable allows it to be attached to the element it is damping.

Because Stockbridge dampers proved to be very economical, effective and easy to install, they became routinely used on overhead powerlines. Their performance is well understood and they are very reliable. Additionally, their construction enables them to operate in both the vertical and lateral directions, which is adventageous.

2.1 Typical Applications for Stockbridge Dampers

In addition to their ubiquitous use in the US power industry, Stockbridge dampers have found themselves into bridge constructions.

2.1.1 US Highway Sign Truss Bridges

Stockbridge dampers have been installed on aluminium highway sign truss bridges throughout the Midwest states. The application of Stockbridge dampers to aluminum highway sign structures can be traced back to 1969 to mitigate against excessive vibration of the trusses observed after they were erected but prior to installation of the sign panels. They are also used to reduce truck gust induced stress cycles [Ref 1].

2.1.2 Unbraced Arch Pedestrian Bridge

The Stawamus Chief Pedestrian Bridge uses Stockbridge dampers installed inside the pipe arches near each crown (on each side of the field splice) such that the sleek appearance of the bridge is unaffected [Ref 2]. The location of the dampers coincides with the maximum horizontal deflections occurring from transverse wind loads, optimizing the effectiveness of the dampers to mitigate against any wind excitation.

2.1.3 Box Girder Internal Tendons

In the UK, Stockbridge dampers have been attached to internal tendons during a retrofit project of post-tensioned bridges by Mott MacDonald. The tendons experienced vibration due to traffic on the bridge.

2.1.4 Bridge Stays

In the Netherlands, the Hovenring is suspended from a cone of cables anchored to the 70-m high pylon. Stockbridge dampers are clamped to the upper ends of the stay cables to mitigate wind vibrations [Ref 3].

Fig. 1. a) Aluminum highway sign truss bridge, b) Stockbridge damper, c) Stawamus Chief Footbridge

2.2 Why Stockbridge Dampers?

The most trusted method of adding damping in modern bridges is by using TMDs. They do have many attractive characteristics, but as stated by Setra there are also disadvantages [Ref 4].

Stockbridge dampers have a wide operating frequency range, which makes them very robust against de-tuning. Installation is basic, requiring a simple bolted connection that can be done by the same individuals involved in the bridge construction without the sophisticated equipment needed to "tune" conventional TMDs. Finally, Stockbridge dampers are very economical.