Summary Story

The behavior of bridges, while often conceptualized as a static system, is in reality, a dynamic system in motion and the member level responses are dependent on the position of that system at any state in time. Admittedly, the responses can often be reasonably predicted by static analysis, but in some cases the true maximum response can be greater than that predicted by static analyses, **far greater even than the 33% specified by AASHTO codes**.

The inadequacy of design and evaluation codes for predicting dynamic amplification was particularly evident for a bridge that we had the opportunity to investigate and monitor. The bridge was an eleven span viaduct that carried a heavily trafficked interstate highway and had been repeatedly reported by motorists for “excessive” vibrations. Through a series of operational monitoring efforts we were able to measure and characterize the bridge vibrations and quantify the level of dynamic amplification. With the help of finite element (FE) simulations, the driving mechanisms and features that contributed to the observed vibrations were identified and their influence characterized. **Roadway profile proved to be one of the most influential factors of dynamic amplification**.

Now armed with tools that have been shown capable of simulating vehicle-bridge interaction, a more in-depth investigation into the effect of roadway profile on dynamic amplification was performed. These studies revealed that a rough roadway (e.g. high IRI) will likely result in increased dynamic amplification but **the magnitude of that amplification cannot be reasonably estimated without considering the bridge and vehicle as a coupled system. Furthermore, the positioning of the profile can have a large effect on amplification levels and must be included in any simulation efforts**. This provides further reason for why roughness metrics (e.g. IRI, ISO 8608) are incapable of reliably predicting amplification.

Fortunately, there are tools available to simulate vehicle-bridge interaction and provide accurate prediction of dynamic amplification. Finite Element (FE) analysis of a 3D, element-level model of the structure is the most capable of representing the distribution of mass and stiffness correctly and therefore will provide the most accurate estimation of amplification. However, for many bridges, their simple geometry warrants a simple model. This study proposes **two possible models that reduce the vehicle-bridge system to two degrees of freedom and demonstrates their ability to accurately estimate amplification**.

If a bridge is suspected to exhibit large dynamic amplification as a result of a rough roadway, the bridge owner may wish to grind the roadway smooth. Furthermore, to reduce dynamic amplification in new construction, pavement specifications should provide smoothness targets. **Current roughness criteria are shown to be inadequate at limiting amplification. Several alternative criteria are proposed and their effect assessed through simulations**.

While the majority of this work focuses on bridge dynamics with a single vehicle, a bridge really experiences innumerable vehicle configurations. **A few scenarios are simulated including random traffic flows and truck trains. Preliminary findings and future work is discussed.**