Summary Story

The response of bridges to live load, while often conceptualized as a static structural analysis problem, is in reality a complex structural dynamics problem that involves the interaction between stationary and moving dynamic systems. Admittedly, the responses of most bridges can be reasonably predicted by static analysis modified by a dynamic load allowance factor. However, in certain cases excessive dynamic amplifications have been observed, which far exceed **the 33% specified by AASHTO codes**. The overarching goals of this research are to (1) establish the underlying mechanisms that give rise to excessive dynamic amplifications, and (2) develop simplified analysis tools that may be implemented in practice to guide the design, evaluation, and life-cycle management of such bridges.

The inadequacy of design and evaluation codes for predicting dynamic amplification was particularly evident for a bridge that was investigated and monitored as part of this research. 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, the bridge vibrations were measured and characterized, and the level of dynamic amplification was quantified. 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. Together with the dynamic characteristics of the bridge and trucks, the **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 observed in the field, 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 that **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.

Although there are tools available to simulate vehicle-bridge interaction and provide accurate prediction of dynamic amplification, these tools are likely not compatible with current engineering practice due to the time and expertise required for their implementation. 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 can be adequately simulated with simpler models. This study proposes **two possible models that simulate vehicle-bridge systems using 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, deck profile 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.**