

USE OF NONDESTRUCTIVE TECHNIQUES TO ESTIMATE THE ALLOWABLE VIBRATORY COMPACTION LEVEL DURING CONSTRUCTION

BACKGROUND

The Superpave™ mixture design method was developed under the Strategic Highway Research Program (SHRP). During the early stages of the Superpave™ implementation effort, few problems were encountered while producing the mix. However, obtaining density on the roadway was a consistent problem across the U.S., and higher density specifications have generally been implemented by highway agencies. Larger vibratory rollers are often used because of their efficiency. However, ground motions caused by these vibratory rollers have been suspected of potentially resulting in damage to adjacent infrastructure, particularly in or near urban areas.

OBJECTIVES

The objective of this study was to develop a practical methodology to identify areas where vibratory compaction is not recommended during construction of Hot Mix Asphalt (HMA) pavements based on falling weight deflectometer (FWD) data obtained as a part of the preliminary design study. Both vibratory drum rollers and the FWD device apply impact loads to pavements. The FWD device employs an impulse load by dropping weights from predetermined heights, while vibratory compactors continuously apply impact loads at a given vibration frequency. Therefore, it may be possible to use the FWD device to predict the effect of vibratory compactors on adjacent structures or buried systems.

FINDINGS AND CONCLUSIONS

Earthborne vibrations from vibratory compaction equipment can be described as single-frequency continuous vibrations. Human perception of such ground vibrations is subjective and depends upon a number of factors. Damage to structures caused by these earthborne vibrations can be categorized as either architectural or structural. Architectural damage is superficial damage such as hairline cracks in plaster walls or ceilings. While catastrophic damage to buildings from construction operations is extremely rare, some structural damage such as separation of masonry blocks and cracking in foundations may occur in cases where earthborne vibrations exceed threshold levels.

Various federal, state, and foreign agencies have proposed vibration limit criteria, some intended to mitigate damage to structures, others to limit human annoyance. Two of these existing criteria (the U.S. Office of Surface Mines blasting level criteria and the German DIN 4150 Standard level for human annoyance) were selected to form the basis of the recommendations presented in

this study. These criteria are used to differentiate three distinct zones on a plot of peak particle velocity versus vibratory roller frequency.

A square root scaling law of ground motion is used to predict the ground motions from vibratory compaction equipment based on FWD data. With this predictor, a potentially vibration-sensitive portion of a resurfacing project can be identified using displacement-time histories from the FWD obtained during routine pre-construction testing. Detailed knowledge of the layering of the pavement structure or the geology of the surrounding site is not required. This research demonstrates that this predictor can successfully be used to restrict vibratory compaction near sensitive structures, including fragile buried infrastructure.

BENEFITS

This research provides a rational means of quantifying vibration-sensitive portions of resurfacing projects during routine pre-construction testing that does not require a detailed knowledge of the layering of the pavement structure or the geology of the surrounding site. When a requesting District Engineer identifies a project as potentially vibration-sensitive, the State Materials Office personnel will be alerted to record the full FWD displacement time histories on each FWD test performed during pre-design testing. The data will then be processed to develop a plot of peak velocity versus scaled range for the project. This plot provides an upper bound predictor of ground motion at the site. By knowing (or assuming) a frequency for the vibratory roller to be used during construction, the peak particle velocity can be used to identify locations along a given project where vibratory compaction is not to be employed. Effective implementation of this approach should result in a reduction of incidental damage to adjacent infrastructure and the disruption and annoyance to those near the construction.

However, the effects of multiple rollers in sequence needs to be studied in the field and additional seismic analysis needs to be performed to validate the prediction models. To this end, FDOT is identifying potential projects in the pre-design phase per the Flexible Pavement Design Manual, which requires sufficient notice be given to perform FWD evaluation and which will allow more effective scheduling for its statewide customers.

This research was conducted by N. Mike Jackson, Ph.D., P.E., of the University of North Florida. For more information, contact Charles Holzschuher, Project Manager, at (352) 955-6341, charles.holzschuher@dot.state.fl.us