National Concrete Pavement Technology Center

Tech Center

# Comparison of Setting Time Measured Using Ultrasonic Wave Propagation with Saw-Cutting Times on Pavements

tech transfer summary

**The ultrasonic pulse velocity (UPV) method has the potential to predict the saw-cutting window.**


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**RESEARCH PROJECT TITLE**
Comparison of Setting Time Measured Using Ultrasonic Wave Propagation with Saw-Cutting Times on Pavements

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**PRINCIPAL INVESTIGATOR**
Peter Taylor, Director
National Concrete Pavement Technology Center
Iowa State University
515-294-9333
ptaylor@iastate.edu

**CO-PRINCIPAL INVESTIGATOR**
Kejin Wang, Professor
Civil, Construction, and Environmental Engineering
Iowa State University


**MORE INFORMATION**
www.cptechcenter.org


**National CP Tech Center**
**Iowa State University**
**2711 S. Loop Drive, Suite 4700**
**Ames, IA 50010-8664**
**515-294-3230**


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## Background

To conduct pavement finishing effectively and schedule saw-cutting at joints accurately, contractors need to know when the sawing window will open. If the cuts are made too early, there is a risk of raveling, but if the cuts are made too late, there is a risk of random cracking.

Commonly used methods to determine sawing time include scratching the surface with a penknife or standing on the slab and observing the footprint depth. However, these methods are subjective, and the results are open to dispute. In addition, different aggregate types, sawing machines, ambient temperatures, and wind speeds make it difficult for contractors to determine saw-cutting times using these methods.

One approach to more reliably predicting saw-cutting time is to monitor temperature rise using a semi-adiabatic calorimeter. However, concerns have been raised that temperature is not uniquely tied to setting, and that tests conducted using a semi-adiabatic calorimeter may not represent the environment to which a given slab is exposed.

A pilot project conducted by the research team indicated that the ultrasonic pulse velocity (UPV) method has the potential to predict the saw-cutting window for early entry sawing. This method is based on the principle that the velocity of an impulse through a concrete sample begins to increase when hydration products start to interact, i.e., when initial set occurs.

*Non-typical conventional gang-saw machine used at one site*

*Typical conventional saw-cutting process*

In the pilot project, however, all field work was conducted with early entry saws and all sites used similar mixtures, most of which contained limestone aggregate. Therefore, there was a need to widen the range of the data to include different mixtures, aggregate types, and sawing methods. There was also a need to assess the viability of using thermal-based approaches, including i-buttons placed in the slab or calorimeters.

## Objective

The objective of this research was to evaluate the effectiveness of the UPV method along with thermal-based systems to predict sawing time by measuring the initial set of a mixture in situ.

## Research Methodology

Sixteen construction sites using a variety of mixtures, aggregate types (granite, limestone, quartzite, gravel), and sawing methods were visited in Minnesota and Missouri over a two-year period. At each site, a concrete sample was collected at the front of the paver and cast into three 4 by 8 in. cylinder molds: one for a UPV measurement and two for the semi-adiabatic calorimetry test.

Initial set was determined using a commercial UPV device, which was set up next to the pavement during paving to expose the sample to the same conditions as the slab. Calorimetric data were collected using a commercial semi-adiabatic device at a majority of the sites. No additional instructions were provided to saw-cutting crews regarding when sawing should take place, and site staff were asked to report the time at which that portion of the slab was sawn.

Data collected included paving start time, initial set determined by the calorimetry and UPV methods, sawing time, and average ambient temperature on the day of testing.

## Key Findings

- Early entry sawing times measured via the UPV method at the sites in Minnesota fit well within the previously established relationship observed in the pilot study.

- The UPV data for the observed mixtures indicated that once initial set is achieved, conventional sawing should begin in accordance with the relationship established in the following equation: Saw time = 1.24 × initial set time (UPV) + 273. Conventional sawing should thus begin about 310 to 390 minutes later for an initial set between 150 and 500 minutes.

- The UPV approach appears to be promising for timing early entry sawing (sawing beginning about 220 minutes after initial set) and conventional sawing (sawing beginning about 310 to 390 minutes after initial set).

- Both early entry and conventional sawing can be predicted effectively using the UPV method for the range of mixtures tested in this research.

## Implementation Readiness and Benefits

An approach that can be used to apply the UPV method in the field is for the contractor to conduct sawing using traditional approaches for the first day or two while developing a relationship between sawing time and initial set time based on UPV measurements for the materials at hand. The relationship can then be extended based on the equation under Key Findings and used to guide saw timing for the remainder of the contract.

*Typical early entry saw-cutting process*