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Consolidation of the entire area of concrete pavement is essential for good quality. During the paving process, concrete vibrators contribute to consolidation by producing rapid vibratory impulses, liquefying the mortar and reducing the internal friction between the aggregate particles. In liquid condition, concrete settles under the action of gravity. When vibration is discontinued, friction is reestablished. Vibrators must operate at specified frequencies to achieve proper consolidation and to avoid premature deterioration.

**Problem**

Premature deterioration of portland cement concrete (PCC) pavements has been a concern for the Iowa Department of Transportation (DOT). In the early 1990s, deterioration was observed in some projects only 3 years after construction. The deterioration appeared throughout the panels as a longitudinal pattern of lines spaced about 18 inches apart—a spacing that corresponded to paver vibrator positions (see Figure 1).

**Solution**

An Iowa DOT in-house research project evaluated the longitudinal lines of premature concrete deterioration. Researchers examined cores extracted from areas of deteriorated pavement. The conclusion was that excessive vibrator frequency during concrete consolidation had contributed to this deterioration.

Spot checks with a handheld tachometer revealed that the frequency was often outside the specified range of 5,000 to 8,000 vibrations per minute. Using the tachometer to determine vibrator frequency is a cumbersome, time-consuming procedure. Errors are not uncommon, and continuous measurements are difficult to obtain.

Paving operations were observed on several projects to determine how much control was maintained over the operating frequencies of the paver vibrators. A vibration system consists of a bank of approximately 20 individual, uniformly spaced vibrators positioned under the front of the paver (see Figure 2). The vibrators fluidize and consolidate the concrete that is being molded into shape by the moving paver.

The frequency-measuring procedure involves probing into the concrete below the paver, to make contact and sense the frequency for each vibrator. In general, paver operators and field inspectors did not have a thorough knowledge of the actual operating frequencies or the means for controlling vibrator frequency. No indicators warned of frequency changes or equipment failure. As a result, paver vibrators often operated at different frequencies, resulting in nonuniform consolidation of the concrete across the pavement.

Inability to control vibrator frequency caused excessive vibration, leading to concrete segregation, loss of entrained air, and subsequently to premature concrete deterioration. The handheld tachometer could measure the frequency only for one vibrator at a time. Subsequent changes of frequency, whether caused by equipment adjustments or failure, were not detected until another frequency measurement was made. It became apparent...
that an automated frequency monitor that
could provide a continuous visual readout
and a recording of all vibrators’ frequencies
would address the lack of information on
operating frequency.

A meeting of paver and vibrator manu-
facturers, paving contractors, and Iowa
DOT Research and Construction personnel
was convened to discuss the basic needs
and requirements for a vibrator monitor.
All participants agreed that a vibrator mon-
itor in full view should show the operating
frequencies of all vibrators at all times dur-
ing paving. Participants identified the need
for a system to record data such as vibrator
frequency, paver location, travel speed, and
air temperature in a way that would facili-
tate downloading.

Two major manufacturers of vibrators
soon developed prototypes of vibrator
monitors that were field-tested on two
pavers in Iowa in 1996. Second-generation
prototypes were tested the following year,
and federal funding was provided through the Priority
Technologies Program for further field evaluations. The
two brands of monitors proved reliable and were found
to be beneficial by paver operators and field inspectors.
The improved control of vibrator frequency led to more
uniformly consolidated concrete and a higher quality
PCC pavement.

Application

Iowa DOT specified use of vibrator monitors on paving
machines in 1999, and current specifications require
the use of vibrator monitors on pavers for projects of
50,000 yd² or more. The specification was applied to 3
projects in 1999, 9 projects in 2000, and 15 projects in
2001. Use of monitors has provided appropriate control
of vibrators and has eliminated trails of segregated, low-
air content, deterioration-prone concrete.

Benefits

With vibrator monitors, paver operators and field
inspectors can conveniently see and know the operating
frequencies of all the paver vibrators at all times during
paving. This information contributes to a better quality
paving operation and helps eliminate vibrator trails.

The time-consuming handheld tachometer tests are
no longer necessary, and the safety risks of maneuvering
around the paver to obtain frequent readings while in
operation have been eliminated. The continuous display
of frequency readings alerts the operator to possible
equipment failure or to vibrator problems when unex-
pected changes are noticed.

The initial prototype monitors provided only the
basic information on vibrator frequencies. Second-gen-
eration monitors have added a variety of data, such as
paver station location, forward speed, and air tempera-
ture. The current generation of vibrator monitors also
offers full-screen displays of menu options and equip-
ment performance and the option of setting and con-
trolling vibrator frequency by preprogrammed
settings. The paver operators, mechanics, and field
inspectors can have a clear view—watching an instru-
ment panel—of the performance of every vibrator on a
paver during concrete placement and consolidation.
The technology contributes to substantial savings of
time in obtaining the vibrator frequency data for assess-
ing the quality of the paving and the concrete consoli-
dation.

The increased knowledge of vibrator performance
will help to avoid inadequate or excessive vibration and
to ensure that the concrete consolidation is uniform and
adequate. Use of vibrator monitors can reduce the occur-
rence of premature concrete pavement deterioration
from segregation or from loss of air content, as well as
the need for related reconstruction and repair expendi-
tures.

For example, a partial depth repair would be
appropriate for repairing deteriorated joints. However,
if longitudinal cracks caused by improper vibration
also develop, an asphalt concrete overlay would be
necessary, at repair costs of $66,000 per mile. Vibrator
monitoring technology also provides a market for the
export of U.S. technology, and several systems have
been exported to paving contractors in other countries.

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