Paving the Way with Research and Innovation

The Kansas Interstate Example

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In the dark of night, a car zips along Interstate 70 toward the deceleration ramp at California Avenue. No one else is on the road.

Veering out of control, the car smashes head-on into a sign. When the driver finally is able to stop, he pinches himself to see if he is still alive. He scratches his head, wondering why he wasn't killed. Then he shrugs, throws his car back into gear, and zooms away.

At the speed the car was traveling, the driver should have died. The car should have been demolished, split in half. As it is, the car isn't dented. The driver hasn't suffered a scratch.

Why?

The sign post the careening car hit was a product of research. The post was joined in such a way it withstood normal wind but broke off when struck by a car traveling at more than 30 miles per hour. The sign flew over the top of the car, and neither the sign nor the post was seriously damaged.

This incident, with a few conjectures, was reported in the *Topeka State Journal*, January 18, 1967. It was part of a feature article about the importance of the research that the Kansas Highway Commission[1] was doing to protect the traveling public—as well as the taxpayers' investment in the highway system.

Research always has played an essential role in building and maintaining the nation's transportation system. The Kansas Highway Commission cooperated with the Texas Transportation Institute, 11 other states, and the Bureau of Public Roads[2] to develop the break-away sign post more than 40 years ago, and research on sign posts and other roadside obstacles continues.

The first segment of the National System of Interstate and Defense Highways designated by the Federal-Aid Highway Act of 1956 was completed in Kansas on November 14, 1956. During the building of the Interstate System across Kansas, many research studies were conducted, and the technologies that were developed have played a role in building safer and more durable public roadways.

Among the advances that research related to Interstate 70 has made possible are the following:

◆ **Drake device.** Frank Drake, an engineer with the Kansas Highway Commission, developed a mechanism for cross-slope control of asphalt paving machine screeds or leveling devices, which allowed for the placement of a smoother asphalt pavement. The Drake device is the basis for the automatic, electronic screed controls now incorporated into all pavers. The Drake device was required for equipment in Kansas in the 1950s and other states soon adopted it.

◆ **Durable (Class I) concrete aggregate.** Research showed that by evaluating individual beds of rock in limestone quarries, the department could identify sources of freeze–thaw resistant limestone for crushing into concrete aggregate. Implementation of this finding, along with a concrete freeze–thaw testing program that evaluates aggregates from each of the ledges, has extended the service life of concrete pavements produced since 1980.

In unfavorable weather conditions, fogging of concrete—here, during placement on an I-70 bridge—reduces cracking on new decks.

◆ **Optimized mix design.** With the optimized mix design, concrete pavement consolidates much more easily than with previous mixes, yielding higher strengths for the same amount of cement. The mix design reduces the amount of cement needed, easily obtains good density and air void systems, and yet yields pavements that are as strong as or stronger than pavements with other mixes. Studies show that higher-density pavements are less prone to faulting.

◆ **Bridge deck protective systems.** Several different types of high-performance concrete have been used for bridge deck construction and reconstruction of I-70 and for the bridges over I-70. These include new bridge deck overlays with silica fume or ground blast furnace slag admixtures. In addition, the rehabilitation of bridge decks with Kansas System dense concrete overlays, Iowa System dense concrete overlays, and polymer concrete two-coat broom and seed methods has extended the service life of many bridges.

◆ **SuperPave® with quality control and quality assurance testing.** All bituminous pavements placed on I-70 in the late 1990s have used this pavement design system, which evolved from research sponsored by the Strategic Highway Research Program. Kansas was the first state to implement concurrently the SuperPave binder and mix design spec-

[1] Now the Kansas Department of Transportation.

[2] Now the Federal Highway Administration.

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I-button electronic device installed on an Interstate 70 bridge to record pavement temperatures; the data assist in modifying concrete curing specifications to increase durability.

ifications and the quality control and quality assurance (QC–QA) testing specification. The contractors perform the QC testing, and KDOT staff or representatives are responsible for the QA testing. To support this specification, Kansas State University has developed a Certified Inspector Testing and Training program.

◆ **Bituminous recycling.** Several methods have been used on I-70 to recycle in-place pavements for reconstruction and to extend the life of bituminous pavements. These include partial and full-depth projects, as well as surface, hot, and cold methods, depending on pavement conditions.

◆ **Use of Class C fly ash.** I-70 construction projects have used many tons of Class C fly ash—a waste product of the electric power industry—for subgrade stabilization, cold in-place recycling of bituminous pavement, concrete pavement, and slurry injection of wide depressed transverse pavement cracks.

◆ **Passive cathodic protection of bridges.** Cathodic protection uses a sacrificial zinc foil layer beneath an overlay to protect the steel reinforcement in bridge decks from corrosion caused by chloride intrusion.

◆ **I-buttons.** Embedded at various depths in concrete, i-buttons are small electronic devices used to investigate temperature changes over time. The i-button stores the temperature every few minutes for several days and then is "read" with a special device that captures the stored information. Findings from a research project on an I-70 bridge west of Topeka, Kansas, in the summer of 2003, for example, showed that temperatures were more severe than expected. As a result, curing specifications were modified so that bridge deck concrete would undergo less stress during curing and would gain durability.

◆ **Curing specifications.** In 1994, Kansas was the first state to require a full seven-day wet burlap cure for concrete and in 1995 was the first to require fogging of concrete during placement when the ambient weather conditions were not acceptable. These specifications have reduced bridge deck cracking on new bridge decks. Because of its research with the University of Kansas on ways to reduce bridge deck cracking, Kansas DOT serves as the lead on a $950,000 pooled-fund project supported by the Federal Highway Administration and several states.

◆ **Bridge repair with epoxy injection.** Epoxy injection technology, first investigated by Kansas DOT researchers in the 1970s, recently was used to repair the debonded deck on the I-135 bridge over I-70 in Salina, Kansas. The method is less costly than removal and replacement of the affected deck areas. Kansas DOT researchers developed another use of epoxy injection that involved angle-drilling of cracked bridge girders, insertion of extra reinforcing steel, and then epoxy injection into the void and surrounding cracks to strengthen the bridge and extend its life. Several bridges on I-70 were repaired using this technique, although some have been replaced. The technique had saved an estimated $25 million statewide in bridge repair costs by 1990.

◆ **Air-void analyzer.** This device allows real-time evaluation of concrete air voids to ensure that the concrete does not fail prematurely from freezing and thawing. Immediately after the pavement is placed, a concrete sample is taken for analysis. Testing takes about 30 minutes, so that changes can be made to the mix on the same day, if necessary. Kansas was the first state to incorporate use of this device in pavement specifications.

The construction of the Interstate Highway System across the country required the development of ways to improve safety, cut costs, reduce maintenance, and increase the effectiveness of materials. Research is ongoing to expand on the advances that were made during the height of Interstate construction. The findings will help to ensure that the roads built today are the safest and most cost-effective possible.

"Over the years, many dedicated people have worked to give Kansas a top-notch transportation system and to improve the art of highway construction," Kansas DOT Secretary Debra Miller observed at the department's 75th anniversary celebration, April 1, 2004.

Kansas claims the first segment of the Interstate system that was completed under the Federal-Aid Highway Act of 1956, 8 miles of concrete pavement for U.S. 40.