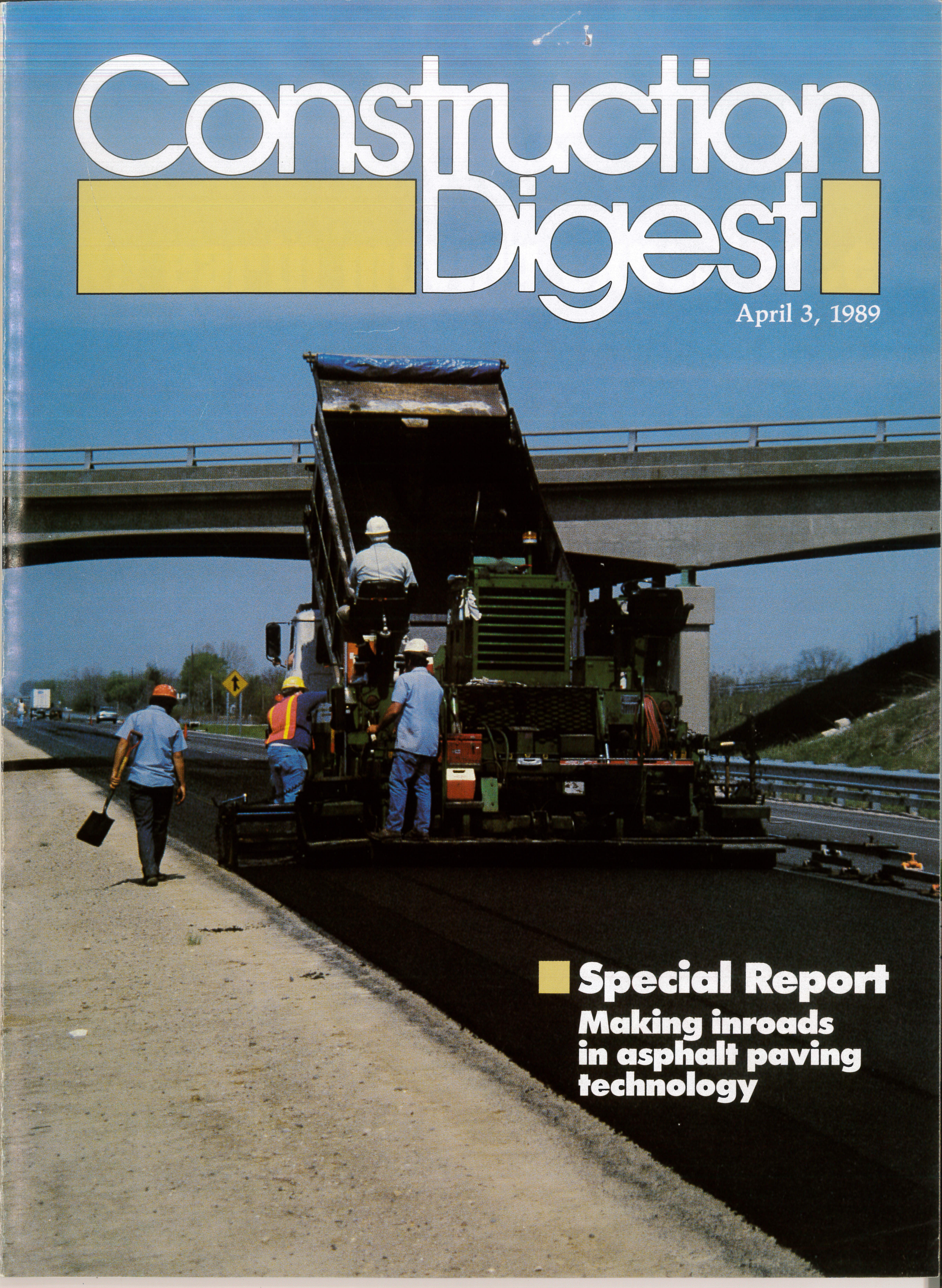
Construction Digest

April 3, 1989



Special Report

Making inroads in asphalt paving technology

April 3, 1989
CONSTRUCTION DIGEST
East Edition for Indiana, Ohio, and Kentucky

by Terry L. Rainier, P.E.

Crack and seating done without removing asphalt surface on runway rehab project.

The rehabilitation of Runway 5-23 at the Columbus (Ind.) Municipal Airport was unique in that it incorporated crack and seating of the underlying portland cement concrete pavement without removal of the asphaltic concrete surface. Nondestructive testing was used to evaluate the effectiveness of the crack and seating efforts, and this report is confined to these aspects of the project.

Columbus Municipal Airport was constructed in 1942 for military purposes. Four runways were built comprised of 8-inch-thick portland cement concrete. These pavements were nonreinforced, having keyed longitudinal joints spaced at 12 1/2 feet and doweled transverse joints spaced at 15 feet.

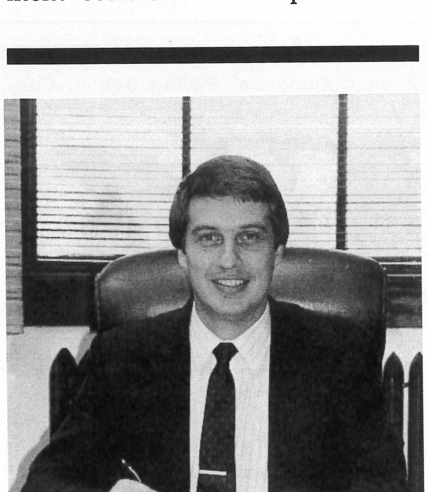
The airport was deeded to the city in 1972. An overlay of all the runway and taxiway pavements that were to remain active was accomplished in 1975. Also at this time Runway 5-23 was extended to 6,400 feet and a partial parallel taxiway constructed.

These new pavements were constructed as flexible pavements consisting of 4 inches of asphalt concrete surface, 5 inches of AC base and 6 inches of subbase. The overlay thickness of Runway 5-23 ranged from 6 inches at the centerline to 2 inches at the edges.

In 1985, the pavement condition of the airport was surveyed as part of a statewide Indiana Division of Aeronautics program. The overlaid portion of Runway 5-23 was determined to have a Pavement Condition Index (PCI) ranging from 45 to 59, and the extended section a PCI of 73. Based on this runway condition, Columbus was programmed by the state to receive an FAA grant in 1988 for rehabilitating its primary runway.

Rehabilitation approach

Prevalent pavement distresses of the runway were tenting and mild blow-ups of the underlying PCC pavement, and reflective cracking. Furthermore, it was determined that the PCC beneath the asphalt was de-



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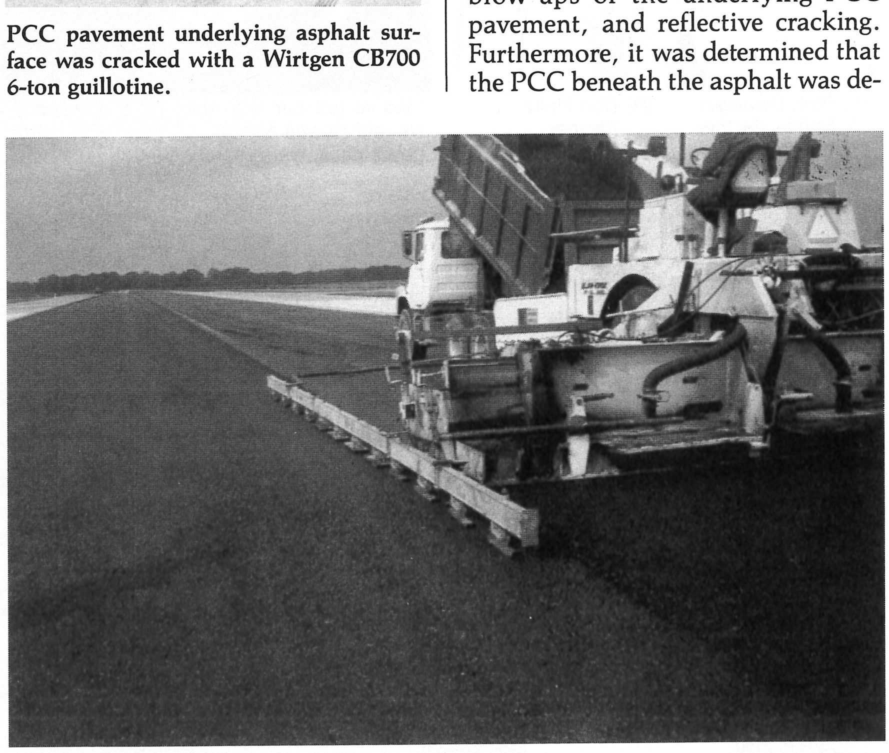
This report is a condensation of a presentation made by Rainier at the Federal Aviation Administration's Engineering Conference, held last November in Chicago.

PCC pavement underlying asphalt surface was cracked with a Wirtgen CB700 6-ton guillotine.



CUI's Blaw-Knox 220 paver with 30-foot ski puts down asphalt leveling course on the runway.

teriorating due to a 'D' cracking.

We theorized that the debris from the 'D' cracking, along with outside debris filtering through the reflective cracks, was clogging the PCC joints. The PCC was also weakened at the joints because of the 'D' cracking. The tenting and blow-ups were apparently being caused by a combination of insufficient room for the PCC panels to expand due to temperature and moisture variations, and the weakened concrete at the joints no longer being able to withstand the strong expansive forces.

The distresses were exaggerated further by water filtering through the reflective cracks, thus accelerating the 'D' cracking by a freeze-thaw process. In addition, the asphalt overlay absorbed heat, inducing expansion of the underlying PCC. Although we theorized what was actually causing the tenting/blow-up type distresses, we were certain that the major contributing factor was the underlying PCC pavement and its slab action.

Nondestructive testing equipment being operated by Roy D. McQueen & Associates crew.

Alternative methods which were considered for rehabilitating the runway included the following:

- Cut expansion relief and then overlay with AC.
- Overlay runway with AC and continue to blade or grind tenting areas individually as they occur.
- Crack and seat pavement and then overlay with AC. Milling off the existing AC might be required to accomplish and verify the crack and seating efforts.

In the final analysis, it was determined that crack and seating, if properly executed, would serve to best reduce excessive horizontal and vertical movement of the underlying PCC. It was hoped that the AC would not have to be removed because of the expense to do so, the additional new asphalt that would be required to reestablish crown and grade, and the loss of overlay pavement strength.

A Nondestructive Testing (NDT) program was undertaken to evaluate the effectiveness of crack and seating the underlying PCC pavement without removing the AC overlay, and to develop project construction performance criteria. Based on evaluation of the NDT results, we determined that the proposed crack and seat rehabilitation concept was a viable option.

It was decided to proceed with construction documents based upon not removing any of the existing AC material. An undistributed quantity of AC milling was included in the pay items in case some of the AC had to be removed to accomplish satisfactory crack and seating of the underlying PCC. The construction documents specified the establishment of a test strip by the contractor for reevaluation of the construction criteria, and for the development of hammer force and machine travel speed ranges.

The overlay thickness for Runway 5-23 was not determined based upon maintaining or increasing strength, but rather was established based upon the required minimum thickness needed for placement of AC over cracked and seated pavement, and for restoring the overall line and grade.

The gross allowable aircraft weights, taking into account the rehabilitation, were calculated using a modified FAA flexible design procedure. An equivalency factor of 0.8 was used for equating cracked and seated PCC to an equivalent AC thickness.

Nondestructive testing

The NDT program was undertaken by Roy D. McQueen & Associates, Ltc., using a heavy mass Dynamic Loading System. This machine is designed to generate a dynamic load on a pavement surface and measure the resultant vertical response of the pavement system, including subgrade, base courses, and surface layers.

Two types of nondestructive tests were performed. The first test sequence, termed Deflection Basin, involved measuring deflection at the center of the machine loading plate and at fixed radial distances from the center. The resultant deflection basin data set was then grouped by lane according to similar pavement thickness sections, and statistically processed.

Since the elastic modulus of the PCC layer *after* cracking and seating was the focus of the testing program, and since the AC surface layer did not visually indicate deterioration or excessive cracking and raveling, it was assumed that the elastic modulus of the AC layer was dependent upon the modulus-temperature relationship for AC surface as described in Report No. FAA-RD-80-9-II, "Nondestructive Testing for Light Aircraft Pavements, Phase II, Development of the Nondestructive Evaluation Methodology."

The second test sequence, termed Load Sweep, resulted in the Dynamic Stiffness Modulus (DSM) which measures the response of the total pavement system, including subgrade. The DSM test procedure is described in FAA Advisory Circular 150/5370-11 and Airport Paving Bulletin, "Evaluation Using Nondestructive Testing and Overlay Design."

Test strip results

A 75 by 240 foot (6 lanes by 16 slabs) portion of Runway 5-23 was used as the test strip to gauge the effectiveness of the contractor's crack and seat operations. Cracking was perfomed with a Wirtgen 6-ton guillotine, operating at varying drop heights, offsets and forward travel speed. Various combinations of 35-ton pneumatic and 10-ton vibratory rolling were evaluated for seating.

The test strip was divided into two sections to evaluate construction processes. On Section I, the guillotine operated at a lower drop height, tighter grid and slower speed that used on Section II. A variety of rolling patterns were followed for seating each section.

Nondestructive tests were performed on each section prior to cracking seating, after cracking, and after each rolling pattern. After cracking operations, the asphalt was removed from portions of each section for inspection of exposed concrete and subsequent rolling. These exposed concrete areas were also subjected to NDT after each of the following operations: (a) Cracking and AC removal; (b) one pass with vibratory roller; (c) four passes with 35-ton roller. *continued on page 43*

We concluded that the most efficient construction process resulted from Section I operations with seven passes of the 35-ton roller. Use of the vibratory roller for seating was not considered particularly effective.

To further check the effectiveness of cracking and seating, the deflection basin data were reduced to obtain the elastic moduli of PCC layers, before cracking and after cracking and seating, at optimal levels deduced from the DSM data.

The average concrete modulus after cracking and seating was 533,333 psi for Section I versus 233,333 for Section II. Since the FAA Report suggested that the final concrete modulus from cracking and seating should range between 500,000 and 1,000,000 psi (which is also consistent with AASHTO recommendations), it was decided to proceed with the Section I cracking prodedures, followed by seven passes with the pneumatic roller. Also the contract documents would require a maximum PCC elastic modulus of 750,000 psi.

We decided to base construction control on the DSM criteria in order to obtain immediate feedback to our construction inspection staff. The test strip results suggested that the DSM after cracking and seating should range between 0.4 and 0.5 times the original uncracked DSM.

Criteria met

Nondestructive tests were performed after cracking and seating of the runway pavement. The average cracked and seated DSM for the project was 785 k/in which is 0.45 times the uncracked DSM of 1741 k/in. Therefore, the DSM criteria was met.

The deflection basis reduction indicated that the average elastic modulus of the PCC layer was 500,000 psi, which fell in the lower range of the criteria established during the FAA research. Application of the standard deviation for the concrete elastic modulus indicates that most of the concrete layers would have an elastic modulus ranging between 300,000 to 700,000 psi. Thus the specification requirement for cracked and seated elastic modulus was also met.

The elastic modulus of the uncracked PCC was quite variable and ranged between 2,000,000 and 6,000,000 psi. The variable strength detected by NDT was also verified from concrete cores.

Therefore, the relatively low elastic moduli of concrete on some sections of the runway is not surprising due to the deteriorated and variable condition of the original concrete. However, since the objective of the project was to reduce concrete slab action, preventing blow-ups, it appears from the NDT results and final concrete moduli that this objective was achieved.

Construction highlights

The contractor, Contractors United, Inc., Columbus, Ind., was issued a Notice to Proceed on May 2, 1988 and they completed all paving by June 15. During that period, the contractor cracked and seated 95,000 square yards of pavement, laid 33,000 tons of AC, and sealed 14,000 square yards of overrun at the north runway end.

A batch plant on the site provided for excellent AC unit prices. The unit price for AC 1/2-inch maximum gradation was $20 per ton, and for the 1 1/2-inch maximum gradation was $17 per ton. CD