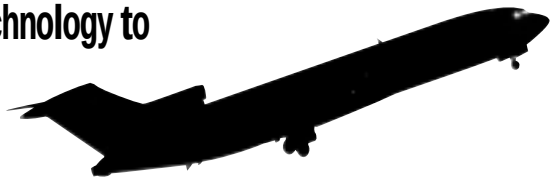
Consultants Apply Elastic Layer Theory and Crack and Seat Technology to

Rehabilitate Taxiway at Memphis International Airport



by Frank Gianotti, Vice President, PDR Engineers, and Ron Powell, Principal Engineer, PDR Engineers

Crack and Seat technology, along with application of elastic layer theory, enabled PDR Engineers, Inc. and its consulting team to rehabilitate Taxiway "N" at Memphis International Airport in 30 days at a cost of less than $2 million.

The airport is the global headquarters for Federal Express and a major passenger hub for Northwest Airlines/-KLM Royal Dutch Airlines. It is the world's largest cargo airport, which dictated a taxiway design for 50,000 MD-11 annual departures.

PDR looked at six paving alternatives to rehabilitate the taxiway's 14 to 16-inch thick concrete pavement built more than 20 years ago. The cement-treated base built at the same time was also rapidly deteriorating. The six alternatives included total replacement with concrete, total replacement with asphalt, an unbonded concrete overlay, a partially bonded concrete overlay, an asphalt overlay, and cracking and seating with asphalt overlay.

Alkali silica reaction

PDR concluded that a partially bonded overlay would not last because of alkali silica reaction (ASR) in the concrete. ASR is a chemical process where the alkali in the cement reacts with silica in the aggregate in the presence of moisture. The process forms an expansive jell that breaks the cement paste between the aggregates. This weakens the concrete pavement by causing it to expand. Heat and moisture causes steam to occur within the pavement structure, which also leads to stripping and deterioration of the asphalt overlay, as well as continued deterioration of the concrete. Although not often recognized, the presence of ASR is a leading cause of poor performance in asphalt overlays over concrete pavements.

Cracking and seating or fractured-slab mechanics reduces ASR and rubblization eliminates it. PDR brought in Roy McQueen of Oakton, Virginia, as a consultant in the areas of pavement design and for specialized testing before, during, and after construction. He also acted as special consultant on the ASR problem.

PDR knew if we simply overlaid the taxiway with asphalt, we would be fighting a reflective cracking problem. By cracking the concrete, we allowed the pavement to breathe. That, in turn, permitted ASR to occur and not damage the concrete.

Part of PDR's evaluation was gathered from a petro-graphic analysis, a technology that was not available when the taxiway was first constructed 20-some years ago. This chemical, microscopic examination showed us if ASR was present or not. The petro-graphic analysis, along with crack and seat research and asphalt overlay data provided by Dr. Bob Boyer, Senior District Engineer for the Asphalt Institute, indicated that crack and seat with

asphalt overlay was a viable option. AI's Boyer also provided support for PDR's engineering presentation to Memphis Airport officials.

Critical Design

Another problem was that the concrete pavement wasn't thick enough to accommodate Memphis International's heavy aircraft. The pavement was 14 to 16 inches thick but should have been at least 18 inches thick with substantially more subgrade preparation. All this meant that time was running out for Taxiway N. Even If the concrete would have been in good shape, it would still fall short of the design for the annual 50,000 Equivalent Annual Departures of MD-11s over the next five to twenty years. An MD-11 weighs approximately 605,000 lb. at takeoff. As with all airports, design of the taxiways are critical.

Taxiway N couldn't be out of service very long or it would cause chaos at the airport. Concrete rehabilitation would take at least 6 months. After careful evaluation of the rehabilitation alternatives, PDR concluded that crack and seat technology with asphalt overlay was the best option. PDR believed the construction team could complete the project in 30 days. PDR convinced the airport authority that McQueen Associates should do pavement tests with the Falling Weight Deflectometer (FWD) while the taxiway was under construction. In addition, PDR did four different test strips with different patterns. McQueen came right behind the pavement breaker and made adjustments while the cracking was in progress.

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Cracking and Seating

The theory of cracking and seating is that fracturing the slab turns the rigid pavement into a flexible one. Our purpose was to create a compatible modulus—one that would be equal to the new asphalt overlay. To determine the optimum cracking pattern, these variables with the guillotine breaker were evaluated on the test strip:

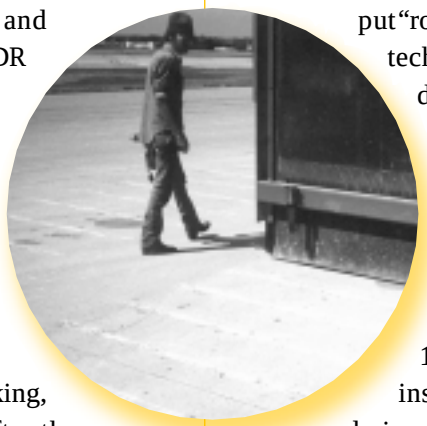
- 2-foot drop, 18-inch spacing, 2 passes across slab;
- 3-foot drop, 20-inch spacing, 2 passes across slab;
- 3-foot drop, 20-inch spacing, 3 passes across slab;
- 4-foot drop, 20-inch spacing, 2 passes across slab;
- 4-foot drop, 20-inch spacing, 3 passes across slab;
- 3.5-foot drop, 16-inch spacing, 3 passes across slab.

Modulus is an engineering term used in elastic layer theory to describe the stiffness or flexibility of a material layer. The higher the modulus, the stiffer the material. An ideal modulus for compatibility of the cracked concrete and the asphalt overlay would be between 500 and 700 ksi.

McQueen Associates conducted pavement tests with the Falling Weight Deflectometer (FWD) to help determine the pavement modulus of the test sections. After the optimum cracking procedure was chosen, McQueen continued with FWD testing while the taxiway was under construction, and necessary adjustments were made while the cracking was in-progress.

Elastic Layer Theory

FWD data on the rigid concrete was used to determine the modulus of the existing pcc pavement. In order to effectively use the elastic layer theory, the modulus of the concrete had to be substantially reduced to work with the asphalt overlay. To make the concrete and asphalt compatible, PDR made the rigid concrete into a flexible base with a similar modulus to asphalt.



To assure quality throughout the cracking and seating operation, PDR tested the pavement before cracking, during cracking, and after the cracking. It was the first project where PDR collected pre-project, in-progress and post-project data. With that information, PDR and the Asphalt Institute will continue to compare and analyze Taxiway N's pavement performance.

After cracking, we rolled the cracked concrete with a 50-ton roller. As we rolled, we adjusted the number of roller passes to create the proper modulus.

Mix Design

The mix design was conducted in accordance with the Federal Aviation Administration P401 specification. PDR made the mix slightly stiffer, however, by making the mix on the coarse side of the specification band. This resulted in a slightly higher stability to meet the heavy Federal Express plane loads and the sharp turns necessary when preparing for takeoff. We designed the mix to fit our specific needs within the context of the FAA P401 specification. To assure consistency of the mix, we put "round-the-clock" lab technicians in the field, directly supervised by PDR's engineers.

We started work on the project September 15, 1995 and completed it October 15, 1995. PDR also installed new edge drains. The taxiway was 4,400 feet long and 75-feet-wide. The project encompassed the northern half of Taxiway N. The pavement has been in service for two winter seasons and is performing very well. There is no cracking and no visible rutting.

PDR was the prime engineering consultant and construction manager on the project. Roy McQueen Associates provided special pavement non-destructive testing and

Quality Assurance. APAC Tennessee was the paving contractor and was also responsible for the cracking and seating. S & ME Laboratory of Arden, North Carolina, and Kimley-Horn supplied design assistance and construction administration assistance.

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Partnering was also an important aspect of the project. Nick Haynes, Division President for APAC Tennessee, Inc. said that the success of the project "couldn't have happened without our partnering agreement." Haynes said that both contractors and engineers from the industry told him that the project couldn't be built in the time specified, but it was. "We've been involved in several projects that endorsed partnering," said Haynes. "But this was one project where we did more than talk the talk. We walked the walk."

Memphis International Airport president Larry D. Cox accurately summed up the success of the project with these words: "The timely and successful completion of the Taxiway N Rehabilitation project was of critical importance to the Memphis hub and its tenant airlines. The unusual demand to compress what would normally be a 4 to 6 month replacement project into a 30-day period required exceptional and unique attention and techniques. We commend PDR Engineers, Inc. for meeting our requirements under pressing and unusual circumstances. We are hopeful that this project could set a national precedent as another option for airfield pavement repair."▲

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Florida DOT is developing a Warranted Asphalt Specification and plans to build one project on lower traffic volume roads in each District to evaluate the specification. It includes a five-year maintenance warranty based on milling and replacing one inch of the structural course plus the friction course. The pavement would be evaluated on the basis of ride, rutting, cracking and initial skid resistance.

In June of this year, Michigan DOT began letting 11 asphalt mill-and-overlay resurfacing projects with preventive maintenance warranty provisions. Each warranty will be for three years. The warranties, in part, reflect MDOT's attempt to manage projects with fewer personnel as a result of ongoing reductions in work force. The agency also intends to require warranties on chip seal, microsurfacing, crack-filling and concrete joint repair projects.

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