

FAST TRACK PAVING: MEETING THE NEED FOR EARLY USE OF PAVEMENT

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Fast Track is the name that has been given to a technique that permits Portland cement concrete pavements to be opened to traffic in a day or less. The method has been developed and used in the state of Iowa to minimize the time that a roadway is denied to traffic because of the placement of new pavement. Through the proper selection of cement type, mix design, and curing conditions, it has been possible to achieve beam flexural strengths in excess of 400 psi in 12 hours. The Iowa Department of Transportation (DOT) considers 350 psi the minimum flexural strength necessary to open a pavement to traffic. The Fast Track paving technique was first used on several demonstration projects in 1986. In 1987, the technique was used for nine additional projects where there was a need to open the roadway to traffic as soon as possible or to facilitate subsequent paving operations. This paper discusses the development effort, mix design, construction techniques, and pavement performance for several projects. Fast Track paving offers an attractive solution to private owners and governments who cannot allow a roadway to be closed to traffic for a significant period of time.

Introduction

The trend in highway construction is toward renovation and rehabilitation and the construction of smaller projects rather than toward the construction of new highways on new alignments. For example, in 1985 and 1986, the state of Iowa completed 907 miles of reconstruction, rehabilitation, and resurfacing (3R) projects but constructed only 90 miles of new roadway.

Although the traveling public expects to be inconvenienced to some extent by these projects, they want that inconvenience minimized. Rehabilitation methods that minimize the inconvenience to the

traveling public and yet provide an economical and high quality riding surface are needed.

In an effort to help meet this need, the Iowa DOT, in cooperation with the Iowa Concrete Paving Association and other industry groups, has developed a system of using a special Portland cement concrete (PCC) mix for both new pavements and overlays that permits traffic to use the paved section in as few as seven hours. This system is known as Fast Track concrete paving. Several trial projects in the spring of 1986 were followed by a demonstration project in Buena Vista County that summer and by several applications in 1987. This paper discusses the development of the process and the uses of Fast Track to date.

Background

As highway systems have deteriorated throughout the country, a variety of rehabilitation techniques have been used. Full depth patching, asphalt overlay, complete replacement, and PCC overlays in various thicknesses have been used. Each of these has distinct advantages and disadvantages.

In Iowa, PCC overlay projects have been completed on literally hundreds of miles of interstate, primary, and secondary highways since 1974. These pavements are performing satisfactorily, and it is expected that they will meet their design life. Factors which have favored the use of concrete overlays include economics, increased load capacity of the new pavement, reduced consumption of new resources, and shortened construction times.

However, PCC overlays have a disadvantage when compared to asphalt overlays because asphalt overlays can be opened to traffic sooner and thus minimize the inconvenience to the public. In an effort to overcome this disadvantage and to capitalize on the other advantages of PCC overlays, Iowa began the development of

Fast Track concrete paving. The idea underlying Fast Track paving was to develop materials and paving techniques that would allow traffic on fresh pavement as early as possible. Typical delays of five to ten days for curing time and strength development had to be shortened.

In late 1985, a task force from the Iowa Concrete Paving Association (ICPA), material producers and suppliers, equipment manufacturers, Federal Highway Administration (FHWA) representatives, and engineers representing the Iowa DOT met to discuss the possible development of a new generation of paving mixes, equipment, and methods. Their goals were to have the concrete paving industry develop a mix design that would permit traffic on the paved area within 24 hours. Also, it would be helpful if a zero clearance paver could be developed that would permit traffic to use the adjoining lane during paving operations. On the basis of experience and judgment, the Iowa DOT recommended that the design mix develop a 24-hour compressive strength of 3500 psi and a flexural strength of 350 psi to accommodate early traffic (1).

Development of a Satisfactory Mix Design

The ICPA formed a task force to research various mix designs which might meet the criteria. Two mixes were proposed to the Iowa DOT materials section in January 1986. One mix was designed for 2,500 psi compressive strength in 12 hours, and the other for 2500 psi in 18 hours. Because the DOT believed that higher early strengths were possible, the DOT, using these two mixes as a point of departure, began investigating other potential mixes.

To obtain the necessary early strengths, the DOT decided in favor of using Type III cement. However, in testing samples of that cement from various cement companies throughout Iowa, they found that the early strengths of cement cubes made with these cements varied considerably. In an effort to improve the consistency of the end product, the DOT then met with the cement companies and asked them to furnish Type III cement which, when tested in accordance with ASTM C109, would produce 12-hour cube strengths of at least 1300 psi. The cement companies accepted this challenge. Subsequently, samples of Type III Portland cement met the criteria established. The mix designs developed by the DOT are shown in Table 1.

Laboratory tests showed that concrete cylinders made with these mixes developed 12-hour compressive strengths between 1910 psi and 4750 psi, depending on the source of the Type III cement and whether an accelerator was used. The highest strength was obtained by

Table 1. Mix design developed by the Iowa Department of Transportation.

Designation	Type III Cement (pounds)	Flyash (pounds)	Fine Aggregate (pounds) 40% of total	Coarse Aggregate (pounds) 60% of total
D57-O	710	0	1130	1696
D57-OFA	640	70	1130	1696

Slump: 1-1/2" at paver; air content: 6.5% $\pm$ 1.5%. Water reducer in accordance with manufacturer's recommendation.

using a flyash mixture with 1.5% calcium chloride as an accelerator.

Preliminary Trial Projects

In April 1986, just six months after the concept for Fast Track originated, a small test project was selected for a trial run. The project was the paving of a truck terminal at the Dundee Cement Co. terminal in Des Moines, Iowa. Several mixes, as shown in the top half of Table 2, were selected for use on this project. The cement was specified by the cement company to be their own Type III cement. On the day that the paving took place, weather conditions were cool and windy. Iowa DOT personnel were present to observe the paving operation and to monitor the quality and strength of the concrete. Five mixes were used, each on a separate portion of the project.

The results of the flexural strength tests, conducted in accordance with ASTM C 293, are also shown in Table 2. A minimum of 350 psi flexural strength was required before traffic would be permitted on the pavement. Flexural strengths in excess of 400 psi in 12 hours were obtained. The results were therefore very encouraging, considering that the pavement had been placed when the weather was cooler than what would normally be anticipated.

In May, 1986, arrangements were made between the Iowa DOT and the County Engineer of Marshall County, Iowa, to use Fast Track concrete on a 300-foot long portion of a secondary paving project on a county road in Marshall County. The paving was full depth on a prepared subgrade, rather than an overlay. The equipment used included a conventional drum mixer at a stationary, portable batch plant; nonagitating hauling units with regular dump bodies; and a conventional crawler-type slip-form paver fitted with extra internal vibrators. The extra vibrators were a precaution added by the contractor to insure adequate consolidation of the mix. As it turned out, the mix was readily

Table 2. Preliminary Iowa Fast Track pavement trials.

Mix Class	Flyash Source & Class	Cement Source & Type	Coarse Agg. (%)	Fine Agg. (%)	Cement Content lb/yd ³	Flyash Content lb/yd ³	Water Reducing Admix. & Type	Accelerating Admix. Source & Type	W/C Ratio lb/lb	W/C + F. A Ratio lb/lb	Slump (in.)	Air Content (%)	Flexural Strength (psi)			Compressive Strength (psi)				
													8 hrs	12 hrs	24 hrs	8 hrs	12 hrs	24 hrs		
Dundee Terminal																				
Dundee Special	None	Dundee III	60	40	700	-	WRDA-82 "A"	None	0.313	-	1.5	6.0	-	330	-	190	1400	3890		
Dundee Special	None	Dundee III	60	40	700	-	WRDA-82 "A"	DARASET "C"	0.337	-	0.25	4.8	-	-	-	270	1290	2980		
Dundee Special	None	Dundee III	60	40	700	-	WRDA-82 "A"	DARASET "C"	0.392	-	3.0	7.0	430	-	-	-	-	-		
D-57	None	Dundee III	60	40	710	-	WRDA-82 "A"	None	0.359	-	0.75	6.0	190	440	840	730	2590	4700		
D-57	Ottumwa "C"	Dundee III	60	40	640	70	WRDA-82 "A"	None	-	0.353	1.5	6.0	150	430	740	540	2060	4040		
Marshall County																				
D-57	None	Nor. West III	60	40	710	None	WRDA-82 "A"	None	0.353	-	2.0	4.0	400	560	690	2700	3700	4160		
D-57	Ottumwa "C"	Nor. West III	60	40	640	70	WRDA-82 "A"	None	-	0.301	0.75	5.0	360	530	560	2360	3310	4100		
D-57	Ottumwa "C"	Nor. West III	60	40	640	70	WRDA-82 "A"	CaCl ₂ 0.5%	-	0.299	-	-	-	-	-	-	-	-		
D-57	Ottumwa "C"	Nor. West III	60	40	640	70	WRDA-82 "A"	CaCl ₂ 1.0%	-	0.307	2.25	4.8	400	540	700	3680	4340	5270		

workable, and the extra vibrators were not necessary. In subsequent projects in 1987, extra vibrators were not added to the pavers.

Four mixes were used, as shown in the bottom half of Table 2. Three of the mixes contained flyash, and the fourth did not. Twelve-hour flexural strengths in excess of 500 psi were obtained in the three cases where they were measured. These results were very encouraging and confirmed an earlier decision to go ahead with a larger project at Buena Vista County, Iowa, during summer 1986. Information from this Marshall County project was made available to the Iowa Concrete Paving Association so that potential bidders would have confidence in using this new mix.

Buena Vista County Demonstration Project

The major road project selected by the Iowa DOT for a demonstration of the Fast Track paving technique was a 7.5-mile stretch of U.S. highway 71 in Buena Vista County. The pavement was originally constructed in 1937 with integral curbs and a 20-foot-wide traveled way (10 feet in each direction). The condition of the pavement was generally sound, but it was starting to show signs of deterioration and was in need of widening to current standards. The original curbs had been removed as part of an earlier improvement project.

The new design was based on a daily traffic volume of 3070 vehicles per day, 14% of which is truck traffic. The new design, shown in Fig. 1, provided for both a new 4-inch-thick bonded overlay and the widening of the pavement from 20 feet to 24 feet. The new pavement is 9-1/2 inches thick at the widened portion of the roadway. The widened portion is held to the original pavement by #6 epoxy-coated tie-bars, spaced 2 feet apart in the edge of the original pavement.

In order to prevent the loss of moisture, curing compound must be applied immediately after paving. One and one-half times the normal rate of 1 gal/15 sq. yd was specified. To promote early strength gain by the

freshly laid concrete, the DOT specified insulating blankets with an R value of 0.5.

A regular water-reducing agent complying with ASTM C494, Type A, was specified for all mixes in order to improve workability while minimizing water demand. An air entraining agent was also specified for improved workability and increased frost resistance. At intersections with county roads and farmstead entrances where early traffic was anticipated, 1% calcium chloride was specified as an accelerator in order to obtain earlier strength gain at these critical locations (2).

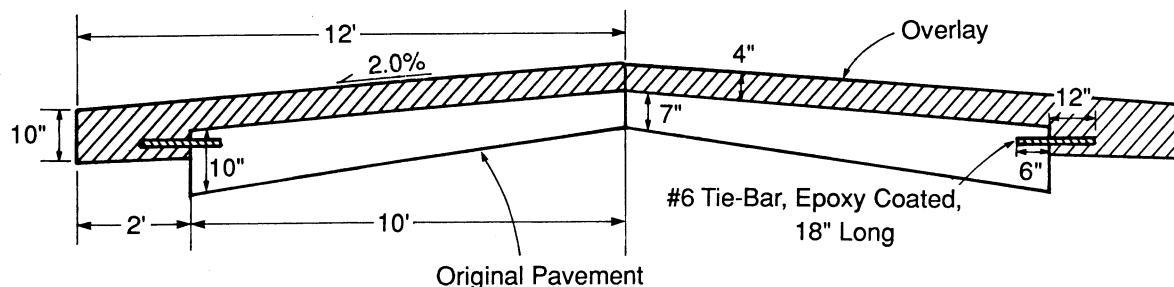
The road was closed to through traffic while the overlay construction was in progress; however, local traffic was permitted. All operations were to be confined to one traffic lane at a time, except for minor encroachment into the adjacent lane for such activities as sawing, cleaning, and placing equipment. Whenever the adjacent lane was restricted, the shoulder was required to be open so that local traffic could be routed around the site.

A special field laboratory was established by the DOT to make and test cylinders and beams and to obtain and test cores from the pavement. This permitted early testing of concrete strengths at 6, 8, 12, 18, and 24 hours. The early-strength specimens were cured in the field under the insulating blankets, immediately adjacent to the new pavement. In any particular day, 3 specimens were obtained for each of the curing times.

Project Execution

The successful bidder on the Buena Vista County project was Central Paving Corporation of Indianola, Iowa. Their bid was \$1,654,286.46, which amounts to \$110,285 per lane mile. They were also the contractor on the Marshall County project. Thus, their experience in the earlier project was instrumental in helping them prepare a realistic bid.

Figure 1. Cross section of improvements to U.S. 71, Buena Vista County (3).



Because this was an overlay, rather than new construction, certain features not common to new pavement were present. For example, prior to paving, the surface of the pavement had to be repaired and cleaned, and consideration had to be given to creating joints over the existing joints in the old pavement. Where necessary, full depth patches were made to the old pavement. Where partial depth patches would suffice, the locations were milled out as required, cleaned, and left to be filled by the overlay mix when the paver passed over the patch.

In preparing the pavement, the contractor elected to use shotblasting to provide a satisfactory surface for bonding. Asphaltic material, normally present at the joint between the pavement and the shoulder, was removed by a milling machine. After the pavement had been cleaned, a grout of Portland cement and water was sprayed on the pavement surface immediately in front of the paver. The purpose of this grout was to bond the overlay to the pavement. Some sections were not grouted so that a comparison could be made of the performance of the pavement with and without grouting.

Markers were placed beside the roadway to identify the location of transverse joints in the old pavement. Full depth sawed joints were cut in the overlay at these locations. Other transverse cracks were allowed to reflect through the overlay, to be sawed and filled later.

To prevent longitudinal cracks in the old pavement from reflecting through the overlay, workers placed #5 epoxy-coated reinforcing bars, 30 inches long, across the cracks at two-foot intervals. The centerline longitudinal joint was sawed in the overlay after paving. No attempt was made to create a new longitudinal joint in the overlay at the line where the two-foot strip of widened pavement meets the old slab. It was anticipated that the tie-bars connecting the widened pavement to the old slab (Fig. 1) would control the formation of a longitudinal joint at that location.

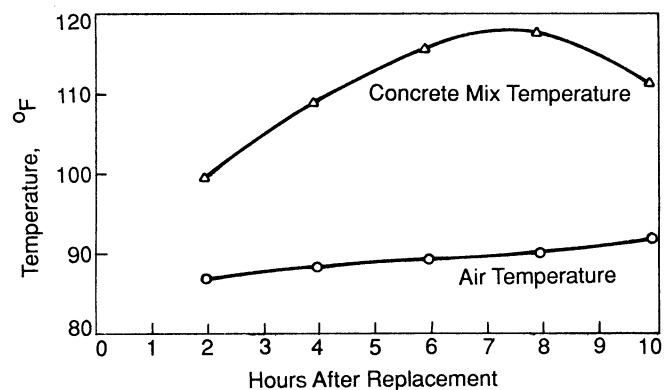
To help prevent irregular transverse cracks from reflecting through the overlay, the DOT decided to experiment with not bonding the overlay at several locations. To prevent bonding, workers laid an 8-inch width of debonding tape over cracks at three locations. After the overlay was placed, a transverse joint was sawed the full depth of the overlay along the centerline of the transverse crack below. The goal was to transform an irregular transverse crack in the old pavement into a straight sawed joint in the overlay.

The mix selected for the overlay consisted of 640 pounds of Type III cement, 70 pounds of Type C flyash, an air entraining agent to produce 6-1/2 % entrained

air, and a water-reducing agent. The slump averaged approximately 1-1/2 inches, and the water/cement ratio varied from 0.43 to 0.45. The overlay was placed in 12-foot widths by a conventional slipform paver, paving one traveled lane and the two-foot extension at the same time (4).

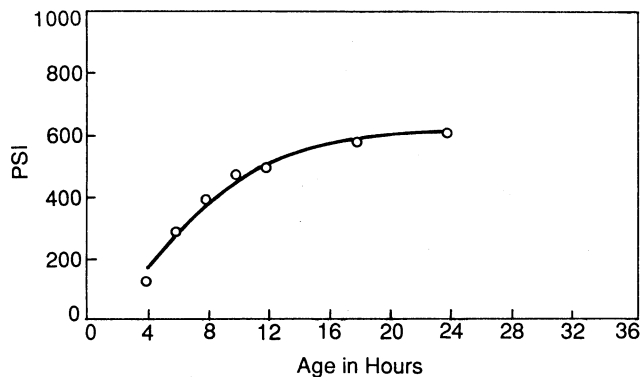
Curing compound was applied immediately after the surface was textured. Approximately 3-4 hours after application of the curing compound, joints were sawn. Immediately after the joints were sawn, the pavement was covered with insulating blankets to keep the heat of hydration in the pavement and to accelerate strength gain. The blankets were left on the overlay overnight and were removed the following morning. Figure 2 shows the temperature of the pavement during the first 10 hours after placement. These temperatures were measured by inserting thermocouples into wells that had been previously formed in the overlay. As can be seen, the temperature peaked at approximately 116° F, 7-1/2 hours after placement. The effect of this curing procedure on the strength of the concrete can be seen in Fig. 3. At 8 hours, the average flexural strength of 6 in. × 6 in. beams tested in accordance with ASTM C293, was in excess of the 350 psi necessary to sustain traffic. In 12 hours, it was 494 psi, and in 24 hours, it was 604 psi. This strength continued to improve with time. It reached 825 psi in 14 days and continued at that level to 28 days. Six-inch × 12-inch cylinder compressive strengths reached 2500 psi in 12 hours and 3500 psi in 24 hours. The compressive strength also continued to increase with time, reaching just under 6,000 psi in 28 days (4).

Figure 2. Fast Track concrete mix temperature.



With few exceptions, local traffic was accommodated during the paving operation. This was one of the original goals of the program. The conventional paver worked satisfactorily, even though one side of it encroached on the adjacent lane. An attempt was made to use a modified paver which would not encroach into

Figure 3. Flexural strength, 6-inch x 6-inch beams, center loading.



the adjacent lane, but additional improvements were necessary before it could be used.

Pavement Performance

The pavement was evaluated in May 1987, after one winter, to determine how it was performing. The evaluation consisted of visual observations, compressive and shear strength tests on cored specimens, profilometer tests, delamination tests, and deflection tests (5).

The visual examination revealed a small amount of additional transverse cracking, which would be sawed through and sealed later.

Core tests showed a continual gain in compressive strength. At 295 days, the test results, which are an average of 3 tests, showed that the specimens with no calcium chloride had reached an average compressive strength of 6160 psi and those with 1% calcium chloride had reached an average compressive strength of 6690 psi (5).

Direct shear at the bond line showed that the bond strength had decreased slightly, but was well above the minimum considered necessary for the pavement and overlay to function effectively as a unit.

Profilometer testing, using a California-type 25-foot profilometer, showed no perceptible deterioration of the ride quality in the intervening year between overlay and re-testing. Values ranged from a low of 7.5 inches per mile to a high of 20.5 inches per mile (5).

Three 1,000-foot-long sections had been selected for delamination testing. The test was performed along two lines, one on either side of the pavement centerline. Delamination occurred on a total of 41 linear feet or 0.68% of the test sections (5). Such a result is considered minor and is not a cause for concern.

Road-rater deflection tests were made before the overlay operation in June 1986. The tests were repeated in April 1987. The Iowa DOT uses an effective thickness analysis approach whereby one inch of sound concrete has been calibrated to be 0.5 structural rating numbers. Therefore, a 10-inch-thick portland cement concrete pavement would be expected to have a structural rating (SR) of 5.0. The average structural rating at mid-panel in 1986 was 3.49, and at the joints it was 3.27. In 1987 after the overlay, the average SR at mid-panel was 6.04, and at the joints it was 4.21 (5). These results show the significant improvement in the pavement structural system provided by the new overlay.

Results of the use of the 8-inch-wide strips of tape to prevent bonding at the irregular transverse cracks were very encouraging. Five of the six one-lane applications were blemish free. One had a small crack which deviated from the saw cut. These results warrant additional trials of this localized debonding procedure so that reflective transverse cracking is minimized.

Reflective cracking over longitudinal cracks was completely controlled by the use of the tie bars. None of the longitudinal cracks had reflected through the overlay.

The pavement condition and performance is considered very satisfactory. The concept of single lane construction to permit usage of the adjacent lane for public and construction traffic is considered viable. Iowa DOT professionals judge that the projected service life for this project is 20-30 years.

Additional Projects in 1987

Nine Fast Track paving projects were constructed in 1987 in Iowa. These projects totaled more than 100,000 square yards of concrete. Several of them are briefly described below (6).

A county road providing access to a grain and railroad salvage company was selected for Fast Track so that it could be re-opened in minimum time without disrupting the services. The project was 2,400 feet long and 22 feet wide. The mix, without flyash, developed beam flexural strengths of over 500 psi in 24 hours. The contractor began paving on Thursday, and the project was opened to local access, without granular shoulders, on Saturday.

One project was an industrial road providing sole access to a major retail distribution center. The project was a 7-inch PCC overlay 10,666 feet long, 22 feet wide.

Another project was the exclusive access to a residential subdivision. The road was 5,440 feet long and 22 feet wide. The contractor started paving at 7:30 one morning, and the road was opened to traffic by 5 p.m. of the following day.

Still another project involved the reconstruction of an arterial street in the town of Burlington. The length of the project was 4098 feet and the width was 49 feet. Fast Track construction was required only on the east-bound lanes of this four-lane street.

Another project was a county road that provided access to Castana, Iowa. The required detour was 25 miles, providing a strong argument for minimizing construction time. The Fast Track portion of the project was 5,170 feet long and 22 feet wide. The flexural strength of the test beams exceeded 350 psi in 12 hours and thus allowed shoulder operations to commence within 12 hours of paving.

In another project, the contractor who was paving the runway at the Osceola airport opted to use Fast Track construction to facilitate and expedite the subsequent paving operations. The new runway was 4,000 feet long and 75 feet wide. Fast Track paving was selected to be used on the center 25 feet so that paving operations could proceed on adjacent lanes without costly curing time.

These additional projects in 1987 showed that the newly developed Fast Track paving technique could be used to meet specific applications where it was necessary to open roads to traffic as early as possible or otherwise take advantage of the early strength of the concrete.

The cost differential for Fast Track concrete paving can be divided into two components: a material increment for Type III cement and an increment for furnishing, placing, and removing insulating blankets. The increment for the cement is \$5.25 per cubic yard, and the increment for the insulating blankets ranges from one to two dollars per square yard of pavement.

Conclusions and Future Directions

Although continued experimentation will be necessary to fully develop Fast Track paving, Fast Track has moved from the experimental stage to the practical stage. The Buena Vista County Project and the other projects discussed above have demonstrated that the concept is sound and that it can be implemented with existing equipment and materials.

Future improvements in Fast Track paving are probable. The advent of higher strength concretes and faster mixes will make it possible to place concrete

faster and provide access sooner. Zero-clearance pavers, which do not intrude into the adjacent lanes, are under development. As high-strength, rapid-curing concretes are used, consideration will have to be given to the development of new methods. Some methods being considered include on-site batching plants, mobile mixer trucks, and combining the use of retarders at the plant and accelerators at the job-site (7). According to Marlin Knutson, president of the American Concrete Paving Association, the ultimate goal is to open a pavement to traffic in eight hours or less (1). In the meantime, the technique is adequate to meet the needs of users who require earlier access than was previously considered practical.

Fast Track paving is an excellent example of what can be accomplished by the combined efforts of an effective government and industry team working cooperatively toward common goals.

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