Fast Track and Fast Track II, Cedar Rapids, Iowa

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Two lanes of a major four-lane arterial street in Cedar Rapids, Iowa, needed reconstruction. Because of the traffic volume and the detour problem, closure of the intersections, even for 1 day, was not feasible. Use of Fast Track concrete paving on the mainline portion of the project permitted achievement of the opening strength of 400 psi in less than 12 hr. Fast Track II, used for the intersections, achieved the opening strength of 350 psi in 6 to 7 hr. Flexural and compression specimens of two sections each in the Fast Track and Fast Track II sections were subjected to pulse velocity tests. Maturity curves were developed by monitoring the temperatures. Correlations were performed between the pulse velocity and flexural strength and between the maturity and flexural strength. The project established the feasibility of using Fast Track II to construct portland cement concrete pavement at night and opening the roadway to traffic the next day.

Experience with the first Fast Track concrete in Buena Vista County on US-71 in 1986 and on several subsequent projects has shown that Fast Track is a viable construction alternative for certain locations. Strengths for opening Fast Track pavement have always been achieved within 24 hr and often within 12 hr. Fast Track concrete is produced from a high cement factor mix incorporating a special Type III Portland cement. The construction requires only conventional equipment and techniques, except for the use of insulating blankets to contain and uniformly distribute the heat in the pavement during the early stages of curing.

Contractors and contracting authorities have begun thinking of portland cement concrete (PCC) pavement as an option for locations with critical traffic control requirements. This was the situation on a reconstruction project in an urban area in Iowa. Neither the city nor the area businesses would support closing intersections for the duration of the paving. A compromise was reached by which the intersections would be closed during the nighttime hours and be open during the day. The reconstruction was scheduled to be PCC pavement, but the intersection would require concrete that could achieve opening strength in 6 to 8 hr.

The conventional Fast Track pavement and a higher cement content concrete (Fast Track II) were subjected to laboratory tests to evaluate their early strength and temperature gain. At a rate of 822 lb of special Type III cement per cubic yard, flexural strengths exceeding 300 psi were achieved at 6 hr. On the basis of this information, the design and specifications were completed for letting.

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CONSTRUCTION PROJECT

The project was along a section of Iowa-100 located in the northern part of the city of Cedar Rapids, Iowa. The work involved replacing two westbound lanes of a 1.84-mi, four-lane urban section of road divided by a raised median. The road carries 15,400 veh/day, and 4 percent of these are trucks. The lanes to be replaced were 29 years old and of PCC construction.

The project design called for 10.5-in. plain doweled and jointed PCC pavement using 33,000 yd^2 of Fast Track mix and 1,700 yd^2 of Fast Track II mix. Figure 1 shows the project layout. Westbound traffic was to be detoured to a roadway north of the project. Closures of the intersections were restricted. Council Street, Duffy Drive, Park Lane, Rockwell Drive (Station 53+), C Avenue, Northland Avenue, and Twixt Town Road could be closed from 6:00 p.m. to 6:00 a.m. any day. Rockwell entrance (Station 68+) could be closed from 6:00 p.m. to 6:00 a.m. Monday through Thursday and from 6:00 p.m. Friday to 6:00 a.m. Monday. K-Mart entrance (Station 110+) could be closed from 10:30 p.m. to 10:30 a.m. any day. The following pairs of streets were not to be closed at the same time: Council Street and Rockwell Drive (Station 53+), Rockwell entrances (Station 68+) and C Avenue, and Northland Avenue and K-Mart entrance (Station 110+). Within 3 days after each mainline segment was completed past an intersection, the contractor was required to open that segment to traffic.

MATERIALS

The project called for the following materials:

Cement—
  Continental Type III (special—1,300 psi at 12 hr, ASTM C109)
  Lehigh Type III (special—1,300 psi at 12 hr, ASTM C109)
Fly Ash—
  Louisa Class C
Coarse Aggregate—
  Lee Crawford, Cedar Rapids (A57022)
  South Cedar Rapids, Cedar Rapids (A57018)
Fine Aggregate—
  Open Pit, Cedar Rapids (A57528)
Air-Entraining Admixture—
  Daravair, Double Strength, W. R. Grace & Co.
  Protex A.E.S., Prokrete Industries

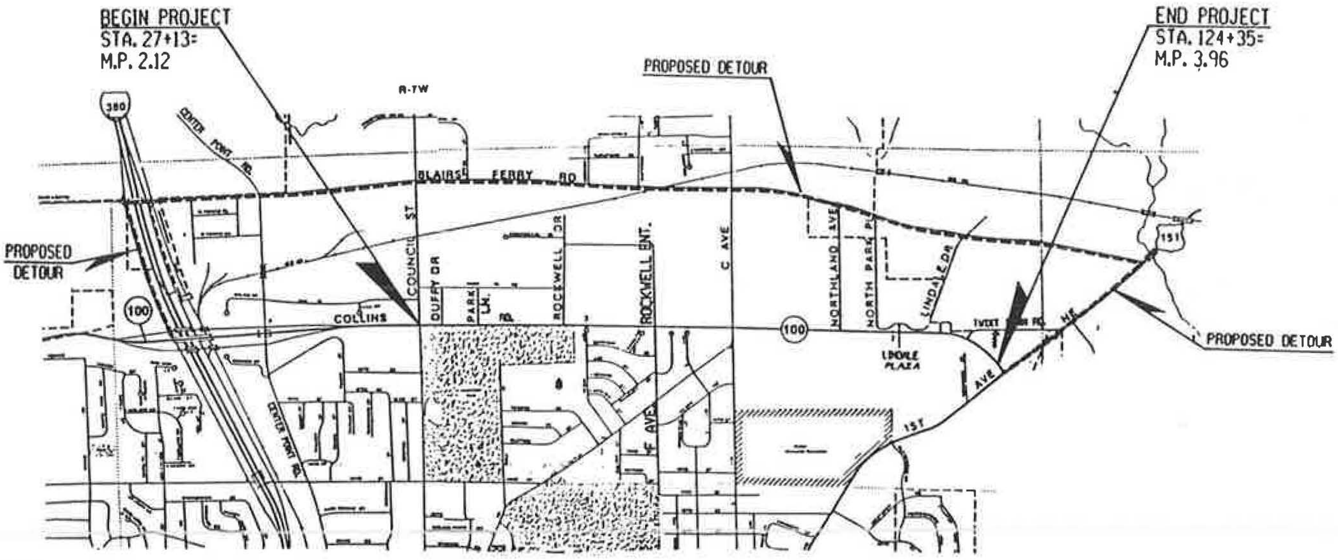

FIGURE 1 Project location.

Water-Reducing Admixtures—
WRDA-82, W. R. Grace & Co.
Pro-krete N-3, Prokrete Industries

The conventional Fast Track mix (Class F) consists of 710 lb of special Type III cement, 6 percent entrained air, 50 percent fine, and 50 percent coarse aggregate. Fast Track mix with fly ash contains 10 percent Class C fly ash substituted for Type III cement on a 1:1 weight basis. Fast Track II mix (Class FF) contains 822 lb of special Type III cement. The Fast Track II mix also permits a 10 percent fly ash substitution. The water/cement ratio for Fast Track mixes generally ranges from 0.48 to 0.40. Tables 1–3 show the Fast Track and Fast Track II concrete mix proportions, absolute volumes, and gradations used on the project.

CONSTRUCTION PROCESS

Cedar Valley Corporation of Waterloo, Iowa, was the successful bidder for this $1.9 million project. General weather conditions during paving were sunny and warm with few rainy days. The average daily high temperature was 85°F and the average daily low temperature was 61°F. Paving started on June 19, 1989, and the roadway was entirely open to traffic on June 30, 1989. The remaining work was to be finished in 3 to 4 weeks.

Paving began on the west end of the mainline. As the paving train approached the intersection, a header was placed and paving was resumed on the other side of the intersection. A Rex-TBM belt placer and a CMI-SF350 slip form paver were used to place the 26.5-ft pavement and inside curb.

Before paving in the intersections, the pavement was removed and replaced with granular base and 3 in. of asphaltic concrete for a temporary wearing surface. The contractor was able to complete the removal and replacement during the 6:00 p.m. to 6:00 a.m. closure period. The remaining work on the westbound lanes proceeded without interference to intersection traffic.

Once the mainline pavement adjacent to an intersection gained sufficient strength to allow construction traffic, the contractor was permitted to begin the intersection work. The intersection was closed to traffic at 6:00 p.m. to begin the asphalt removal. The contractor removed the 3 in. of asphalt and base and prepared the grade in 3 to 4 hr. This left 2 to 3 hr to place 50 to 79 ft of Fast Track II pavement. The

TABLE 2 BASIC ABSOLUTE VOLUME OF MATERIALS

Material	Fast Track (Class F)	Fast Track II (Class FF)
Cement	0.120	0.139
Fly ash	0.016	0.018
Fine aggregate	0.312	0.294
Coarse aggregate	0.312	0.293
Water	0.180	0.196
Air voids	0.060	0.060

TABLE 1 MIX PROPORTIONS

Mix	Cement (lb/yd³)	Fly Ash (lb/yd³)	Fine Aggregate (lb/yd³)	Coarse Aggregate (lb/yd³)	Air Entraining Admixture (oz)	Water Reducer Admixture (oz)	Mix Temperature (°F)
F	641	73	1,393	1,359	10	28.6	80
FF	742	80	1,305	1,302	11	24.8	93

TABLE 3 GRADATION PERCENT PASSING

	Aggregate Size					
	Fast Track (Class F)			Fast Track II (Class FF)		
Sieve	Coarse	Fine	Combined	Coarse	Fine	Combined
1-in.	100	–	100	100	–	100
¾-in.	88	–	94	77	–	89
½-in.	54	–	77	42	–	71
⅜-in.	20	100	60	9.6	100	55
#4	1.5	97	49	1.5	96	49
#8	1.1	89	45	0.6	88	44
#16	–	75	38	–	76	38
#30	–	45	23	–	45	23
#50	–	8.7	4.4	–	8.2	4.1
#100	–	0.8	0.4	–	1.2	0.6
#200	1.4	0.4	0.9	0.9	0.6	0.8

intersections were generally open by the 6:00 a.m. requirement. Penalties were assessed for being ½ hr late on opening two intersections and for being 3 hr late on one intersection.

No major problems were encountered in placing the Fast Track II mix, although initially maintaining the target entrained air content was a problem. Type III cement traditionally has required higher dosages of air entrainment than Type I cement. Finishers reported some difficulty in finishing the surface, although finishers on an experimental section of Fast Track II in Dubuque County had reported the mix to be easy to finish. No definite reason for this problem was determined. Some possible reasons are higher mix temperature, warmer weather, longer elapsed time between batching and finishing, or a different gradation or particle shape.

Concrete for the mainline was batched from a portable batch plant two blocks from the project. A local ready-mix plant 4 mi from the project supplied the Fast Track II concrete. Haul times were generally less than 20 min.

Both the intersections and the mainline were cured using a white pigmented curing compound, and burlene thermal blankets were placed over the pavement. At the intersections, the contractor placed the blankets within 1 hr after the section was poured. To avoid marring the surface on the mainline, placement of the blankets was usually delayed for several hours after pouring the concrete.

Joint sawing and sealing at the intersections began 4 to 5 hr after the concrete was placed. Preformed neoprene joint material was used to expedite the sealing process in the intersections. An ASTM D3405-type hot-pour material was placed on the mainline pavement.

PROJECT TESTING

The Fast Track mixes were subjected to strength testing, pulse velocity testing, and maturity testing.

Strength Testing

Both the flexural and compressive strength of the concrete were determined for two placements of Fast Track and two placements of Fast Track II. The locations and the results are presented in Table 4.

Seventy-five beams and cylinders were cast for testing. Vibrators were used for molding cylinders and beams. An external vibrator was used for 4½- × 9-in. horizontal cylinders, and an internal vibrator was used for 6- × 6- × 20-in. beams. Beams and cylinders were sprayed with curing compound and then were placed on the slab under the blankets.

Three beams and three cylinders were tested at each test time. The flexural strength of the concrete was determined using centerpoint loading. The test results are presented in Table 5 and shown graphically in Figures 2–5 both for the flexural and compression tests.

Pulse Velocity Testing

The FHWA staff has used the V-meter on active projects in several states, including Virginia, Pennsylvania, Ohio, Indi-

TABLE 4 PLACEMENT LOCATIONS AND CONCRETE TEST RESULTS

Mix	Station	Slump (in.)	Air (%)	Water/ Cement Ratio
Mainline				
Fast Track (F)	48+00	2.00	5.5	0.415
Fast Track (F)	118+75	1.75	5.0	0.411
Intersection				
Fast Track II (FF)	81+30	2.50	5.2	0.376
Fast Track II (FF)	99+80	2.25	5.2	0.382

TABLE 5 STRENGTH TEST RESULTS

Age	Average Flexural Strength[a] (psi)		Average Compressive Strength (psi)	
Fast Track (Mainline)				
	Station 48+00	Station 118+75	Station 48+00	Station 118+75
6 hr	270	150	1,680	1,500
12 hr	420	420	3,550	3,590
20 hr	460	NA	4,570	NA
24 hr	530	550	4,660	5,080
7 days	720	810	5,840	NA
14 days	790	810	NA	6,440
Fast Track II (Intersection)				
	C Avenue	Northland Avenue	C Avenue	Northland Avenue
5 hr	180	190	1,130	1,570
7 hr	360	380	3,840	3,550
9 hr	500	560	NA	4,250
12 hr	570	640	4,990	4,430
24 hr	690	840	5,260	5,230
7 days	950	940	NA	NA
14 days	1,000	1,040	7,090	7,470

NOTE: NA = Not available.
[a]Center point loading.

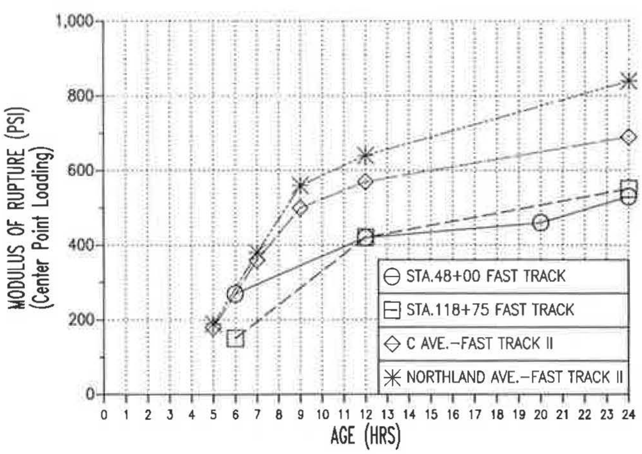

FIGURE 2 Early flexural strengths.

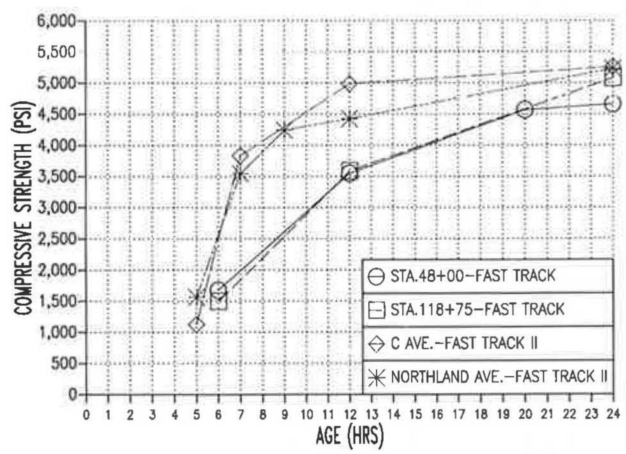

FIGURE 4 Early compressive strengths.

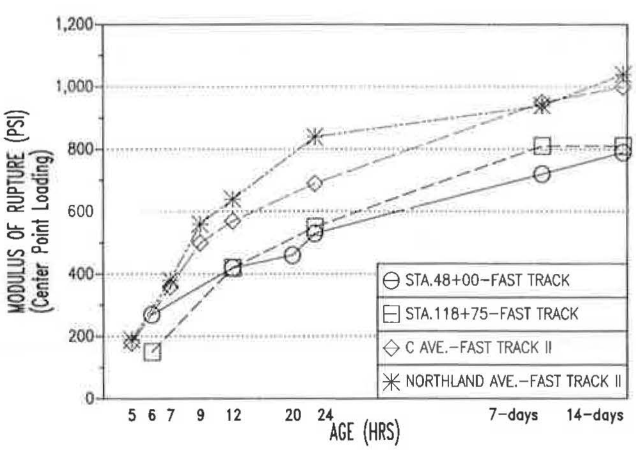

FIGURE 3 Long-term flexural strengths.

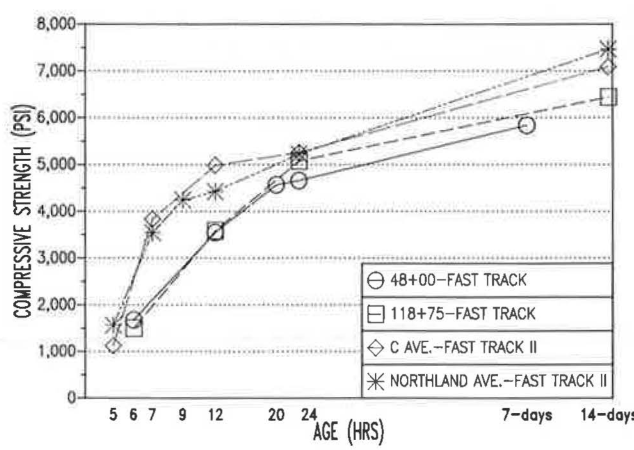

FIGURE 5 Long-term compressive strengths.

ana, Iowa, and Michigan. In general, good correlation was obtained between strength and pulse velocity, as measured by multiple correlation coefficients of ≥0.8. A unique setup for measuring pulse velocity on the pavement was established in the Cedar Rapids–Collins Road Fast Track project. The Iowa Department of Transportation designed and provided a hollow block-out device to form a hole 6 × 6 × 6 in. in the pavement after the texturing operation. The test required two holes 3 ft apart. The surface in contact with the ultrasonic transducers was smoothed out using a steel trowel. The two holes were then covered with insulating blankets. Every time a strength test was performed, ultrasonic pulse velocity measurement of the pavement was also taken. The best-fit line between the flexural strength and pavement pulse velocity is shown in Figure 6.

Maturity Testing

Maturity is defined as the accumulated product of the time and temperature. The precast/prefabricated concrete industry has widely used maturity-strength curves. Several commercial products are available that record temperatures on a continual basis. All use a temperature-measuring probe and a triggering time clock. Information is stored in a microchip board and can be retrieved after the test. The test for maturity is covered by ASTM C1074-87.

In the Cedar Rapids–Collins Road Fast Track project, the test locations in the pavement and field-cured test specimens were monitored by an M-meter. The following locations were monitored with the temperature probe thermocouples:

- At center slab—0.5 in. from top, 0.5 in. from bottom, and middepth;
- One foot from edge of slab—same locations as at center slab;
- In air; and
- At test specimens—4½-in.-diameter cylinder and 6- × 6- × 20-in. beam.

Figures 7 and 8 show the time-temperature data for one Fast Track section and one Fast Track II section, respectively.

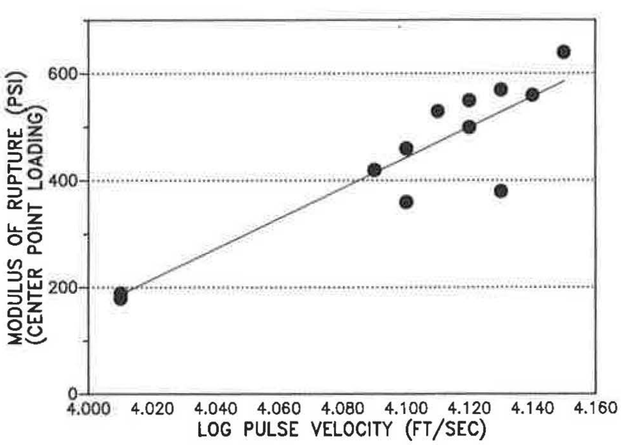

FIGURE 6 Pulse velocity versus flexural strength.

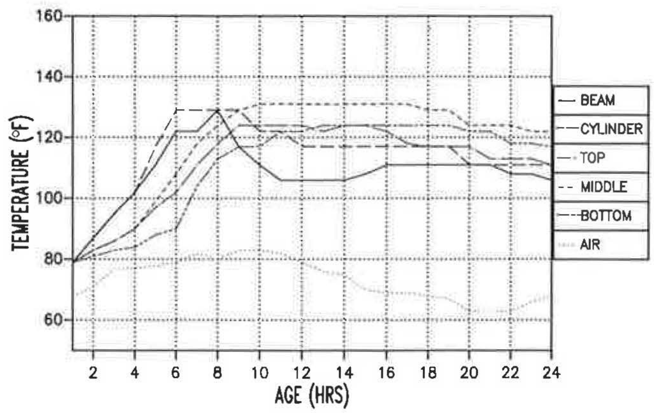

FIGURE 7 Fast track temperatures, Mainline Station 118+75.

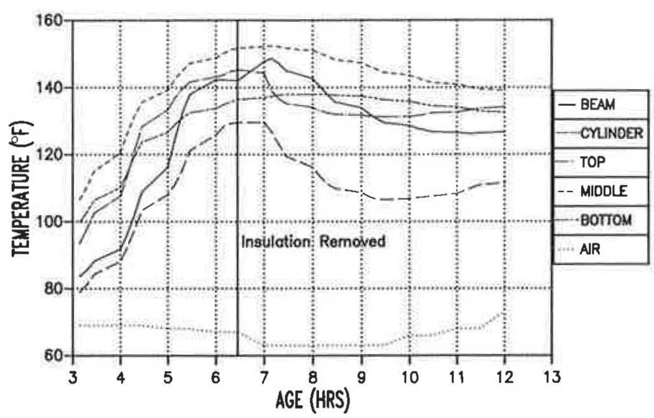

FIGURE 8 Fast Track II temperatures, C Avenue intersection.

The data were used to measure the correlation between maturity and flexural strength (integration of time-temperature plot using the Nurse-Saul equation). These correlations are shown in Figure 9.

RESULTS

The various tests and procedures that were carried out produced several results that have implications for determining when pavement may be opened to traffic.

Strength

The two Fast Track sections exhibited similar strength gains. The flexural tests resulted in nearly identical strengths at 12 hr, 24 hr, and 14 days. The compression tests were nearly identical for the first 20 hr. This consistency is an important verification of the results.

In less than 12 hr, both mainline test sections reached the 400-psi flexural strength required for opening. They reached 500 psi, the opening strength required for conventional paving, in less than 24 hr. The results of these tests, shown in Figures 2 and 3, are similar to other Fast Track projects constructed in Iowa in the past 3 years.

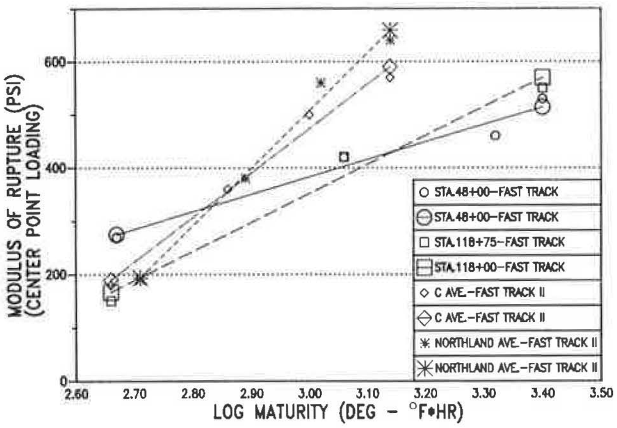

FIGURE 9 Maturity versus flexural strength.

The two Fast Track II test sections exhibited some variation, not only between the two intersections, but also between the flexural and compression test results. The differences do not suggest unusual problems or specific trends. Construction variations would likely account for the differences. Northland Avenue exhibited a continual increase in the rate of flexural strength gain when compared to C Avenue throughout the first 24 hr. At 7 days, however, the tests from the two sections showed virtually the same flexural strength.

The flexural strengths at both intersections were nearly identical for the first 7 hr. By that age, both intersections exceeded the 350-psi flexural opening strength requirement, even though both had strengths of less than 200 psi at 5 hr. The goal of this mix was achieving 350 psi in 6 hr. In both test sections, that strength was reached in less than 7 hr, but it required more than 6 hr. These results closely matched research the Iowa Department of Transportation conducted with the Fast Track II mix in Dubuque County, Iowa, in October 1988. This test took place under very different weather conditions and with different materials than in the Cedar Rapids–Collins Road project. Because all three test sections reached opening strength between 6 and 7 hr, achieving these results in future projects appears likely.

The compression tests gave impressive results. The cylinders gained considerable strength in 5 to 7 hr. The compressive strength went from about 1,500 psi to more than 3,500 psi in that 2-hr period. Although the rate of gain then began to decline, compressive strength still reached almost 4,500 psi at Northland Avenue and about 5,000 psi at C Avenue in 12 hr. The rate of flexural strength gain at these early ages was slower than that for compressive strength. The rapid rate of strength gain began to decrease at approximately 7 hr, according to the compression tests, but the rate of gain in flexural strength did not decrease until 9 hr.

Pulse Velocity

Figure 6 shows the relationship between the pulse velocity and the flexural strength. This integration yielded R^2 values of 0.88. Pulse velocity has potential for this type of application. The difficulty comes in trying to establish vertical surfaces from which to take measurements. Because materials change from project to project, application of the pulse velocity test will probably be limited to larger projects. Those projects involving a large quantity of concrete will justify the initial correlation effort.

Maturity

The temperature-age plots for one of the Fast Track mainline test sections are shown in Figure 7. The maturity of the pavement was only slightly higher than that of the flexural beams at the 12-hr test.

Compression tests were performed on the cylinders. The maturity of the cylinders differed between the two test sections. At Station 48 + 00, the cylinder reached a higher maturity than the slab at 12 hr, except at Station 118 + 75, in which the maturity of the cylinder was lower than that of the slab. The cause is certainly a result of the sun's heating up the small specimen at the first section. This research suggests that the flexural beams give a strength reading that more closely represents the actual concrete in the pavement than do cylinders.

For Fast Track II, the temperature-time plots are shown in Figure 8. The maturity of the concrete in the two Fast Track II test sections was more consistent than in the Fast Track sections. The temperatures in the pavement of the Fast Track II and the test specimens were more consistent in the Fast Track sections. The sun's shining on the specimens during the day caused them to become warmer than the slab on the Fast Track sections. This warming effect was not a factor in the nighttime Fast Track II tests. The flexural beams and cylinders exhibited consistently less maturity than the pavement slab. Apparently, a margin of safety exists between the strength the test specimens indicate and that of the actual pavement. The strength in the pavement is in fact higher than the test results show.

Figure 9 is a plot of the maturity-flexural strength results. The figure shows the best-fit lines for the test data and represents predictive models that have R^2 values >0.8.

Maturity testing for opening time has potential for Fast Track paving. Future maturity evaluations on Fast Track may prove the viability of maturity testing instead of flexural beams to determine opening time.

CONCLUSIONS

The results of the Cedar Rapids project imply the following conclusions:

1. Fast Track and Fast Track II can be placed with conventional paving procedures and equipment.
2. Fast Track II will achieve a 350-psi flexural strength for opening to traffic in less than 7 hr.
3. Fast Track will achieve a 400-psi flexural strength for opening to traffic in less than 12 hr.
4. Fast Track II will require higher than normal amounts of air-entraining agent to obtain desired entrained air. The high cement factor mix may require more effort to float and finish.
5. Construction staging and restrictions required for the project were achievable. The system is applicable for certain future projects.

RECOMMENDATIONS

1. This project should be evaluated for performance after 5 years of service. Cracking, smoothness, and friction properties should be summarized.
2. Study should continue on the occasional problem of finishing Fast Track II concrete.
3. Further evaluation of the maturity concept should be performed on future Fast Track projects.

ACKNOWLEDGMENTS

The evaluation portion of the research was partially funded by the FHWA under Special Project 201, "Accelerated Rigid Paving Techniques." The authors wish to extend appreciation to the District 6 Materials staff and the Cedar Rapids Construction Residency staff for performing the additional testing this project required. The commitment by the FHWA of their mobile concrete laboratory and personnel contributed to the success of the research and was greatly appreciated. The authors also want to thank Cedar Valley Corporation for its cooperation during the project.

Publication of this paper sponsored by Committee on Rigid Pavement Construction and Rehabilitation.