FAST TRACK AND FAST TRACK II CEDAR RAPIDS, IOWA

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FAST TRACK AND FAST TRACK II
CEDAR RAPIDS, IOWA

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8. ABSTRACT

Two lanes of a major four lane arterial street needed to be reconstructed in Cedar Rapids, Iowa. The traffic volumes and difficulty of detouring the traffic necessitated closure for construction be held to an absolute minimum. Closure of the intersections, even for one day, was not politically feasible. Therefore, Fast Track and Fast Track II was specified for the project.

Fast Track concrete paving has been used successfully in Iowa since 1986. The mainline portion of the project was specified to be Fast Track and achieved the opening strength of 400 psi in less than twelve hours.

The intersections were allowed to be closed between 6 PM and 6 AM. This could occur twice - once to remove the old pavement and place the base and temporary surface and the second time to pave and cure the new concrete. The contractor was able to meet these restrictions. The Fast Track II used in the intersections achieved the opening strength of 350 psi in six to seven hours.

Two test sections were selected in the mainline Fast Track and two intersections were chosen to test the Fast Tract II. Both flexural and compression specimens were tested. Pulse velocity tests were conducted on the pavement and test specimens. Maturity curves were developed through monitoring of the temperatures. Correlations were performed between the maturity and pulse velocity and the flexural strengths. The project was successful in establishing the feasibility of construction at night, with no disruption of traffic in the daytime, using Fast Track II. Both the Fast Track II pavements were performing well four years after construction.

9. KEY WORDS

Portland cement concrete
Fast track concrete
Rapid set concrete, early opening

10. NO. OF PAGES

30

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DISCLAIMER

INTRODUCTION

Experience with the first Fast Track concrete in Buena Vista County on US 71 in 1986 and in several additional projects constructed since has shown that Fast Track is a viable construction alternative for certain locations. Strengths for opening Fast Track pavement have always been achieved in less than 24 hours and often in less than 12 hours. The construction is performed using conventional equipment and techniques. The one new technique is the use of insulating blankets to contain and uniformly distribute the heat of hydration in the pavement during the early stages of curing.

Both 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 in an urban area on a reconstruction project in Iowa. Neither the city nor the area businesses would support closing intersections for the duration of the paving. A compromise was reached where the intersections would be closed during the nighttime hours and be open during the day. The reconstruction was scheduled to be PCC pavement. The question became, "could the pavement be conventional PC concrete in the intersections?" This would require concrete that could achieve opening strength in about 6 to 8 hours.

Testing was performed in the laboratory using the Fast Track concept and higher cement content concrete. At a rate of 822 pounds of special Type III cement per cubic yard, flexural strengths of above 300 psi were achieved at 6 hours. With the laboratory information, the design and specifications were completed for letting.

OBJECTIVE

The objective of the research was to evaluate the early strength and temperature gain of both conventional Fast Track and the new Fast Track II mixes.

PROJECT DESCRIPTION

The project is a section of Iowa Highway 100 located in the northern part of the city of Cedar Rapids, Iowa. The work involved replacing 2 lanes of a 1.84 mile, 4-lane urban section divided by a raised median. A 10.5 inch plain dowelled and jointed PCC pavement was designed to replace the 29 year old PCC westbound lanes. The project involved 33,000 sq. yds. of Fast Track mix and 1700 sq. yds. of Fast Track II mix. Figure 1 is the layout of the intersections. Restrictions on closures of the intersections are given: Council Street, Duffy Drive, Park Lane, Rockwell Drive (Sta. 53+), Rockwell entrance (Sta. 68+), C Avenue, Northland Avenue, and Twixt Town Road could be closed from 6:00 p.m. to 6:00 a.m. any day. K-Mart entrance (Sta. 110+) could be closed from 10:30 p.m. to 10:30 a.m. any day. In addition, the following restrictions were specified: Council Street and Rockwell Drive (Sta. 53+) shall not be closed at the same time. Rockwell entrances (Sta. 68+) and C Avenue shall not be closed at the same time. Northland Avenue and K-Mart entrance (Sta. 110+) shall not be closed at the same time. Note that Rockwell entrance (Sta. 68+) may be closed from 6:00 p.m. Friday to 6:00 a.m. Monday.

Current traffic on the road is 15,400 vehicles per day with 4 percent trucks. Westbound traffic was detoured to a roadway north of the project. Within three days after each mainline segment was completed past an intersection, the contractor was required to open that segment to traffic.

MATERIALS

The following materials were used:

Cement - Continental Type III (special - 1300 psi at 12 hrs. ASTM C109)

Lehigh Type III (special - 1300 psi at 12 hrs. 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

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

The conventional Fast Track mix (Class F) consisted of 710 pounds 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 fly ash substituted for Type III cement on a 1:1 weight basis. Fast Track II mix (Class FF) contains 822 pounds 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 varies from .48 to .40. Refer to Tables 1, 2 & 3 for Fast Track and Fast Track II concrete mix proportions, absolute volumes and gradations used on the project.

CONSTRUCTION

Cedar Valley Corporation of Waterloo, Iowa was the successful bidder for this 1.9 million dollar 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 on the project started on June 19, 1989. The roadway was entirely open to traffic on June 30, 1989 with the remaining work to be finished in three to four weeks.

Prior to paving, the pavement in the intersections was removed and replaced with granular base and 3 inches of asphaltic concrete for a temporary wearing surface. The contractor was able to complete the removal and replacement during the 6 p.m. to

6 a.m. closure period. The remaining work on the westbound lanes proceeded without interference to intersection traffic.

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 slipform paver were used to place the 26.5 foot pavement and inside curb.

Once the mainline pavement around 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 inches of asphalt and base and prepared the grade in 3 to 4 hours. This left 2 to 3 hours to place 50 to 79 feet of Fast Track II pavement.

No major problems were encountered in placing the Fast Track II mix. Some initial difficulty was encountered in maintaining the target entrained air content. Type III cement traditionally has required higher dosages of air entrainment than Type I cement. Finishers reported some difficulty in finishing the surface. This was somewhat surprising since finishers on the experimental section of Fast Track II in Dubuque County reported the mix to be very easy to finish.

Concrete for the mainline was batched from a portable batch plant two blocks from the project. The Fast Track II concrete was supplied by a local ready mix four miles from the project. Haul times were generally less than 20 minutes.

Both the intersections and the mainline were cured using a white pigmented curing compound. Burlene thermal blankets were also placed over the pavement. At the intersections, the contractor placed the blankets within an hour after the section was poured on the mainline, placement of the blankets were usually delayed for several hours after placement of the concrete.

Joint sawing and sealing at the intersection began about four to five hours 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 joint seal material was placed on the mainline pavement.

PROJECT TESTING

Testing to evaluate the Fast Track mixes consisted of 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 of placement and the results are listed 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" x 9" horizontal cylinders and an internal vibrator was used for 6" x 6" x 20" 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 center point loading. The test results are listed in Table 5 and shown in Figures 2, 3, 4 and 5 for both the flexural tests and the compression tests. In Table 5 a dash (---) is used for data that is not available.

Pulse Velocity Testing

The V-meter has been used by the FHWA staff on active projects in several states, including Virginia, Pennsylvania, Ohio, Indiana, Iowa, Michigan. In general, good correlation was obtained between strength and pulse velocity as measured by multiple correlation coefficients of not less than 0.8. A unique set-up for measuring pulse velocity on the pavement was established in the Cedar Rapids-Collins Road Fast Track project. A hollow block out device was designed and provided by Iowa Department of Transportation to form a hole 6" x 6" x 6" in the pavement after the texturing operation. Two holes three feet apart were required to perform the test. 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. A best fit line between the flexural strength and pavement pulse velocity measurement of the pavement was also taken. A best fit line between the flexural strength and pavement pulse velocity is developed and presented in Figure 6.

Maturity Testing

Maturity is defined as the accumulated product of the time and temperature. Maturity-strength curves have been widely used in the precast/prefabricated concrete industry with much success. Several commercial products are available in the marketplace which record temperatures on a continual basis. All utilize a temperature measuring probe and a triggering time clock. Information is stored in a micro-chip board and can be retrieved at any later time. 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 positions for the temperature probe thermocouples were monitored:

- At center slab - 0.5 inch from top, 0.5 inch from bottom, and mid-depth

- One foot from edge of slab - same as at center slab
- Air
- Test Specimens - 4½ inch diameter cylinder and 6" x 6" x 20" beam

Figures 7 and 8 present the time/temperature data for the above positions in one Fast Track section and one Fast Track II section, respectively. A maturity versus flexural strength correlation was developed from the data (integration of time/temperature plot using the Nurse-saul equation).

The correlations are presented in Figure 9.

DISCUSSION OF RESULTS

The results of the various tests and procedures are discussed below.

Strength Results

Fast Track: The two Fast Track sections exhibited strength gains which were similar. The flexural tests resulted in virtually identical strengths at twelve hours, twenty-four hours, and fourteen days. The compression tests were virtually identical for the first twenty hours. This consistency is an important verification of the results.

Both mainline test sections reached the 400 psi flexural strength required for opening in less than twelve hours. Also, they reached 500 psi, the opening strength required for conventional paving, in less than twenty-four hours. The results of these tests are shown in Figures 2 and 3 and are very similar to other Fast Track projects constructed in Iowa in the past three years.

Fast Track II: The two 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 twenty-four hours. But, at seven days, the tests from the two sections showed virtually the same flexural strength.

The flexural strengths at both intersections were virtually identical for the first seven hours. Both intersections exceeded the 350 psi flexural opening strength requirement by that age, even though both had strengths less than 200 psi at five hours. The goal of this mix was achieving 350 psi in six hours. In both test sections, that strength was reached in less than seven hours but more than six hours. These results closely matched research conducted by the Iowa Department of Transportation in October 1988 with the Fast Track II mix in Dubuque County, Iowa. The previous work was conducted under very different weather conditions and with different materials. With all three test sections reaching opening strength between six and seven hours, some degree of confidence can be placed in achieving these results in future projects.

The compression tests gave very impressive results. The cylinders gained considerable strength between five and seven hours. The compressive strength went from around 1500 psi to over 3500 psi in that two hour period. The rate then began to slow, but still achieved almost 4500 psi at Northland Avenue and approximately 5000 psi at C Avenue in twelve hours. A comparison between the flexural strength and the compressive strength is interesting to note. The rate of strength gain was not the same at these very early ages. The rapid strength gain began to decrease at approximately seven hours as represented by the compression tests but the flexural strength did not exhibit this decrease until an age of nine hours.

Pulse Velocity Results

Figure 6 shows the relationship between the pulse velocity and the flexural strength and compressive strength, respectively. This integration yielded R-squares of 0.88.

Maturity Results

Fast Track: The temperature versus age plots are shown in Figure 7 for one of the Fast Track mainline test sections. Maturities were determined at the two locations being monitored and indicate that the test beams exhibit a maturity which is within the range of maturities within the slab.

Compression tests were performed on the cylinders. The maturity of the cylinders varied between the two test sections. At Station 48+00 the cylinder had a higher maturity than the slab at this age but at Station 118+75, the maturity was lower than the slab. The cause is certainly a result of the sun heating up the small specimen at the first section. This research would suggest that in terms of the test specimens representing the actual concrete in the pavement, the flexural beams give a strength which represents the pavement more closely than cylinders.

Fast Track II: The temperature versus time plots are shown in Figure 8. The maturity exhibited by the locations monitored in the two Fast Track II test sections was more consistent than those in the Fast Track sections. The temperatures in the pavement and the test specimens were rather consistent when compared to the Fast Track sections. The affect of the sun on the specimens was eliminated with this night work. The flexural beams and cylinders exhibited maturity consistently less than the pavement slab. This would indicate that a margin of safety exists between the strength indicated by the test specimens and that of the actual pavement. The strength in the pavement is in fact higher than what the test result would show.

Figure 9 is a plot of the maturity versus the flexural strength results. The figure illustrates the best fit lines of our test data and represent predictive models which have R-square values greater than 0.8.

Visual Evaluation

A visual review of the project was completed on November 1, 1993. The Fast Track and Fast Track II are both performing very well. There were only 17 corner cracks at the joints which is only approximately 3 percent of all joints. There were only eleven transverse cracks which is a little over one crack to every 1000 ft. No other visible signs of deterioration were apparent. It appears this Fast Track project is performing as well as a project of the same age using normal paving mixes.

SUMMARY AND CONCLUSIONS

Based on the results of this project, the following is concluded:

1. Fast Track and Fast Track II can be placed with conventional paving procedures and equipment.

2. Fast Track II achieved a 350 psi flexural strength for opening in less than seven hours.

3. Fast Track achieved a 400 psi flexural strength for opening to traffic in less than 12 hours.

4. Fast Track II will require higher amounts than normal 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 may be applicable for certain future projects.

6. This Fast Track project appears to be performing as adequately as any paving project using a conventional mix would after four years of service.

ACKNOWLEDGEMENT

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The authors wish to extend appreciation to the District 6 Materials staff and the Cedar Rapids Construction Residency staff for their efforts in performing the additional testing required by the project. The commitment by the FHWA of their mobile concrete laboratory and personnel contributed to the success of the research and was greatly appreciated. We also want to thank Cedar Valley Corporation for their cooperation during the project.

TABLE TITLES

TABLE 1
MIX PROPORTIONS

Mix	Cement lb. per cu. yd.	Fly Ash lb. per cu. yd.	Fine Aggregate lb. per cu. yd.	Coarse Aggregate lb. per cu. yd.	Air Entr. Admix. oz.	Water Reducer Admix. oz.	Mix Temp. (°F)
F	641	73	1393	1359	10	28.6	80
FF	742	80	1305	1302	11	24.8	93

TABLE 3
GRADATION PERCENT PASSING

Sieve	Fast Track (Class F) Coarse Agg.	Fast Track (Class F) Fine Agg.	Fast Track (Class F) Combined	Fast Track II (Class FF) Coarse Agg.	Fast Track II (Class FF) Fine Agg.	Fast Track II (Class FF) Combined
1"	100		100	100		100
3/4"	88		94	77		89
1/2"	54		77	42		71
3/8"	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

TABLE 2
BASIC ABSOLUTE VOLUME OF MATERIALS

	Fast Track (Class F)	Fast Track II (Class FF)
Cement	.120	.139
Fly Ash	.016	.018
Fine Aggregate	.312	.294
Coarse Aggregate	.312	.293
Water	.180	.196
Air Voids	.060	.060

TABLE 4
PLACEMENT LOCATIONS AND CONCRETE TEST RESULTS

MIX	STATION	SLUMP IN.	AIR %	W/C RATIO
MAINLINE				
Fast Track (F)	48+00	2.00	5.5	.415
Fast Track (F)	118+75	1.75	5.0	.411
INTERSECTION				
Fast Track II (FF)	81+30	2.50	5.2	.376
Fast Track II (FF)	99+80	2.25	5.2	.382

TABLE 5
STRENGTH TEST RESULTS

FAST TRACK (MAINLINE)

AGE	Average Flexural Strength (PSI) (Center Point Loading) STA. 48+00	STA. 118+75	Average Compressive Strength (PSI) STA. 48+00	STA. 118+75
6 hour	270	150	1680	1500
12 hour	420	420	3550	3590
20 hour	460	---	4570	----
24 hour	530	550	4660	5080
7 day	720	810	5840	----
14 day	790	810	----	6440

FAST TRACK II (INTERSECTION)

AGE	Average Flexural Strength (PSI) (Center Point Loading) C Avenue	Northland Ave.	Average Compressive Strength (PSI) C Avenue	Northland Ave.
5 hour	180	190	1130	1570
7 hour	360	380	3840	3550
9 hour	500	560	----	4250
12 hour	570	640	4990	4430
24 hour	690	840	5260	5230
7 day	950	940	----	----
14 day	1000	1040	7090	7470

NOTE: Unavailable data are indicated with a dash (----).

FIGURE CAPTIONS

FIGURE 1

PROJECT LOCATION

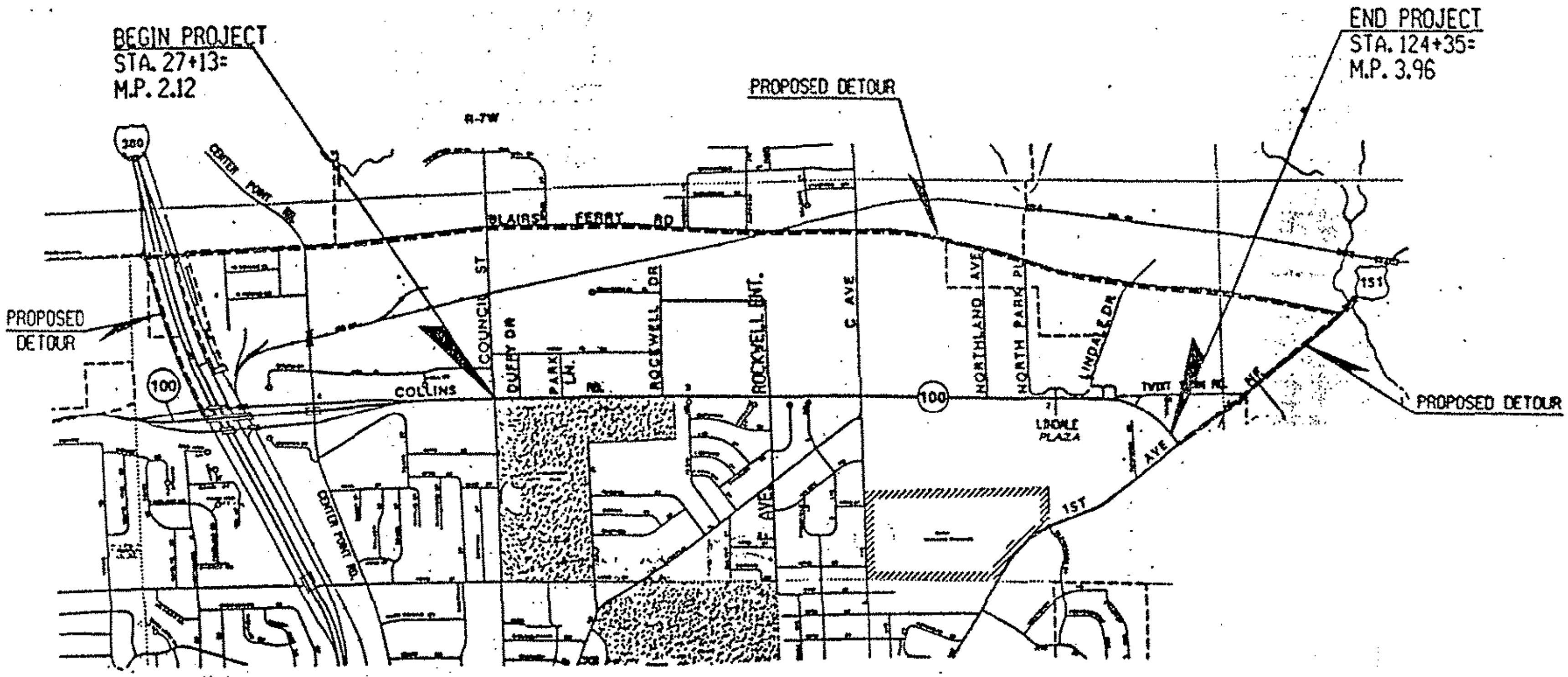

FIGURE 2
EARLY FLEXURAL STRENGTHS

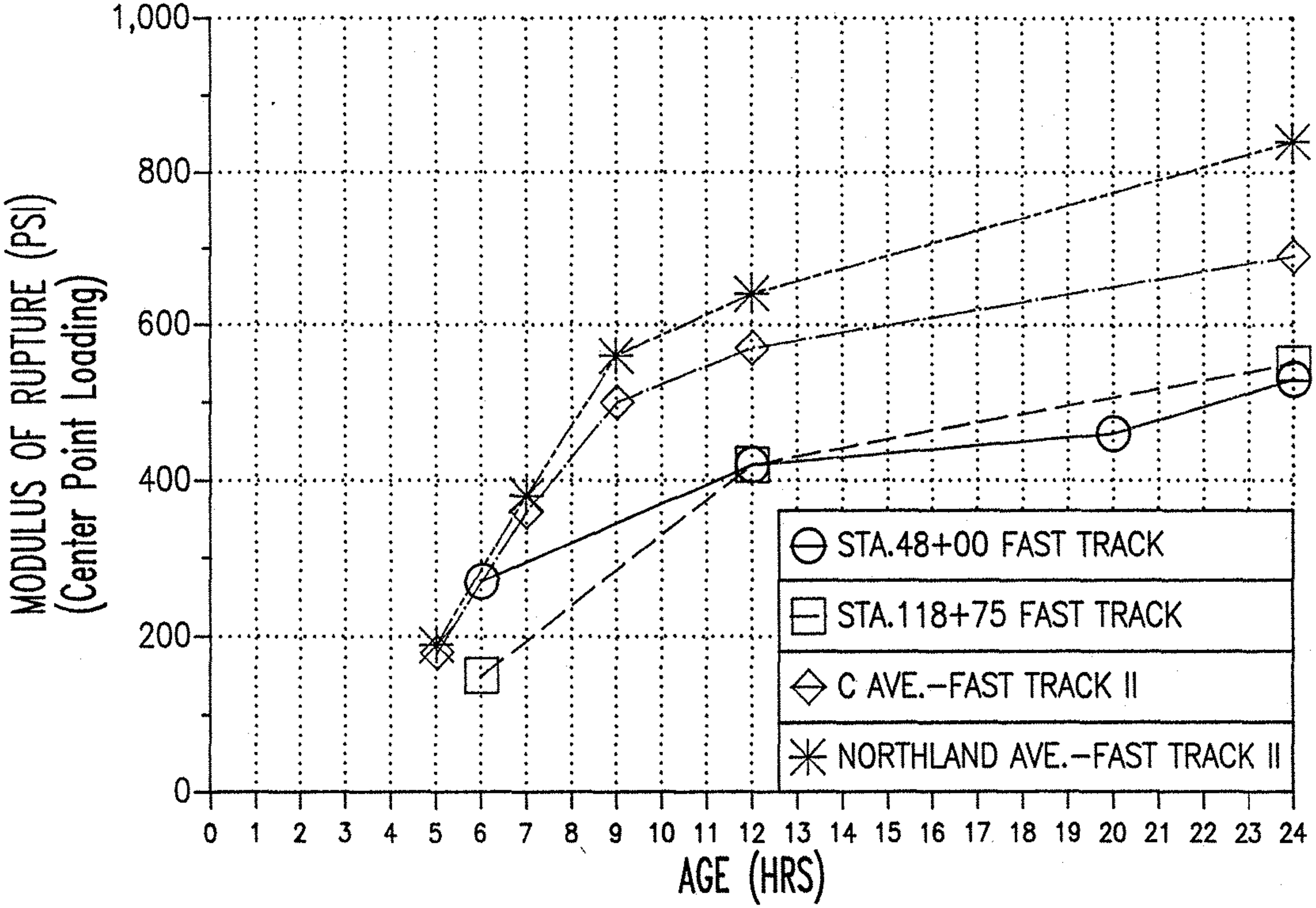

FIGURE 3
LONG TERM FLEXURAL STRENGTHS

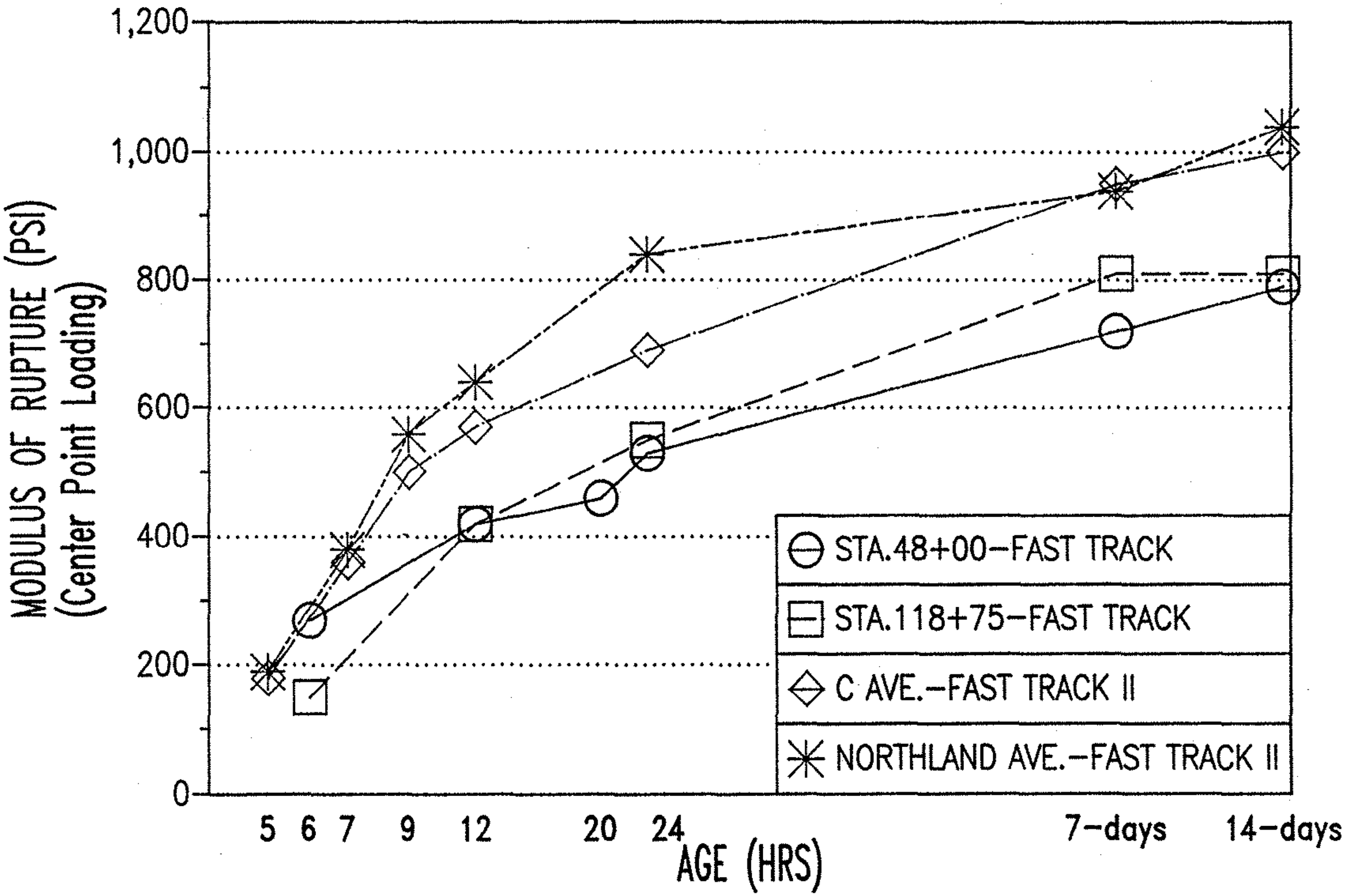

FIGURE 4
EARLY COMPRESSIVE STRENGTHS

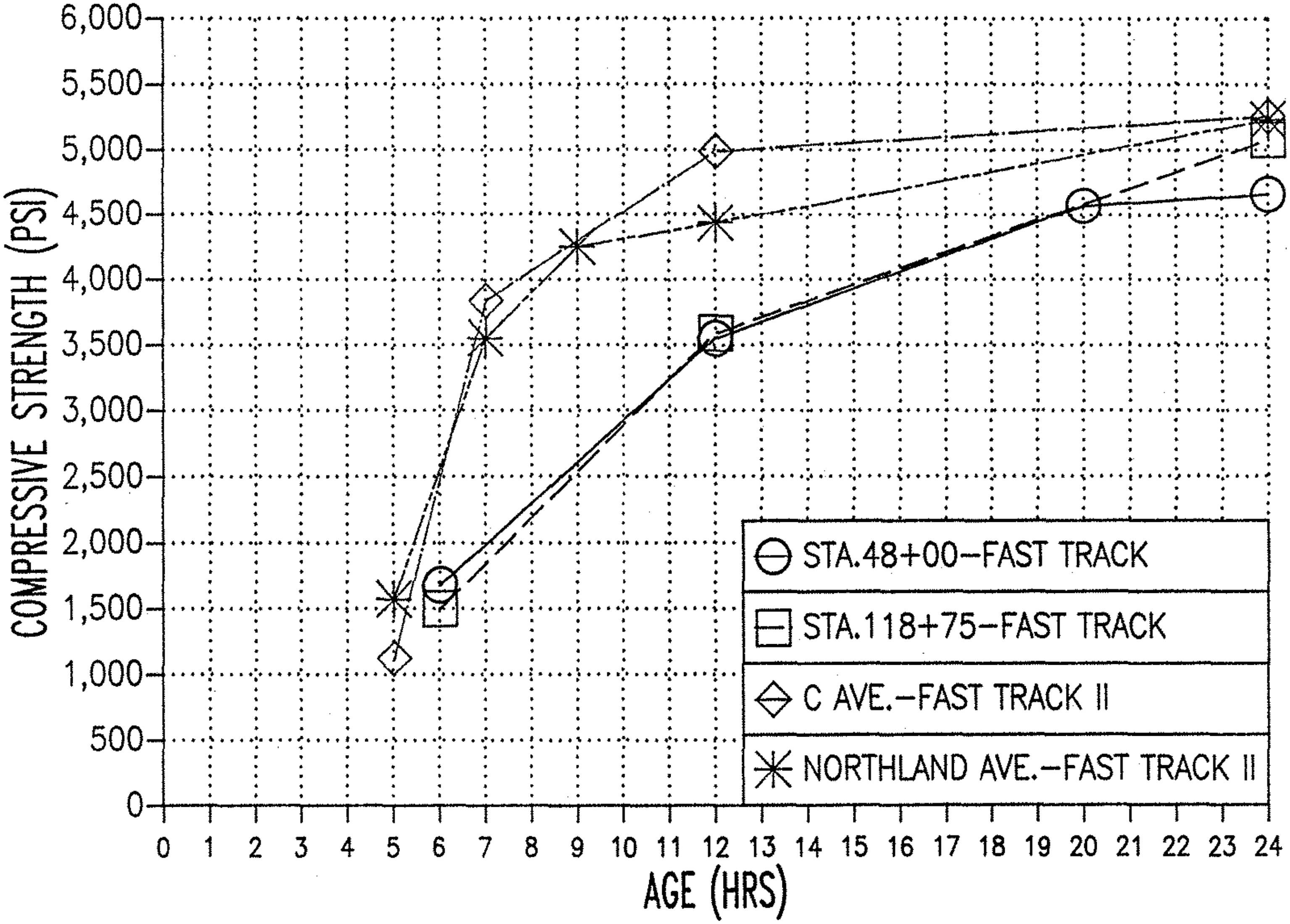

FIGURE 5
LONG TERM COMPRESSIVE STRENGTHS

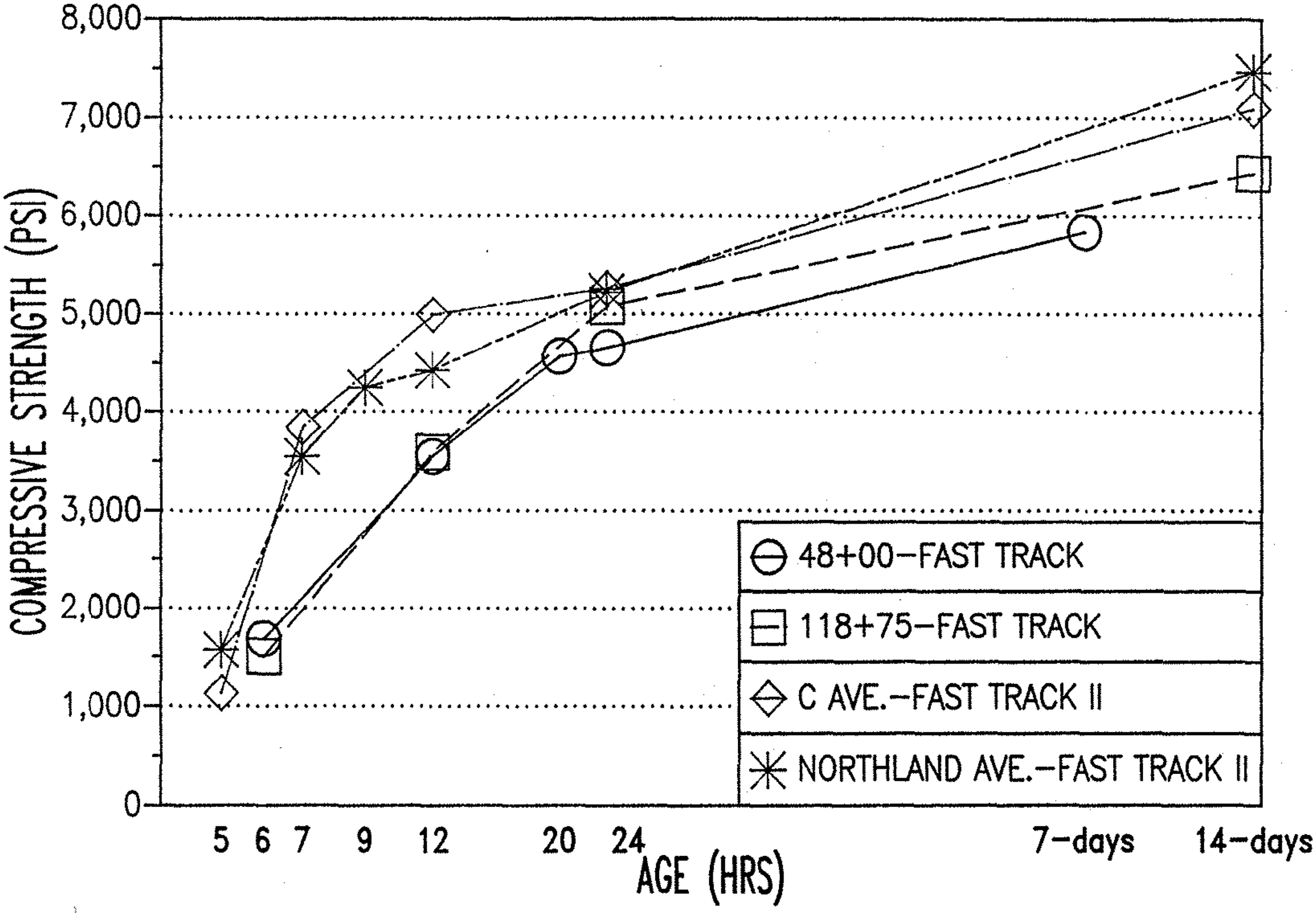

FIGURE 6
PULSE VELOCITY VS. FLEXURAL STRENGTH

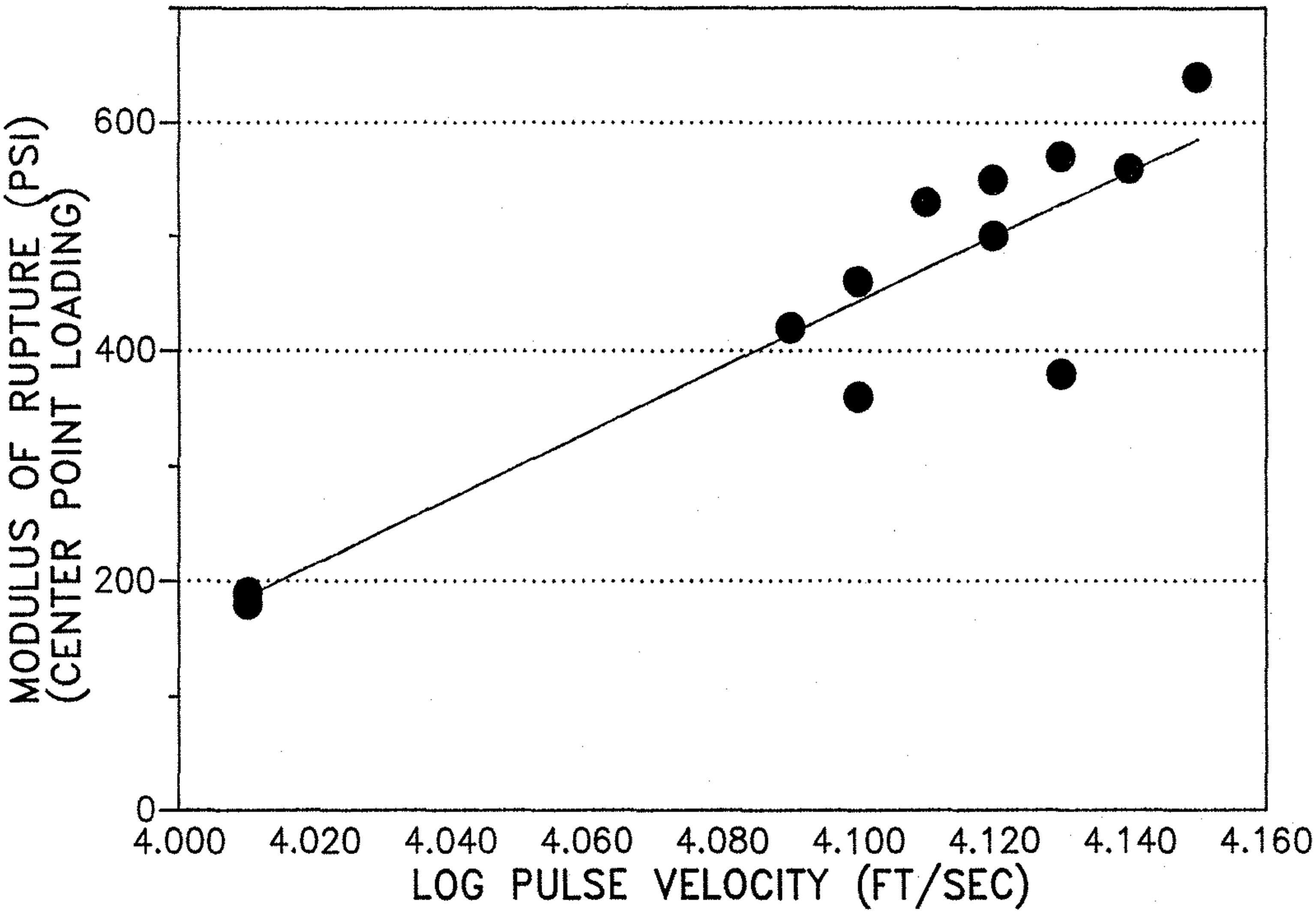

FIGURE 7
FAST TRACK TEMPERATURES
MAINLINE STA. 118+75

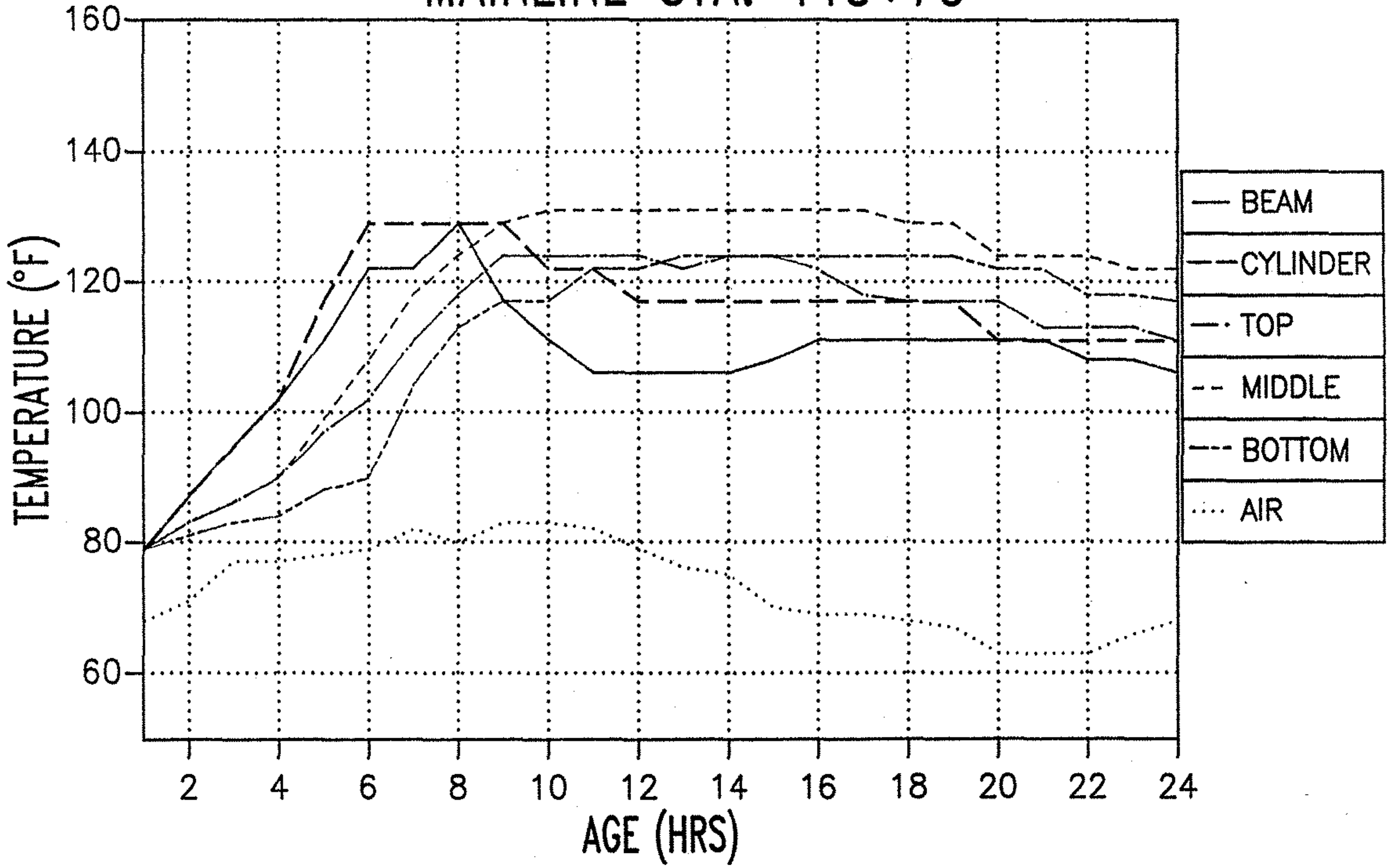

FIGURE 8
FAST TRACK II TEMPERATURES
C AVE. INTERSECTION

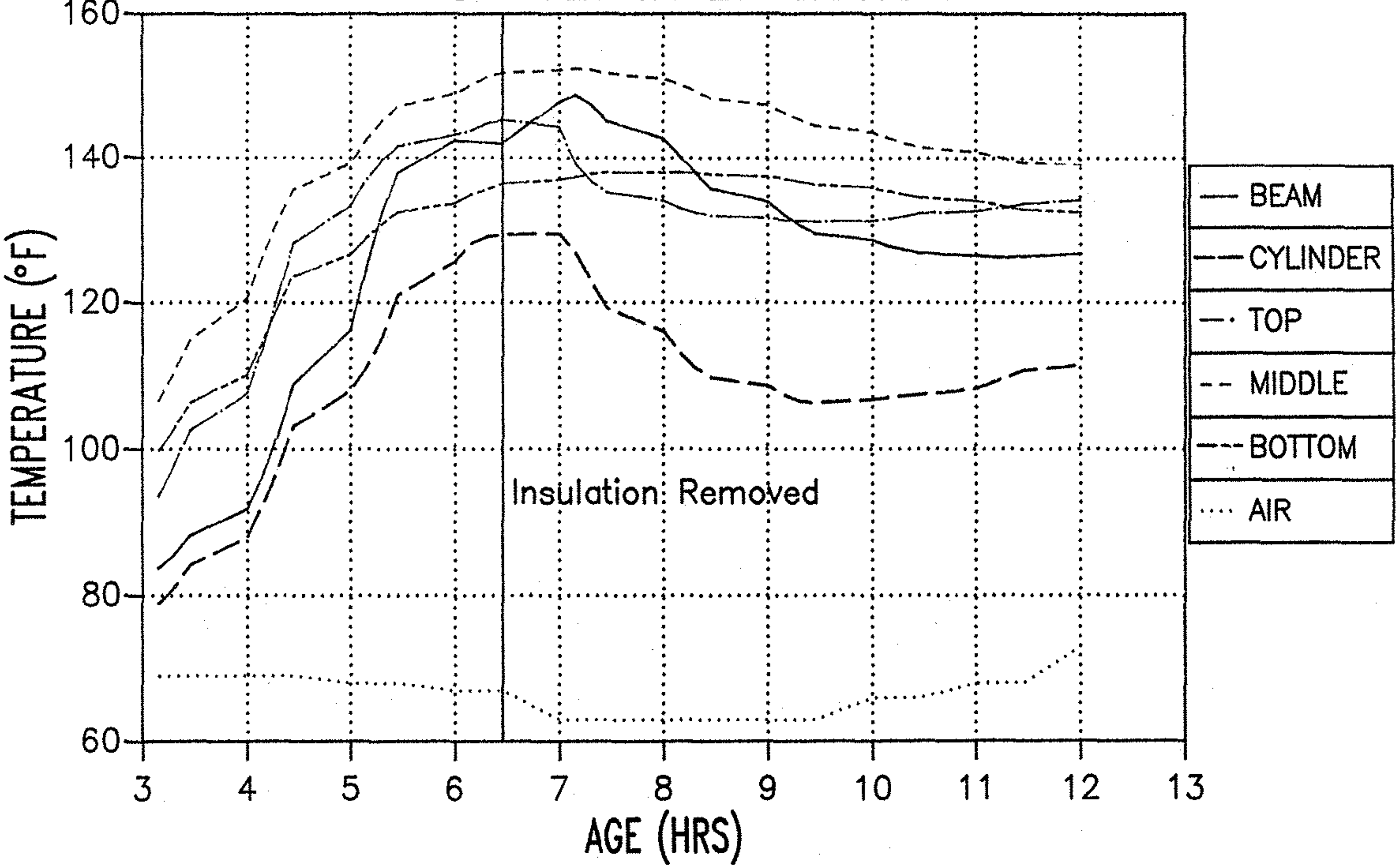

FIGURE 9
MATURITY VS. FLEXURAL STRENGTH