New Rigid Pavement Construction and Testing At the FAA National Airport Pavement Test Facility (NAPTF)

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Abstract:
Three rigid airport test items were constructed at the NAPTF on medium-strength subgrade to investigate the effect of different pavement support conditions on pavement life under full-scale airplane traffic loading. The selection of dimensions, concrete mix, quality control and construction approach were the result of extensive investigations previously conducted at the NAPTF in order to reach structural failure before secondary failures occurred. The test items were trafficked with 4- and 6-wheel load using 55,000 lbs. (24,950 kg) per wheel. The test items were trafficked with up to 31,000 passes between April 27 and December 10, 2004. Deterioration of the pavement was monitored using a combination of non-destructive testing, visual inspections, and dynamic pavement responses measured with sensors embedded in the pavement. No corner cracking due to curling was observed in the PCC slabs either before or after trafficking started.

INTRODUCTION

The Federal Aviation Administration (FAA) built the National Airport Pavement Test Facility (NAPTF) at the William J. Hughes Technical Center, to develop reliable failure criteria for new airport pavement design procedures, through full-scale testing. NAPTF has the capability of imparting loads representative of the new generation of heavy civil transport aircraft on typical pavement structures. The first rigid pavements built at the NAPTF developed corner cracking during the early stages of traffic testing. This premature failure was due to curling of the slab corners and the results were considered to be inadequate for normal life cycle determination since failures attributed to non-typical mechanisms could affect the test data obtained for development of structural failure criteria [1]. Extensive investigations were conducted prior to the construction of a second set of rigid test items to guarantee structural failure before secondary failures occurred, which included geometric design, concrete mix design, construction methods, curing, curling and warping, and trafficking of a specially constructed test strip [2, 3, 4].

In the new rigid construction, PCC slabs of 12 in. (30.5 cm) thickness were placed on conventional subbase, on grade and on stabilized subbase primarily to (1) compare life and performance for the different support conditions; (2) compare the pavement life and performance under 4-wheel versus 6-wheel traffic using the same dual and tandem distances in both gears; (3) update the failure model for rigid pavement design. Other objectives were the comparison of the joint efficiency data obtained from HWD tests and sensors at the joints to the 25% load transfer assumption in the design procedure; comparison of interior and edge stresses under gear loads; and measurement of the slabs shrinkage and curling.

This paper presents the work recently completed at the NAPTF and describes the steps taken in the analysis of the collected data and their application.

RIGID PAVEMENT DESIGN

Geometric Design

Each of the three new test items was 75 ft. (22.9 m) long by 60 ft. (18.3 m) wide and separated by 25 ft. (7.6 m) long rigid transitions. The slab size was 15 by 15 ft. (4.57 by 4.57 m). There was a total of 20 slabs per test item. The selection of the slab size was based on the results of a previous experiment conducted at the NAPTF, documented in [2, 4]. The results demonstrated the reduction of corner cracking due to curling when using a smaller size slab.

Pavement Design

The materials were selected according to FAA construction standards [5]. The test item built on 10 in. (25.4 cm) of conventional subbase (P-154 Uncrushed Aggregate) was called MRC, on grade MRG and on 6 in. (15.2 cm) of stabilized base (P-306 Econocrete), built during the original rigid pavement construction, MRS. All the test items were placed on a medium strength clay subgrade. The upper 4 ft. (1.2 m) of the subgrade were rebuilt to a target CBR of 7 under MRG and MRC. The slab thickness of 12 in. (30.5 cm) was selected as optimum to support heavy loads and fail within a reasonable time. The design layout of the test items is presented in Figure 1.

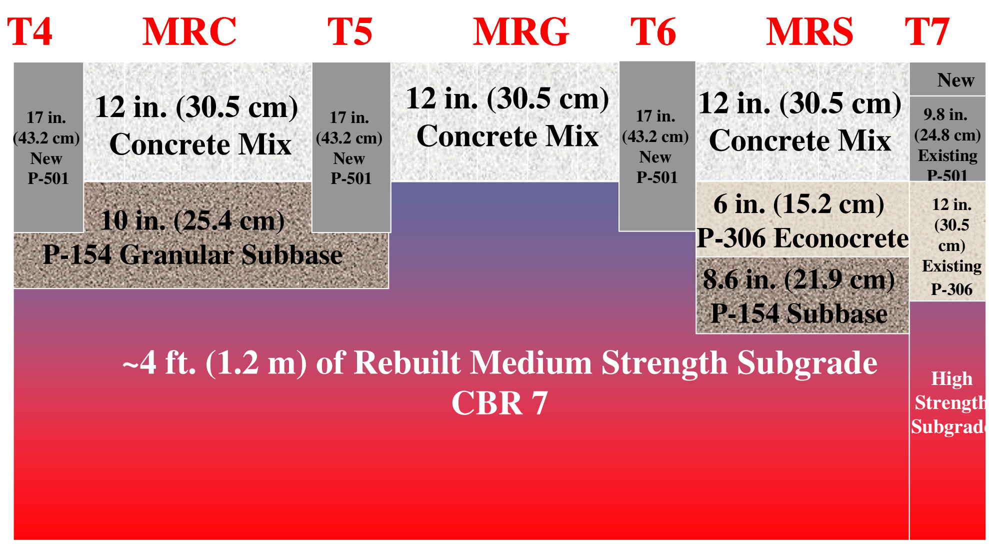

Figure 1. New Rigid Pavement Items Layout.

Material Properties

The target values for the material properties for the new rigid test items were as follows:

- P-501 (PCC Slab) E=4,000,000 psi (*R*=750 psi)
- P-306 *E*=700,000 psi
- P-154 *E*= (Variable)
- Subgrade (Clay CH) *E*= 10,500 psi (CBR=7)

The *k* values obtained from plate load testing for the North Wheel Track (NWT) and South Wheel Track (SWT) are presented in Table 1:

Table 1. Plate Load Test Results

TEST ITEM	LAYER TESTED	K, psi/in (MPa/m)	
		NWT	SWT
MRC	Subgrade Top	132 (35.85)	130 (35.30)
	Top of P-154 Granular Subbase	159 (43.18)	149 (40.46)
MRG	Subgrade Top	149 (40.46)	133 (36.12)
MRS	Top of P-306 Econocrete	532 (144.47)	479 (130.08)

The concrete mix laboratory flexural and compressive strengths at 28 days for the three test items are presented in Table 2. The mix, designed for 750-psi (5.2 MPa) flexural strength, contained 50% flyash class "C" in the cementitious mix. The flyash was used to reduce the concrete strength and control curling of the slabs by allowing thicker slabs for a given pavement life. The properties of mixes with various replacement proportions of the flyash were studied previously at the NAPFT [2].

Table 2. Test Items Concrete Mix Laboratory Strength

Test Items	Flexural Strength At 28 Days, psi (MPa)			Compressive Strength At 28 Days, psi (MPa)		
	Placement 1	Placement 2	Average	Placement 1	Placement 2	Average
MRC	780 (5.38)	709 (4.89)	744 (5.13)	3,620 (24.96)	3,431 (23.66)	3,526 (24.31)
MRG	792 (5.46)	873 (6.02)	833 (5.74)	3,478 (23.98)	3,596 (24.80)	3,537 (24.39)
MRS	747 (5.15)	636 (4.38)	691 (4.77)	3,785 (26.10)	3,290 (22.68)	3,537 (24.39)

Predicted Life

The current FAA design procedures, Layered Elastic Design FAA (LEDFAA 1.3) based on layered elastic theory and the Finite Element Design FAA (FEDFAA 1.3) beta testing procedure were used to predict the number of passes to failure for the three test items under 4- and 6-wheel gear loads. Table 3 shows the calculated life by FEDFAA and LEDFAA for the new rigid test items with Subgrade CBR 7 and 9, and the average flexural strengths shown in Table 2.

Table 3. Life Calculated by FEDFAA and LEDFAA

Number of Passes to Failure by FEDFAA (as configured at the time the predictions were made)

CBR	4-wheels			6-wheels		
	MRS	MRC	MRG	MRS	MRC	MRG
7	7,981	674	703	4,304	422	443
9	68,713	1,254	1,408	36,361	810	920

Number of Passes to Failure by LEDFAA

CBR	4-wheels			6-wheels		
	MRS	MRC	MRG	MRS	MRC	MRG
7	3,309	2,495	3,932	7,373	1,688	2,609
9	17,667	3,809	6,628	17,690	3,809	6,576

Traffic Load

The test items were planned to be trafficked by a 6-wheel gear configuration on the north side and a 4-wheel gear configuration on the south, but the plan was modified as noted below in the Trafficking section. The dual distance was 54 in. (137.2 cm) and the tandem 57 in. (144.8 cm) for both configurations. The selected load was 55,000 lbs. (24,950 kg) per wheel at 210 psi (1,448 kPa) tire pressure.

CONSTRUCTION

Foundation

Work began with the rebuilding of the subgrade in September 2003. A total of 1,550 yd^3 (1,185 m^3) of clay were brought from the FAA storage yard. The clay was stockpiled indoors, spread and tilled to dry. The in situ moisture content was approximately 42%. Inside the NAPTF, a maximum 250 yd^3 (191 m^3) of clay were spread out for drying. The clay was tilled periodically during drying and fans assisted in drying the clay. When the moisture content reached 34%, the clay was re-stockpiled for placement into the test items, MRC and MRG. The subgrade was built in 9 lifts; the last two were built under MRG only. CBR acceptance criteria were developed; see Item P-152LM Subgrade (for medium strength subgrade) in reference [5]. Although the target CBR was 7, the acceptance criteria allowed a CBR range from 5.5 to 8. An example of lift acceptance is presented in Table 4. Plate load tests [6] were also taken on the finished subgrade. Table 1 shows the k values measured during construction.

Table 4. Lift 6 Summary - Lift Tested On 10/28/03

Lot ID	Test Item	Sublot ID	Test ID	Station	Lane	CBR	Test Avg.	Lot Avg	Moisture
Lot 1	MRC	A	1	3+40 11L	North	6.9	7.0		31.41
			2	3+40 11L	North	6.8			
			3	3+40 11L	North	7.2		7.1	
	MRG	B	10	4+40 10L	North	7.5	7.2		31.02
			11	4+40 10L	North	7.6			
			12	4+40 10L	North	6.6			
Lot 2	MRC	A	4	3+40 10R	South	8.0	8.0		30.32
			5	3+40 10R	South	8.1			
			6	3+40 10R	South	7.9		7.7	
	MRG	B	7	4+40 10R	South	7.0	7.4		31.86
			8	4+40 10R	South	7.1			
			9	4+40 10R	South	8.2			

Once the subgrade was accepted on MRC, a 10 in. (25.4 cm) layer of granular subbase (P-154) was placed in two lifts and the k value measured using a plate load test. Then box-shaped forms of 15 ft. by 15 ft. (4.57 m by 4.57 m) were individually built on top of the granular subbase on MRC, on grade for MRG and on top of the stabilized subbase on MRS.

Concrete Mix

The concrete forms were prepared with 1 in. (2.54 cm) diameter steel dowels on all four sides to ensure uniform load transfer and to minimize cracking due to slab curling using the “speed dowel” system. Each slab was formed individually (checkerboard pattern) to provide uniform slab-to-slab interfaces and to minimize the use of dowel baskets (chairs), avoiding stress concentrations that could initiate cracks at the bottom of the slabs.

Transitions 4 and 5 were placed on December 9 and transition 6 on December 30, 2003. The concrete mix design used in the transitions had a target compressive strength of 4,500 psi (31 MPa) and included 15% flyash class C. Transition thicknesses were 17 in. (43.2 cm).

The designed concrete mix with 50% flyash and air entrapment admixture had a target flexural strength of 750 psi (5.2 MPa). Just before concrete placement the air temperature began to drop just above freezing. A test slab was placed on January 7, 2004 at the SW corner of MRC (slab 16). The air temperature at placement was 33ºF (0ºC) and 65ºF (18ºC) for the concrete. The temperature of the concrete dropped immediately after placement to 45ºF (7ºC) at the top and 60ºF (16ºC) at the bottom of the slab. After 24 hours, the slab was covered with thermal blankets and the temperature increased to 65ºF (18ºC) at the top and bottom of the slab.

The remaining slabs were placed between January 13 and March 2, 2004 using the same concrete mix. A total of 60 slabs were placed. Because of the checkerboard pattern, 10 slabs were placed at a time in each test item using a concrete pump and overhead boom. Slump and air were measured on the concrete for truckload acceptance before entering the pump and repeated at placement. The measured slump and air leaving the pump were lower but the concrete mix was more homogeneous in all the cases. To verify the water cement ratio in the concrete mix, the Microwave Oven Drying Test (AASHTO TP 23) was used; the results were inconclusive.

The concrete placement extended duration was due to (1) the cold weather, air temperature ranging from 14 to 49ºF (-10 to 9ºC) at 8 am, and high flyash content; 7 days were required before stripping the forms; (2) the original concrete on test item MRS was left to support the paving operations in the other two test items; once the concrete placement on test items MRC and MRG was completed, the original concrete from MRS was removed and the test item prepared to receive the new concrete.

Instrumentation

The Data Acquisition System retrieved and processed data from dynamic and static sensors placed in and around the concrete. The new rigid test items were instrumented with a total of 281 sensors, grouped as follows:

- Dynamic
  - 54 Vertical Displacement Transducers (VDT)
  - 24 Horizontal Displacement Transducers (HDT)
  - 116 Concrete Strain Gages (CSG)
  - 12 Joint Gages (J)
- Static
  - 53 Thermister (T)
  - 18 Relative Humidity Gages (RH)
  - 4 Soil Moisture Gages (SM)

Curing

Wet burlap was placed on the complete length of the new rigid test items after setup of the concrete. In addition, due to the cold environmental conditions, thermal blankets were placed on top of the burlap for the 28- day duration of the wet curing. After the blankets and burlap were removed from the rigid test items the surfaces were watered at intervals necessary to keep the measured vertical displacement at the corners of the slabs lower than 20 mils (0.5 mm). The intervals were typically of three to four days. In most cases, following this procedure, the surface of the concrete was completely dry when time came to apply more water. The time for areas of the surface to be visually dry varied from 24 to 48 hours. This procedure was continued throughout the traffic testing and kept the slabs essentially flat.

MONITORING

Traffic Test Monitoring

Visual inspections were conducted periodically after the concrete was subjected to traffic loading. The distresses were recorded using the procedures in ASTM D 5340-03 [7]. A detail distress map was kept up to date with cracks, spalls and other structural distresses, as well as traffic counts and comments for each test item. The inspections were made after every complete wander cycle up to 2,000 passes, every other wander cycle up to 4,000 passes, every day up to 10,000 passes, every other day up to 15,000 passes and every week beyond 15,000 passes. Incidental inspections were made at more frequent intervals to identify sudden, and large, changes in the level of distress.

The non-destructive test Heavy Weight Deflectometer (HWD) was used to track the deterioration of the different support conditions and the loss of joint load transfer efficiency (LTE). The embedded sensor readings provided evidence of structural failure when a sensor stopped working or any unusual readings were detected.

Curling

The slabs were monitored for evidence of upward curling. The vertical displacement transducer (VDT) readings at the slab corners and interiors never were higher than 15 mils (381 microns) in all the test items. This was corroborating evidence of the flatness of the slabs in all the test items due to the strategy of frequent watering.

TRAFFICKING

Original plans for trafficking considered 6-wheel loading (north side) and 4-wheel loading (south side) with 55,000 lbs. (24,950 kg) per wheel at speed 2.5 mph (4 km/h) and standard wander pattern of 66 passes per cycle. The pass-to-coverage ratio (P/C) was 4.71 for both 4-wheel and 6–wheel gear configuration. However, due to the variable flexural strength of the built test items: MRC - 744 psi (5.13 MPa), MRG - 833 psi (5.74 MPa) and MRS - 691 psi (4.77 MPa) and the short life predicted by FAA design procedures, it was decided to first test only MRC south under 55,000 lbs. (24,950 kg) and 4-wheel load.

Trafficking Test on MRC Test Item

On April 27, traffic testing was conducted on MRC to observe the effect of the heavy wheel load on the new rigid pavement. Initially only the SWT of MRC was trafficked using the standard wander pattern with 66 passes. The corresponding gear positions are shown in Figure 2.

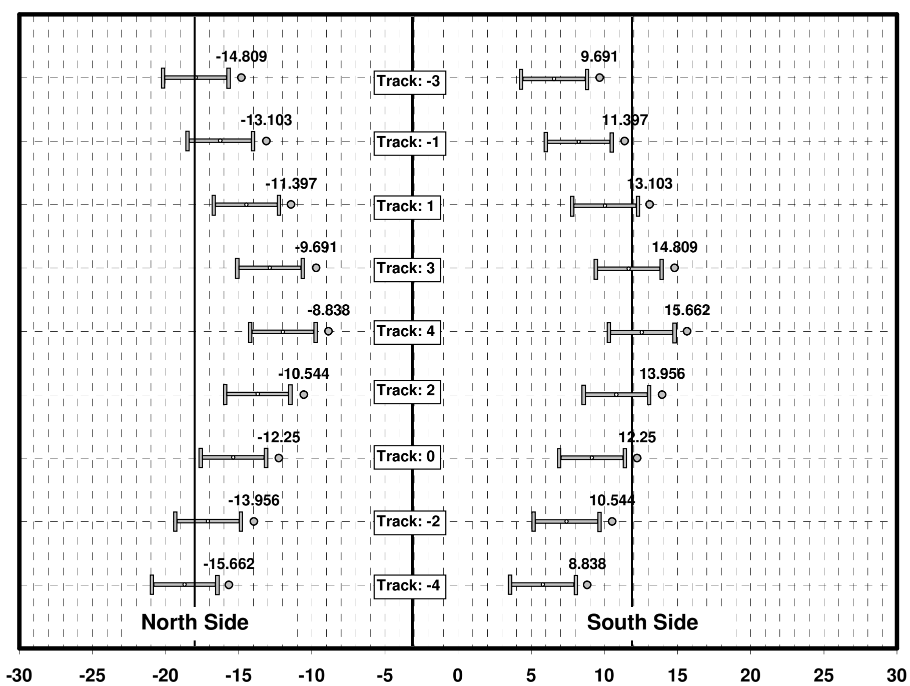

Figure 2. Standard Wander Pattern Gear Positions

At about 400 passes, bottom-up cracks, perpendicular to the longitudinal joint, were detected by the CSG's. But before these cracks propagated to the slab surface, top-down cracks were observed in four out of five outer-lane slabs in the south side of MRC. Since the effect of outer-lane top-down cracks on the initiation/development of the inner-lane bottom-up cracks was unclear, the wander pattern for the NWT of MRC was modified to eliminate direct loading of the outer lane slabs, maintaining the 4-wheel gear loading.

The modified wander pattern did not consider trafficking on the outer slabs of the NWT (Positions -1 through -4 were removed from the wander pattern) and the number of passes was increased to match the number of repetitions at critical locations (76 passes). The abbreviated wander pattern was used to traffic the NWT (P/C = 3.80) while the original wander pattern, increased by 10 passes to match the number of passes in the modified wander, was used to continue trafficking the SWT of MRC (P/C = 4.74). Figure 3 presents the final distress map and Table 5 the summary of events for the MRC test item.

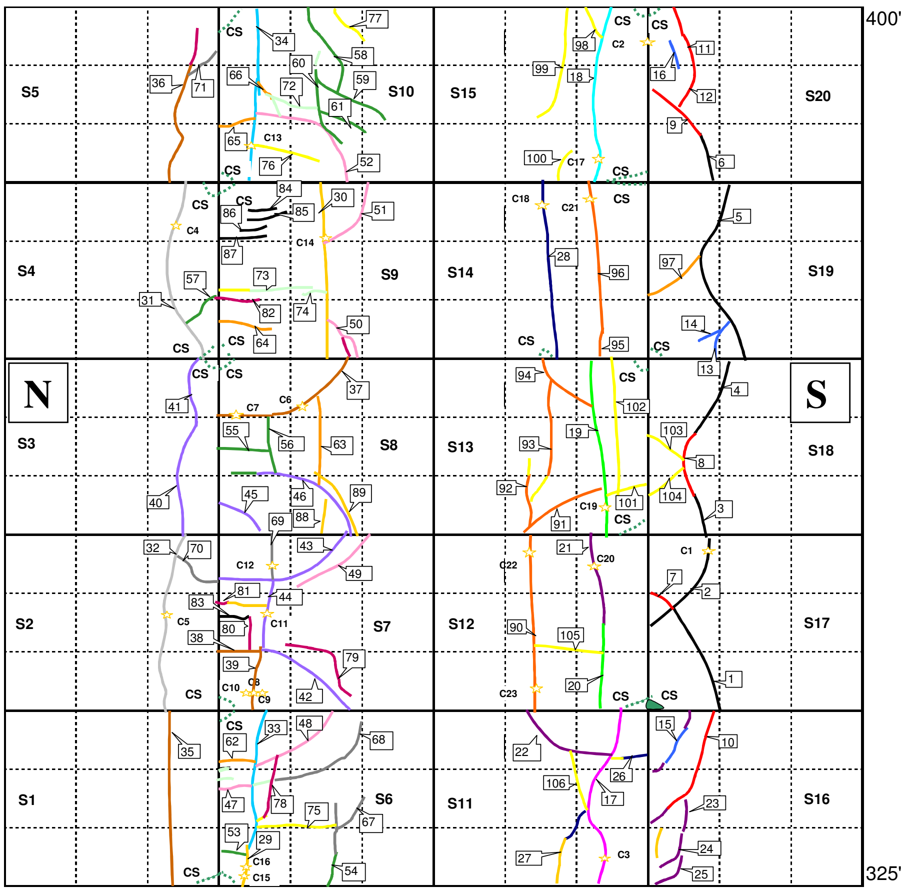

Figure 3. MRC Distress Map After 12,675 Passes on North Side (4-wheels) and 5,405 on South Side (4-wheels)

Table 5. Summary of Traffic Events for MRC Test Item

Date	South Passes	South Coverage	North Passes	North Coverage	Comment
04/27/2004	0	0	0	0	Trafficking started.
04/29/2004	990	211	0	0	First top-down crack in MRC south outer lane.
05/05/2004	1,496	315	0	0	Wander patterns changes. Started trafficking north side.
05/10/2004	2,458	517	1,069	281	First top-down crack in MRC south inner lane.
05/19/2004	4,662	981	3,273	861	First top-down crack in MRC north inner lane.
05/20/2004	4,720	994	3,331	877	Traffic stopped on south side.
05/21/2004	4,720	994	3,653	961	First top-down crack in MRC north outer lane.
06/02/2004	4,720	994	6,085	1,601	North side shows similar distress as south side.
06/30/2004	5,405	1,138	12,675	3,336	MRC trafficking completed.

Trafficking MRG and MRS Test Items

MRG and MRS were trafficked using the following parameters: (1) Six-wheel loading in the north lane and four-wheel loading in the south lane, with a wheel load of 55,000 lbs. (24,950 kg), to compare the effect of the load configuration on pavement life; (2) Standard wander pattern of 66 passes per wander cycle (Figure 5). The carriages were positioned with the zero wander position having the outer sets of wheels on the inner slab lanes and adjacent to the longitudinal joints between the inner and outer slab lanes. The north and south carriages were programmed to move together, with the same distance held between the carriages, at all times; (3) Since frequent watering was successful in maintaining the slabs nearly flat in MRC, it was continued for the duration of the trafficking on MRG and MRS.

MRG and MRS were trafficked between July 6 and December 10, 2004. Distress maps were kept updated for each test item during trafficking with comments of significant events. The final distress maps for MRG and MRS are shown in Figures 4 and 5 respectively. Tables 6 and 7 present a summary of the significant events during trafficking of the MRG and MRS test items

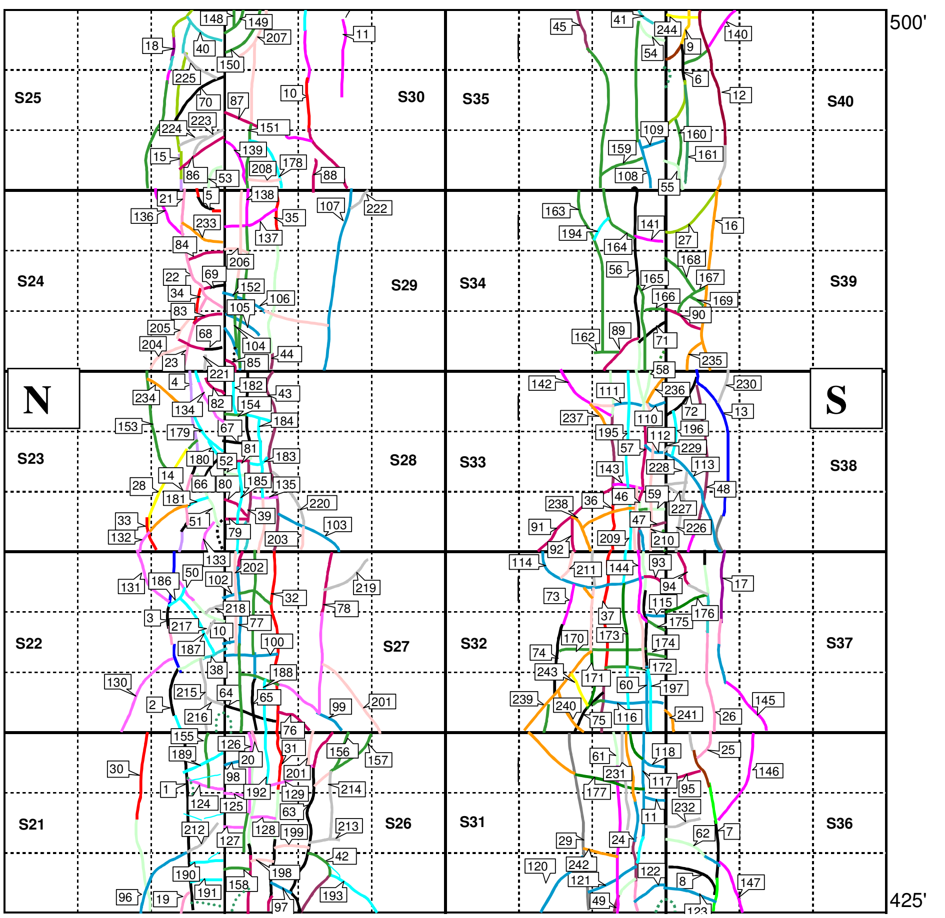

Figure 4. MRG Distress Map After 31,020 Passes on North Side (6-wheels) and 30,996 on South Side (4-wheels)

Table 6. Summary of Traffic Events for MRG Test Item

Date	South Passes	South Coverage	North Passes	North Coverage	Comment
07/06/2004	0	0	0	0	Trafficking started.
07/13/2004	1,452	308	1,452	308	First top-down crack in MRG north & south outer lanes.
07/20/2004	2,575	547	2,575	547	First top-down crack in MRG north inner lane.
08/24/2004	10,101	2,145	10,125	2,150	First top-down crack in MRG south inner lane.
12/10/2004	30,996	6,581	31,020	6,586	MRG trafficking completed.

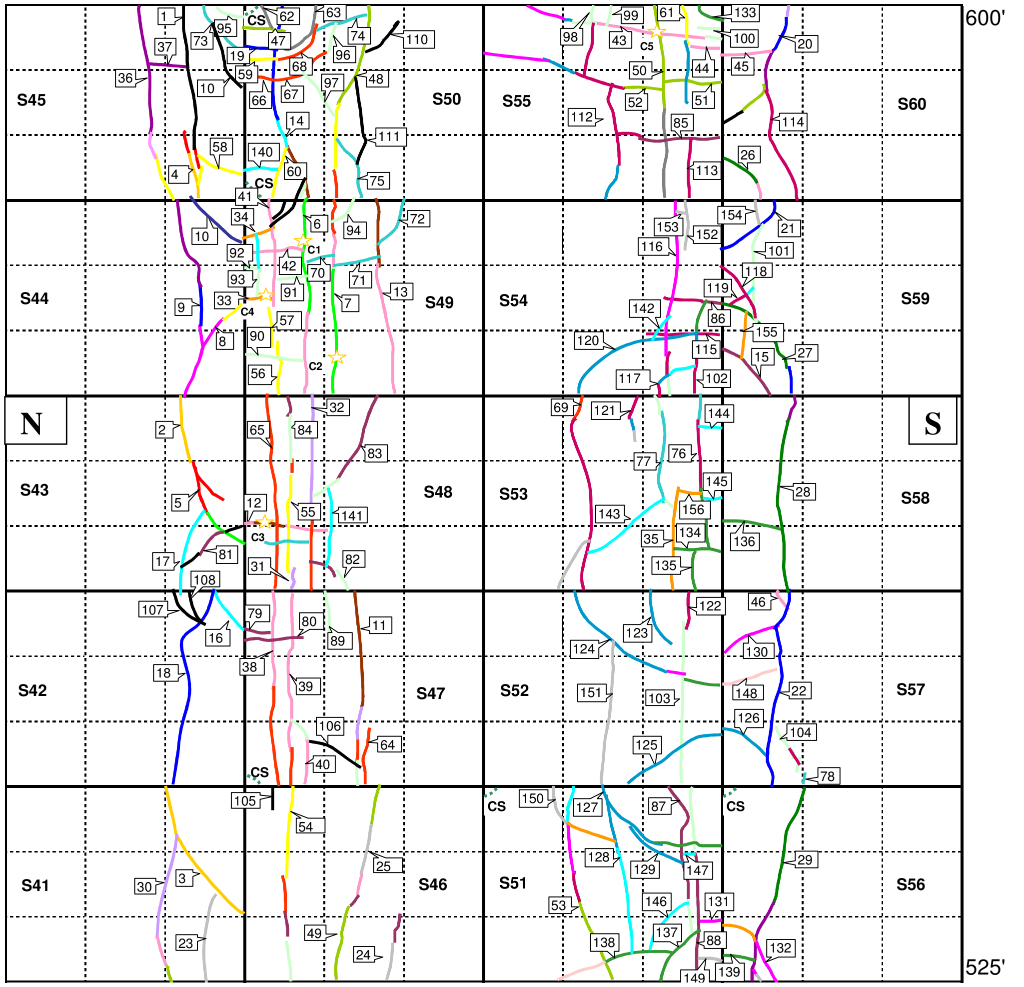

Figure 5. MRS Distress Map After 20,262 Passes on North Side (6-wheels) and 30,996 on South Side (4-wheels)

Table 7. Summary of Traffic Events for MRS Test Item

Date	South Passes	South Coverage	North Passes	North Coverage	Comment
07/06/2004	0	0	0	0	Trafficking started.
07/13/2004	1,452	308	1,452	308	First top-down crack in MRS north outer lane.
07/19/2004	2,255	479	2,255	479	First top-down crack in MRS north inner lane.
08/02/2004	4,885	1,037	4,885	1,037	First top-down crack in MRS south outer lane.
08/18/2004	8,029	1,705	8,053	1,705	First top-down crack in MRS south inner lane.
09/23/2004	20,238	4,297	20,262	4,297	MRS north traffic stopped.
12/10/2004	30,996	6,581	20,262	4,297	MRS trafficking completed.

MATERIAL TESTING

Laboratory Testing

A total of 246 concrete beams and 246 cylinders were cast from the concrete placed in the two center-lane slabs of the three test items of the new rigid pavements. The beams and cylinders were used for laboratory strength tests. One set of samples was laboratory cured and the other set field cured. Laboratory cured samples were tested at ages 2, 5, 7, 14, 28, 56, and 90-days (Table 2).

Non-Destructive Testing

Portable Seismic Pavement Analyzer (PSPA)

PSPA measurements were taken in eight slabs (six in the traffic path, and two outside the traffic path), 24 hours after concrete placement. The following slabs in MRS were tested and monitored on a regular basis: S-43, S-47, S-48, S-49, S-52, S-53, S-54, and S-58. The tests were performed at 1, 3, 7, 14, and 28 days after concrete placement. Pulse velocity tests were also conducted.

Free-Free Resonance Tests On Concrete Beams And Cylinders

Free-free resonance tests were performed on all the beams and cylinders tested for strength on the day of strength testing.

Heavy Weight Deflectometer (HWD) on New Rigid Pavements

HWD testing was conducted on the three rigid pavement test items before trafficking. On MRC the test was run two additional times during trafficking and a final measurement was taken when traffic stopped. For the MRG and MRS test items a plan was developed which considered running an HWD test every 15 full wanders until 5,000 passes had been completed, then every 30 full wanders to 7,000 passes completion, and finally intervals of 60 full wanders for the remainder of the testing.

The data obtained from HWD testing achieved the following objectives:

- Back-calculation of layer properties (test at the slab center);
- Verification of sensor's correct operation;
- Correlation of responses under HWD and wheel load;
- Verification of joint load transfer capabilities (test at the slab's longitudinal joint).

Post-traffic Testing

Sawed Beams and Cores

A total of 48 cores and 54 sawed beams were taken from the test items as soon as the traffic was completed. Two slabs per test item were cut (concrete mix placed in two phases). Eight cores were drilled and nine beams saw cut per slab in the north side of each test item. Three of the cores were tested for compressive strength and the remaining five for split tensile strength. The beams were saw cut for flexural strength testing (three beams cut from the top of the slab, three from the middle and three from the bottom of the slab). The average post-traffic laboratory results are compared to the initial results obtained from the molded beams and cylinders and presented in Table 9.

Table 9. Concrete Mix Tests Comparison

Test Items	**Flexural Strength (Molded Beams) 28 Days, psi (MPa)**	**Flexural Strength (Sawed Beams), psi (MPa)**	**Split Tensile Strength (Cores), psi (MPa)**	**Compressive Strength (Molded Cylinders) 28 Days, psi (MPa)**	**Compressive Strength (Cores), psi (MPa)**
MRC	744 (5.13)	617 (4.25)	399 (2.75)	3,526 (24.31)	3,896 (26.86)
MRG	833 (5.74)	675 (4.65)	415 (2.86)	3,537 (24.39)	4,385 (30.20)
MRS	691 (4.77)	688 (4.74)	429 (2.96)	3,537 (24.39)	4,619 (31.85)

SUMMARY

Frequent watering after 28-days wet curing maintained flatness, less than 15 mils (0.38 mm) at the corners, of the slabs in all test items (no curling).

HWD testing before traffic measured uniform deflections for the new rigid test items, less than 10 mils (0.25 mm). With the increased traffic, HWD measured deflections indicated deterioration of support conditions with maximum deflections in the 6-wheel traffic lane, 30 mils (0.76 mm) for MRC and MRS and 48 mils (1.22 mm) for MRG.

Abbreviating the traffic on the north side to the inner slabs only did not stop the formation of top-down cracks on the outer slabs. The formation of the top-down cracks was delayed by a factor of three to four. Regardless of the use of the standard or abbreviated wander pattern, the pavement deterioration behaved in a similar manner. However, the north side required a longer time to reach the same condition as the south side by a factor of 1.27 in terms of passes and 1.59 in terms of coverage. Assuming that the pavement structural conditions were the same, north-to-south, it can be concluded that the abbreviated wander pattern causes less damage to the pavement per pass or per coverage than the standard wander pattern.

From the comparison of distresses on MRG and MRS under identical traffic load, it can be concluded that up to 25,000 passes the deterioration of MRS was more extensive than MRG under both gear loads. However, after 25,000 passes MRG deterioration increased rapidly and MRS maintained the same level of deterioration. The initial rapid deterioration of MRS is suspected to be related to the low flexural strength of the concrete. Average R=691 psi (4.77 MPa) for MRS compared to that of MRG, average R= 833 psi (5.74 MPa).

For the standard wander pattern (66 passes per cycle) the first top-down crack always occurred on the outer slabs for all test items. The first observed crack in the inner slabs of the 4-wheel side occurred much later than in the 6-wheel side for all test items. However, CSG responses indicated that cracks started propagating from the bottom of the slabs early in the trafficking even though these cracks were not visible at the surface.

The distress data collected have been used to calculate an equivalent Structural Condition Index (SCI) per test item. These data will be introduced into the Design Factor (DF) vs. coverage curve to modify the failure model in current design procedures, which was calculated using historical data.

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REFERENCES

1. McQueen, R. D., Rapol, J., Flynn, R., "Development of Material Requirements for Portland Cement Concrete Pavements at the U.S.FAA National Airport Pavement Test Facility," 4th International Conference on Road and Airfield Pavement Technology 2002, Kunming, China, April 23-25, 2002.

2. Ricalde, L., McQueen, R. D., "Portland Cement Concrete Test Strip Pavement At The FAA National Airport Pavement Test Facility (NAPTF)" Proceedings of the Specialty Conference The 2003 Airfield Pavements Challenges and New Technologies, ASCE, 217-230.

3. Guo, E., Dong, M., Daiutolo, H., Ricalde, L., "Analysis Of The Observed And Predicted Responses Of A Curled Single Slab," Proceedings of the 2004 FAA Worldwide Airport Technology Transfer Conference & Exposition, Atlantic City, New Jersey, USA.

4. Hayhoe, G.F., "Traffic Testing Results from the FAA's National Airport Pavement Test Facility, " Proceedings of the 2nd International Conference on Accelerated Pavement Testing, University of Minnesota, Minneapolis, Minnesota, 2004, USA.

5. Federal Aviation Administration, Standards for Specifying Construction of Airports. Advisory Circular (AC) 150/5370-10A, FAA, Washington, DC.

6. American Association of State Highway and Transportation Officials (AASHTO), 2004. Nonrepetitive Static Plate Load Test of Soils and Flexible Pavement Components for Use in Evaluation and Design of Airport and Highway Airports. Designation: T222-81 (2000), Washington, DC.

7. American Society for Testing and Materials (ASTM), 2003. Standard Test Method for Airport Pavement Condition Index Surveys. Designation D5340-03, ASTM International, West Conshohoken, Pennsylvania, USA.

8. NAPTF web site http://www.airporttech.tc.faa.gov/naptf