Analysis of CC2 Rigid Pavement Test Data From the FAA's National Airport Pavement Test Facility

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FAA Airport Technology R&D Program

- Effort conducted at the William J. Hughes Technical Center, Atlantic City, NJ, USA.
- Sponsor: FAA Office of Airport Safety and Standards, Washington, DC.
- Provide support for development of FAA pavement standards (Advisory Circulars).
- http://www.airporttech.tc.faa.gov/

National Airport Pavement Test Facility - Background

- Commissioned on April 12, 1999.
- Joint venture of FAA and Boeing Co.
- Primary Objectives:
  - Provide additional traffic data for incorporation in new FAA thickness design procedures.
  - Provide full-scale pavement response and failure information for use in airplane landing gear design and configuration studies.
  - Reexamine the CBR method of design for flexible pavement ACN (6-wheel gear).

National Airport Pavement Test Facility - Specifications

- Test pavement: 900 ft long by 60 ft wide.
- Test vehicle: Up to 12 aircraft tires at wheel loads up to 75,000 lbs.
- Dynamic data acquisition (20 samples/second).
- Static data acquisition (4 samples/hour).

Construction Cycles

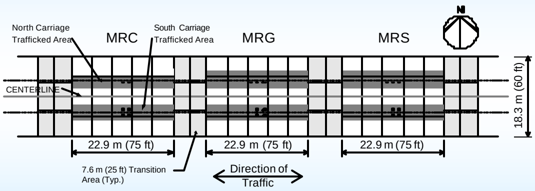
A **construction cycle** is defined as the complete cycle of planning, construction, trafficking, posttraffic testing, and demolition, needed to obtain a set of usable data.

- CC1: Initial construction, consisted of 6 flexible and 3 rigid test items.
- CC2: Rigid pavement reconstruction
  - Test strip and free standing test slab
  - Three new rigid test items
- CC3: Flexible pavement reconstruction.
  - Four conventional flexible test items.

CC2 - Objectives of Test

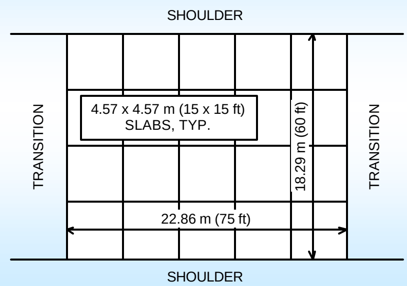
- Main Objectives:
  - Compare rigid pavement life and performance for different support conditions.
  - Compare pavement life and performance for 4- and 6-wheel gear traffic.
  - Obtain data on pavement performance as measured by the Structural Condition Index (SCI) versus traffic repetitions.
- Other objectives included comparing interior and edge stresses under gear loads, and measuring shrinkage and curling of the concrete slabs.

CC2 Test Item Layout

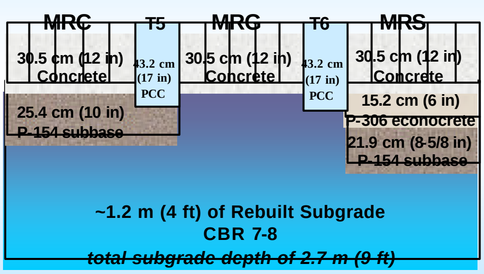


- **MRC**: **M**edium-Strength / **R**igid / **C**onventional (aggregate) foundation
- **MRG**: **M**edium-Strength / **R**igid / Slab placed directly on **G**rade
- **MRS**: **M**edium-Strength / **R**igid / **S**tabilized base (econocrete)

Detail Plan of PCC Test Item



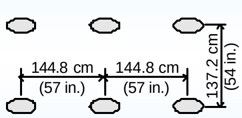
Profile of CC2 Test Items



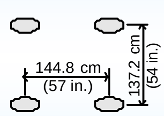
Structural Design Data for CC2 Test Items

Test Item	MRC	MRG	MRS
PCC Surface	30.5 cm (12 in.) PCC (P-501)	30.5 cm (12 in.) PCC (P-501)	30.5 cm (12 in.) PCC (P-501)
Subbase 1	25.4 cm (10 in.) aggreg. subbase (P-154)	none	15.2 cm (6 in.) econocrete base (P-306)
Subbase 2	none	none	21.9 cm (8.6 in.) aggregate subbase (P-154)
Subgrade	Clay (CH) *k*=35.3 MPa/m (130 pci)	Clay (CH) *k*=38.0 MPa/m (140 pci)	Clay (CH) *k*=38.0 MPa/m (140 pci)

Gear Load Dimensions for CC2 Traffic Tests



(a) 6-wheel gear.



(b) 4-wheel gear.

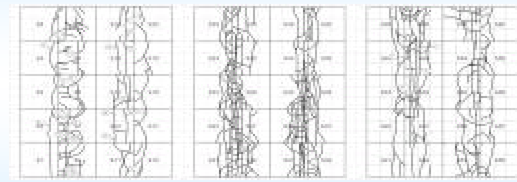
Traffic Summary for CC2 Test Items

Test Item	Gear Type	Passes Completed Apr-Jun 2004	Jul-Sep 2004	Oct-Dec 2004	Total
MRC-North	4-wheel	12675	0	0	12675
MRC-South	4-wheel	5405	0	0	5405
MRG-North	6-wheel	0	21186	9834	31020
MRG-South	4-wheel	0	21162	9834	30996
MRS-North	6-wheel	0	20262	0	20262
MRS-South	4-wheel	0	21162	9834	30996

Performance Monitoring

- Visual Distress Surveys.
  - ASTM D 5340-93 and FAA AC 150/5380-6.
  - Daily up to 10,000 passes. Weekly after 10,000 passes.
- Embedded Sensors.
  - Responses monitored for early indication of cracking.
- Nondestructive Tests.
  - HWD every 15 wanders (990 passes) up to 10,000 passes. Every 30 wanders after 10,000 passes.
- Destructive Testing.
  - Cores to investigate origin of cracks.

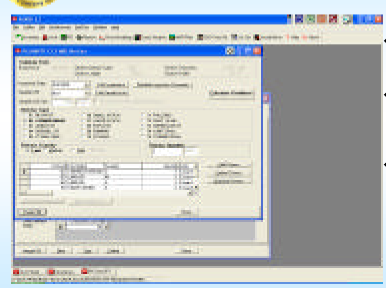
Final Distress Maps



Structural Condition Index (SCI)

- Rollings (1988).
- SCI is structural component of rigid PCI.
  - Only load related distress types are considered (e.g., L/T/D cracks, corner breaks, shattered slab).
  - SCI is always equal to or higher than PCI for the same pavement feature.
  - Joint and corner spalling was excluded from the SCI computation for CC2 test items.
- SCI definition is not the same as "Structural PCI" as adopted by the U.S. Navy (MicroPAVER).

Micro PAVER Computations

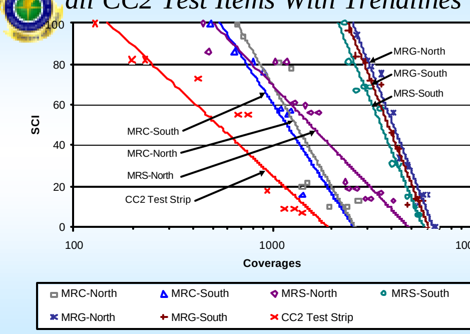


- Record structural distresses based on visual surveys.
- Treat each test item (north side or south side) as a sample unit.
- Follow ASTM procedures for counting distresses and assigning severity levels.

SCI Versus Coverage Analysis

- Plot SCI as a function of applied coverages.
  - P/C ratio is computed from wander pattern.
  - All slabs in sample unit versus inside traffic lane only.
- Obtain linear regression of SCI versus log(*C*).
  - Intercept with SCI=100 line yields C_O (cov. to 1st crack).
  - Intercept with SCI=0 line yields C_F (cov. to full failure).
  - New rigid design concerned with coverages to SCI=80.
  - Lower portions of failure curve (below SCI = 80) are important for overlay designs.

Plot of SCI vs. Log of Coverages for all CC2 Test Items With Trendlines



Regression Data for Analysis of SCI Versus Coverages

Test Item	Regression Constants* A	B	R^2	Coverages to Initial Crack, C_O	Coverages to Full Failure, C_F	P/C
MRC-N	-167.43	572.15	0.821	661	2613	3.80
MRC-S	-148.36	506.04	0.827	546	2576	4.71
MRG-N	-247.03	941.57	0.964	2551	6480	4.71
MRG-S	-246.96	935.12	0.965	2408	6117	4.71
MRS-N	-101.71	374.94	0.896	505	4855	4.71
MRS-S	-231.66	871.57	0.961	2141	5784	4.71
Test Strip	-90.33	296.37	0.904	149	1910	4.13

* $SCI = A\log(C) + B$

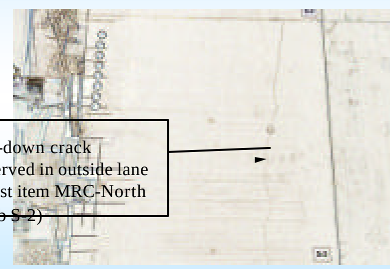
Distress Modes in CC2 Test Items

- Measured uplift at all corners was kept minimal (0.38 mm / 15 mils or less).
- Top-down cracks were not eliminated in either the outside or inside lanes.
  - Inside lanes: Received traffic from both wheels. Both top-down and bottom-up fatigue cracks were observed.
  - Outside lanes: Received either no traffic (MRC) or traffic from only one wheel of the dual gear. Top-down cracks were observed.
- Top-down cracks appeared first on outside slabs, even though those slabs received relatively less traffic.

Fatigue Cracks Observed in CC2 Test Items

Core Sample Showing a Bottom-up Crack in Test Item MRS-South

Fatigue Cracks Observed in CC2 Test Items



Top-down crack observed in outside lane of test item MRC-North (Slab S-2)

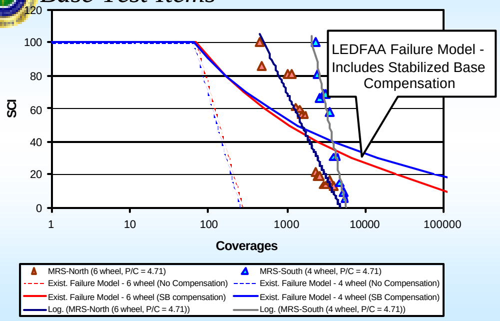
SCI Evaluation

- To avoid distortion of the SCI-vs.-coverage analysis due to the early appearance of top-down cracks in the outside lanes, only those slabs receiving traffic from <u>both</u> tires of the dual gear (i.e., the 5 inside slabs) were included in the SCI sample units.
- For SCI evaluation, no distinction was made between visible top-down and bottom-up cracks.

Results: Stabilized and Nonstabilized Test Items

- Deterioration of SCI is best represented by a model that is *linear* in log of coverages, regardless of whether a stabilized base is used.
- In general, CC2 test results support the principle that higher-quality subbases extend pavement life.
  - Additional durability is reflected in the slope of SCI-vs.-log(C) trendline. In general, stabilized base structures exhibited the flattest slope, followed by conventional, and (lastly) slab-on-grade structures.
  - Exception was MRS-S.

SCI vs. Coverage Curves for Stabilized Base Test Items



Design Factor vs. Coverages

- Design Factor (DF) = ratio of concrete flexural strength to maximum calculated bending stress.
- LEDFAA model based on Rollings (1988) regression:
  - DF = 0.5234 + 0.3920 log (C_O) *coverages to onset of cracking*
  - DF = 0.2967 + 0.3881 log (C_F) *coverages to full failure (SCI 0)*
- Recompute design factors for all test items using FEDFAA (3D-FEM) edge stress.
- Evaluate parameters including 7 new NAPTF data points.
- Preliminary analysis - design factors subject to change as we continue to characterize the material properties.

Conclusions

- Rigid pavement full-scale traffic tests recently completed at the FAA's National Airport Pavement Test Facility provided pavement performance and failure data for three new rigid pavement test items and a test strip.
- The performance data were analyzed using the SCI concept to obtain coverages to initiation of structural cracking and to full structural failure.
- The test results are currently being analyzed in conjunction with previous full-scale tests and will be used to update the failure model for rigid pavement and overlay design in future FAA design software.

Questions?