Full-Scale Traffic Tests on Flexible Pavements with 6- and 10-Wheel Gear Configurations

Gordon F. Hayhoe

- U.S. DOT, Federal Aviation Administration, AJP-6312
- William J. Hughes Technical Center
- gordon.hayhoe@faa.gov

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OUTLINE

- FAARFIELD flexible failure model update.
- Construction Cycle 5 (CC5) background and design.
- Traffic tests.
- Normalization of test results for temperature and load (mixed traffic).
- Results.
- Future work.

FAARFIELD FLEXIBLE MODEL UPDATE

- Currently calibrated to AC 150/5320-6D (CBR method).
  - Old alpha factors.
  - 16 wheels for 747 (very different thicknesses than 4-wheel design and 4-wheel ACN).
  - Bi-linear failure model incompatible with the new alpha factor curves.
- The most important objective of the CC5 tests was to resolve the difference between CBR and LED gear interaction effects (16- versus 4-wheel 747 design).

EFFECT OF NUMBER OF WHEELS IN CBR THICKNESS DESIGN

CBR = 3

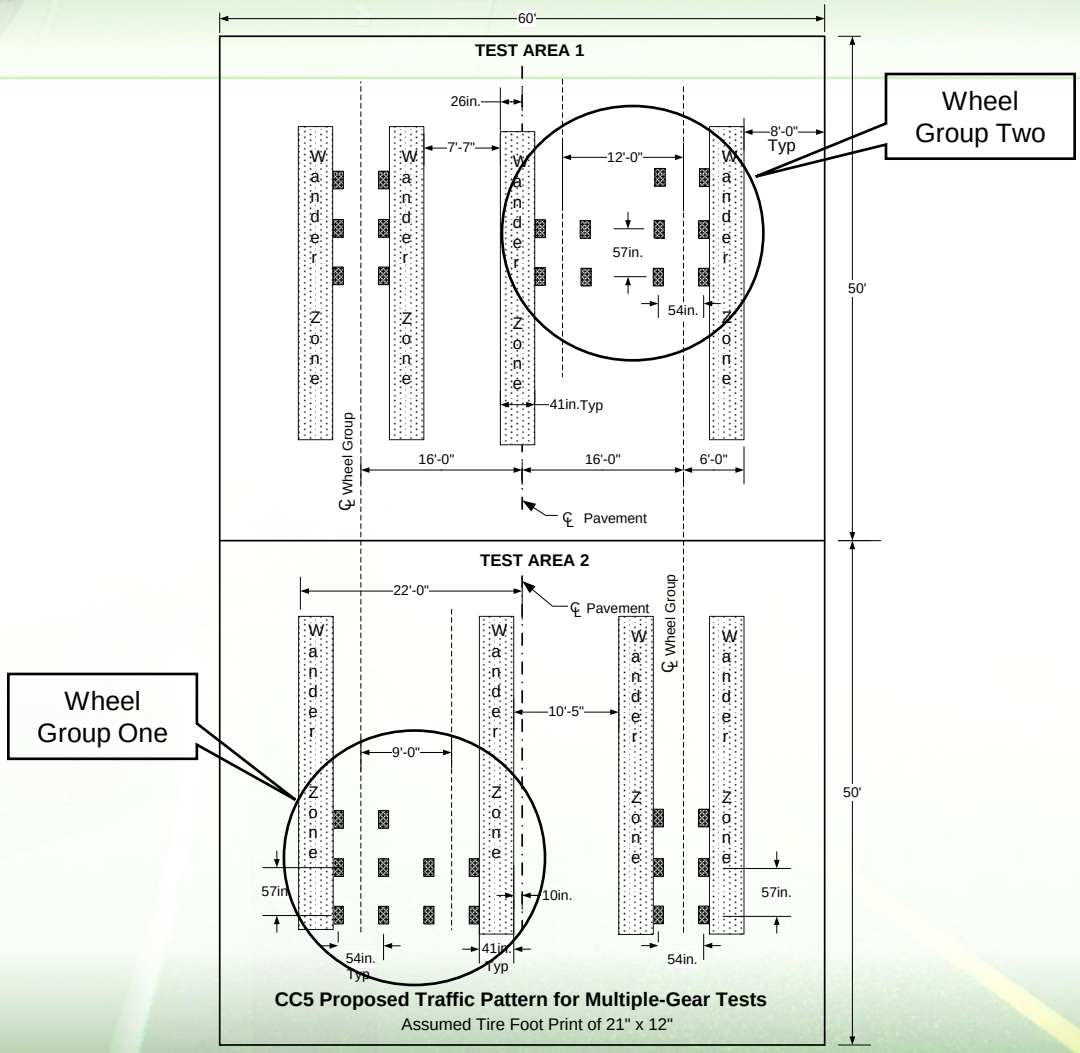
Annual Departures = 1,200

Aircraft Name	Des. Thickness Old Alphas, cm (in)	Des. Thickness New Alphas, cm (in)	Thickness Delta, cm (in)
B-747-400 4 wheels	173.3 (68.23)	166.3 (65.47)	7.0 (2.76)
B-747-400, 8 wheels	187.0 (73.62)	162.9 (64.14)	24.1 (9.48)
B-747-400, 16 wheels	203.7 (80.20)	178.4 (70.24)	25.3 (9.96)
A-380, 6 Wheels	200.2 (78.83)	174.4 (68.68)	25.8 (10.15)
A-380, 12 Wheels	214.6 (84.50)	184.7 (72.73)	29.9 (11.77)
A-380, 20 wheels	238.2 (93.76)	209.3 (82.39)	28.9 (11.37)

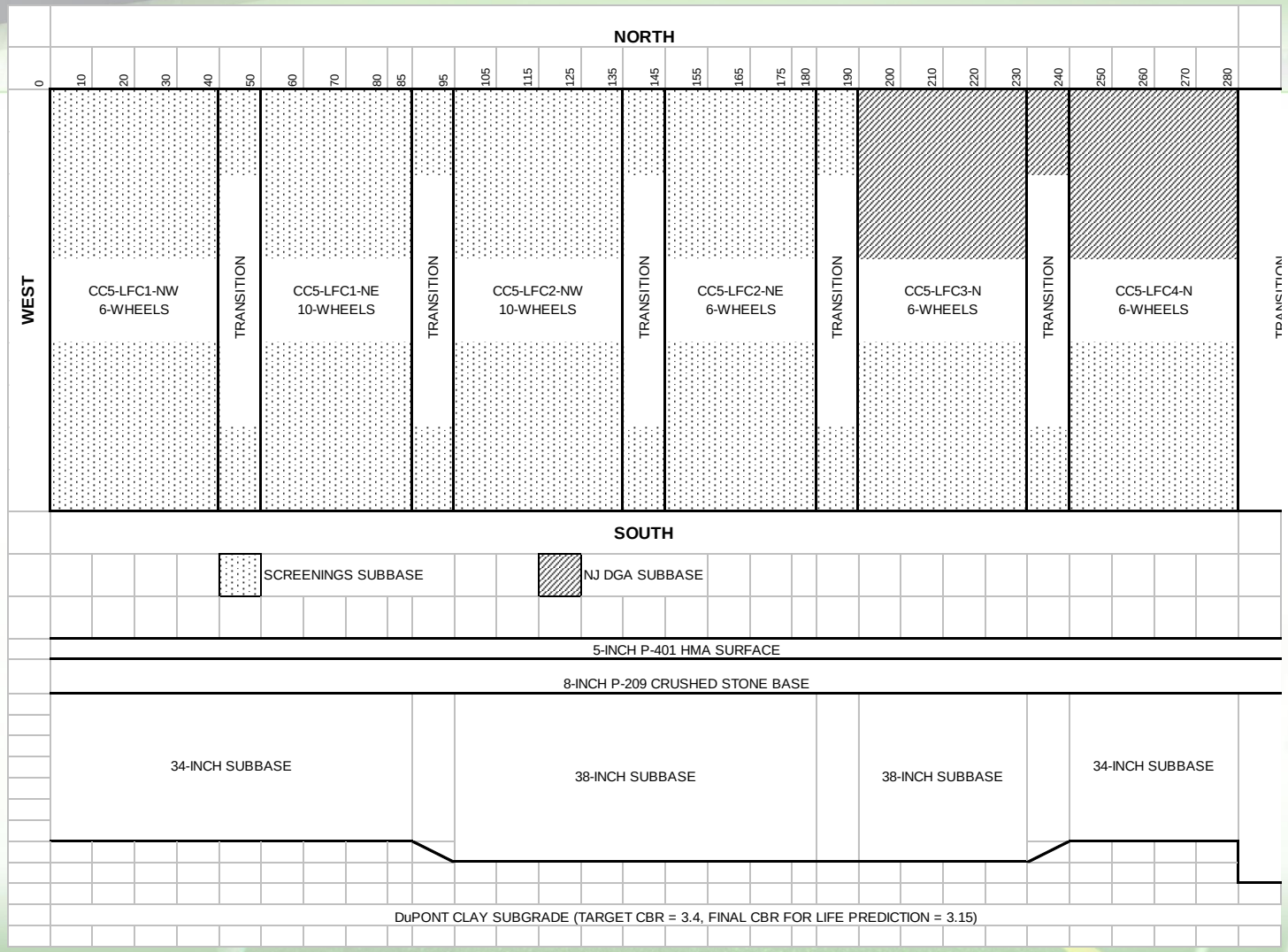
CONSTRUCTION CYCLE FIVE TEST ITEMS (CC5-TI) OBJECTIVE

- Determine the effect of gear interaction on low-strength subgrade flexible pavement life.
- Run six- and four-wheel carriages in close proximity on one half of a test item and run only the six-wheel carriage on the other half.

CC5-TI MULTIPLE-GEAR CONFIGURATIONS



CC5-TI TEST ITEM LAYOUT



CC5 GEAR CONFIGURATION

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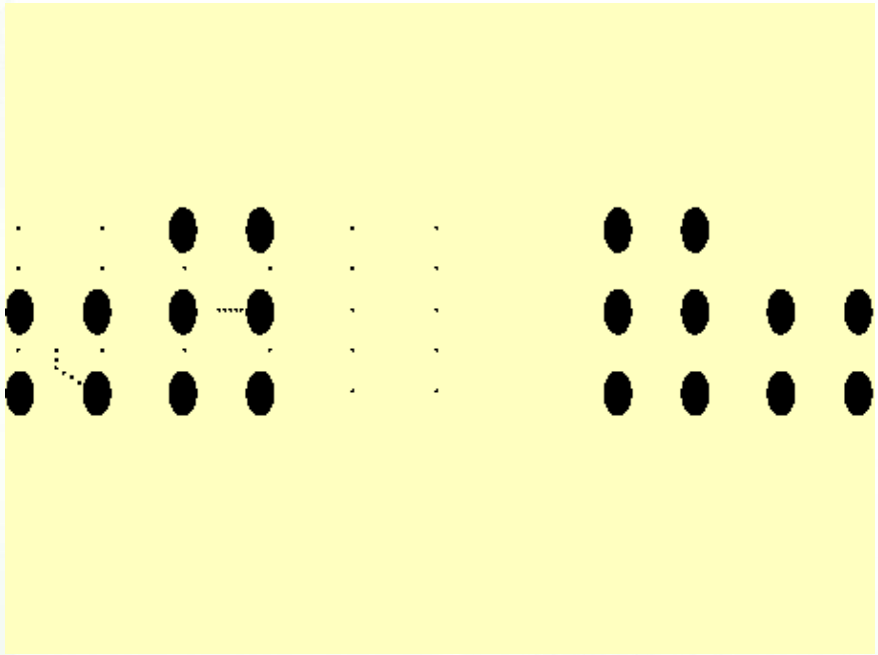
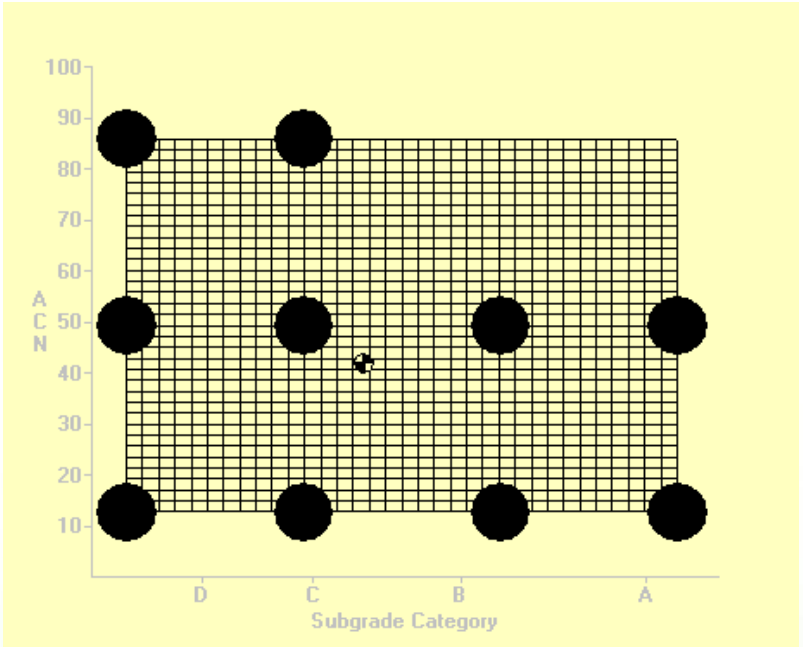
FAARFIELD Model



COMFAA Model



CC5-TI – PREDICTED LIFE

- Subgrade Strength = 3.15 CBR.
- Wheel Loads = 24.95 MT (55,000 lb).
- Subbase Thickness = 965 mm (38 in).

Number of Wheels	Passes to Failure - CBR Method (07 Alphas)	Passes to Failure - FAARFIELD
6	2,260	2,118
10	440	1,220
Ratio 6/10	5.1	1.7

TRAFFICKING CC5 AT 31.8 MT (70,000 LB)

TRAFFIC TESTING COMPLETED

- North side with mixed load traffic in 2008 and 2009.
- South side with 31.8 MT (70,000 lb) load only in 2010.

STRUCTURAL FAILURE CRITERION

- One-inch (25.4 mm) upheaval outside the wheel tracks.

MEASURING TRANSVERSE PROFILES – 9.75 m (32 ft)-LONG PROFILER

CC5-TI LFC1-NORTH AT FAILURE

CC5-TI LFC1-NORTH AT FAILURE

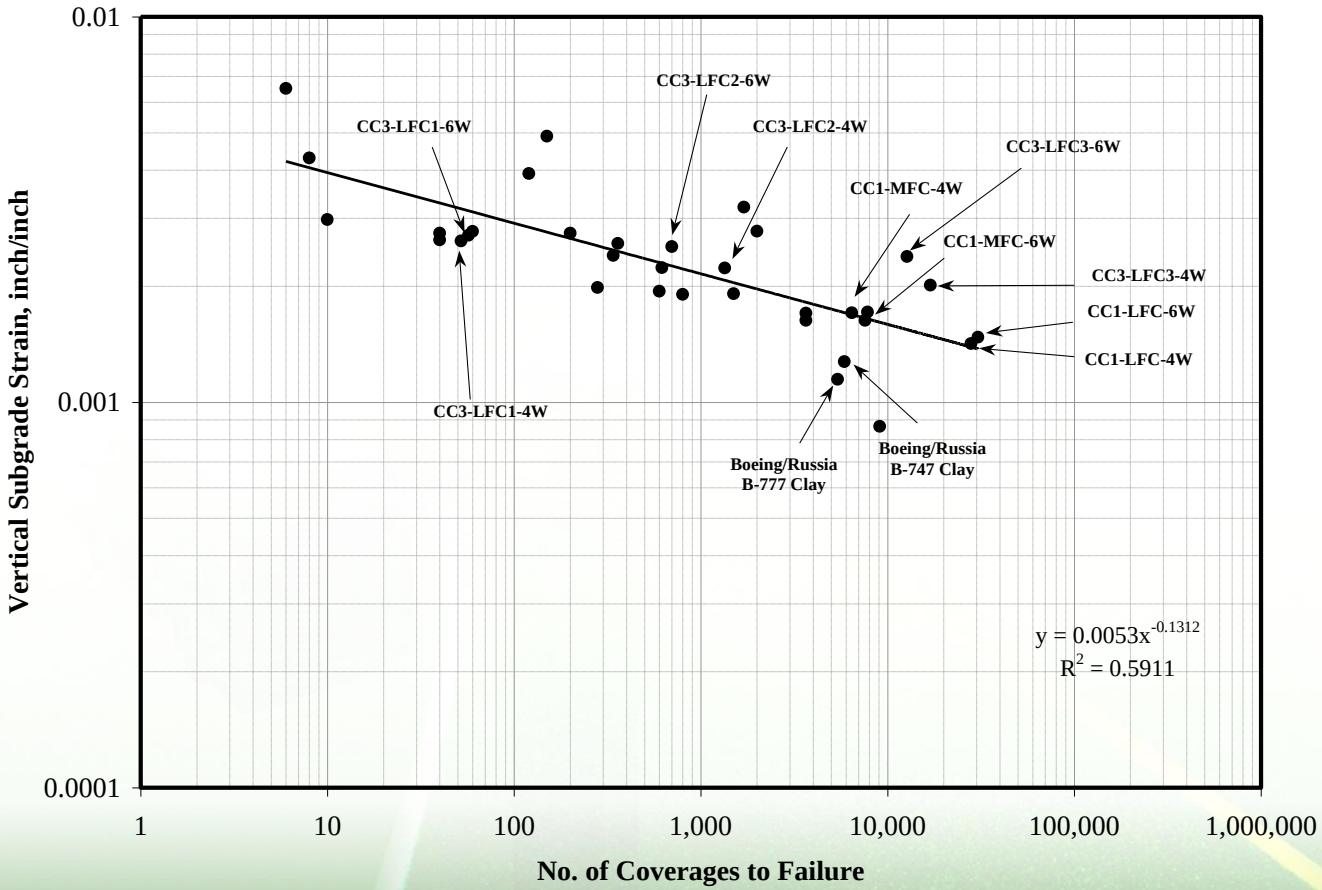
CC5-TI LFC1-NORTH AT FAILURE

CC5-TI LFC1-NORTH AT FAILURE

COMPENSATION FOR TEMPERATURE AND LOAD CHANGES

- A methodology had previously been developed for normalizing the number of passes to failure to a standard temperature.
- The procedure was extended to include changes in load and normalization to a standard load.
- Also, the FAARFIELD models were used for strain computation with a non linear failure model calibrated to the 4- and 6-wheel CBR method alpha factor curves.

Illustration of the General Method for Temperature Compensation Assuming a Linear Failure Model



For a given pavement structure, it is assumed that the slope of the model is as shown in the figure but that the curve for the given structure may be moved up or down relative to the curve in the figure.

FAILURE MODEL

$$C_F = \left(\frac{A}{\varepsilon}\right)^B$$

Where:

C_F = Coverages to failure

ε = vertical strain at the top of the subgrade

A = vertical offset of the log-log failure model

B = slope of the log-log failure model

Hold B constant and find the value of A which satisfies $CDF = 1$ at the end of testing.

TEMPERATURE COMPENSATION METHODOLOGY

1. Separate the rut depth versus passes curve into distinct temperature regions.
2. Estimate the modulus of the asphalt using a suitable model.
3. Compute strain at the top of the subgrade.
4. Convert passes to coverages.
5. Find the value of A to give a CDF of 1 summed over all temperature regions.
6. Find the number of passes to failure at the reference temperature (asphalt modulus = 1,380 MPa (200,000 psi)).

TEMPERATURE COMPENSATION METHODOLOGY (continued)

$$CDF = \frac{C_1}{C_{1F}} + \frac{C_2}{C_{2F}} + \frac{C_3}{C_{3F}} + \ldots$$

$$= \frac{C_1}{A^B}\varepsilon_1^B + \frac{C_2}{A^B}\varepsilon_2^B + \frac{C_3}{A^B}\varepsilon_3^B + \ldots$$

$$= \frac{C_1\varepsilon_1^B + C_2\varepsilon_2^B + C_3\varepsilon_3^B + \ldots}{A^B}$$

Therefore, to give a CDF of 1

$$A = \left(C_1\varepsilon_1^B + C_2\varepsilon_2^B + C_3\varepsilon_3^B + \ldots\right)^{\frac{1}{B}}$$

TRAFFIC PASSES ON CC5-TI LFC1-NORTH

Load, MT (lb)	Passes With 10-Wheel	Passes With 6-Wheel
22.68 (50,000)	7,917	7,917
26.31 (58,000)	4,954	4,954
29.49 (65,000)	5,621	5,621
31.75 (70,000)	3,778	9,031
Sum, Not Normalized	22,270	27,523
Sum, Normalized to 31.75 MT and 33.3 °C (92 °F)	6,185	11,432
Ratio 6-Wheel to 10-Wheel, Normalized		1.8

CC5-TI LFC1 – SUMMARY OF ALL APPLIED TRAFFIC (PRELIMINARY RESULTS)

Load	Passes With 10-Wheel	Passes With 6-Wheel
LFC1-North Sum, Normalized to 31.75 MT (70,000 lb) and 33.3 °C (92 °F)	6,185	11,432
Ratio 6-Wheel to 10-Wheel		1.8
LFC1-South Trafficked at 31.75 MT (70,000 lb) and about 27 °C (80 °F)	10,560	12,936
Ratio 6-Wheel to 10-Wheel		1.2
Predicted Ratio 6-Wheel to 10-Wheel		CBR = 5.1, FF = 1.7

CONCLUSIONS

- The current 10-wheel alpha factor curve is very conservative compared to the 6-wheel alpha factor.
- The layered elastic design procedure provides a good estimate of the relative life for 6- versus 10-wheel loading.
- The flexible pavement failure model in FAARFIELD should be recalibrated.

RECALIBRATION OF THE FAARFIELD FLEXIBLE PAVEMENT FAILURE MODEL

- Calibrate to AC 150/5320-6D (CBR method) under the following conditions:
  - CBR thickness calculations based on the new alpha factors.
  - Do not include multiple-gear aircraft, such as 747 and A380, in the calibration aircraft traffic mix.
  - Replace the current FAARFIELD bi-linear failure model with a continuous curve derived from the alpha factor full-scale test.

FUTURE WORK

- Posttraffic testing (started September, 2011).
  - Measure material properties.
  - Measure rutting and upheaval in all layers.
- Traffic CC5-LFC4-South with 5 duals in tandem (10 wheels)
- Recalibrate FAARFIELD flexible thickness design.