Pilot Course – Airfield Construction Training

A Corp of Engineers and FAA Concrete Paving for Airfields Accredited Training Program

Program Introduction
From: Purpose, Vision and Strategic Objectives of American Concrete Pavement Association

To expand the use and *improve the quality* of concrete pavement for highways, airports, streets, roads and commercial facilities.
Program Objective

- Promote quality
- Prequalify Construction Industry
  - Contractor
  - Engineer
  - Owner
- Present best practices for constructing airport concrete
Not your typical highway pavement

- Non channelized traffic
- Heavy load
- Heat
- Mission based
- No detours
Not as channelized traffic
Heavy Loads/Higher tire pressures

Tire Pressure
300 PSI (+)
No Detours
Introduction

● Issues facing military airfields
  ● High cost of shutdowns
  ● Operational readiness
  ● SAFETY!

● Desired performance
  ● Well-designed
  ● Withstand aircraft loadings
  ● Withstand climatic conditions
  ● Minimum maintenance and repair
FOD Damage / Result
Risk of Distress must be minimized

- Proper pavement thickness
- Adequate foundation support – free-draining and non-erodible
- Proper joint layout and construction
- Adequate load transfer
- Proper materials for concrete
- Adequate consolidation
- Proper finish
- Maintenance – particularly joint sealant

Sound design and construction principles
Airport Concrete Pavement Fundamentals

- Airport concrete pavement types
  - Typically JPCP (no steel),
    - doweled vs. non-doweled
    - transverse vs. longitudinal joints.
  - Generally little use of JRCP & CRCP for production paving.
Commercial Airfields

- FAA Design procedure required
- FAARFIELD software
- Finite element computer model
- Design for 20 years based on traffic
- Federal Specification Guidance
- Federal Agency defines the minimum requirements
- But, the airport sponsor is the ultimate owner
Department of Defense funds
Corp of Engineers UFGC define the requirements
PCASE (Pavement-Transportation Computer Assisted Structural Engineering) Program
Mission based design life
UFG Specifications
Government owns the pavement
The devil is in the details!

- Joints
- Load Transfer
- Seal vs. no seal
- Compressive vs. flexural strength
- ASR testing
- Deicers
- Deleterious Material requirements
Deleterious Testing Recurring Issues

- Insufficient lead time given to lab to perform testing
- Deleterious examination report should be review and approved prior to starting mix design studies
- Contractor complaints of associated cost of test and length to time to obtain test evaluation data
- DOT Quality testing likely inadequate for airfield materials
- Assure testing is performed and never waived
- Assure testing performed during construction

“Highway practices, FAA policy, etc. does not change military requirements. These military limits have been selected and adjusted over time based on specific reasons.” – Dr. Ray Rollings, Nov. 2009
Deleterious Testing Recurring Issues

- Submission of Outdated Information or ASTM C 295
  - Evaluation (smaller samples)
  - Evaluation does not address all deleterious materials Required in UFGS
- Submission of test data performed by:
  - Non-validated accredited Lab
  - Non-validated petrographer
- Lab/Petrographer NOT provided copy of spec or testing sequences described in UFGS prior to testing
- Petrographic Examiner unaware of minimum test sample sizes or required testing sequence noted in UFGS
- Petrographers splitting sample or evaluating 100/300 pieces
Comparison of selected military UFGS 32 13 11 and ASTM C 33 Requirements

<table>
<thead>
<tr>
<th>Deleterious Material</th>
<th>Test Standard</th>
<th>USAF/ Army Maximum %</th>
<th>Navy Maximum %</th>
<th>ASTM Maximum %</th>
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</thead>
<tbody>
<tr>
<td>Clay lumps and friable particles</td>
<td>ASTM C 142</td>
<td>0.2</td>
<td>1.0</td>
<td>3.0</td>
</tr>
<tr>
<td>shale</td>
<td>ASTM C 295</td>
<td></td>
<td>0.1</td>
<td></td>
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<tr>
<td>Material finer than 0.075 mm (No. 200 sieve)</td>
<td>ASTM C 117</td>
<td>0.5</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Lightweight particles (SG &lt; 2.0)</td>
<td>ASTM C 123</td>
<td>0.2</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>Clay ironstone</td>
<td>ASTM C 295</td>
<td>0.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chert and cherty stone</td>
<td>ASTM C 123/C 295</td>
<td>0.1</td>
<td></td>
<td>5.0</td>
</tr>
<tr>
<td>Claystone, mudstone, siltstone</td>
<td>ASTM C 295</td>
<td>0.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shaly and argillaceous limestone</td>
<td>ASTM C 295</td>
<td>0.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other soft particles</td>
<td>COE CRD-C 130</td>
<td>0.1</td>
<td></td>
<td></td>
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<tr>
<td>Coal and lignite</td>
<td>ASTM C 123/C 295</td>
<td></td>
<td></td>
<td>0.5</td>
</tr>
<tr>
<td>Total deleterious substances exclusive of material finer than 0.0075 mm</td>
<td></td>
<td>1.0</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>Sum of clay lumps, friable particles, and chert</td>
<td></td>
<td></td>
<td></td>
<td>5.0</td>
</tr>
</tbody>
</table>
Deleterious Materials

- Major difference between Civil and Military airports
- FOD hazard increased – high performance aircraft
- 32 13 11 Supplementary report – page 58 and 59
- Requirements are mandatory for military airfields!
  - Waivers for USAF Bases by MAJCOM Engineer only
  - Significant cost increased is recognized
- Specifically enforced to reduce pop-outs (FOD)
Qualifying Construction Materials

Aggregates

- Review State DOT records for performance history & certification
- Use largest max. size consistent with placement requirements
- Must meet project specs (typically ASTM C33)
  - Test for ASR
  - Test for F/T durability
- Lead time required for test results
ASR Test Methods

- C 295 – Petrographic Examination
- C 289 – Quick Chemical Test (False Negatives)
- C 277 – Mortar Bar Test (False Negatives)
- C 1260 – Accelerated Mortar Bar Test (Aggregate)
- C 1567 – Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Aggregate Mortar Bar and not aggregate combination and SCM)
- C 1293 – Concrete Prism Test (CPT)
Alkali Silica Reactivity (ASR)

- Evaluate Track record
  - Aggregates from operational pits and quarries – include cementitious materials, w/cm, age
- ASTM C 1260
  - Expansions \( \leq 0.10\% \) -- Accept
  - Expansions \( > 0.10\% \) -- Suspect. Do more tests.
- Use mitigation measures if aggregate is reactive
  - Pozzolan
  - Blended or low-alkali cement
  - Lithium nitrate???

ASR results in significant expansion and cracking of concrete.
Freeze-Thaw Testing (D-Cracking)

- Reject D-Cracking susceptible aggregates (porous)
- Test all suspect aggregates
  - ASTM C 666
  - 5 year successful performance
  - 3 projects

D-Cracking – Disintegration of coarse aggregates after they become saturated and are subjected to F-T cycles
Lead Time – ASR & F-T Testing

- ASTM C 1260 (ASR) - 30 days for testing.
  - Corp requires 0.08% expansion at 28 days of soaking
  - FAA requires 0.10% expansion at 28 days of soaking
- ASTM C 1293 (ASR) - 1 year to test aggregate for potential reactivity; 2 years to test effectiveness of mitigation measures.
- ASTM C 666 (F-T) - 2 to 3 months.

Notes:
1. About 60 days is available from contract award to start of work, so aggregate acceptance needs to be done within that time or before award.
2. ASTM C 1567 can be used to test the effectiveness of mitigation measures. Several combinations of cementitious materials can be tested simultaneously.
Test Strip Construction (if required)

- Used to evaluate concrete batching, transporting, placement, finishing, curing & QA/QC
  - Photos of acceptable and unacceptable sawcuts
  - Establish/validate maturity data or NDT for sawcutting
Test Strip Construction

- Some agencies require a test strip

Options:

- Build the test strip and remove it
- Consider the first day of paving as a test strip
- Consider the first day of paving as a test strip and remove the first 200 ft
Test Strip Construction

Test strip details

- Preferably non-critical location on finished grade
- 1,000 ft length – good production run, full paving width
- All processes same as for production work
- Possibly include paving at/around blockouts (light cans, etc.)
- Possibly include hand placement (e.g. fillet)
- Include at least one header
Test Strip Evaluation

- Test strip acceptance
  - Perform specified QA/QC tests
  - Inspect all processes
- Identify & implement actions to correct/resolve deficiencies in any process
- Review and adjust QMP/CQC Plan

Test Strip Documentation:
Documentation for the test strip should be developed, submitted, and reviewed as if production paving was taking place on the project.
Cores will tell a story

- DoD will always take cores
- Beams don’t tell full story
- Cores for thickness, consolidation, gradation, etc.
Isolation Joints

- **Note A:** 1.25 T to nearest 1 in. (25 mm) but at least T + 2 in. (50 mm).
- **Note B:** To nearest joint; 10 ft (3 m) minimum.
Where to Isolate...

Different Movement Axis
Terminology Change

Isolation/Expansion Joints

- Doweled
- Thickened Edge

Cap

Filler

1.25T
JOINT SEALANT DETAIL (FIGURE 12-31)

THICKENED EDGE LONGITUDINAL

JOINT SEALANT DETAIL (FIGURE 12-31)

EXISTING PAVEMENT

NEW PAVEMENT

NO. 5 DEFORMED STEEL BARS 2" LONG, SPACED ON 1'-6" CENTERS, AND PLACED PARALLEL TO THICKENED EDGE

ALL OF THE CONCRETE LOWER THAN THE BOTTOM OF THE EXISTING PAVEMENT SHALL BE HAND PLACED AND THOROUGHLY VIBRATED WITHIN 24 HOURS BEFORE THE PAVING TRAIN REACHES THIS POINT.

SPECIAL JOINT BETWEEN NEW AND EXISTING PAVEMENT TRANSVERSE OR LONGITUDINAL

CONVERSION FACTORS

MILLIMETERS = 25.4 x INCHES
METERS = 0.3048 x FEET

Figure 12-32. (Sheet 2 of 3)
9. **Expansion Joint**

- Joint Sealant: Detail Size A
- Expansion Cap: Slip fit
- Paint and Oil: End of Cap

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5. **Connection to Existing Concrete (Odd Shaped Panel)**

- Joint Sealant: Detail Size A
- Expansion Joint: 4" Max
- Reinforcing Steel: 20 gage, 12" O.C.
- Special Joint Between New and Existing Pavement

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[Diagram showing details of expansion joint and connection to existing concrete]
Fillet Details
Contraction Joints

- Note: Use an initial sawcut depth of $T/4$ on unstabilized (granular) subbases and $T/3$ on stabilized subbases.
Establish procedures to follow in case of impending rain
- Stop paving operation ASAP
- Cover freshly placed concrete
- Do not remove excess water before covering

Damage due to rain
- Surface damage – wash away of paste
- Rapid cooling - potential for cracking & greater slab curling

Evaluate rain damage by examining & testing core samples – effect on durability
One day's paving entire surface ground to remove rain damage....10+ years of service, no problems
California Profilograph is old Technology—

—So what do we specify?
Why Be Concerned About Runway Roughness?

- Aborted Takeoff
- Poor Braking Performance
- Increased Operational & Support Costs & Aircraft Fatigue Damage
- Reduces Pavement’s Useful Life and Could Result in Costly Unscheduled Repairs
- Pilot and Passenger Complaints
Runway Roughness Evaluation: A Unique Problem

- Landing Gear Spacing of nearly 100 Feet
- Speeds up to 150 Knots
- Aircraft will Respond to Bumps 300 Feet Long or Longer
- Multiple Bumps in Succession; Non-Linear Effect
- Struts are Primarily Designed for Landing Impact
What is Smooth?

How smooth is smooth?

- **Shock**
  - Sharp Change in Elevation
  - Suspension system cannot absorb the energy

- **Short Wavelengths**
  - Bump (in 16 feet)
  - Suspension system can react too

- **Long Wavelengths**
  - Deviations from grade control or interaction with crown
  - Aircraft Responds as a whole
How do you measure smooth?

- 16 foot straightedge
- California Profilograph
- Lightweight Profilers
- Wet/Dry Profilers
- Contact Profilers
Existing Smoothness Indices

- Profile Index (PI)
- International Roughness Index (IRI)
- Ride Number (RN)

No relationship exist between the IRI and RN to the straightedge measurements.

No correlation exist between profiler measurements and straightedge measurements.
FAA Criterion

- 16 Foot Straightedge
- Directly related to construction practices
- Cannot account for non-linear effects of multiple bumps at regular intervals
- Does not account for aircraft velocity
- Indices cannot be used to categorize straightedge results
Evaluation Criteria

- What do we measure?
- What accuracy is required?

“It is actually counter-productive to measure accuracies that do not affect aircraft response.”
Current Smoothness Criteria

- 16 feet straightedge
- Threshold of Acceptability – \( \frac{1}{4} \) inch measured anywhere along the length of the straightedge
- No criteria for long wavelength profile of a pavement feature
- Therefore no criteria exist for smoothness of an entire pavement feature
No Official Rejection Criteria For Existing Pavements

- Unofficial Methods Being Used
  - The Boeing Curve
  - IRI / PI / RN
  - Pilot Reported Roughness
  - Aircraft Simulation
Straight Edge Methods (New Pavement Acceptance)

- FAA AC 150/5370-10A - 16-Foot Straight Edge
- California Profilograph
- These Methods Will Produce Smooth Pavement when Combined with Grade Control (.5-inch to Design Elevation)
Deeper look into the background

- Developed for highways
- Automobile suspension systems
- CA PI relates to driver experience
- 1950’s technology—subjective
- Does PI values correlate to quality?
- Lightweight profiling equipment
Evolution of the California Profilograph

- Slipform pavers became experienced with California Profilograph—highways
- Build long runs with low PI numbers
- Easier than “kicking” a 16-foot straightedge
- ACPA proposed conservative PI number for acceptance
- FAA & USACoE adopted PI
- Threshold and removal criteria began to show up
- Now leads to dispute
Problems with Profilographs

- Highway industry
- 16-foot straight vs. profilograph suggest highway criteria is much too conservative
- Profilograph doesn't consider amplification of attenuating wavelengths
- Profilograph cannot emulate the 16-foot straightedge (25 feet instead)
- Therefore the PI cannot reflect smoothness as used in P-501 criteria
Misapplication and Misinterpretation of the Profilograph Specification

- Low PI = smooth
- Requiring low PI (e.g. 4” per mile)
- Low PI apron—phased project
- Short Sections
- Tying to existing pavement
- Using existing is measurements
- Effects of speed
Agency & Industry Supported Research

- Airfield Concrete Pavement Smoothness – A Handbook
- Evaluates Effectiveness of Various Profiler Types
  - Non-Contact Type
  - Contact Type
- Identifies Key Factors in Constructing Smooth Concrete Pavements
California Profilograph is old Technology—

—So what do we specify?
Proposed smoothness criteria

- 25 foot rolling straightedge (or simulated from profile measurement).
- Threshold of acceptability – 0.35 inches deviation
- Pavement sections length – 500 feet minimum.
- After must grind areas are corrected no more than 3% of the measurement should exceed the threshold values.
- Must repair for Keel Sections – deviation ½ inch.
- Must repair for outer lane sections – deviation ¾ inch.
- Transverse measurement at 500 feet intervals – more for special design sections.
- 2 longitudinal measurements per paving lane
- 3 or more repeated bumps may need repair.
- Exceptions for intersecting runways, aprons, taxiway with drainage
Thank You!
Questions?

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