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Rubbilization of Airfield Concrete Pavements

By

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Overview

• Introduction
  – FY 03-04 AFCESA Research
  – FY 05 AMC Research

• FY 03-05 Research Approach
  – Phase 1
    • Equipment & Procedure
  – Phase 2
    • Highway and Airfield Rubblization Evaluations
    • Cost Analysis
      – Grand Forks Air Force Base Study
      – GF AFB Guidelines and Specifications
    • Runway Reconstruction Project

• Results and Conclusions
• Future Research Studies
• Questions
Main Objective:

- Develop a design procedure and criteria for the design of asphalt overlays over rubblized, and crack and seat PCC pavements.

Project History:

- FY 03-04 AFCESA: Rubblization Design Procedure
- FY 05 AMC: Grand Forks AFB Runway Reconstruction Project

Rubblization…

- …is a relatively “new” rigid pavement rehabilitation technique.
- …eliminates existing slab action by breaking the PCC pavement into small particles ranging from:
  - sand size to 75 mm (3 in) at the surface,
  - 150 to 230 mm (6-9 in) on the top half,
  - 305 to 380 mm (12-15 in) at the bottom half of the PCC layer.

Crack and Seat has almost been replaced with Rubblization due to the significant advantages that it proves to have in the rehabilitation of PCC pavements.
Why Rubblization?

- **Pavement Distresses**
  - Reflective Cracking
  - Severe Joint Deterioration
  - Slab Settlement
  - Excessive Patching
  - “Pop-outs”, etc.
Rubblization Equipment

- Current U.S. major contractors:
  - Resonant Machines Inc. (RMI)
    - Resonant Breaker, RB-500
      - Low Amplitude
        » 12 to 20 mm (1/2-3/4 in)
      - High Frequency Hammer
        » 44-47 Hz
  - Antigo Construction, Inc.
    - Guillotine Type Breaker
      - 5,440 kg (12,000 lb), 2.4 m (8 ft) hammer
    - Multi-Head Badger Breaker®
      - 16-450 kg (1,000 lb) hammers
      - 4 m (13 ft) wide
      - 1.5 m (5 ft) individual drops

* Pictures from Antigo and RMI Website
**Particle Size Distribution**

**RMI Particle Size Specifications:**
- **Particle Size Range:**
  - Sand size to 6 inches not greater than 1.25 times $h_{rub}$
- **Majority of the pieces:**
  - Sand size to 0.75 times $h_{rub}$
- **For reinforced PCC:**
  - Larger pieces are accepted and reduced to the best possible size.

**Antigo Construction Inc. Particle Size Specifications:**
- **Size Range:**
  - Sand size to 3 inches or less in the top half of the slab.
  - 9 inches or less in the bottom half of the slab.
- **For reinforced PCC:**
  - Similar to the RMI Specifications

$h_{rub} = \text{maximum depth of the slab}$

$h_p = \text{pavement thickness}$
Highway Rubblization Projects

- **I-10 Louisiana Rehabilitation Project**
  - 11.0 km (7-mi) pavement rubblization
  - Contractor: Resonant Machines, Inc.
  - Pavement Structure:
    - 250 mm (10 in) AC O/L
    - 230 mm (9 in) Rubblized PCC
  - Subgrade: Sandy Soil

- **I-65 Alabama Rehabilitation Project**
  - Contractor: Antigo Construction, Inc.
  - Pavement Structure:
    - 280 mm (11 in) AC O/L
    - 250 mm (10 in) Rubblized PCC
  - Subgrade unknown
  - Test Pits required every 305 m (1000 ft)
Airfield Rubblization Projects

- **Hunter Army Airfield, Savannah, GA**
  - East Taxiway Rubblized in 2003
  - Equipment (Antigo Construction Inc.):
    - Guillotine type breaker
    - Multi-Head Badger Breaker
  - Pavement Structure
    - 250 mm (10 in) AC O/L
    - 11,000 m² (13,167 yd²) of 200 mm (8 in) Rubblized PCC
    - Subgrade: Poorly Graded Sand

- **Selfridge Air National Guard Base, MI**
  - Runway Reconstruction, Summer 2002
  - Equipment (Antigo Construction Inc.):
    - Guillotine type breaker
    - Multi-Head Badger Breaker
  - Pavement Structure
    - 180 mm (7 in) AC O/L
    - 115 mm (4.5 in) Crushed Concrete Base Course (leveling course)
    - Rubblized PCC thicknesses varied from 330 to 530 mm (13-21 in)
    - Subgrade: Silty Sand soils

* Picture from the Antigo Construction, Inc. Website
Rubblization Evaluation Results

• **Pavement Structural Evaluation**
  • Collect and analyze HWD data
  • Maximum load: 114,400 kg (52,000 lb)
  • Data analyzed in the PCASE program
    • Back-calculate Modulus values using WESDEF

• **Airfield Evaluation Results**
  • Hunter Army Airfield
    • Average Rubblized PCC Modulus values:
      • 4,070 MPa (590 ksi)
  • Selfridge ANG Base
    • 530 mm (21 in) Rubblized PCC Modulus values:
      • 8,700 MPa (1,260 ksi)

• **Additional FWD data:**
  • Niagara Falls Joint Air Reserve Station
    • Data provided by AFCESA
    • Runway Pavement Structure:
      • 130 mm (5.0) AC O/L
      • 240 mm (9 in) Rubblized PCC
      • Subgrade: Silty Gravelly Sand
    • Average Rubblized PCC Modulus values:
      • 700 to 1,080 MPa (100-157 ksi)
    • Variations:
      • High Water Table
      • Shallow Depth to Bedrock
Based on the rehabilitation of a 480 mm (19 in) PCC pavement:

- **Grand Forks Air Force Base pavement design:**
  - Air Force Medium Traffic
    - 400 passes B-52
    - 400,000 passes C-17
    - 100,000 passes F-15E

- **Costs:**
  - Rubblization:
    - $1.15 - $5.50 per square meter ($0.95 - $4.50 per square yard)
  - Break & Remove:
    - $3.95 - $7.50 per square meter ($3.30 - $6.50 per square yard)
  - Rubblization cost is approximately 40% of the cost of break and removal.
• **Monitor Ongoing Rehabilitation Project in Grand Forks Air Force Base, North Dakota**
  - Interesting Facts:
    - 250,000 sq. yards of PCC Rubblization
    - Average PCC layer thickness = 16-19 inches
    - Rubblization contract
      - Replaced RMI for Antigo Construction Inc.
    - New pavement will consist of AC and PCC overlays
  - Measure pavement response (HWD/FWD):
    - Before rubblization
    - After rubblization, before seating
    - After seating/ before AC/PCC overlay
    - After AC/PCC Overlay
  - Material characterization
    - Particle size distribution
      - Test pit particle sampling
    - Verify existing Rubblization guidelines and specifications
Grand Forks AFB Rubblization Process

Step 1
Rubblize PCC Pavement

Step 2
Roll surface to crush, settle, and compact rubble for appropriate particle interlock

Step 3
AC/PCC Overlay

6-12 in crushed PCC (leveling course)
GF AFB Phase I Runway Rubblization: 14-inch PCC pavement
Results and Conclusions

• Without proper guidance, rubblization may not be considered a practical solution and there is substantial risk of premature failures.

• Overall cost of rubblization represents a 10% cost savings.

• Important Considerations:
  – Concrete slab
    • Thickness
    • Reinforcement type (if any)
    • Underground utilities
  – Base and Subgrade Strength
    • Soil moisture
    • Type of material
    • Subgrade Modulus >15,000 psi.
  – Proper drainage system

• The engineer may require more roller passes to achieve proper compaction. Over-compaction will break particle interlock.

Proper drainage is required
Test Pits – Verify Cracked Pattern
Traffic Control
Future Research Studies

- FAA Pavement Test Facility, New Jersey
  - Load/Rolling tests
    - HVS
    - Aircraft loading
  - Monitor Long-term Rubblization Projects
    - Existing condition evaluations
    - Non destructive testing:
      - HWD/FWD
    - Evaluate “old” crack & seat projects
      - Aberdeen Proving Grounds
    - Traffic responses
      - 5 (+) year term
      - HVS-A
        - Full-Scale Accelerated Pavement Testing
  - Other projects:
    - USAF – Elimination of Alkali-silica Reaction (ASR)
    - Travis AFB, California
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For additional information on rubblization specifications:
- Asphalt Institute Website, www.asphaltinstitute.org
- Engineering Brief No.66 Rubblized Portland Cement Concrete Base Course, February 13, 2004 Federal Aviation Administration

US Army Corps of Engineers Rubblization Specifications are currently under development. For more information please contact Eileen M. Vélez-Vega at Eileen.M.Velez-Vega@erdc.usace.army.mil
Thank you for your time!

QUESTIONS?
Contact Information

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