# Antigo

### Airport Pavement Rehabilitation: Rubblization of Deteriorated Concrete Pavement



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## **Presentation Outline**

- Antigo Construction Family of Companies
- Intent of concrete pavement rubblization & overlay
- Airfield rubblization with 8600 & MHB Badger Breakers<sup>®</sup> thick pavement
- Airfield rubblization with MHB Badger Breakers<sup>®</sup> only thinner pavement
- ⇒ Design considerations
- Construction sequence
- Airfield rubblization research
- ➡ Questions & answers

## **Antigo Construction Family of Companies**

- -Antigo Construction, Inc.: contractor U.S. projects
  - -Antigo, WI office: HQ and U.S. operations east of Rocky Mountains
  - -Boise, ID office: western U.S. operations
- -Badger State Highway Equipment, Inc.: manufacture breakers
  - -Antigo, WI office
- -Antigo International Inc: contractor international projects
  - -Antigo, WI office
- -Antigo MHB Breakers Ltd: contractor UK & Ireland projects
  - -Lyford, Oxfordshire, England office

## **Countries Where Antigo has Worked**

- Afghanistan
- Belgium
- Canada
- China
- Czech Republic
- Dominican Republic
- Germany
- India
- Ireland
- Philippines

- Poland
- Puerto Rico
- Saudi Arabia
- Slovak Republic
- South Africa
- Suriname
- Turkey
- United Kingdom
- United States

## **Reflective Cracking of Asphalt Overlay**



## Early Research - Fractured Slab Techniques

"In summary, the most significant concept relative to the philosophy of Fractured Slab Techniques, illustrated by Figure 62, is that in order to achieve the best possible performance at minimum cost, the fracturing process should yield an effective modulus as high as possible while satisfying the E<sub>cr</sub> criteria of having less than 5% of the project area exceed the critical threshold level of 1000 ksi."

From "Guidelines and Methodologies for the Rehabilitation of Rigid Highway Pavements using Asphalt Concrete Overlays", page 200, January 1991, PCS/LAW for National Asphalt Pavement Association.

### Early Research - Fractured Slab Techniques



FIGURE 62 INFLUENCE OF PCC FRACTURED MODULUS AND HMA OVERLAY THICKNESS UPON STRUCTURAL AND REFLECTIVE CRACK FAILURE

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#### Square Yards of Rubblization by Project Type Performed by Antigo





## **Rubblization Defined**

"The intent of rubblizing concrete pavement prior to a pavement overlay is to produce a structurally sound base which prevents reflective cracking by obliterating the existing pavement distresses and joints. . . . It is not a typical granular material and it is not an engineered material like crushed aggregate base course."

From "Rubblizing Concrete Pavement" section of WisDOT Construction & Materials Manual

### Distressed concrete: faulting & joint deterioration



### Distressed concrete: d-cracking



### Distressed concrete: mid-panel cracking



### Distressed concrete: longitudinal cracking



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### Distressed concrete: previous asphalt overlay removed



### Distressed concrete: water trapped below





## **Rubblized Pavement Behavior**

"A rubblized and compacted PCCP is an assemblage of PCC segments that form a tightly keyed, interlocked, high-density material layer. A rubblized PCCP layer is fractured, lacks continuity, and cannot sustain flexural stress. However, it possesses high shear strength and rutting resistance. It is not a typical granular material."

From "Hot-Mix Asphalt Overlay Design Concepts for Rubblized Portland Cement Concrete Pavements", Marshall R. Thompson, Transportation Research Record 1684, Paper No. 99-0922

## **Before rubblization**



## After rubblization



## Typical Airfield Specification – Thicker Existing Concrete Pavement

"Rubblization shall reduce the existing PCC pavement into particles with at least 75% (determined by visual inspection) having the largest dimension not exceeding: 3 inches at the surface; 9 inches in the top half of the PCC pavement; 15 inches in the bottom half of the PCC pavement."

"If necessary to achieve rubblization size requirements, Contractor may pre-crack the PCC pavement with a guillotine cracking device."

From Grand Forks Air Force Base project "Repair Runway 17-35" constructed in 2005, Specification Section 02999 "Rubblization".

## Airfield Rubblization with MHB & 8600 Badger Breakers®

Antigo Construction meets the requirements of airfield rubblization specifications for thick (15"+) concrete pavements by first breaking the concrete with the heavy guillotine-style hammer of the 8600 Badger Breaker® and then completes the concrete breaking using the 16hammer MHB Badger Breaker<sup>®</sup>. A grid roller is then used to further pulverize the concrete particles at the surface and begin the compaction process. Final compaction and seating is typically accomplished with a 25-ton pneumatic-tire roller.



## 8600 Badger Breaker®



## MHB Badger Breaker®







## Selfridge Air National Guard Base, Detroit, MI

- Constructed in 2002

- 21" thick, non-reinforced, concrete (10" layer over 11" layer) runway

- 95,000 square yards rubblized in 16 days

- Overlay: nominal 4.5 inch layer of crushed aggregate base (recycled concrete from project) for grade correction and 7 inches of hot mix asphalt



## Selfridge ANGB

"It is evident that the rubblized layer is an order of magnitude less than the concrete, namely 180,000 to 430,000 psi as compared to 3 million psi for the concrete. For comparison, a typical high quality crushed aggregate base has an elastic modulus of 30,000 psi, and hot mix asphalt of about 400,000 psi."

From"Runway Rubblization at Selfridge ANG" paper, John R. Anderson, Ph.D., P.E., Marshall R. Thompson, Ph.D., P.E., David Schilling, P.E., Starr D. Kohn, Ph.D., P.E., and George Shinners.

### Selfridge: truck 8600 pre-cracking 21" concrete



### Selfridge: MHB completing the rubblization



### Selfridge: grid roller



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## Selfridge: test hole



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### Selfridge: new HMA runway





## Grand Forks Air Force Base, ND

- Constructed in 2005
- 19"-24" thick, non-reinforced, concrete runway
- 237,000 square yards rubblized in 25 days

- Overlay: variable depth (4-13 inch) layer of crushed aggregate base (recycled concrete from project) for crown correction and 9 inches of hot mix asphalt

### GFAFB: 8600 starting huge project





### GFAFB: four 8600s & two MHBs



### GFAFB: surface after grid rolling





### **GFAFB: test hole**





## San Juan, Puerto Rico Int'l Airport

- Constructed in 2005 2007
- 15" thick, non-reinforced, concrete runway over cement-treated base (CTB)
- 143,000 square yards rubblized in 33 days (only one 8600 and one MHB utilized).
- Overlay: variable depth (3-6 inch) layer of crushed aggregate base and 16 inches of pcc pavement
### San Juan: longitudinal cracking



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#### San Juan: 8600 pre-cracking 15" concrete over CTB



## San Juan: MHB and grid roller



#### San Juan: surface after grid rolling



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#### San Juan: test hole



### San Juan: placing aggregate base layer

VÖGELE

### San Juan: compacting aggregate base layer



#### San Juan: concrete overlay in process





# Detroit Metro Airport – Michigan

 Rubblizing test in April, 2006 conducted by Northwest Airlines to determine feasibility of rubblizing runways and taxiways at Detroit Metro Airport

- 17" thick, reinforced, concrete taxiway
- Tested 8600 & MHB process and resonant breaker process

 Testing included excavated test holes and deflection testing with Heavy Weight Deflectometer

- Test results: rubblization with 8600 & MHB is viable, predicted HMA overlay thicknesses from 5 to 9 inches depending on traffic usage areas



## Detroit Metro Airport – Michigan

"Based on the data collected in this test program, it appears that the multi-head breaker is capable of rubblizing the full depth of the 17 inch concrete slab. This is also supported by a project performed at Selfridge ANGB where 21 inches of PCC was rubblized. The Selfridge project is now about 6 years in service and is still in excellent condition. The data indicates a modulus of 100,000 psi could be assigned to the rubblized layer for purposes of thickness design. Although, the energy could be slightly reduced and an increased modulus would result."

From July 17, 2006 report to Northwest Airlines by Starr D. Kohn, Ph.D., P.E., Senior Vice President, Soil and Materials Engineers, Inc., Plymouth, Michigan.

#### **Detroit Metro: 8600 and MHB**



## **Detroit Metro: grid roller**









#### Detroit Metro: test trench









## Griffiss Int'l Airport, Rome, NY

- Constructed in 2013
- 16"-24" thick, non-reinforced, concrete taxiways
- 53,000 square yards rubblized in 12 days

- Innovative use of milling machine to remove 5"-6" of rubblized concrete to lower the elevation prior to overlay

- Overlay: variable depth layer of crushed aggregate base and 5 inches of hot mix asphalt

#### Griffiss: 8600 pre-cracking the concrete



#### Griffiss: MHB completing the rubblization



### Griffiss: close-up of MHB





## Griffiss: grid roller





### Griffiss: test hole



## Griffiss: milling rubblized concrete



### Griffiss: placing crushed aggregate layer



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# Airfield Rubblization with MHB® Only

Antigo Construction meets the requirements of airfield rubblization specifications for <u>thinner (<15") concrete</u> pavements by breaking the concrete using only the 16hammer MHB Badger Breaker<sup>®</sup>. A grid roller is then used to further pulverize the concrete particles at the surface and begin the compaction process. Final compaction and seating is typically accomplished with a 25-ton pneumatic-tire roller.

# Typical Airfield Specification – Thinner Existing Concrete Pavement

"... rubblized into particles with at least 75% (as determined by visual observation) particles smaller than: 3 inches at the surface; 12 inches in the bottom half."

"Concrete pieces below reinforcing steel shall be reduced to the greatest possible extent, and no individual piece shall exceed 15 inches in any dimension."

From Sterling, CO project "Rehabilitate Runway 15/33" constructed in 2010, Specification ITEM P-215: BASE COURSE FROM RUBBLIZED CONCRETE PAVEMENTS.



# **Rantoul Airport, Illinois**

- Constructed in 1999
- 6-8" thick, non-reinforced, concrete runway & taxiway
- 45,670 square yards rubblized
- Demonstrated 3 maximum surface sizes: 3", 9" & 18"
- Overlay: 5 inches of hot mix asphalt

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#### **Rantoul: MHB rubblizing**



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## Rantoul: grid roller



### Rantoul: Professor Marshall Thompson's inspection





## Columbus Airport, Indiana

- Constructed in 2000
- 6" thick, non-reinforced, concrete taxiway
- 24,975 square yards rubblized
- Clay subgrade
- Overlay: 7.5 inches of hot mix asphalt

#### Columbus: mill existing overlay prior to rubblization



### Columbus: "clay man" in test hole



## Columbus: rubblized taxiway



### Columbus: rubblized surface



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#### **Columbus: HMA paving**





# Ephrata Airport, Washington

- Constructed in 2004
- 6" thick, non-reinforced, concrete runway & taxiway
- 26,500 square yards rubblized
- Overlay: 4 inches of hot mix asphalt
## Ephrata: MHB rubblizing





## Ephrata: test hole



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### Ephrata: rubblized surface



## Buffalo Niagara Int'l Airport, Buffalo, NY

- Constructed in 2005 & 2006
- 11" thick, continuously reinforced, concrete taxiway
- 21,000 square yards rubblized in 4 days
- Overlay: 8 inches of hot mix asphalt

### Buffalo Niagara: rubblize adjacent to active taxiway



### Buffalo Niagara: rubblize around catch basin







# Sterling Municipal Airport, Sterling, CO

- Constructed in 2010
- 6" thick, mesh-reinforced, concrete runway
- 34,543 square yards rubblized in 4 days
- Overlay: 6 inches of hot mix asphalt

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### Sterling: MHB rubblizing

![](_page_80_Picture_2.jpeg)

## Sterling: mesh debonded

![](_page_81_Picture_1.jpeg)

### Sterling: surface after grid rolling

![](_page_82_Picture_1.jpeg)

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# Sturgis Municipal Airport, Sturgis, KY

- Constructed in 2013
- 6" thick, non-reinforced, concrete runway
- Performed "modified rubblization" due to yielding subgrade
- 42,000 square yards rubblized in 2 days
- Overlay: 4.5 inches of hot mix asphalt

### Sturgis: concrete surface after asphalt milled off

![](_page_84_Picture_1.jpeg)

### Sturgis: MHB performing modified rubblization

![](_page_85_Picture_1.jpeg)

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## Sturgis: test hole

![](_page_86_Picture_2.jpeg)

### Sturgis: test hole verifies full-depth fracture

![](_page_87_Picture_1.jpeg)

![](_page_88_Picture_0.jpeg)

# **Design Considerations**

![](_page_88_Picture_2.jpeg)

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# **Design Considerations**

- 1. Subgrade investigation
  - Preliminary soil review:
    - Maintenance records
    - Soil maps
    - Geotechnical Engineer
  - Detailed subgrade investigation:
    - Falling Weight Deflectometer (FWD)
    - Dynamic Cone Penetrometer (DCP)
    - Subgrade soil samples

## **Subgrade Investigation**

![](_page_90_Figure_1.jpeg)

Figure 2. Subgrade/Base Layer Adequacy

From Wisconsin DOT Facilities Development Manual

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# **Design Considerations**

#### 2. Drainage needs

- Engineering judgment and local practice
- Full-length application or spot locations
- Install as far in advance of rubblization as possible
- Protect trench during construction

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# **Design Considerations**

- 3. Miscellaneous features
  - Cross-slope correction (milling, aggregate, asphalt)
  - Locate and mark utility structures
  - Profile changes (match into adjacent pavements)
  - Existing shoulder condition (overlay or reconstruct bottom up)
  - Underlying rigid layer, e.g., layer of concrete, bedrock (identify in plans)

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# **Design Considerations**

#### 4. Existing pavement

- Any asphalt overlay must be removed (bid item)
- Full-depth asphalt patches evaluated for soundness, replace as necessary
- Partial-depth asphalt patches: removal requirements vary
- Full-depth saw cuts required where rubblized concrete abuts concrete to remain in place

![](_page_94_Picture_0.jpeg)

# **Design Considerations**

- 5. Intermediate base layer
  - Often used for crown correction on airfield runway projects
  - May be used to improve base support in weak subgrade areas
  - May affect structural design

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# **Design Considerations**

- 6. Overlay design
  - Layer coefficients:
    - Nationwide range from 0.14 0.30 (roadways)
    - Wisconsin DOT 0.20 0.24 (roadways)
    - M-E design?
  - FAA Engineering Brief 66, "Rubblized Portland Cement Concrete Base Course":
    CBR method: equate rubblized material w/ P-209 material (conservative)
    - Layered elastic method: 30 300 ksi
  - Minimum overlay thickness over rubblized concrete (4-5"?)
  - Achieve minimum design thickness across pavement

![](_page_96_Picture_0.jpeg)

## **Construction Sequence**

![](_page_96_Picture_2.jpeg)

## **Construction Sequence**

- 1. Establish traffic control
- 2. Remove any existing asphalt overlay
- 3. Saw cut to protect concrete to remain in place
- 4. Rubblize to specified particle dimensions
- 5. Verify results by excavating test holes
- 6. Remove any steel reinforcement exposed at surface
- 7. Roll rubblized area with combination of compactors
- 8. Remove any loose materials from surface
- 9. Fill in any holes, depressions, etc. with filler aggregate or asphalt
- 10. Repair any unstable areas
- 11. Place asphalt overlay

## **Other Construction Considerations**

- 1. Material Transfer Device: heavy load requires adequate support
- 2. Prime coat generally not required on rubblized surface
- 3. Rain
  - a. light-medium rain does not affect rubblization operation
  - b. functioning edge drains are a benefit
  - c. asphalt paving usually can proceed when rain stops

## **Airfield Rubblization Research**

Airfield Asphalt Pavement Technology Program Project 04-01:

#### Development of Guidelines for Rubblization Final Report

<u>Principal Investigator</u> Mark Buncher, Ph.D., P.E., Asphalt Institute

<u>Contributing Authors</u> Gary Fitts, P.E., Asphalt Institute Tom Scullion, P.E., Texas Transportation Institute Roy McQueen, P.E., McQueen and Associates, Ltd.

![](_page_99_Picture_5.jpeg)

Asphalt Institute 2696 Research Park Dr. Lexington, KY 40511-8480

May 23, 2008

![](_page_100_Picture_0.jpeg)

## **AAPTP 04-01 Objective**

The report's abstract states, "The objective was to document the state of the art in rubblization technology for airfield pavements and develop guidelines covering project feasibility, thickness design/material characterization, quality assurance criteria and methods, and construction/equipment issues."

http://www.aaptp.us/Report.Final.04-01.pdf

![](_page_101_Picture_0.jpeg)

# FAA Design Incorporates AAPTP 04-01

AAPTP 04-01 report is now official Federal Aviation Administration design guidance.

Referenced in AC 150/5320-6E, Airport Pavement Design and Evaluation.

- 1. "Performance studies by LA, CO, AL, IL, MI and other highway agencies all show rubblization to be an effective and efficient rehabilitation alternative."
- 2. "With an exhaustive literature review, there was no documented mention of reflective cracking ever occurring from underlying rubblized PCCP on any highway or airfield project."
- "(I)t does appear E<sub>rub</sub> is somewhat related to slab thickness. This research team recommends the following design ranges on airfield projects:
  - a) For slabs 6 to 8 inches thick: E<sub>rub</sub> from 100 to 135 ksi
  - b) For slabs 8 to 14 inches thick: E<sub>rub</sub> from 135 to 235 ksi
  - c) For slabs > 14 inches thick: E<sub>rub</sub> from 235 to 400 ksi"

- 4. "There was no noted change in subgrade moduli values before and after rubblization."
- 5. "The <u>minimum</u> HMA overlay thickness is 5 inches if placing directly on rubblized. This must be placed in a minimum of two lifts, with the first lift at least 3 inches thick in order to achieve density. Unbound material such as P-209, RAP, etc is often placed first on the rubblized as a leveling course for runways and taxiways to reestablish grade. If an unbound layer is placed directly over rubblized, the minimum unbound layer thickness is 4 inches, and the minimum HMA overlay thickness criteria for that particular material should apply."

- 6. "The recommended particle size acceptance criteria is:
  - a) Upper half of slab: No particles > 6 inches in any dimension, and at least 75% of material (by weight) < 3 inches in any dimension
  - b) Bottom half of the slab or below the steel: Virtually no particles > than 2X the slab thickness, up to 24 inches, in any dimension."
- 7. "On the rare occasion of an oversized piece, leave the piece in-place versus trying to remove."
- 8. In general, we recommend the installation of a longitudinal edge drain system for airfield rubblization projects and that it is operating at least two weeks prior to the start of rubblization. It is important that the edge drain be placed next to where the rubblized layer will be constructed and extends to the top of the rubblized layer."

9. "With regard to the concern that a PCCP suffering from Alkali-Silica Reaction (ASR) could potentially expand after rubblization to cause future differential swelling and subsequent roughness on the pavement surface, we found no mention of this concern in the literature or in speaking with rubblization experts. In addition, there has been a long history of highway and airfield projects utilizing fractured slab technology on ASR-infected PCCP and their long-term performance has been excellent."

# **Rubblization is Green**

- 1. Existing concrete pavement and base recycled in-place reduces need for new materials.
- 2. Reduction in truck movements and equipment usage.
- 3. Good long-term performance of asphalt overlay.
- 4. Asphalt surface can be replaced as needed over time leaving rubblized layer as is.
- 5. Accelerated construction reduces impact on travelling public and reduces associated emissions.

## Largest Ever: King Abdulaziz Int'l Airport (KAIA)

![](_page_107_Picture_1.jpeg)
# KAIA, Jeddah, Kingdom of Saudi Arabia

- 1,300,000 square meters rubblized and overlaid with Hot Mix Asphalt

 430 mm, 370 mm & 300 mm thick, non-reinforced, concrete runways (2) and associated taxiways & aprons

 Prime contractor: Almabani General Contractors, Jeddah

- 8600 & MHB Badger Breakers® used for thicker concrete, MHB Badger Breakers® alone for thinner concrete

Rubblization performed in phases from 2008 through 2012

#### KAIA: initial breaking with 8600





### **KAIA: MHB rubblizing**



#### KAIA: rubblized and prepared for overlay







### **Questions & Answers**





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