

*Findings and Recommendations  
from AAPT 04-01, Developing  
Rubblization Guidelines for  
Airport Pavements*

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# Presentation Outline

- Introduction to Rubblization
  - Two Airfield Projects in 2002 on Thick PCC Slabs
- Findings from Project 04-01
  - Thickness Design Considerations
    - Structural characterization (E)
    - Minimum HMA overlay thickness
  - Assessing Project Feasibility
    - For <9” PCC with weak or no base
  - Recommendations for “Marginal” Candidates
  - Other Recommendations



# What is Rubblization?

- Fracturing techniques that:
  - Rubblizes PCC slabs into high quality agg. base
  - Eliminates slab action and other inherent distresses
    - Reflective cracking
    - D-cracking and ASR
    - Slab rocking, pumping, curling, etc.
  - Destroys bond between concrete and any steel
- Converts failed rigid system into new flexible one
- Two distinct methods and equipment types:
  - Multiple Head Breaker (MHB)
  - Resonant Pavement Breaker (RPB)



# State DOTs Adopt Rubblization

- **Predominate PCC rehab technique for U.S. highways since early 1990s**
- **From 1994 - 2004, > 50 million sq meters rubblized**
  - **In over 35 states**
  - **Market shared evenly between MHB and RPB**
- **Slab thicknesses generally between 20-30cm (8-12in)**
- **Lots of good industry references, studies, etc.**



# Rubblization on Airfields

- **30 airfield projects in US through 2006**
  - Shared between MHB and RPB
- **PCC thicknesses range from 6 to 26 inches**
  - Initial questions about very thick slabs



# Rubblization Process with MHB at Selfridge ANGB w/ 21" thick PCC, 2002

- Edgedrains and Cross Underdrains
- Pre-fracture
- Rubblize
- Test Pits
- Rolling
- Aggregate Leveling Course
- HMA Paving



# Pre-fracture Equipment

- Precede MHB to ensure full depth fracture
  - Typically only necessary for PCC >14in
  - Sometimes for PCC with interface (rigid overlays)
  - Spacing affects max size
    - Spec compliance



# Rubblize Selfridge with Multi-Head Breaker 16-Hammer Configuration





# *Video of MHB and Guillotine Hammer*



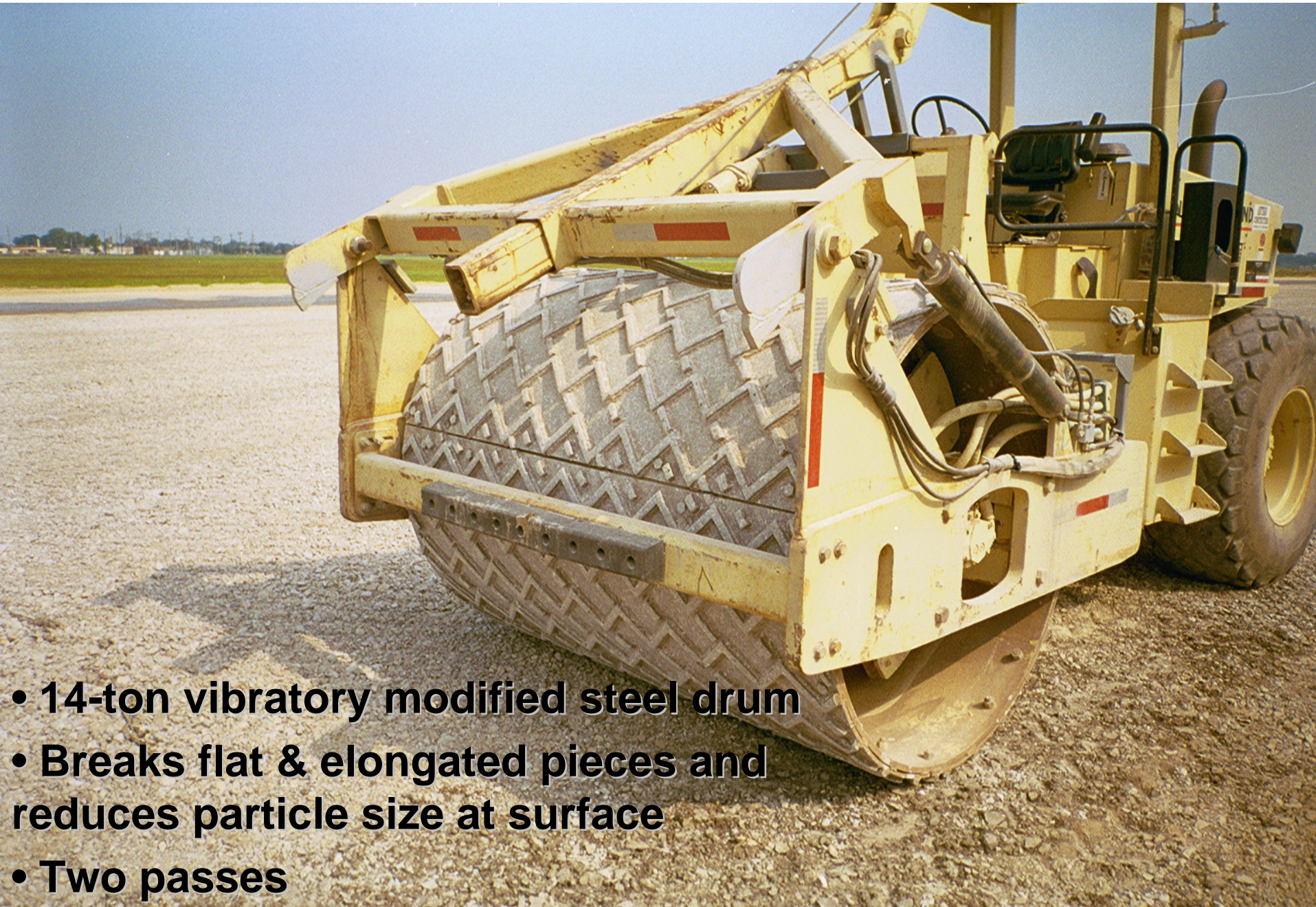
# Selfridge Test Pit

agency approval before full scale rubblelization



MAY 20 2002

# Z-grid Roller at Selfridge



- 14-ton vibratory modified steel drum
- Breaks flat & elongated pieces and reduces particle size at surface
- Two passes

# Leveling Course and Paving at Selfridge



## Aggregate Leveling Course

- Only necessary for grade and profile changes
  - Can't fine grade rubblized surface
- Variable 4-in thick layer

## HMA Overlay

- 7-in thick
- Placed in three lifts

# Completed Selfridge RW

85,000 SYs rubblized in 16 days (5300 SY / day)

# RB-500 at WPAFB in 2002 w/ 26" thick PCC

- 2000 lbf blows @  
44 cycles/second
- < 1 inch amplitude
- 9-12 inch wide  
passes



*Video of RPB Close-up @WPAFB*



# Video of RPB Head – Slow-Mo







**Test pits at WPAFB confirmed:**

- Complete slab destruction full depth (26 inches)**
- Nominal max particle size: 12 inches**

# *Current Guidance and Specs for Airfield Rubblization*

- **Air Force ETL 01-09**
  - Uses guide spec in Asphalt Institute's MS-17
    - Published in 1999
- **FAA EB 66, *Rubblized PCC Base Course***
  - Published in 2004
  - Has particle size criteria from test pit
  - Allows either type equipment

# *Findings from Project 04-01*

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# Characterizing Rubblized Material - Background

- **Airfield Engineers Always Assumed Rubblized Equivalent to Crushed Agg Base (CAB), P-209**
  - Stiffness Modulus ( $E_{rub}$ ) = 50 - 60 ksi
  - $CBR_{rub} = 100$
- **Literature Suggests This is Conservative**
- **O4-01 Approach**
  - Reviewed Literature for Back-calculations of Rubblized
  - Performed New Back-calculations on Several Projects
  - Examined Data for Relationships to Predict  $E_{rub}$



# *What Does the Industry Suggest for a Modulus Value of Rubblized PCC?*

- Witczak Study (1992)
  - 22 sections, range of 200-700 ksi, avg of 412 ksi
- Asphalt Institute MS-17 (1999)
  - At least 250 ksi
- FAA EB-66 (2004)
  - Range of 30-300 ksi
- New AASHTO M-E Design Guide (2006)
  - 150 ksi



# *Projects Where Rubblized Modulus Values Were Obtained*

- **From Literature**
  - Selfridge ANG Runway
  - Niagara Falls ARS Runway
  - Illinois I-57
  - Indiana US 41
  - Detroit Metro Airport Trial
  - FAA's NAPTF
- **New Backcalculations**
  - Texas US 83
  - Michigan I-75
  - Illinois LTPP Sites

• **Data represents the wide range of factors possible: slab thickness and type, equipment and effort utilized, support conditions, etc.**

• **Several projects had more than one unique section.**



# Conclusions on Material Characterization

- Data range of in-service  $E_{rub}$ : 100 to 430 ksi
  - Avg of 205 ksi
- $E_{rub}$  closer to HMA base than CAB
  - For CBR designs: consider equivalency factors
    - 10" Rub = >10" CAB (CBR=100)
  - For Layer-Elastic designs
    - PCC 6-8" thick: 100-135ksi
    - PCC 8-14" thick: 135-235ksi
    - PCC >14" thick: 235-400ksi
- Larger PCC pieces, steel, interlock produce higher  $E_{rub}$



# Other Findings Regarding Material Characterization

- Four (of 4) Projects Show Trend of  $E_{rub}$  Increasing w/ Time
- $E_{rub}$  Dependent On Rubblization Effort
  - Repeated Runs Of Either Equipment Type Reduces  $E_{rub}$ .
- No Change In Subgrade Moduli Before/After Rubblization
- No Consistent Differences in  $E_{rub}$  between Both Equipment Types





# Minimum HMA Overlay Thickness Recommendations

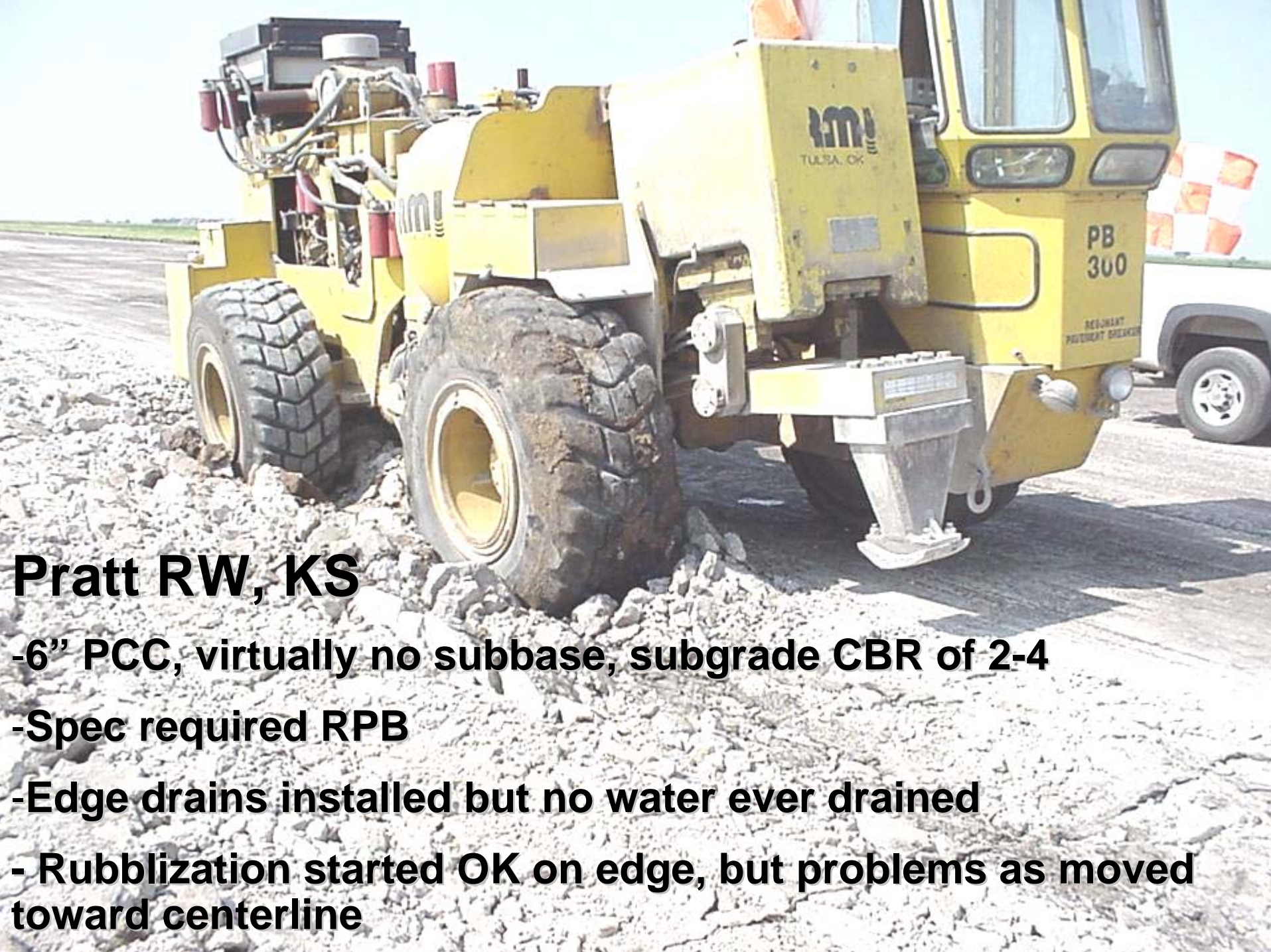
- If HMA Placed Directly Over Rubblized Material
  - 5 inches Minimum HMA
    - Minimum 2 lifts, but 3 preferred (for smoothness)
    - 1st Lift Minimum is 3 inches (to achieve density)
- If Unbound Material Directly Over Rubblized
  - Use Existing Minimum HMA Thickness Criteria for Placing Over that Material (RAP, CAB, Etc)
    - Typically 3 or 4 inches
- Structural Design May Require Greater HMA Thicknesses



# *Assessing Suitability of Project for Rubblization*

- Not All Pavements Are Strong Candidates
- Marginal Candidates Are Thin Slabs (< 9")  
With Poor Underlying Support
  - Thin to No Subbase or Thin Select Fill
  - Weak Subgrade (often saturated)
  - Typical of WWII Built (Now GA) Airfields
  - Issue Demonstrated on Three Runway Projects
    - Pratt KA, Kegelman OK, Tullahoma TN
  - 13 of the 30 Known Airfield Rubblization Projects were  $\leq 8$ " PCC.





## **Pratt RW, KS**

- 6" PCC, virtually no subbase, subgrade CBR of 2-4**
- Spec required RPB**
- Edge drains installed but no water ever drained**
- Rubblization started OK on edge, but problems as moved toward centerline**

# Pratt RW

**-45% of first phase required full depth patching**

**-Project engineer said he would rubblize again under same conditions**

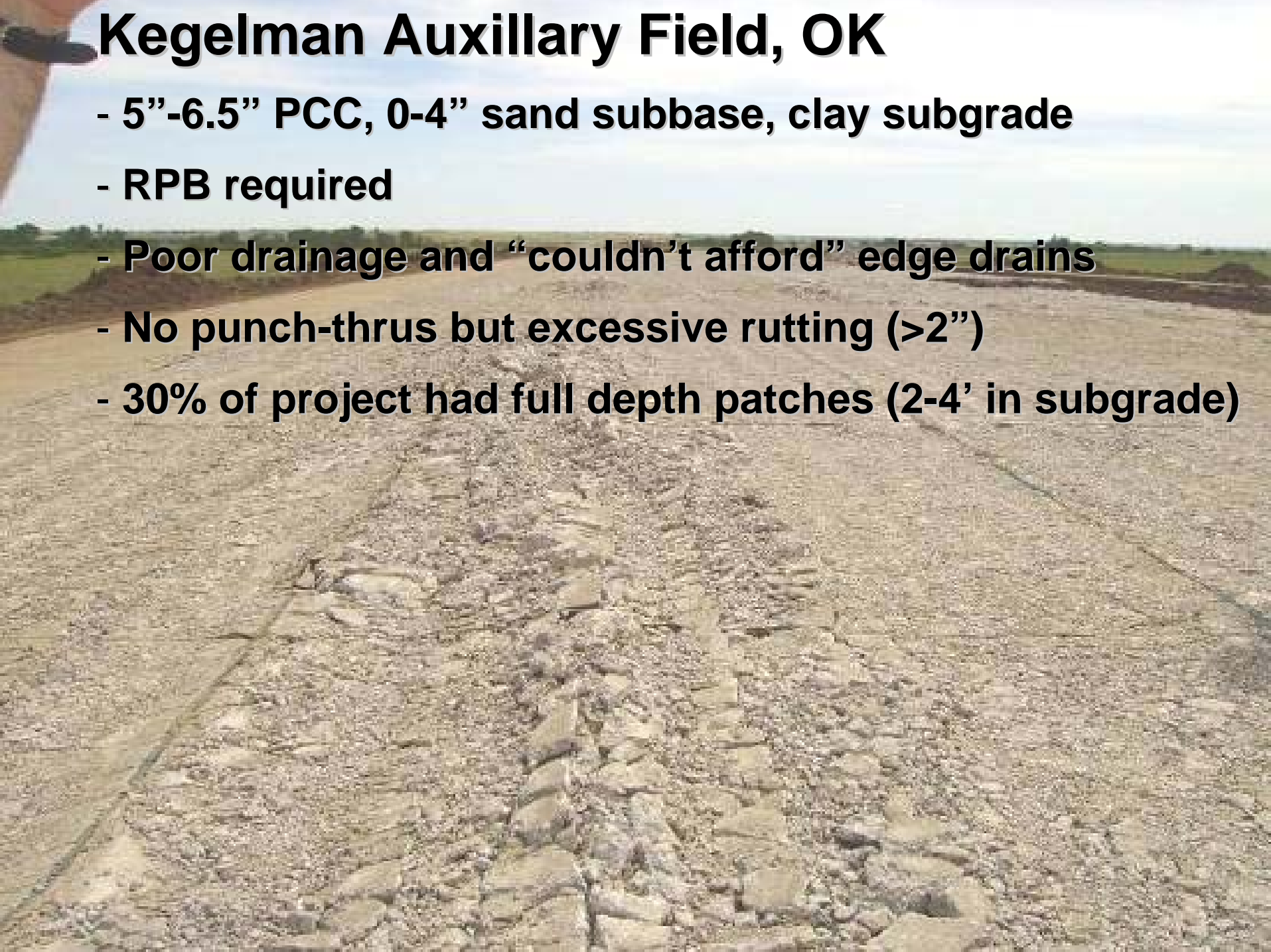






# **Kegelman Auxillary Field, OK**

- **5"-6.5" PCC, 0-4" sand subbase, clay subgrade**
- **RPB required**
- **Poor drainage and "couldn't afford" edge drains**
- **No punch-thrus but excessive rutting (>2")**
- **30% of project had full depth patches (2-4' in subgrade)**







# *Tullahoma TN Airport RW*

- Built During WWII
- 7.25" PCC Over Clay Subgrade
- CBRs Reported of 4 to 12
  - Variable levels of moisture and strength
- Currently Closed (Opportunity!)
- Design Called For Rubblization With 6" CAB and 5" HMA Overlay
- Suggested Trial Demo With Both Types Of Rubblization Equipment Before Project Let



# Start-up of MHB, normal ht (24") and spacing



05/22/2007



**MHB “Modified” Rubblization Process (low drop ht – 16”, large spacing – 10”) Produced Acceptable Surface, But Did Not Meet Criteria**

05/22/2007



**Close-up of Same Test Pit from MHB “Modified”  
Rubblization**

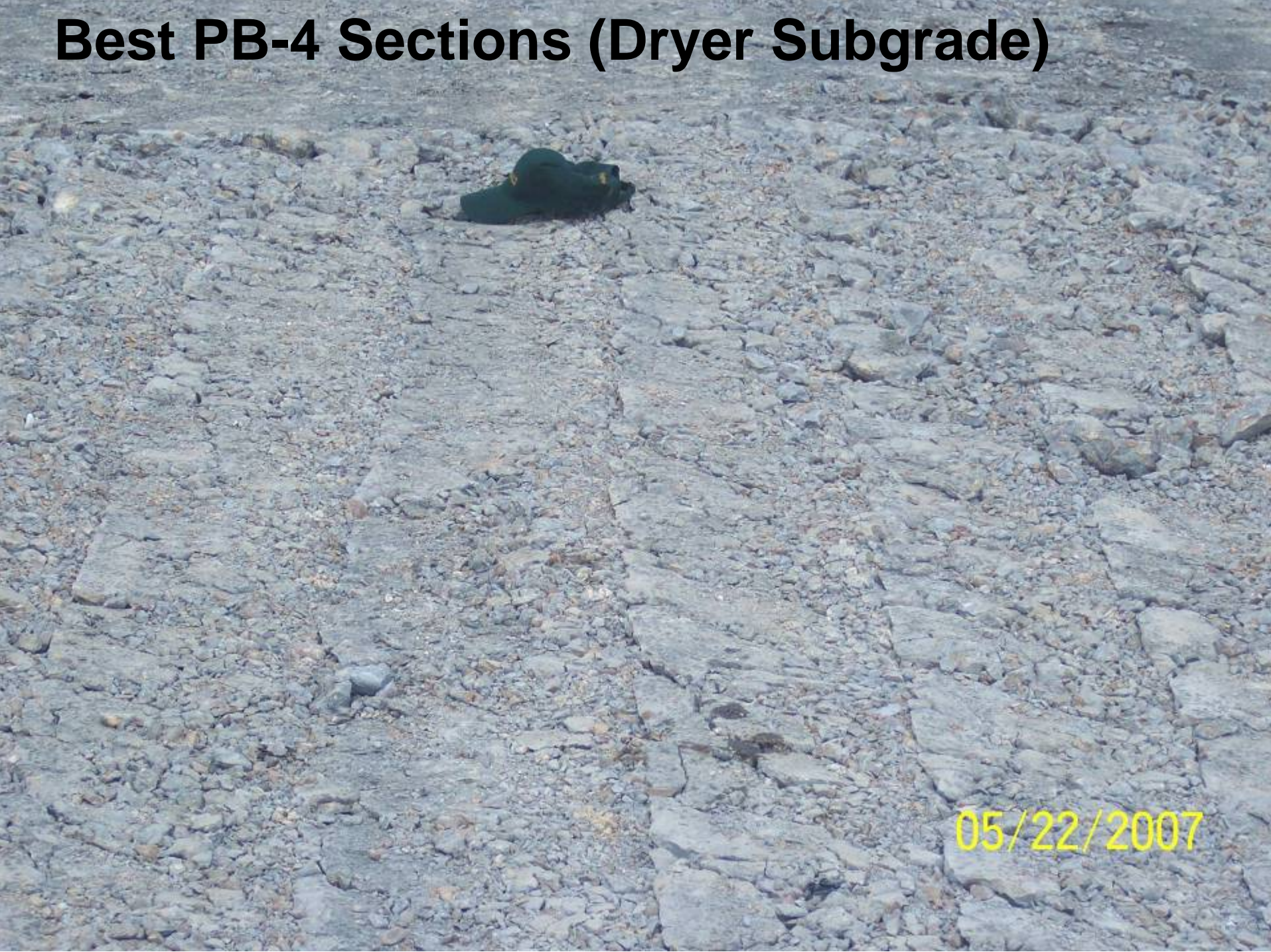
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# Typical PB-4 Sections (rutting, poor breakage)



05/22/2007

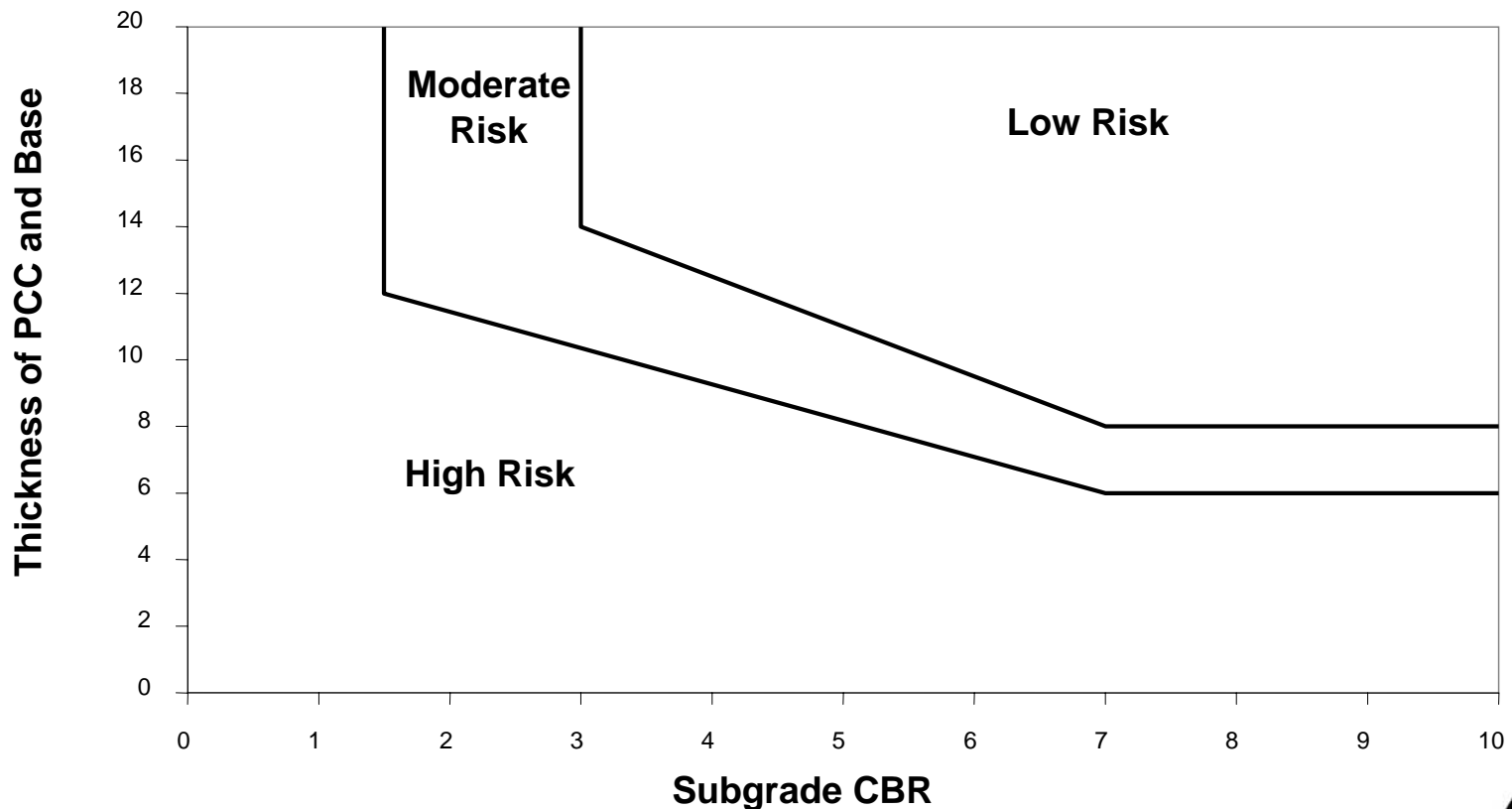
# Best PB-4 Sections (Dryer Subgrade)



05/22/2007

# Assessing Risk to Aid in Project Feasibility Guidance

**Assessing risk of having inadequate structural support for effective rubblization (resulting in inconsistent breakage, large and shifting PCC particles, punch-thus or rutting from construction equipment).**



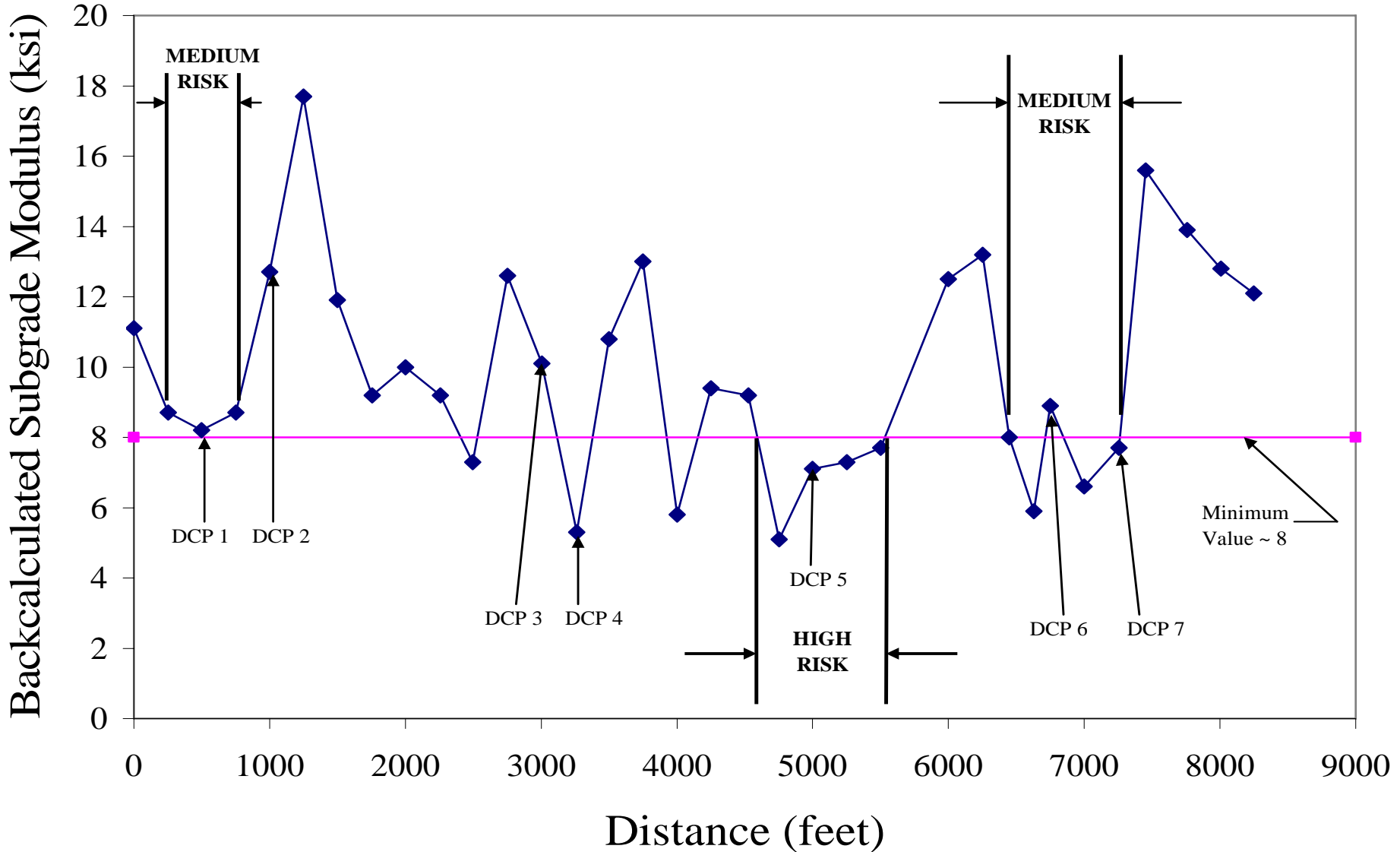
# *Information to Assist with Risk Assessment Protocol*

- Plans
  - Pavement structure and features
- Visual Inspection
  - Pumping and poor drainage
- GPR
  - Global look for trapped water and feature changes
- FWD
  - Range of subgrade modulus (high and low spots)
- Coring and DCP
  - PCC and base thicknesses, layer CBRs





# Example of Identifying Unstable and High Risk Areas



# Recommendations on Avoiding Problems for Marginal Candidates

- Conduct assessment protocol before starting
  - profile of relative risk over entire project
  - % of high, medium and low risk areas
- Install edge drain system before rubblization
  - Exceptions: one already exists/functions or self-draining subgrade
  - Eases rubblization, improves long-term performance
- Avoid wet season for rubblizing
- Proof rolling very important, especially with MHB
  - Don't want to find weak spots when paving starts



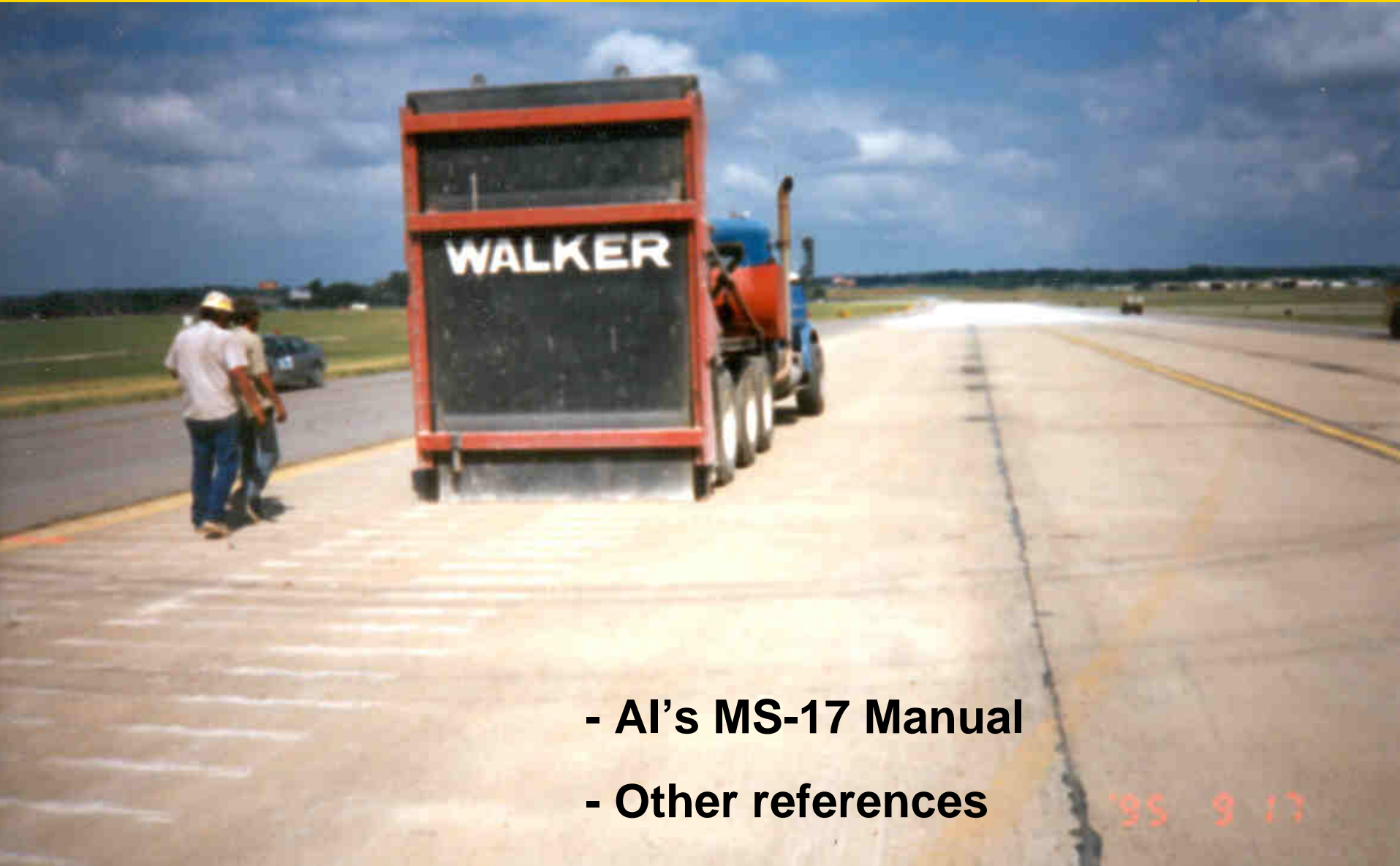
# *Other Recommendations for Marginal Candidates Only*

- Consider trial demo
  - Both RPB and MHB?
- Consider provision for “Modified” Rubblization
  - Waive particle criteria
- Consider other design options
  - Conventional Crack and Seat
    - Retains more of the PCC support
- Separate bid item for full depth patching
  - Provides competitive price



# Cracking/Breaking PCC Pavement

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- AI's MS-17 Manual
- Other references

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# *Other Recommendations for Marginal Candidates Only*

- During rubblization
  - If saturated subgrade, turn vibrators off when rolling rubblized
- Especially with first lift of HMA:
  - No belly dumps and windrows
  - Keep trucks or MTVs on adjacent unbroken PCC or new HMA
    - Easier on airfields
  - Use tracked pavers
- Keeping Perspective
  - In Literature Review of 30 Airfield Projects, 13 were on PCC slabs  $\leq 8''$ . 10 of those 13 did not reveal this issue in any significant way.



# Other Items

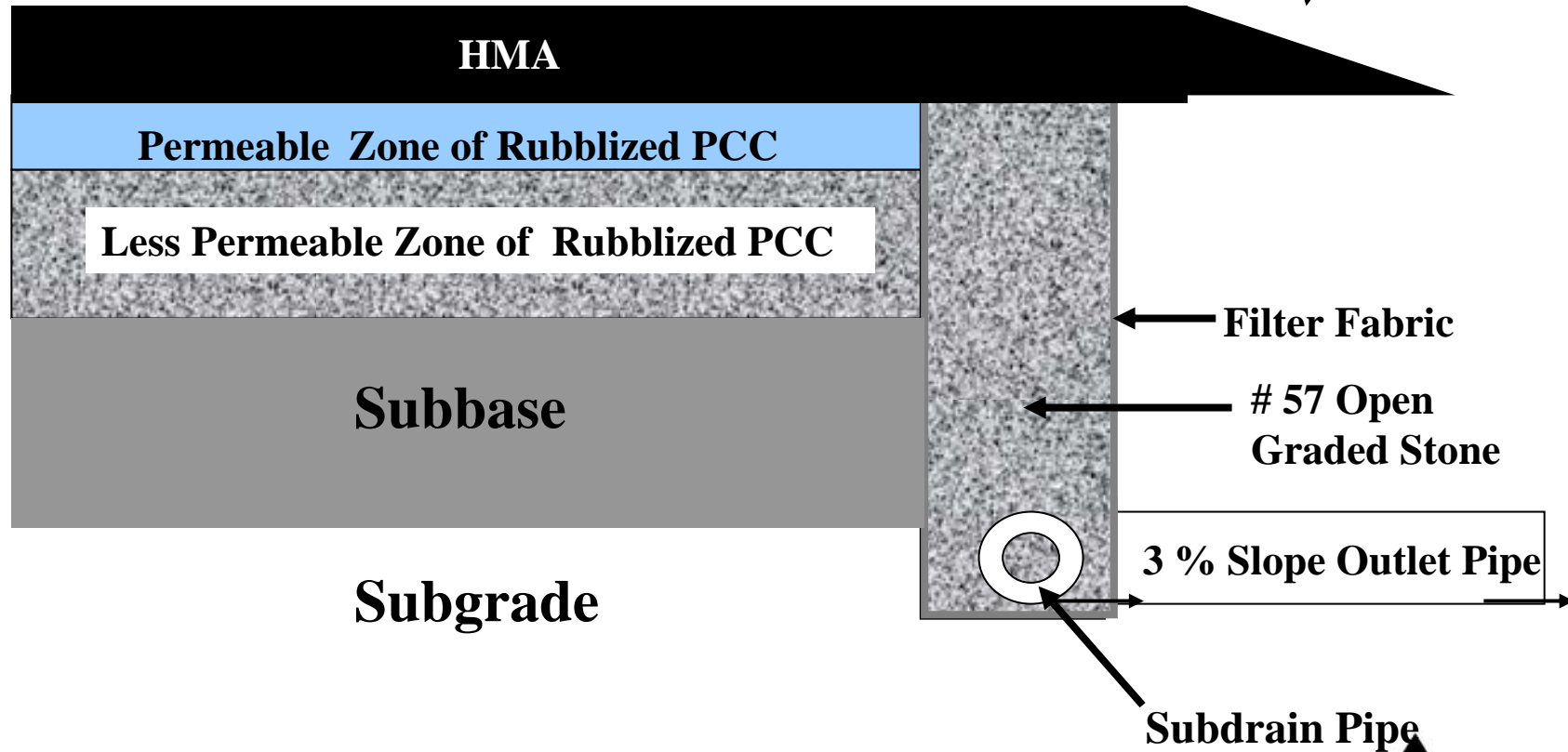
- Must mill All HMA before rubblization
- Edge drains
- Isolation cuts
- Test strips and test pits





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**Shoulder Area**





# Isolate Adjacent Pavements Not To Be Rubblized

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**Protect structural integrity of adjacent pavement with:**

- wheel saw relief trench, or
- two parallel diamond blade saw cuts



# *Quality Assurance*

- Test Strips
- Test Pits
- Particle Size Criteria



# *Test Strips*

- For contractor to demonstrate effective rubblization and rolling practices
- Provides area for test pit
- Minimum: 300 ft long by one slab width
- New test strip for each unique feature



# Test Pits

- Excavate after all fracturing and rolling within test strip
- Include a transverse and longitudinal joint
- Determine if spec criteria is met
  - Full depth fracture
    - Particle size criteria (next slide)
  - Steel “substantially” debonded
    - Dowels can be sawed
- At free edges, allow larger PCC pieces
  - Due to lack of support



# Particle Size Acceptance Criteria

- Upper half of slab
  - All particles < 6"
  - 75% of material (by weight) < 3"
- Bottom half of slab or below steel
  - All particles > 2x slab thickness



# *Significant Non-finding from AAPTP 04-01*

- No documented instance found in literature of any reflective cracking on any rubblization project
  - Hundreds of Highway Projects
  - Over 30 Airfield Projects
  - Totals over 50 Million SYs of rubblization
    - Dating back into the early 1990s



# Airplanes Love Rubblization

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