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Guidelines for Rubblization

AAPTP Project 04-01

SEAUPG Annual Meeting

Nov 15th, 2007

Outline of Today's Presentation

- Background
  - AAPTP, Project, Rubblization
- Structural Characterization of Rub. Layer (E)
- Minimum HMA Overlay Criteria
- Assessing Project Feasibility
  - For thin PCC with weak or no base
- Recommendations for "Marginal" Candidates

AAPTP Background

- Began in 2004, Ongoing
- Projects awarded thru Auburn University
- FAA and U.S. military are chief players
- Structure and execution similar to NCHRP
- 5 to 7 Projects (about $1M) per year
- Projects relate to all airfield asphalt technologies (construction, materials, design, maintenance, rehab, etc)
  - Asphalt research has mostly been for highways
  - Airfield needs different than highways

AAPTP Project 04 – 01: *Development of Guidelines for Rubblization on Airfields*

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- **Research Team:**
  - Mark Buncher (PI), Gary Fitts, Roy McQueen and Tom Scullion
- **Overall Objectives**
  - Document state-of-the-art rubblization technology
  - Develop guidance regarding project feasibility, structural design, construction, quality control, etc
  - Improve quality of airfield rubblization projects
- **Deliverable: Final Report**
- **Completion: 15 Nov 07**

Individual DOT Rubblization Specs.

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- Policies and procedures developed from state's experiences with their set of conditions
- Varies from state to state
  - Design methods, materials, construction practices
- Challenge is to develop guidance that is appropriate for vast multitude of conditions found on airfields in U.S.

What is Rubblization?

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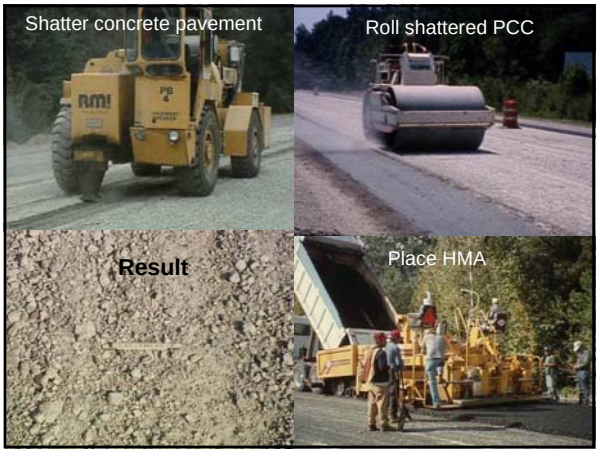
- Fracturing techniques that:
  - Rubblizes PCC slabs into high quality agg. base
  - Eliminates slab action and other inherent distresses
    - **Reflective cracking**
    - **D-cracking**
    - **ASR**
    - **Slab rocking, pumping, curling, etc.**
  - Destroys bond between concrete and any steel
- Converts failed rigid system into new flexible system
  - Utilizes in-place materials/ layers below PCC



Rubblized PCC @ Joint

Earliest Use of Rubblization on Airfields: 1997, 10in PCC, Jacksonville NAS TW "A"

State DOT's Adopt Rubblization

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- Became predominate PCC rehab technique in 1990's
  - > 50 million SYs rubblized between 1994-2004
- Technology developed for highways
- Only 2% of all rubblization SYs has been airfields
  - About 30 airfield projects
  - Only 2% of all crack/break and seat SYs on airfields
- Most highway thicknesses between 8-14 inches

•What About Thicker Slabs for Heavy Load Airfields?
•What About Thinner Slabs for Gen. Av. Airfields?

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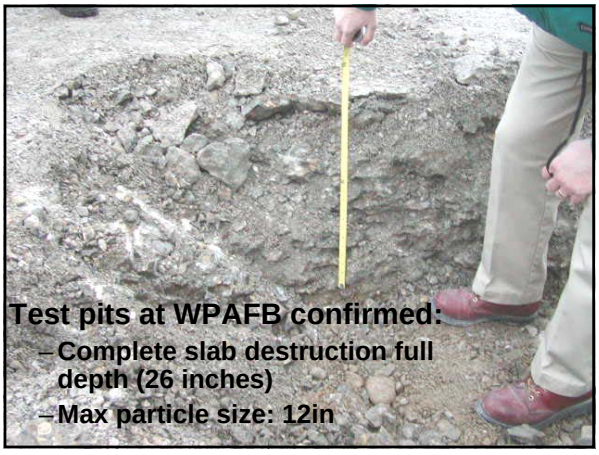
- Resonant Pavement Breaker on Wright-Patterson AFB Apron, OH, 2002
  - Up to 26 inches
  - Max particle size: 12 inches
- Multi-Head Breaker on Selfridge ANGB Runway, MI, 2002
  - Up to 21 inches
  - Pre-fractured with guillotine hammer



Completed Selfridge RW

Some Other Airfield Rubblization Projects

- NAVFAC, C-17 Assault Strip, SC
- Jacksonville NAS, Portions of Main RW, FL (1997)
- Willow Grove NAS, RW 15-33 Thresholds, PA
- Rantoul Municipal Airport, RW, IL (1999) – Demo (3 Rubblized Sizes)
- Hunter Army Airfield, Ramp, GA
- Watertown Airport, RW and Hanger Area, SD (2001, 2003)
- Columbus Airport, Three TWs, IN (2000, 2003, 2004)
- Kalamazoo/ Battle Creek AP, TW, MI (2002)
- Ephrata Municipal Airport, RW and TW, WA (2004)
- Buffalo Niagara Falls International, TW A, NY (2005)
- Capital Airport, RW Overrun, Springfield, IL (2005)
- Grand Forks AFB, Rehab Main RW, ND (2005)
- Kegelman (Vance AFB Auxiliary) Runway, OK (2006)
- Pratt Airport, RW, KA (2005)
- Moses Lake Airport, Runway, WA (2003)
- Toledo Metcalf Field, RW 4-22, OH (2006)
- Lagan Puerto Rico Airport, RW (2006)

FAA Engineering Brief No. 66, *Rubblized PCC Base Course*

- **Guidance and spec for rubblizing PCC airfields**
- **Industry consulted**
- **Released Feb, 2004**
- **Performance based and method spec**
  - **Allows either type equipment. Unique method requirements depending on type.**
  - **Particle size criteria from test pit(s)**
    - **minimum 75% of the broken particles…**
      < 3in at the surface
      < 12in in the bottom half of slab
    - **for Reinforced PCC…**
      - **Steel debonded and left in place**
      - **No single piece > 15in below steel**

Some Findings and Recommendations from AAPTP 04-01

(not necessarily the views of AAPTP, the FAA, etc)

Characterizing Rubblized Material

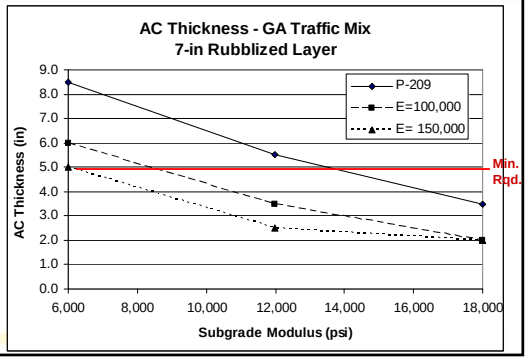
- **Airfield Engineers Always Assumed Rubblized Equivalent to Crushed Agg Base (CAB), P-209**
  - Stiffness Modulus (E_{rub}) = 50 - 60 ksi
  - CBR_{rub} = 100
  - Airfield Procedures Don't Use "Layer Coefficients"
- **Literature Suggests This is Conservative**
- **O4-01 Research Approach**
  - Review Literature for Back-calculations of Rubblized
  - Perform New Back-calculations on Several Projects
  - Examine Data and Relationships to predict E_{rub}?

What's the big deal with E_{rub}?

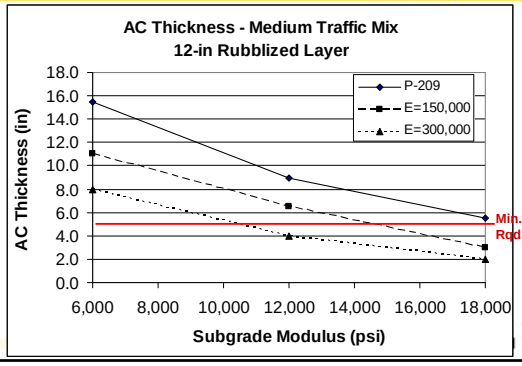
Thickness Design Sensitivity Analysis

– How does the range of rubblized layer moduli effect the HMA overlay thickness design requirements on airfields?

HMA Design Overlay Thicknesses for Light-load Traffic Mix



HMA Design Overlay Thicknesses for Medium-load Traffic Mix



Projects Where Rubblized Modulus Values Were Obtained

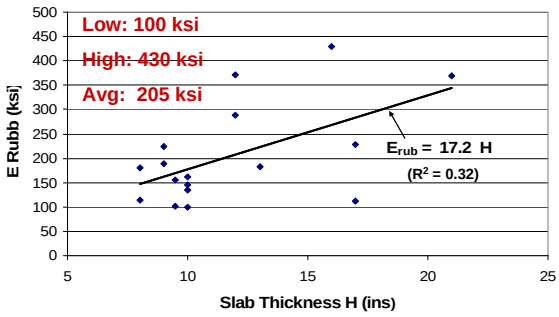
- **From Literature**
  - Selfridge ANG Runway
  - Niagara Falls ARS Runway
  - Illinois I-57
  - Indiana US 41
  - Detroit Metro Airport Trial
  - FAA's NAPTF
- **New Backcalculations**
  - Texas US 83
  - Michigan I-75
  - Illinois LTPP Sites

•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.

Average Initial Moduli vs. Slab Thickness

from All (17) Sections Where Data Was Available



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

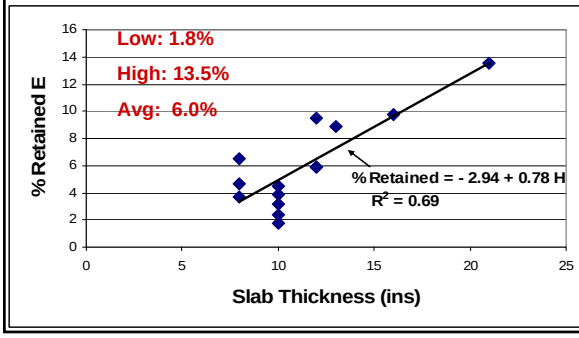
- Witzak Study (2002)
  - Range of 200-700 ksi, Avg of 412 ksi
- Asphalt Institute MS-17 (1999)
  - At least 250 ksi
- FAA EB-66 (2004)
  - Range of 30-300 ksi
- PerRoad (2006)
  - Range of 300-700 ksi, 500 ksi is typical
- New AASHTO M-E Design Guide (2004)
  - 150 ksi

What about a "Retained Modulus" Concept?

- E_{rub} / E_{pcc} , as a %
- Prediction Tool (E_{pcc} known during design)
- Makes Intuitive Sense
  - Rubblization Process affected by:
    - Presence of steel
    - Hardness of aggregate
    - Slab thickness

"Percent Retained Modulus" (E_{rub} / E_{pcc}) vs. Slab Thickness

From All (13) Sections Where Data Was Available



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
  - For AASHTO layer coefficient: .20 - .28
- Marginal correlation of E_{rub} to slab thickness
  - Larger particles, steel and interlock produce higher E_{rub}
- E_{rub} may be related to pre-fractured modulus
  - "Retained Modulus" concept should be explored
    - better correlation, but less data

Other Findings Regarding Material Characterization

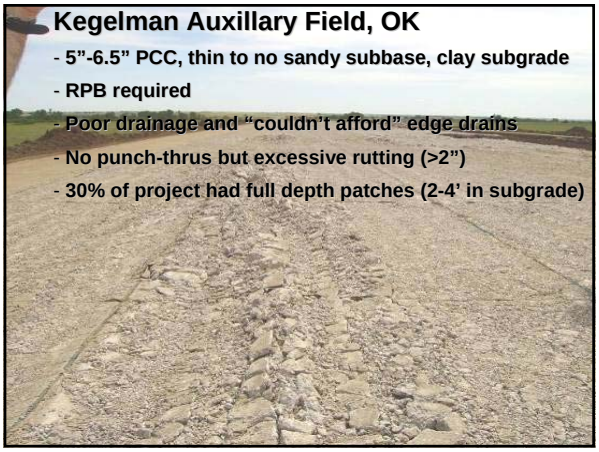
- Several (4) Projects Show E_{rub} Tends to Increase with Time
- E_{rub} Dependent On Rubblization Effort
  - Repeated Runs Of Either Equipment Type Reduces E_{rub}.
- No Rubblization Project Found in Literature that Reported Reflective Cracking from Underlying PCC
  - But full depth fracture can be a challenge where slabs are reinforced or very thick (>20")
- No Change In Subgrade Moduli Before/ After Rubblization
- RPB and MHB Showed No Consistent Differences in E_{rub}

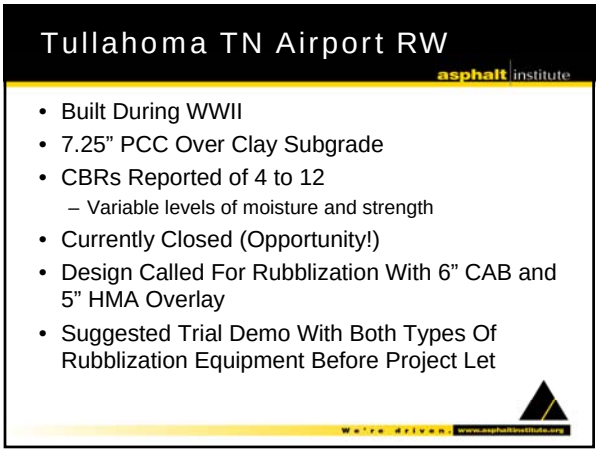
Minimum HMA Overlay Thickness Recommendations

- If HMA Placed Directly Over Rubblized Material
  - 5 inches Minimum HMA
    - Minimum 2 lifts, but 3 preferred (for smoothness)
    - 1st lift Minimum 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
  - Leveling Courses Often Used On Runway and Taxiway Projects To Correct Grade
- Structural Design May Require Greater 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
  - Three Recent Runway Projects
    - Pratt KA, Kegelman OK, Tullahoma TN


Kegelman Auxillary Field, OK
- 5”-6.5” PCC, thin to no sandy 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
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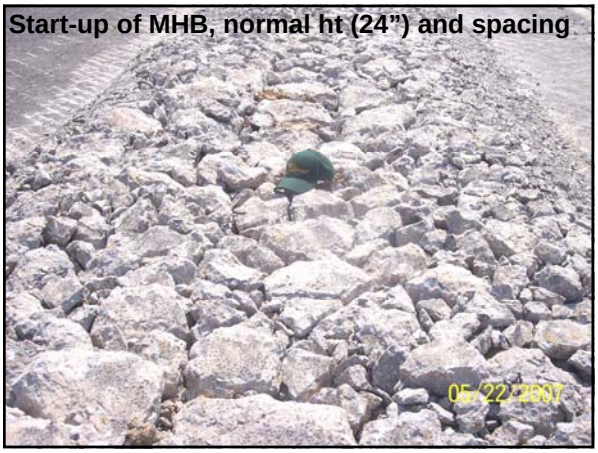
• Built During WWII
• 7.25” PCC Over Clay Subgrade
• CBRs Reported of 4 to 12
– Variable levels of moisture and strength
• Currently Closed (Opportunity!)
• Design Called For Rubblization With 6” CAB and 5” HMA Overlay
• Suggested Trial Demo With Both Types Of Rubblization Equipment Before Project Let


Start-up of MHB, normal ht (24”) and spacing
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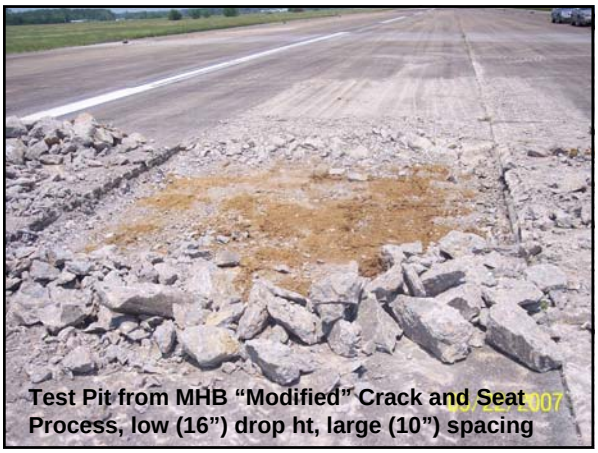
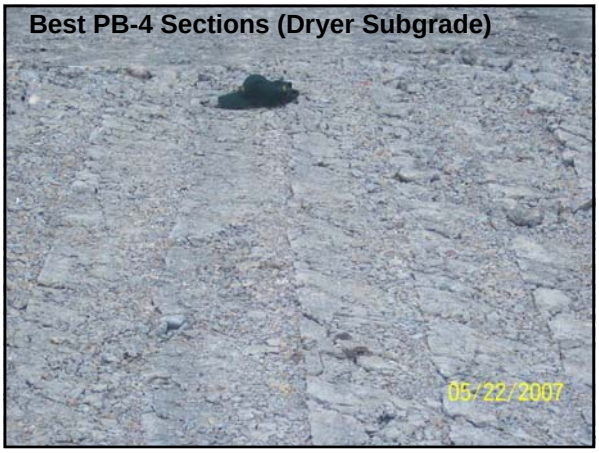
MHB "Modified" Crack and Seat Process (low drop ht, large spacing) Produced Acceptable Surface, But Did Not Meet Criteria



Test Pit from MHB "Modified" Crack and Seat Process, low (16") drop ht, large (10") spacing

PB-4 Proof Rolled and Failed a MHB Section

Typical PB-4 Sections (rutting, poor breakage)

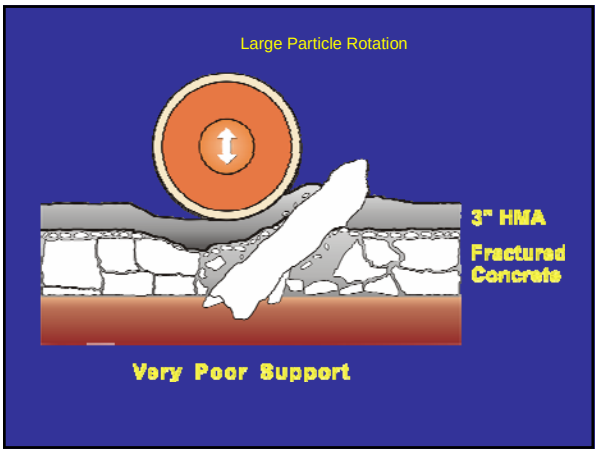


Best PB-4 Sections (Dryer Subgrade)

Best PB-4 Sections (Dryer Subgrade)

SH 70 in TX, MHB, No Base, 9-6-9 slabs on clay subgrade

More difficult to get good break on outer thickened and reinforced edge



Project Feasibility

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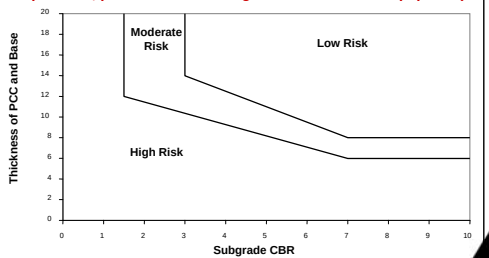
Assessing risk of having inadequate structural support for effective rubblization (resulting in inconsistent breakage, large and shifting PCC particles, punch-thus or rutting from construction equipment).



Evaluation Tools for Assessment Protocol

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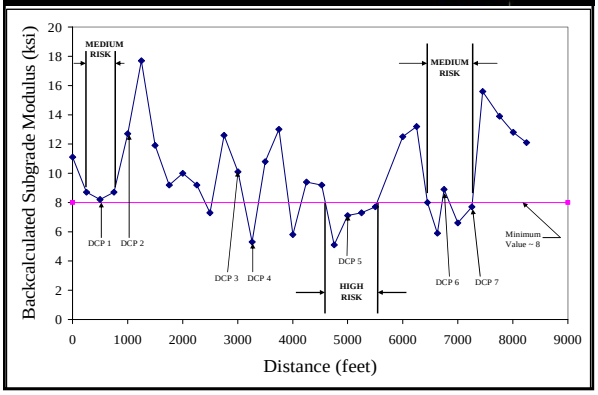
- Plans
  - Pavement structure and features
- Visual Inspection
  - Pumping and poor drainage
- GPR
  - Global look for trapped water and feature changes
- FWD
  - Range of subgrade modulus (high and low spots)
- Coring and DCP
  - PCC and base thicknesses, layer CBRs

Identifying Unstable Areas and Risk



Avoiding Problems on Marginal Candidates

- Assessment protocol before starting
  - profile of relative risk over entire project
  - % of high, medium and low risk areas
- Install edge drains before rubblization
  - Unless one currently, or self draining subgrade
  - Eases rubblization, better long-term performance
- Avoid wet season for rubblization
- Proof rolling very important, especially with MHB
  - Don't want to find weak spots when paving starts

Other Recommendations for Marginal Candidates

- Consider trial demo
  - Both RPB and MHB?
- Consider provision for "Modified Rubblization" or "Modified C&S"
  - Waive particle criteria
  - Separate bid item
- Consider other design options
  - Conventional C&S
  - CAB layer over rubblized
- Separate bid item for full depth patching
  - Estimated quantity
  - Provides competitive price

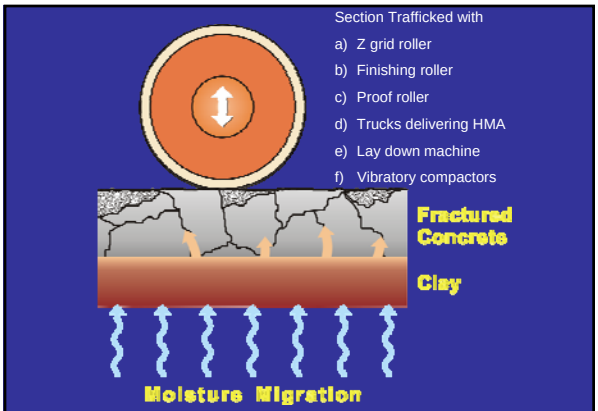
Other Recommendations for Marginal Candidates

- During construction
  - 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
  - Use tracked pavers

Belly Dump operation

Problem Areas Found During HMA Placement

Windrow Placement Not Recommended



Consider Turning Vibrators Off During Rolling

Questions?


Remove all HMA
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Did not completely remove old HMA at all locations
Scraping off HMA after rubblization revealed no breaking accomplished beneath HMA
We're driven. www.asphaltinstitute.org