PAVEMENT REHABILITATION
RESONANT RUBBLIZING

RUBBLIZATION OF PCC USING
A RESONANT BREAKER

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INTRODUCTION
RMI Worldwide

- RMI has been in business since 1984
- RMI is headquartered in Tulsa, Oklahoma with satellite offices in:
  - Kansas City, Missouri
  - Minneapolis Minnesota
  - Shanghai, China
  - Moscow, Russia
- RMI Construction Services is a specialized subcontractor with expertise in:
  - Concrete rubblization
  - Concrete demolition
  - Concrete breaking – Break and Seat, Crack and Seat, Breaking for Removal
  - RMI has successful completed concrete and rubblizing projects throughout North America, China, Eastern Europe and Chili
- RMI Construction Services: BAV Corporation performs subcontractor services for RMI in CIS and Europe:
  - Highway and Street surface rehabilitation
  - Airport runway reconstruction
  - Commercial Parking lot and Warehouse floor reconstruction
- RMI Resonant Machines is a vehicle manufacturer and inventor of the Resonant Beam Technology
Rubblization Technology:

- 40 million m² in the USA
- 3 million m² in Russia-Ukraine & Belarus
- 4 million m² in China
RUBBLIZATION PROJECTS: 41 States in USA
Reflecting cracks is an issue

«Reflecting crack

«Snips» from traffic

HMA

Concrete

Cooling

Warming up

Open

Close
What is Rubblizing?

The Process of Fracturing Pavement of Portland Cement Concrete into Angular “Puzzle-like” Pieces for Direct Overlay
Structural Design: State Studies

Over 20 Studies from Multiple States support that rubblizing provides:
✓ Long life for surfaces – 22+ years
✓ Smooth driving conditions
✓ Rubblization eliminates reflective cracking and dramatically reduces surface defects

Figure 4.3 IRI vs. Pavement Age.

Figure 2. IRI data for sections rubblized between 1988 and 2002 in Michigan.
Resonant Rubblizing

High Frequency (44Hz)
Low Amplitude (20 mm)

Interlocked rubble distributes loads

Slab fractured

Base integrity maintained

Flat Bottom maintains load-bearing capacity of rubble

No displacement into base
Properties of Rubblizing: Comparison

“Rubblizing” doesn’t affect the base integrity due to the low amplitude.
Additional Issues with High Impact Rubblizing

**Warning**

- **High Impact Drop Hammer**
  - Point loading
  - Poor distribution
  - Water trap
  - No drainage

- **Resonant Rubblizing**
  - Broad load distribution

Figure 4
Application of Recycling the Concrete Pavement (Rubblizing)

Environmentally Friendly Construction
Reflection: Evolution of the Deterioration

Quality of the Road

Number of Years
Rehabilitation of Concrete Pavement

![Concrete Pavement Rehabilitation](image)

- **PSI**
  - 5
  - 4
  - 3
  - 2
  - 1

- **Quality of the Road**

- **Number of Years**

The graph illustrates the quality of the road against the number of years. The yellow line shows the degradation of the road quality over time.
Rehabilitation of Concrete Pavement

Rubblizing

New HMA layer
Angular Fracture Pattern for Greater Modulus

\[ \approx 35^\circ \text{ to } 40^\circ \]
Structural Design: Correlations

![Diagram showing correlations between structural failure, reflective cracking, probability of failure, and various parameters like PCC modulus, nominal fragment size, and target zone.](image)
DESCRIPTION OF TECHNICAL RUBBLIZING
Description of Rubblizing Equipment

- Weight
- Computer Controls
- Motor
- Resonant Beam
- Flotation Tires
- Pedestal / Shoe
Description of Rubblizing Equipment:
New computer system was installed in 2008
A new generation screen allows to control and optimize the rubblization process.
Description of Resonant Beam

Frequency: 44 Hz
Amplitude: 13-19 mm (3/4")
Description of Resonant Beam

Vibration Technology

Weight

Frequency 44 Hz
Amplitude 13-19 mm (3/4”)

[Image of a resonant beam with vibration technology and weight shown]
Description of Resonant Beam

Frequency 44 Hz
Amplitude 13-19 mm (3/4"
Operational Data of Equipment

- Strikes PCC 44 Times per Second
- 900 kg. of Pressure Per Strike
- Beam Weighs 4080 kg.
- Raises 13-19 mm. Per Strike
- Machine Speed is at approx. 5-8 km/h
- Breaking Area is 25.4 mm. wide
- Average Rubblized Per Day: 6,000 m²
Rubblizing Process

- Remove existing overlay
- Install drainage system
- Rubblize concrete pavement
- Remove & replace weak areas
- Roll rubblized concrete
- Place HMA leveling course & overlay
Structural Design: Methods

- AASHTO – Procedure Design (SN)
- Asphalt Institute – Series Manuals (MS) -17
- NAPA – Series Information (IS) –117
- Airfield Asphalt Pavement Technology Program - AAPTP
Structural Design: Evaluation

- Pavement after years of use and deterioration.

- Expert analysis is required to insure that the cause of the failure of the pavement.

- If the Damage does Not arise the Subgrade or Sub-Base Problems, Pavement is a Candidate for Rubblization.

- If the Subgrade has Problems, Rubblization will Not Eliminate the Issue.
Structural Design: Drainage

- Proper Drainage System should be Installed or Repaired Prior to Rubblizing the Pavement.

- Varying Methods of Drainage can be Used Depending on the Site.
Three Most Damaging Things to a Highway or Airport

• Water

• Water

• WATER
Structural Design: Drainage

- 10 cm open graded
- 5 cm dense graded
- # 57 Stone
- 3 % Slope Outlet
- Relief Cut @ 9-12 m.

- Shoulder Area
- Permeable Zone
- Rubblized PCC
- Base Course
- Subgrade
- Filter Fabric
- # 57 Stone
- 5 cm dense-graded
- 10 cm open-graded
Dual outlets at approximately 300 feet
Dual outlets - One each direction
The Modulus of the Rubblized Concrete depends on the Thickness, Subbase and Subgrade. Typically Rubblized Concrete is 2.5 Times Stronger than any Granular Material.

\[ E_4 > E_3 \]
\[ E_3 > E_2 \quad \text{Where} \quad E_3 = f(E_2) \]
\[ E_2 > E_1 \quad \text{Where} \quad E_2 = f(E_1) \]
\[ E_1 \]
CONSTRUCTION PROCESS
Rubblizing Process

- Three Stages of Construction:
  - Rubblizing
  - Rolling
  - Asphalt Overlay
Prior to Rubblizing Process

- Repair or Replace Drainage System
- Remove any Asphalt Overlay Currently in Place
Resonant Rubblizing

• Capable of Rubblizing up to 60 cm.
• Ideal Distance Per Run – 1.6 km. / One Lane Wide
• Speed of Resonant Machine 5 – 8 km/h
Advantages

- Complete debonding of concrete
- Removal of mesh reinforcement and rebar
Fracture Pattern at Memphis International Airport

Cement Stabilized Base
Advantages

- Rubblization of airport concrete up to 60 cm.

Wright Patterson Airport, USA
Walla Walla, WA Runway
Rubblized Prior to Rolling

Moses Lake, WA
Advantages

• Rubblization doesn’t effect existing slope and level of the surface
Rubblized Slab Prior to Rolling
Rolling

- 10 Ton High Frequency, Low Amplitude Steel Drum Roller (3 Passes)
- Only Equipment Necessary After Rubblization
- Not Recommended to Drive on Prior to Asphalt Overlay
Result

- Surface after compaction and before overlay
Asphalt Layer

- Leveling Course on First Lift with Ability to Open Traffic
- No Primer Required on Rubblized Layer
- Minimum of 12 cm. of Asphalt Overlay
Next Day - Open Traffic
Recommended State Specification

- High Frequency Low Amplitude Resonant Breaker
- Resonant Breaker shall apply 900 kg. of pressure per strike at 44 Hz
- Removal of any Existing Asphalt Overlay
- Majority of Particle Size of Less than 15 cm.
- Maximum Particle Size of 20 cm.
- 10 Ton High Frequency - Low Amplitude Vibratory Roller
  - 3 Passes with Maximum Speed of 2 m. per Second
- Minimum of 80% Debonding of Existing Steel Reinforcing
- No Traffic on Rubblized Slab Until First Lift is Placed
- Minimum of 13 cm. of Hot Mix Asphalt Overlay
### The Math (One Lane Mile)

<table>
<thead>
<tr>
<th>Rubblize and Overlay</th>
<th>Unbonded Concrete Overlay</th>
<th>Remove &amp; Replace Concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item</td>
<td>Extension</td>
<td>Item</td>
</tr>
<tr>
<td>Edge Drain,</td>
<td></td>
<td>10% Patching existing PCC</td>
</tr>
<tr>
<td>Rubblization</td>
<td></td>
<td>2” HMA Bond Breaker,</td>
</tr>
<tr>
<td>4” Unmodified HMA @</td>
<td></td>
<td>8” Concrete Overlay</td>
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<tr>
<td>145 lb/ft</td>
<td></td>
<td></td>
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<tr>
<td>4” Modified HMA @</td>
<td></td>
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<tr>
<td>145 lb/ft</td>
<td></td>
<td></td>
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<tr>
<td>Total</td>
<td>100%</td>
<td>Total</td>
</tr>
</tbody>
</table>

- **Total 100%**
Results – 22 Year Road
Rubblization Technology Summary

- Rubblization technology eliminates the source of reflective cracks
- Rubblization technology is a process of fracturing concrete slabs into angular interlocked pieces
- Rubblization technology converts non-flexible structure (PCC pavement) into a flexible structure
- Rubblization technology DOES NOT invade, damage the base. NO displacement into the base!
- Guillotine and other Impactor methods DO invade the base. Integrity of the base is compromised!
Rubblization Technology Summary Continued

- Rubblization technology:
  - Reduces project complexity
  - Reduces project cost
  - Creates angular fracture pattern for greater modulus
  - Creates pieces sand size to 12.5 cm – 17.78 cm at the top to 20 cm towards the bottom
  - Microprocessor Impact Adjustment, Consistency in Particle Size
2.5 Summary

Based on the comprehensive review of the different reflection cracking mitigation strategies applied by various airport and highway projects under different conditions, the following summary was obtained:

- No pavement rehabilitation technique has been shown to prevent reflection cracking, with the exception of rubblizing PCC pavements. However, several techniques have demonstrated the ability to reduce reflection cracking when designed and constructed properly.
Thank You!