

PAVEMENT REHABILITATION RESONANT RUBBLIZING



RUBBLIZATION OF PCC USING A RESONANT BREAKER JANUARY 2018



INTRODUCTION

RMI Worldwide

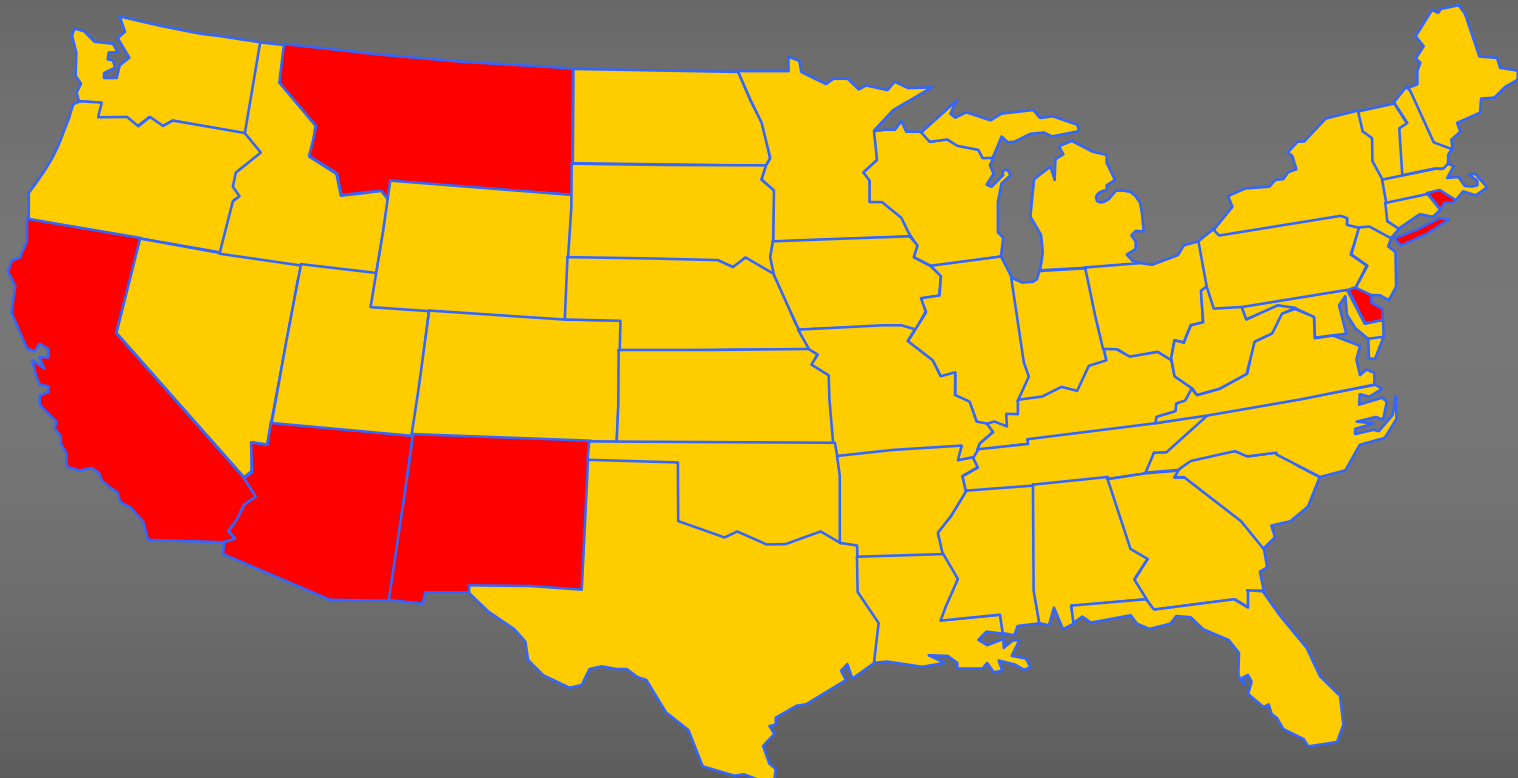
- **RMI has been in business since 1984**
- **RMI is headquartered in Tulsa, Oklahoma with satellite offices in:**
 - **Kansas City, Missouri**
 - **Minneapolis Minnesota**
 - **Shanghai, China**
 - **Moscow, Russia**
- **RMI Construction Services is a specialized subcontractor with expertise in:**
 - **Concrete rubblization**
 - **Concrete demolition**
 - **Concrete breaking – Break and Seat, Crack and Seat, Breaking for Removal**
 - **RMI has successfully completed concrete and rubblizing projects throughout North America, China, Eastern Europe and Chile**
- **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



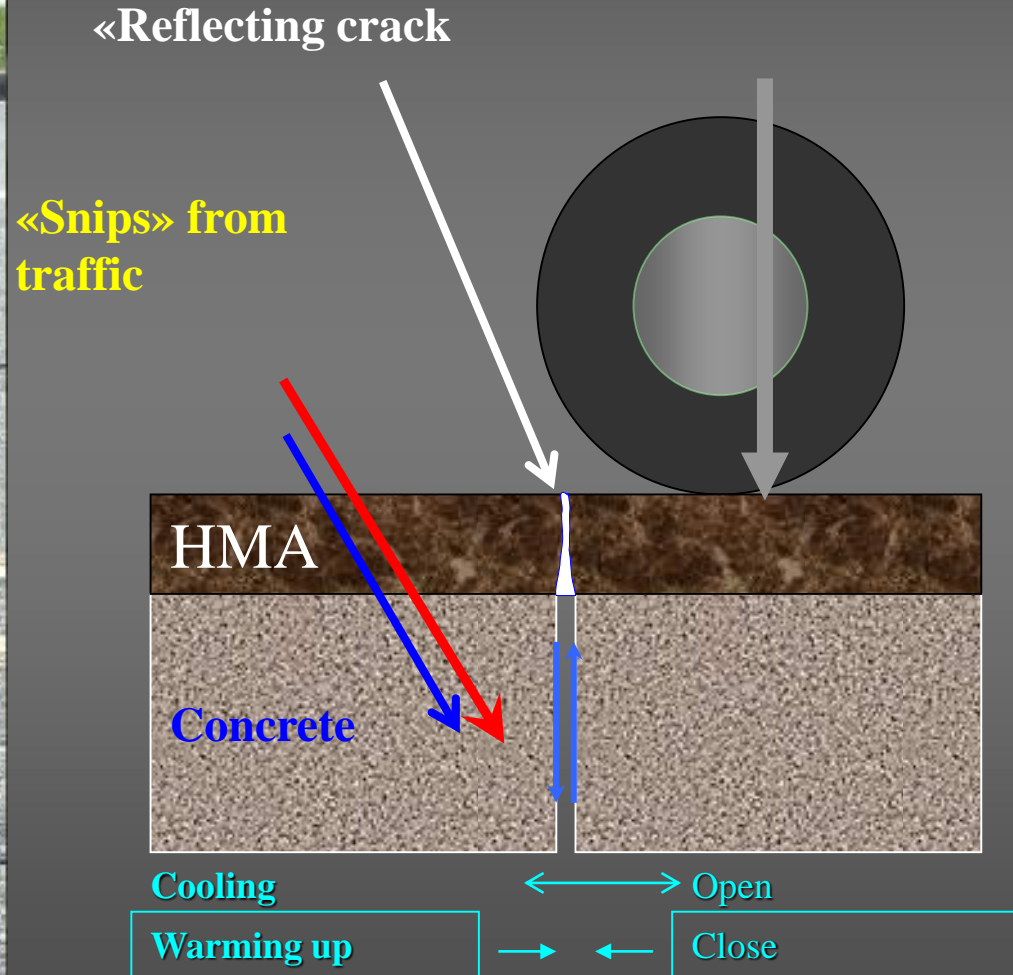
RUBBLIZATION PROJECTS: 41 States in USA



No Projects

**Rubblization
Projects**

Reflecting cracks is an issue



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

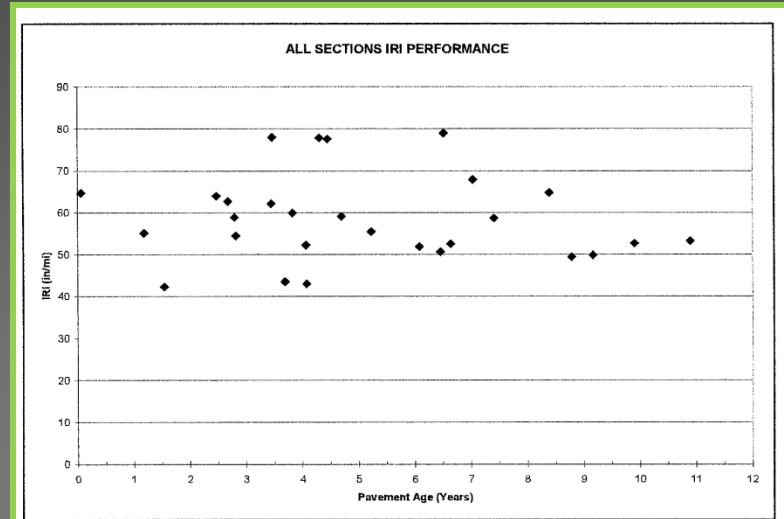


Figure 4.3 IRI vs. Pavement Age.

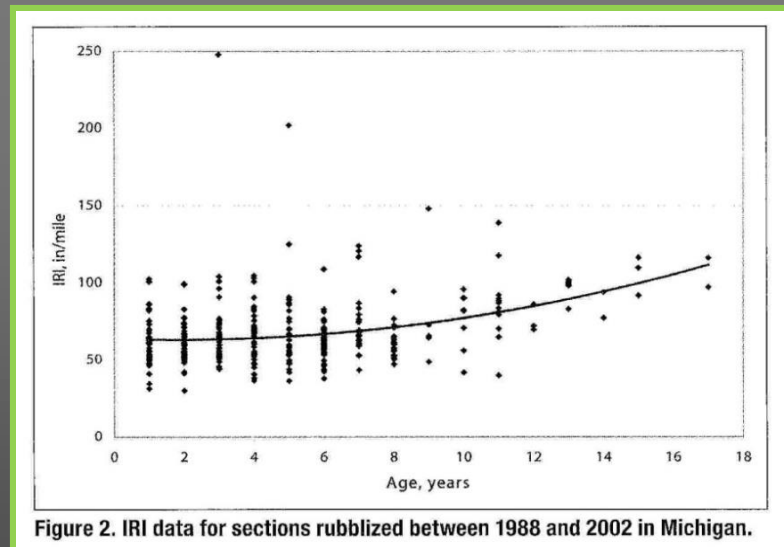
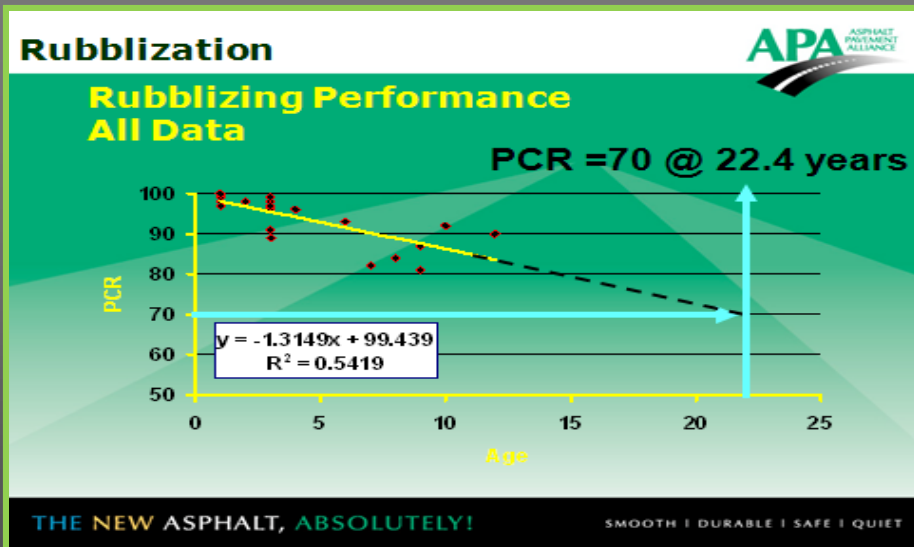
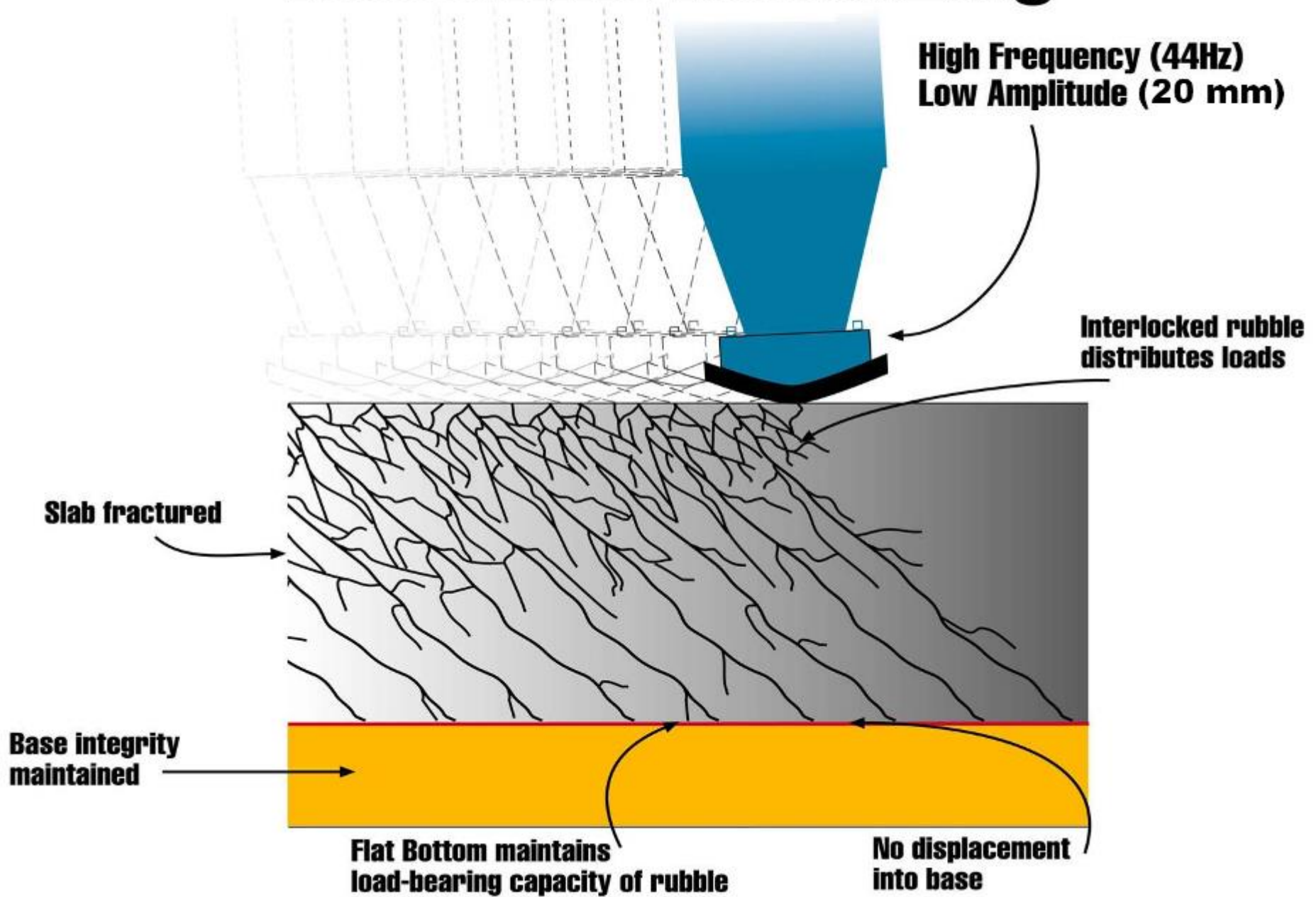


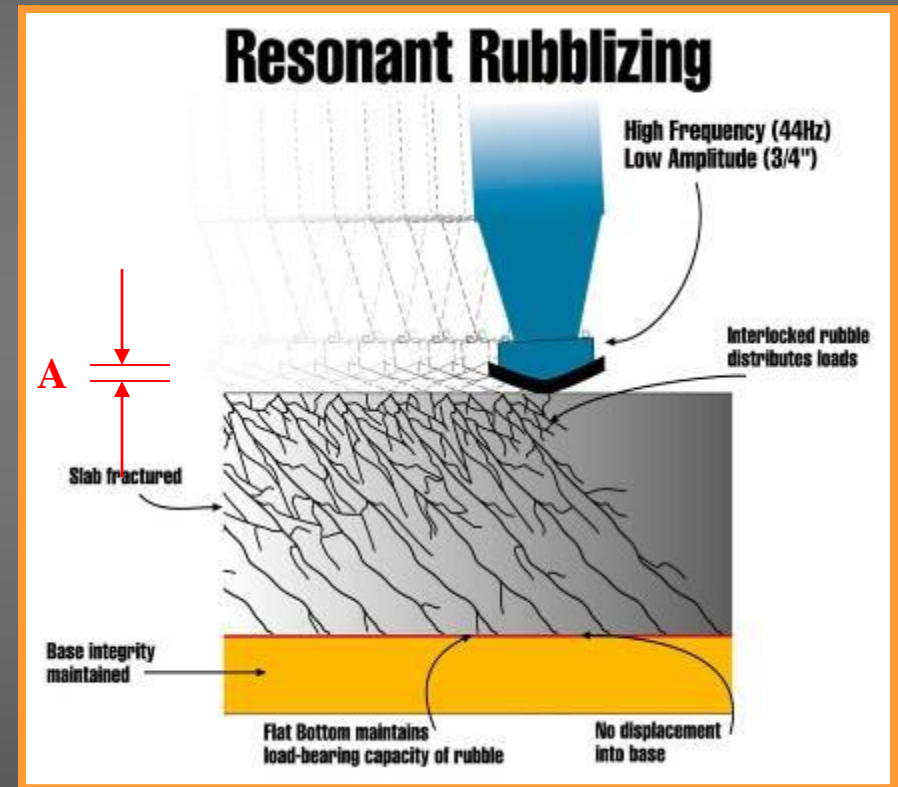
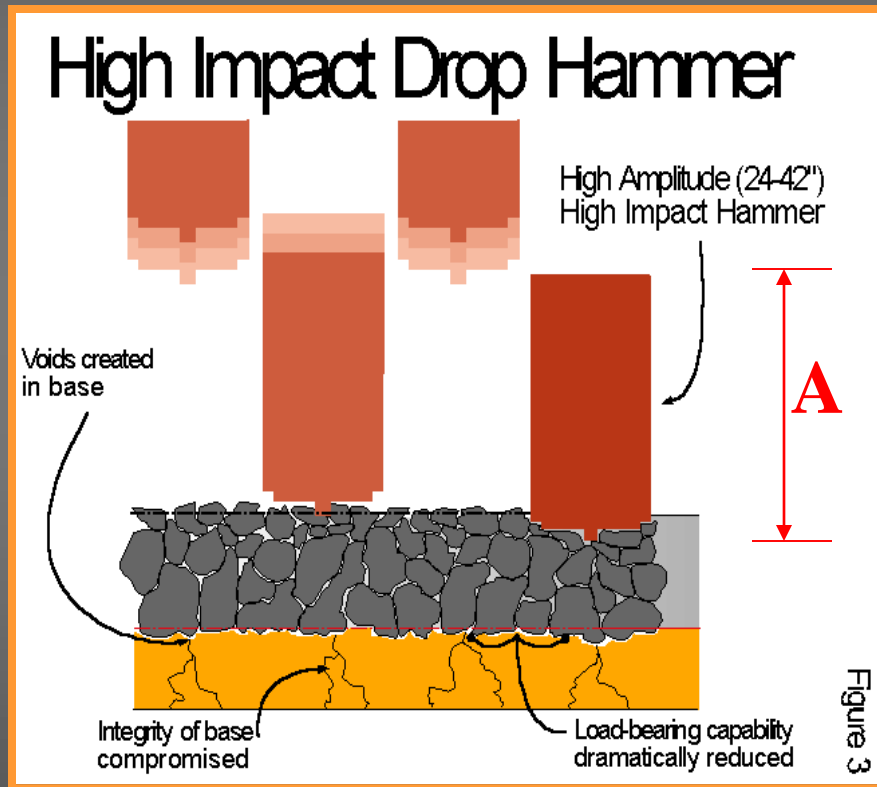
Figure 2. IRI data for sections rubblized between 1988 and 2002 in Michigan.

Resonant Rubblizing



Properties of Rubblizing: Comparison

“Rubblizing” doesn’t affect the base integrity due to the low amplitude

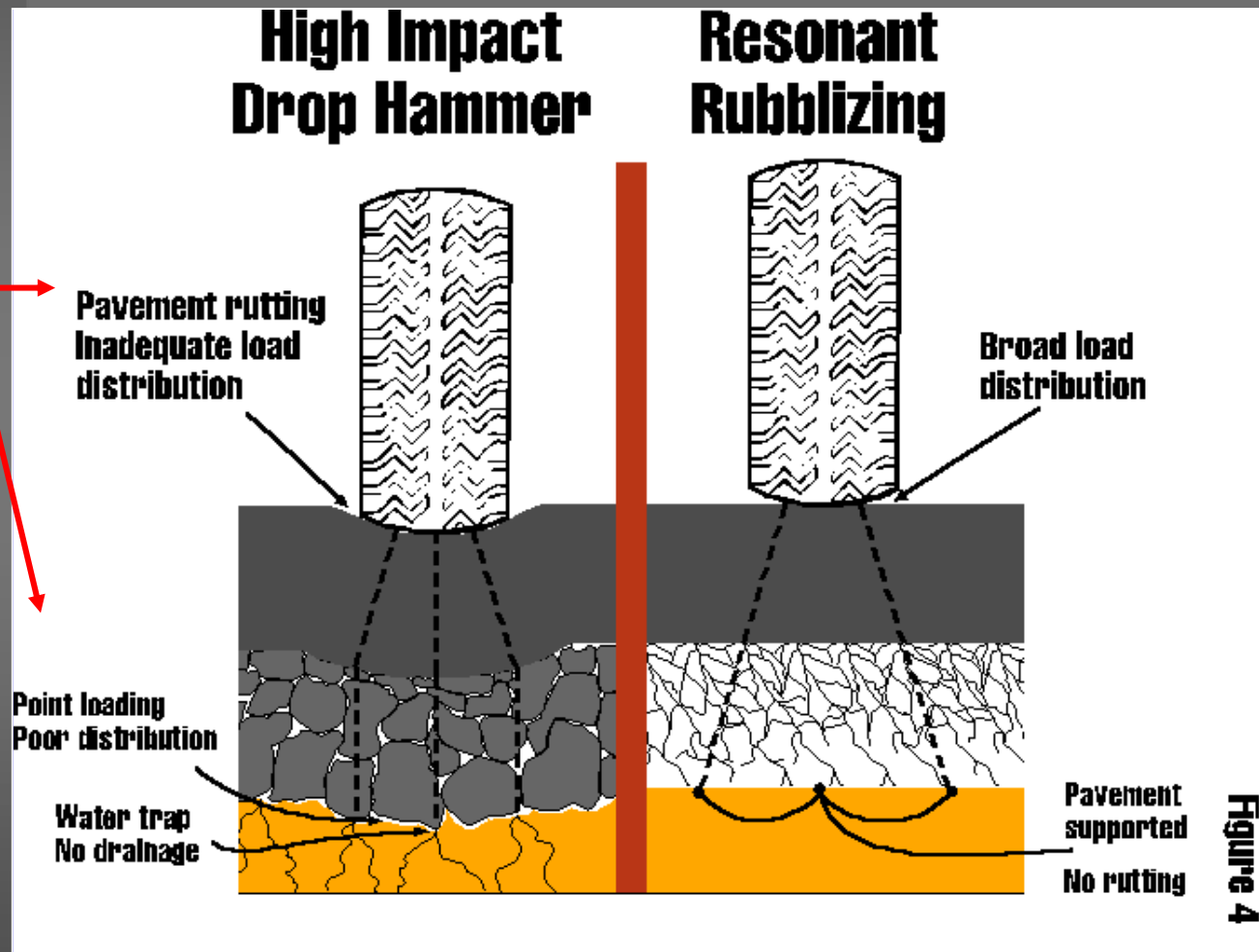


High Amplitude
Damage to Base / Utilities

Low Amplitude
No Violation of Base / Utilities

Additional Issues with High Impact Rubblizing

Warning



Application of Recycling the Concrete Pavement (Rubblizing)

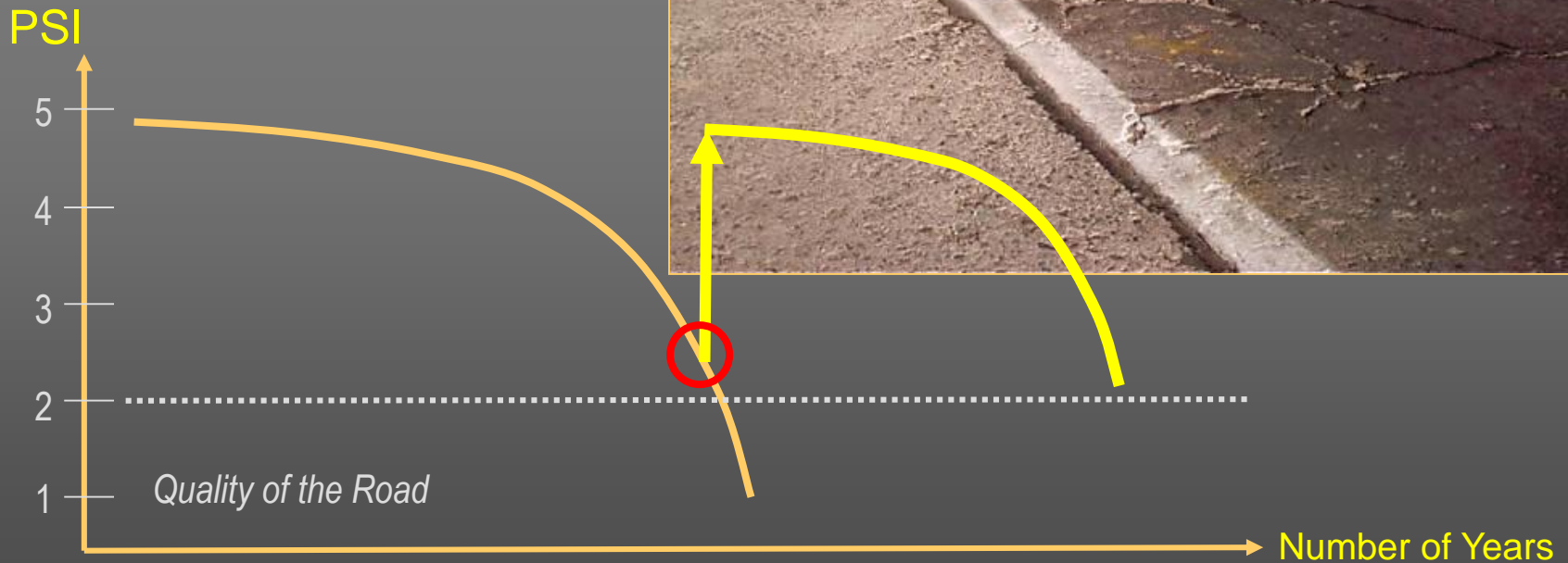
Environmentally Friendly
Construction



Reflection: Evolution of the Deterioration



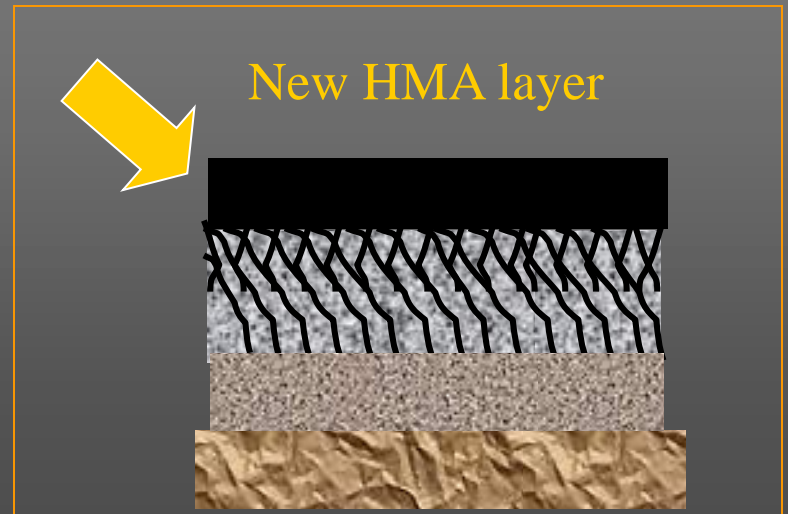
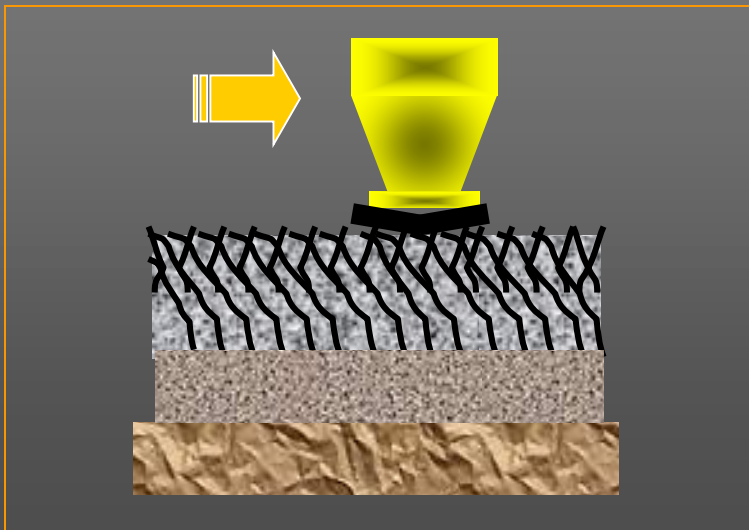
Rehabilitation of Concrete Pavement

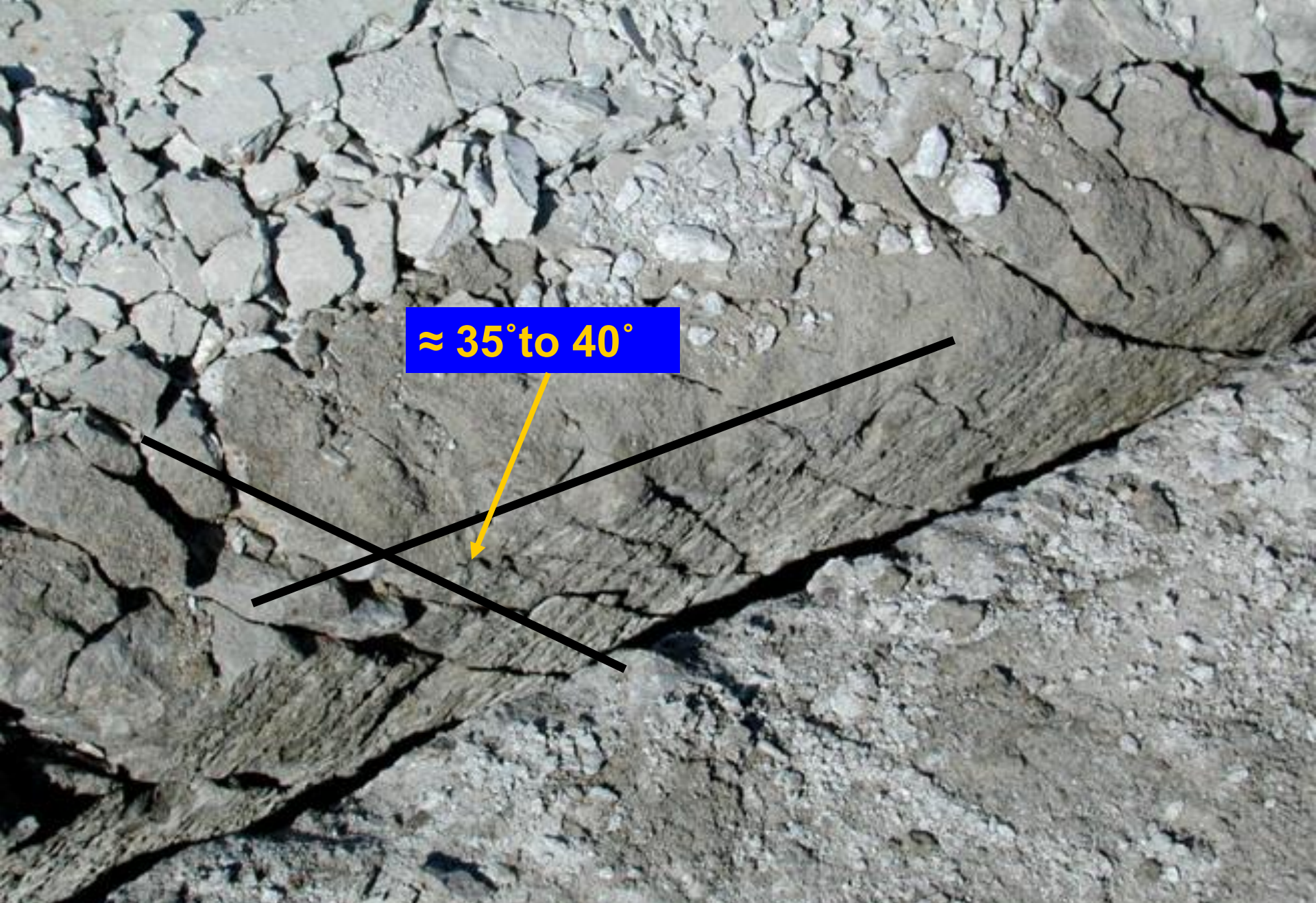


Rehabilitation of Concrete Pavement



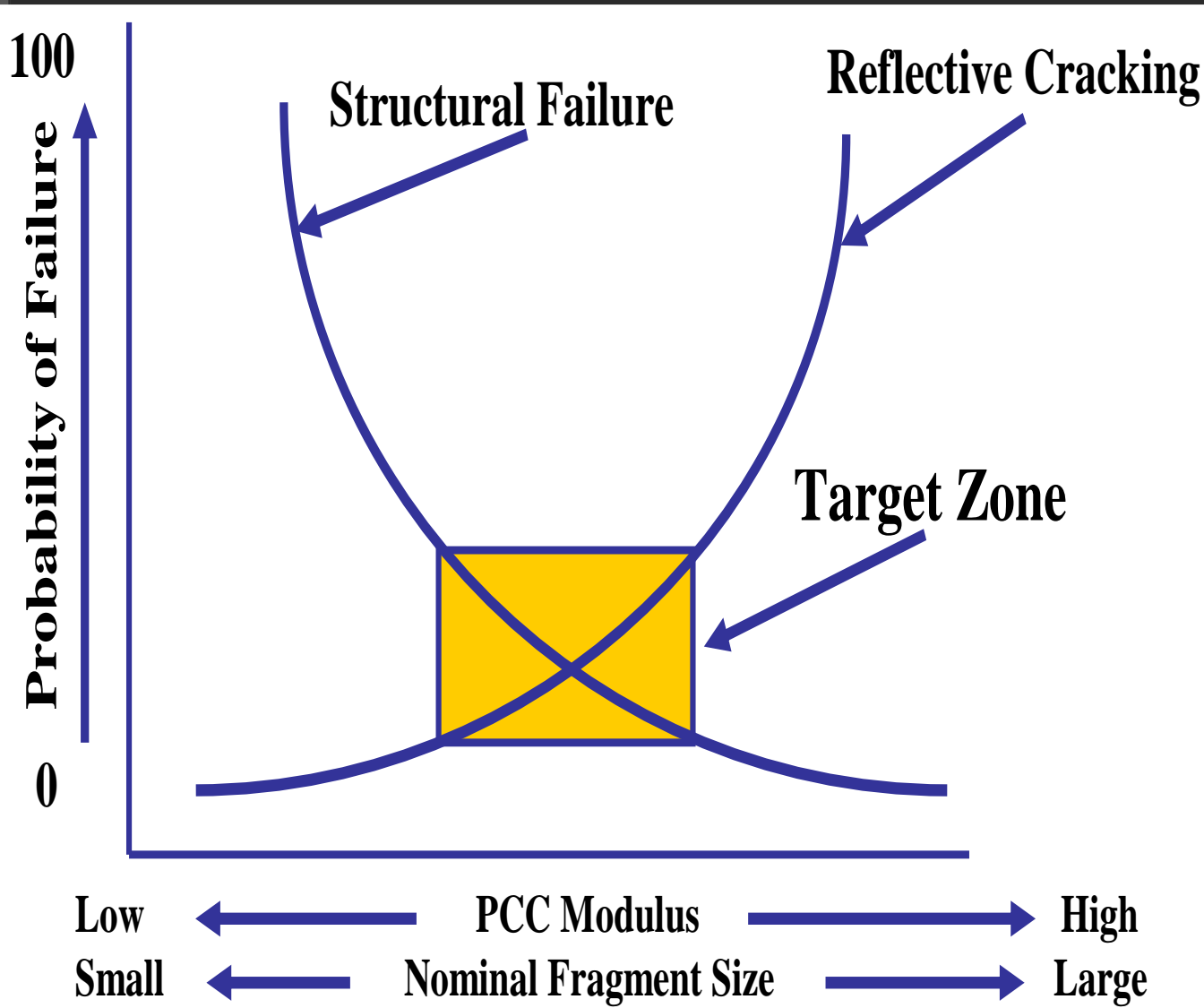
Rubblizing





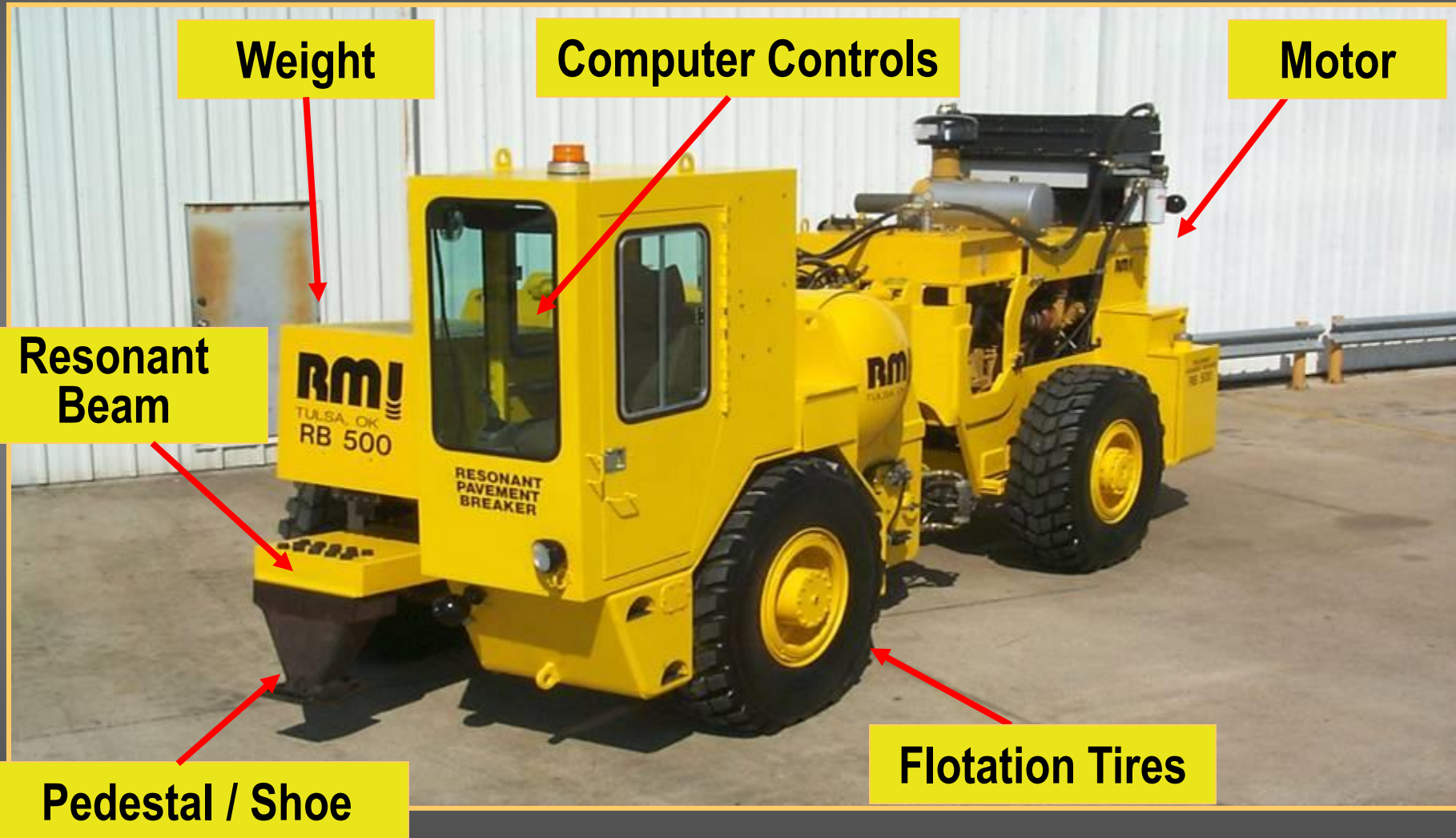
Angular Fracture Pattern for Greater Modulus

Structural Design: Correlations



DESCRIPTION OF TECHNICAL RUBBLIZING

Description of Rubblizing Equipment



Description of Rubblizing Equipment:

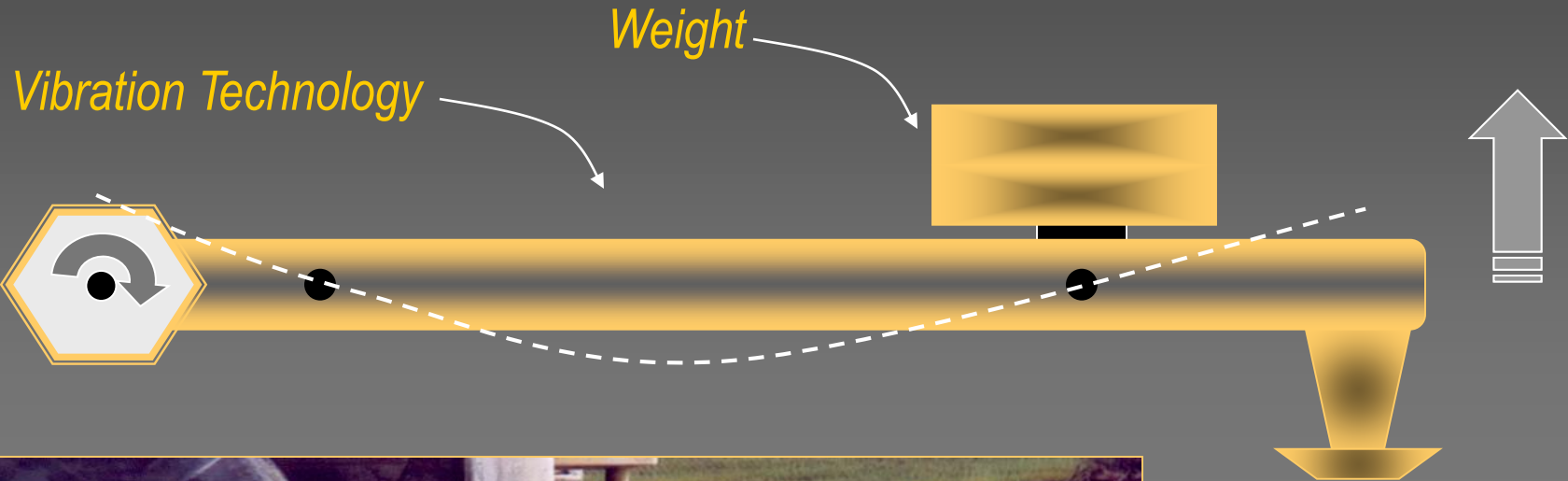
New computer system was installed in 2008



.... A new generation screen allows to control and optimize the rubblization process.



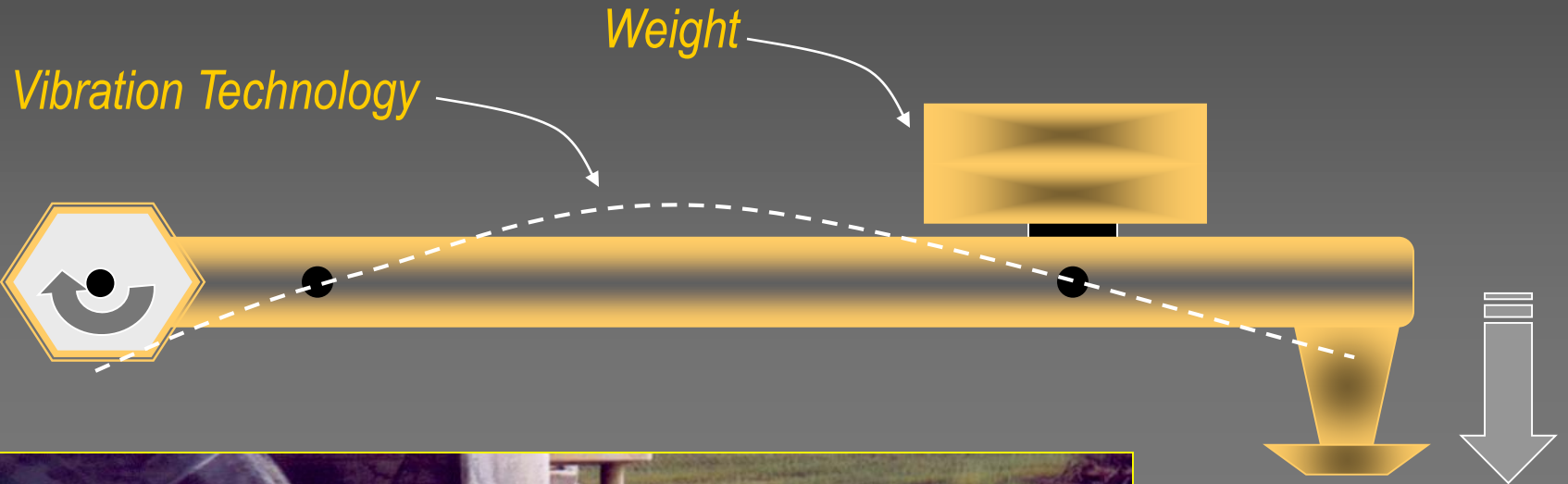
Description of Resonant Beam



Frequency 44 Hz

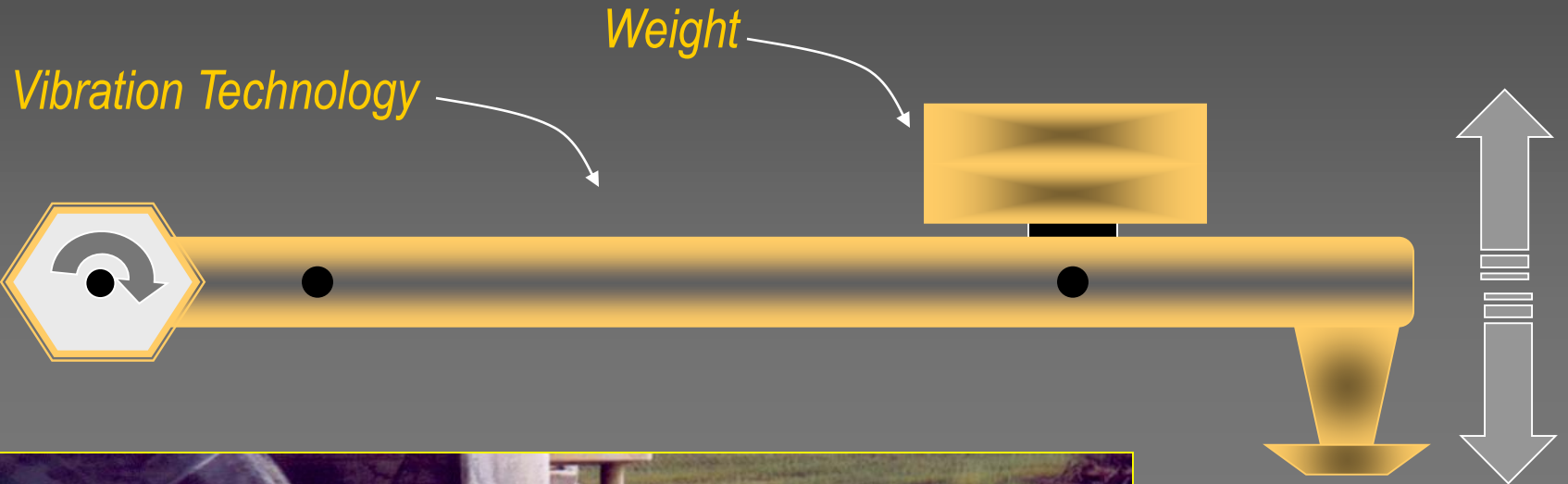
**Amplitude 13-19
mm (3/4")**

Description of Resonant Beam



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

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**



STRUCTURAL DESIGN

Rubblizing Process

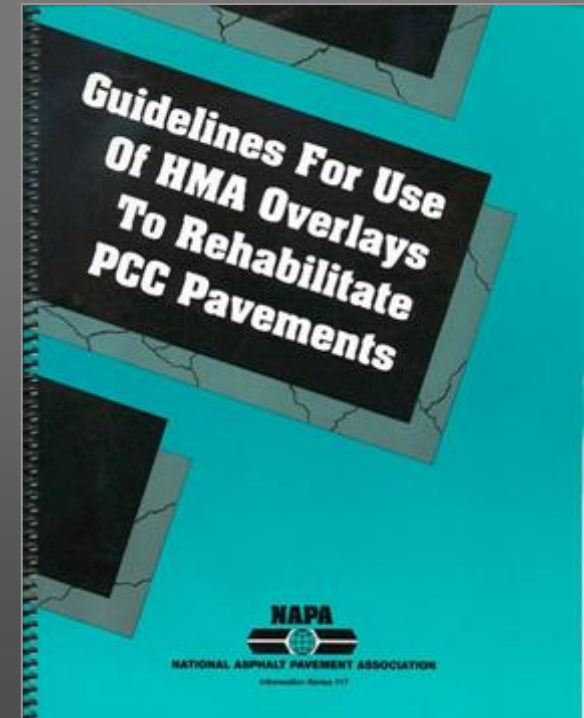
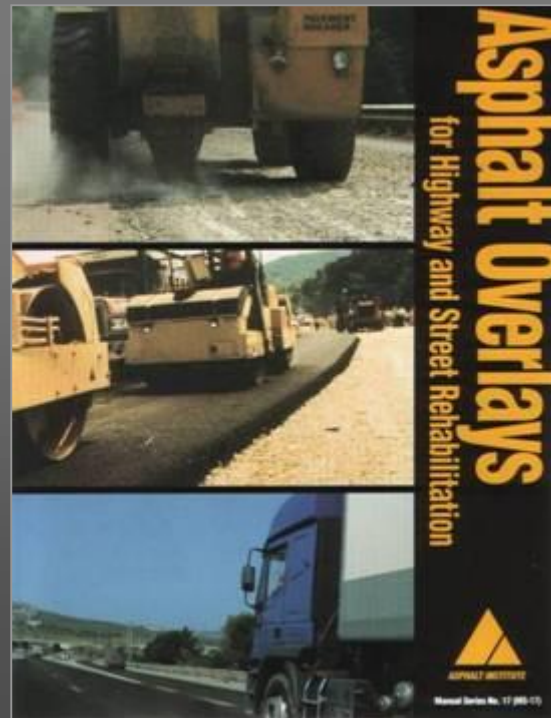
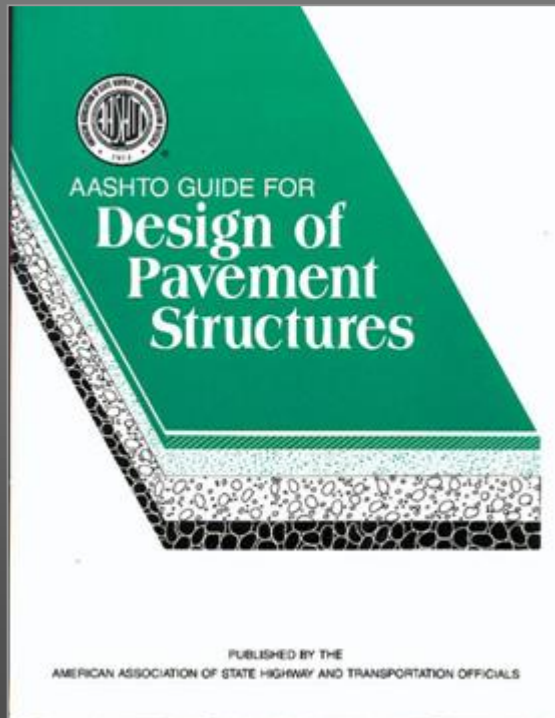
- Remove existing overlay
- Install drainage system
- Rubblize concrete pavement
- Remove & replace weak areas
- Roll rubblized concrete
- Place HMA leveling course & overlay

Major Steps



Structural Design: Methods

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



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

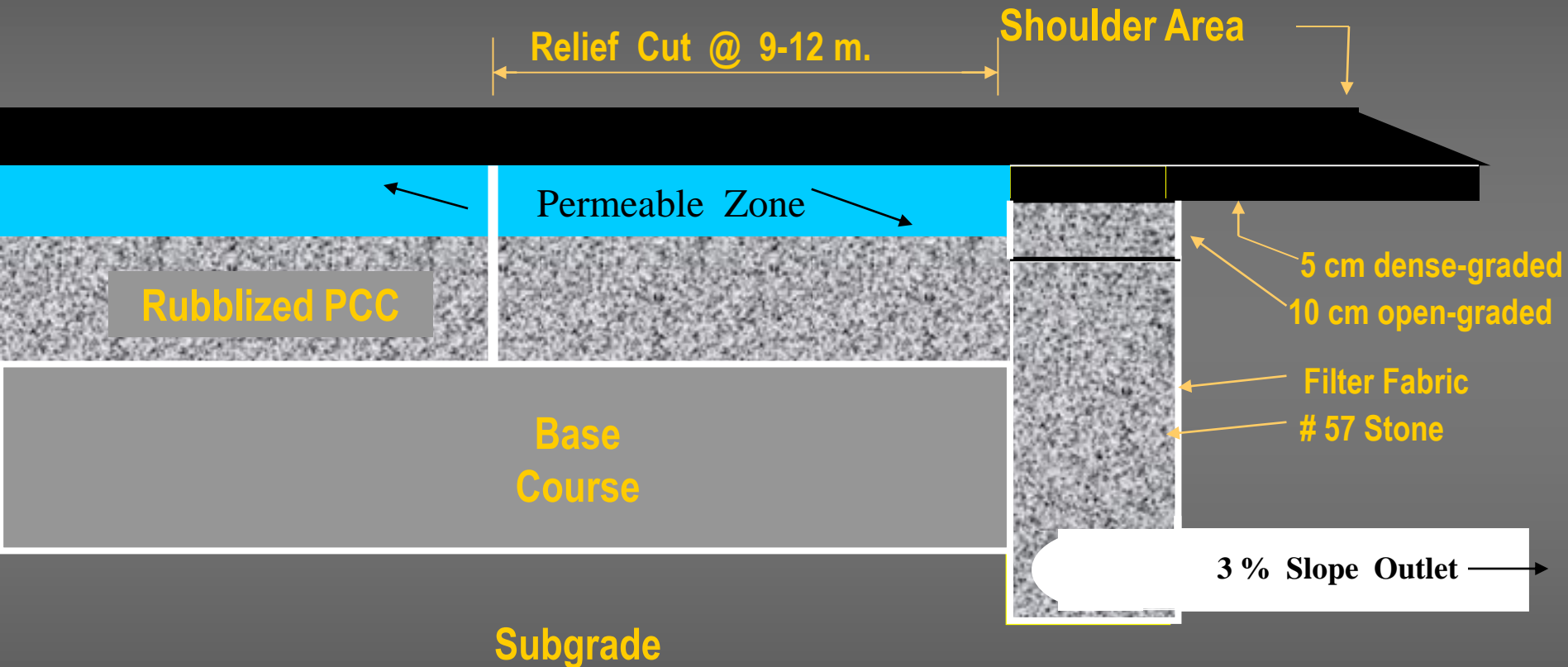
- Water

- Water

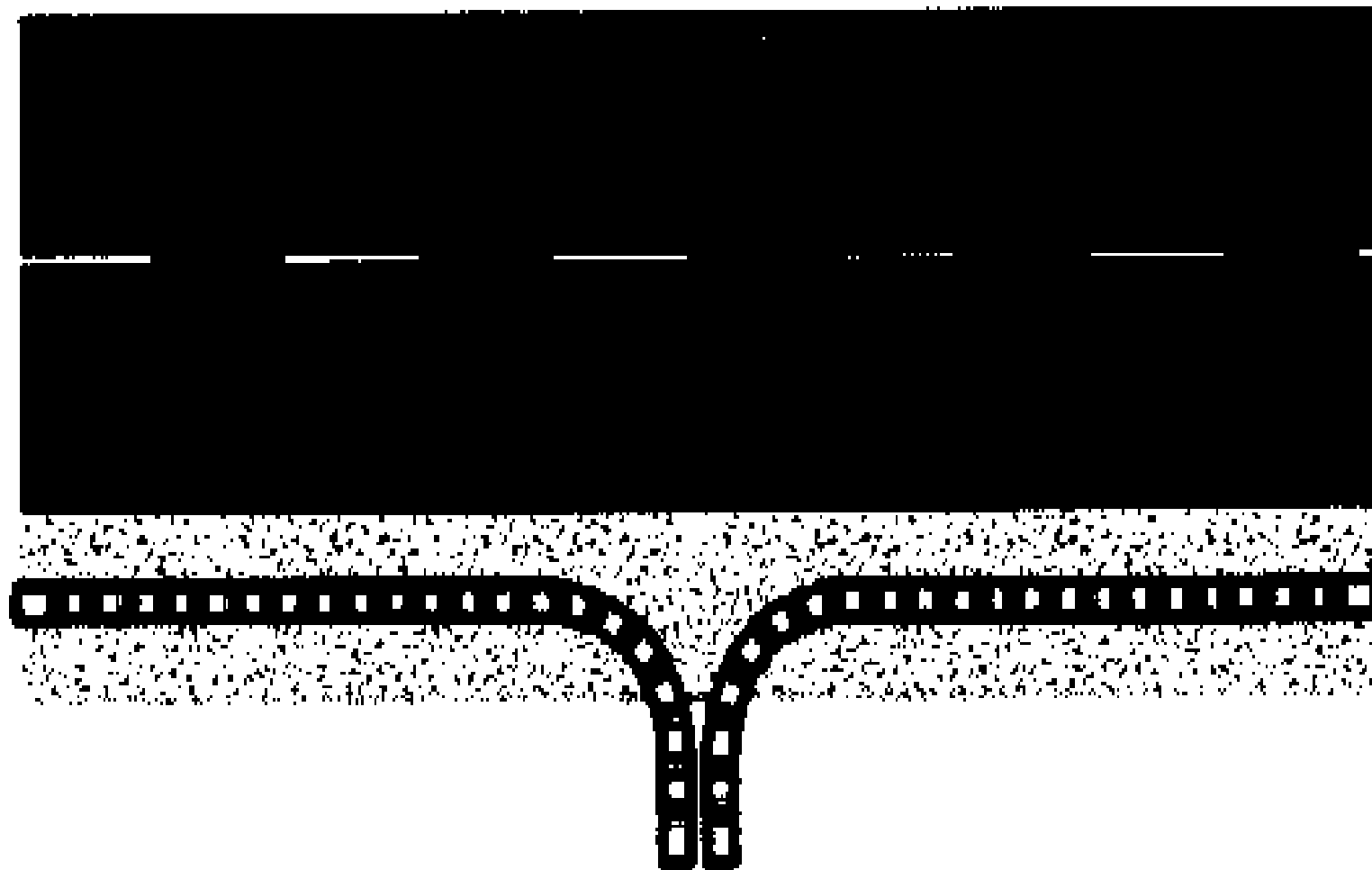
- **WATER**



Structural Design: Drainage



Dual outlets at approximately 300 feet



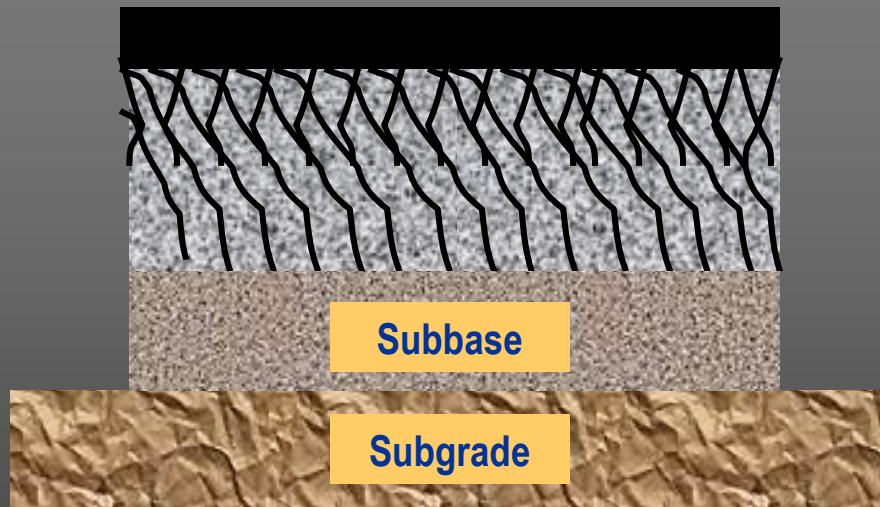
Dual Outlet

Dual outlets - One each direction



Structural Design: Scope

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.



$$E_4 > E_3$$

$$E_3 > E_2 \quad \text{Where } E_3 = f(E_2)$$

$$E_2 > E_1 \quad \text{Where } E_2 = f(E_1)$$

$$E_1$$

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

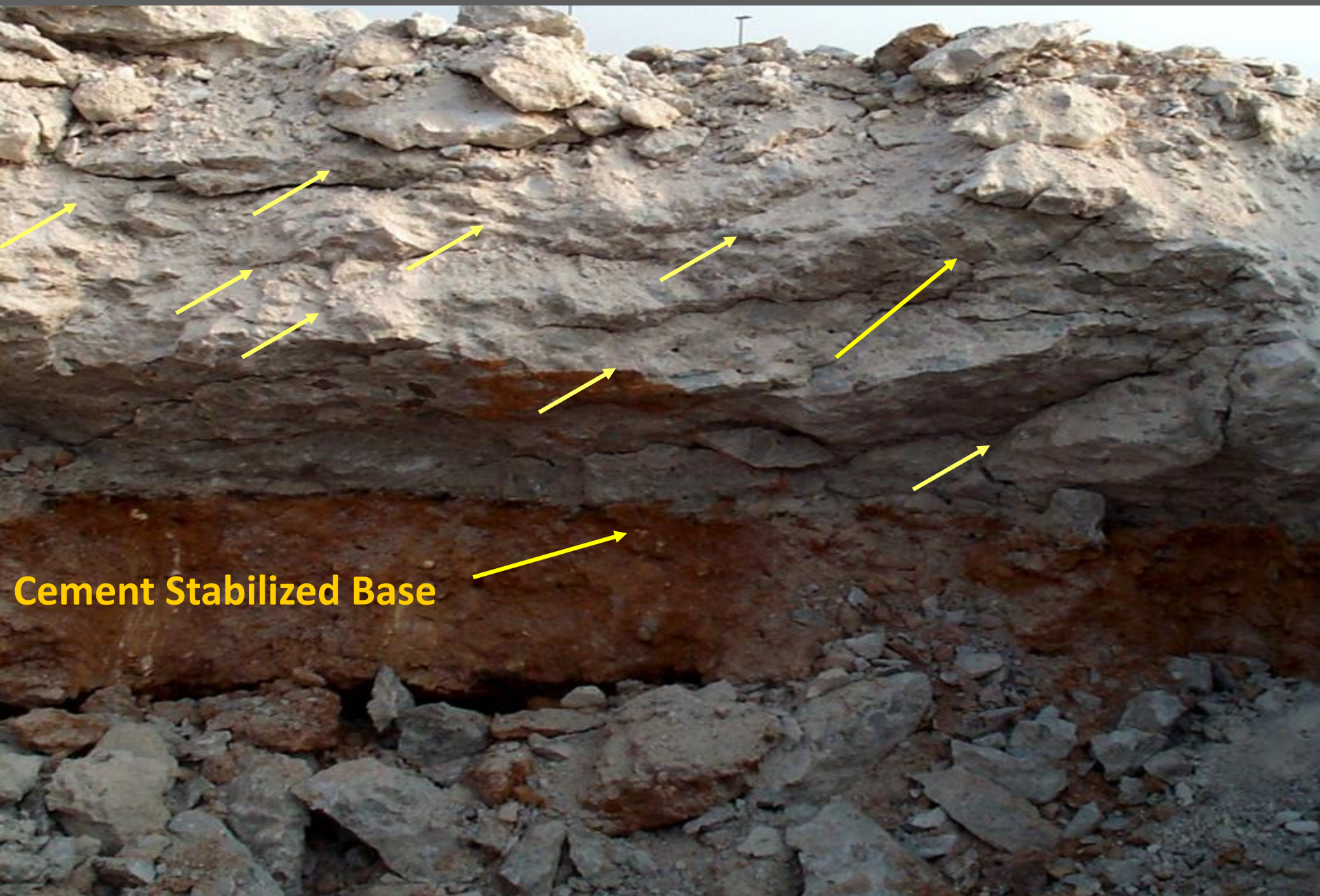
- Complete debonding of concrete
- Removal of mesh reinforcement and rebar



Test Pit

Confirm Specification and Debonding

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)

| Rubblize and Overlay | | Unbonded Concrete Overlay | | Remove & Replace Concrete | |
|---|-------------|---|-------------|-------------------------------------|-------------|
| Item | Extension | Item | Extension | Item | Extension |
| Edge Drain, Rubblization 4" Unmodified HMA @ 145 lb/ft 4" Modified HMA @ 145 lb/ft | | 10% Patching existing PCC 2" HMA Bond Breaker, 8" Concrete Overlay | | Remove 11" PCC, Place 11" PCC | |
| Total | 100% | Total | 155% | Total | 165% |

➡ 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 20cm > towards the bottom**
 - **Microprocessor Impact Adjustment, Consistency in Particle Size**

US Federal Aviation Administration Report



Federal Aviation
Administration

An **AAPTP** Research Report

Airfield Asphalt Pavement Technology Program

Interim Report AAPTP 05-04

Techniques for Mitigation
of Reflective Cracking

April 30, 2007

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!

