NWPMA 2011 Conference

PREMATURE ASPHALT DISTRESS;
CAUSES and CURES

(Dense-Graded Mixes)

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DISTRESS TYPES:

- Raveling
- Rutting
- Flushing
- Cracking
- Moisture Damage

BACKGROUND ON DENSE-GRADED MIXTURES

- **Flexible Pavements**
- **Part of a Layered System**
- **Elastic Behavior**
- **No Definitive Performance Test**

BACKGROUND ON DENSE-GRADED MIXTURES

- National Effort to Improve Asphalt Pavements
- Strategic Highway Research Program (SHRP)
- SuperPave™ Mix Design System
- Rely on good Mix Design Practices and Field Management

BACKGROUND ON DENSE-GRADED MIXTURES

- **Asphalt Mixtures are Composite Systems**
- **Engineers rely on Empirical Means**
- **Goal:**

Select the correct proportions on a <u>volume basis</u> as opposed to a <u>weight basis</u> (i.e. – the correct volume of oil for the volume of aggregate and the volume of space between the aggregate).

BACKGROUND ON DENSE-GRADED MIXTURES

- Mixes with the best performance have by volume:
  - 96% Aggregate and Oil
  - 4 % Air Voids

BACKGROUND ON DENSE-GRADED MIXTURES

- Aggregate and Oil are relatively "incompressible"
- Only the volume of air voids can be reduced by compacting
- Construction rolling only gets us down to about 8% air voids

BACKGROUND ON DENSE-GRADED MIXTURES

- **Traffic further reduces the volume of air voids ("Secondary Compaction")**
  - **Takes 1 to 3 years**
  - **A well designed mix should stabilize at 4% air voids**

BACKGROUND ON DENSE-GRADED MIXTURES

The goal as the asphalt manager is to design and construct an asphalt and aggregate mixture that will stabilize at 4% air voids by volume <u>after one to three years of secondary compaction.</u>

BACKGROUND ON DENSE-GRADED MIXTURES

- QC routinely measures Volume Properties of Mixtures
- The Results are referred to as the Mix "Volumetrics"

BACKGROUND ON DENSE-GRADED MIXTURES

- **Correctly Quantifying Compaction Energy to Model Secondary Compaction is *<u>not easy</u>***

- **Each "Mix Design" is tailored to one level of secondary compaction**

SECONDARY COMPACTION MODEL

- **Oregon DOT Traffic Levels (20 years):**

  - Level 1 HMAC (< 10,000 ESAL’s); 65 gyrations (Va = 3.0)
  - Level 2 HMAC (10,000 to 1,000,000 ESAL’s); 65 gyrations
  - Level 3 HMAC (1,000,000 to 10,000,000 ESAL’s); 80 gyrations
  - Level 4 HMAC (> 10,000,000 ESAL’s); 100 gyrations

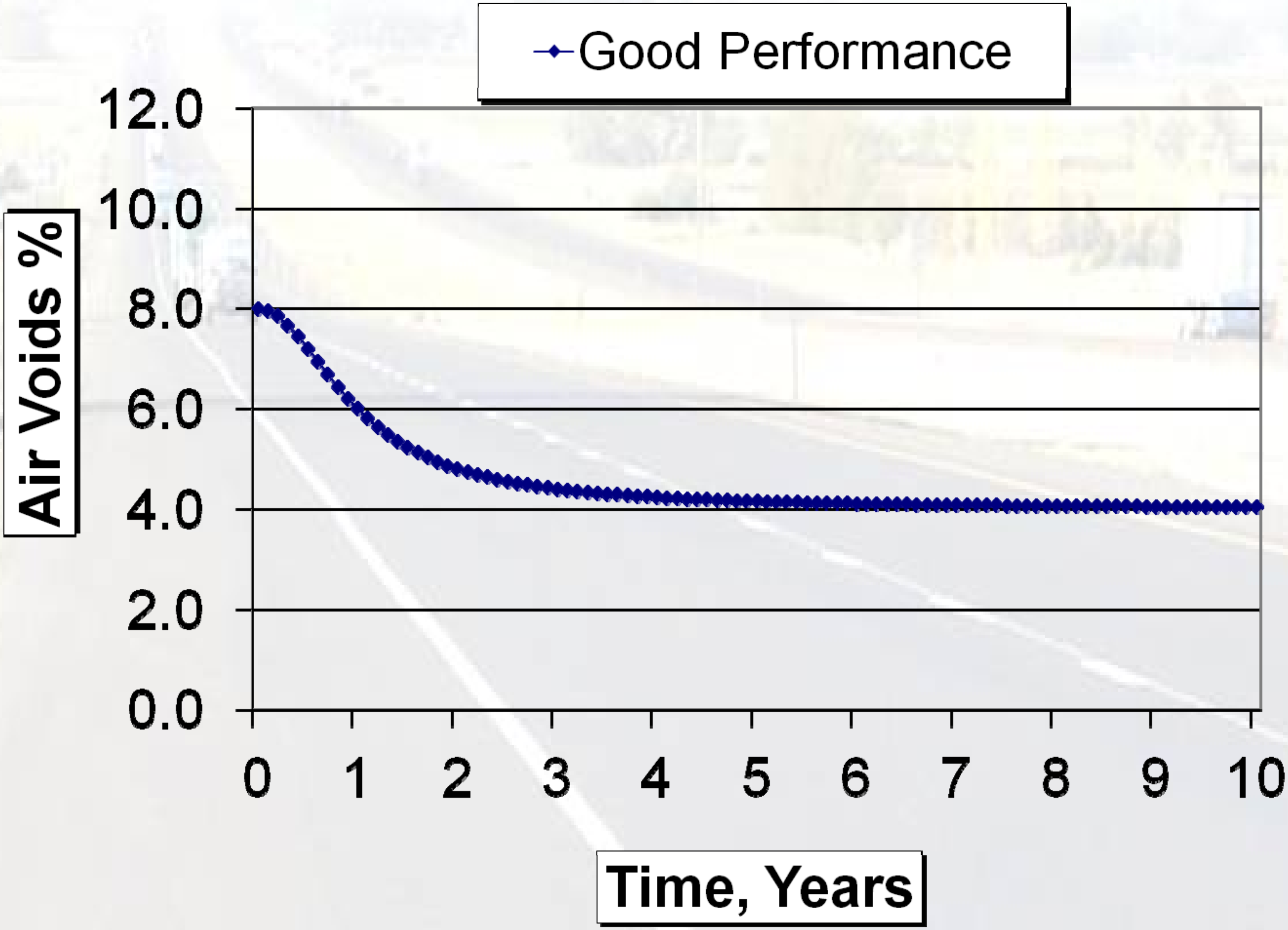
(ESAL = Single axle, dual tires, loaded to 18,000 lbs)
Examples: Dump Truck ≈ 1.30 ESAL’s; Lo-boy ≈ 2.40 ESAL’s

SECONDARY COMPACTION MODEL

- **Idaho TD Traffic Levels (20 years):**
  - SP 1 HMAC (< 300,000 ESAL's); 40 gyrations
  - SP 2 HMAC (300,000 to 1,000,000 ESAL's); 50 gyrations
  - SP 3 HMAC (1,000,000 to 3,000,000 ESAL's); 75 gyrations
  - SP 4 HMAC (3,000,000 to 10,000,000 ESAL's); 90 gyrations
  - SP 5 HMAC (10,000,000 to 30,000,000 ESAL's); 100 gyrations
  - SP 6 HMAC (> 30,000,000 ESAL's); 125 gyrations

BACKGROUND ON DENSE-GRADED MIXTURES

If the pavement receives significantly more or significantly less secondary compaction than the design amount, then performance of the pavement will be negatively impacted.


Good Performance
Air Voids %
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
1
2
3
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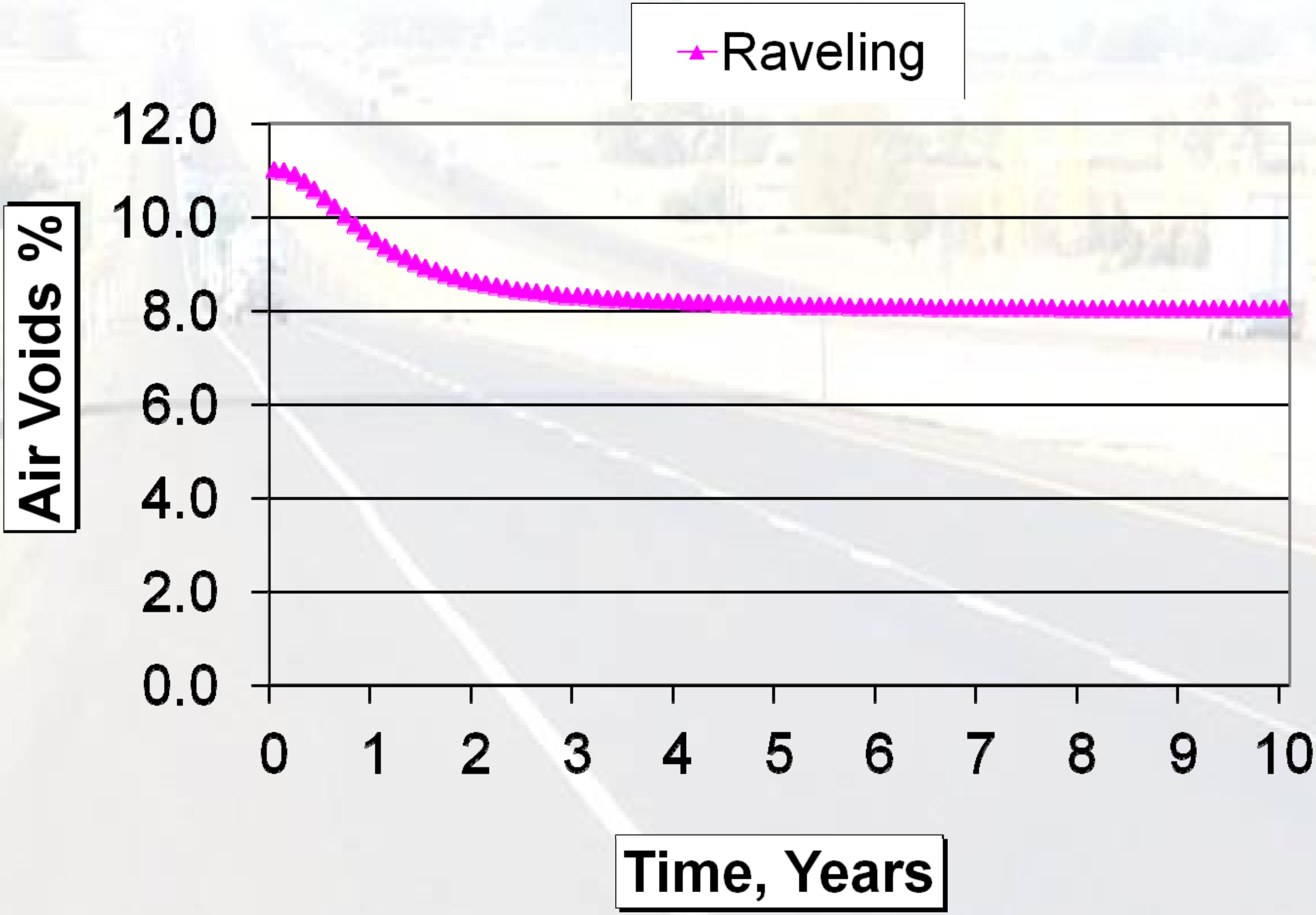
5
6
7
8
9
10
Time, Years

RAVELING

Pavements that don't properly densify after construction are much more prone to "*raveling*" (loss of fine surface matrix).



Raveling
Air Voids %
12.0
10.0
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Time, Years

RAVELING

Raveling is deterioration due to water entering the asphalt mat through interconnected air voids.

CAUSES OF RAVELING

- Raveling is generally caused by failure to achieve design secondary compaction
  - Specifying the wrong mixture parameters
    - Traffic Level
    - Low VMA designs or Low Asphalt Content designs
  - Inadequate drainage (cross slope)
  - Poor Quality Control during production
    - Improper Gradation
    - Low Asphalt Cement Content
    - Failure to Achieve Minimum Specified Density or no Density Requirements in the Contract

CAUSES OF RAVELING

The classic case for creating a raveling pavement is to use a mix design that is to dry (low oil) which then is ***uncompactable*** in the field.

e.g. – Using a Level 4 (Interstate Highway) mix on a Level 1 Residential cul-de-sac.

Raveling is *greatly* exacerbated by studded tires.

CURES FOR RAVELING

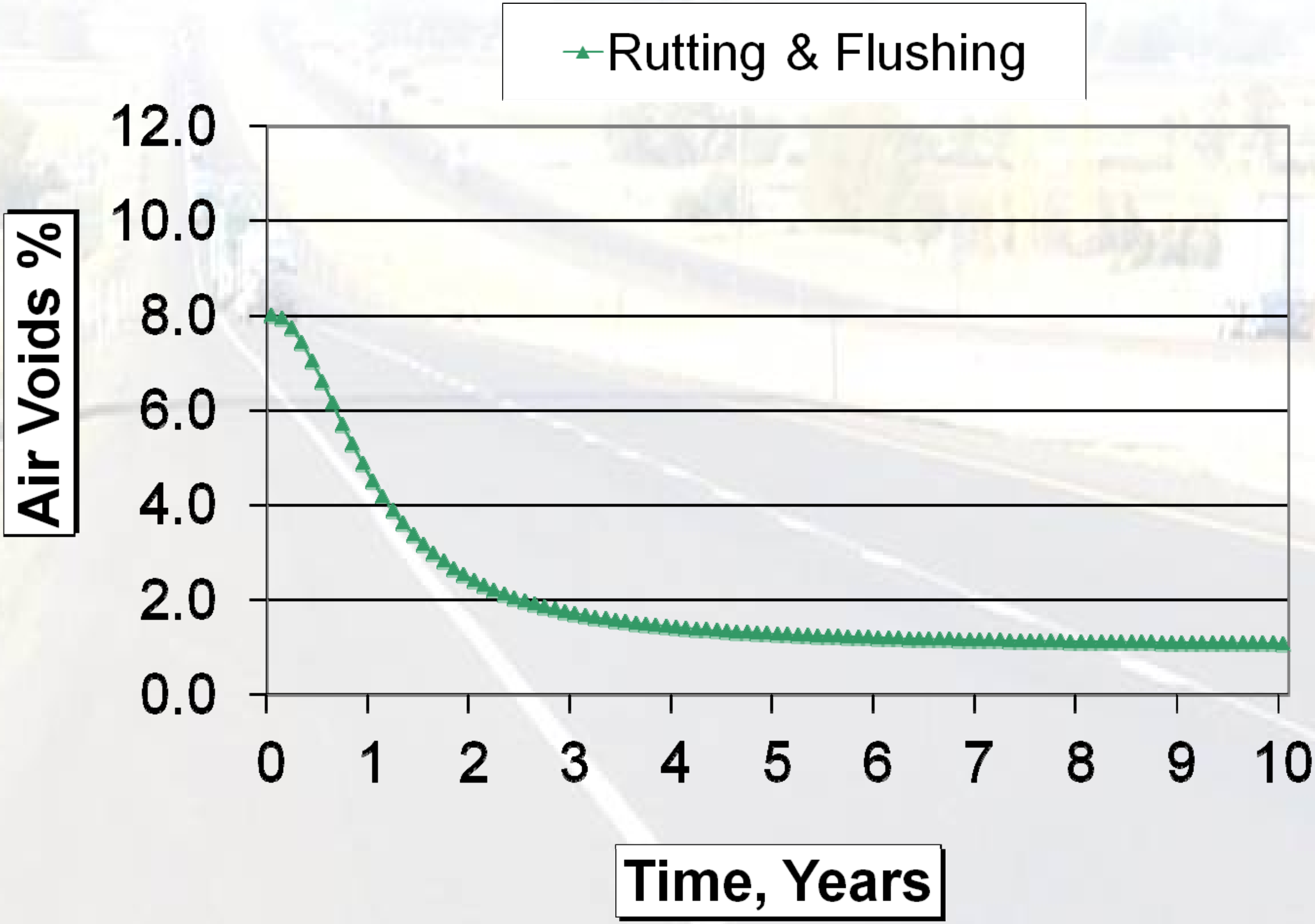
- **Specifications must include the correct mixture parameters for the anticipated secondary compaction.**
  - **Use an established JMF when possible**

- **Require the Contractor to provide timely QC on mixture properties and density.**
  - **It should take reasonable compactive effort to achieve density. (4 to 12 passes with appropriate rollers)**

RUTTING

RUTTING

Pavements that *__continue__* to densify after construction, but do not stabilize at 4.0% air voids are prone to *__rutting, flushing and bleeding.__*



Rutting & Flushing
12.0
10.0
8.0
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4.0
2.0
0.0
Air Voids %
0
1
2
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4
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10
Time, Years

CAUSES OF RUTTING

- Generally a mixture problem
  - Specifying the wrong mixture parameters
    - Traffic Level
    - Grade of Asphalt Cement
  - Poor Mix Design Gradation
    - Generally high VMA mix
  - Poor Quality Control during production
    - Improper Gradation
    - High Asphalt Cement Content

CURES FOR RUTTING

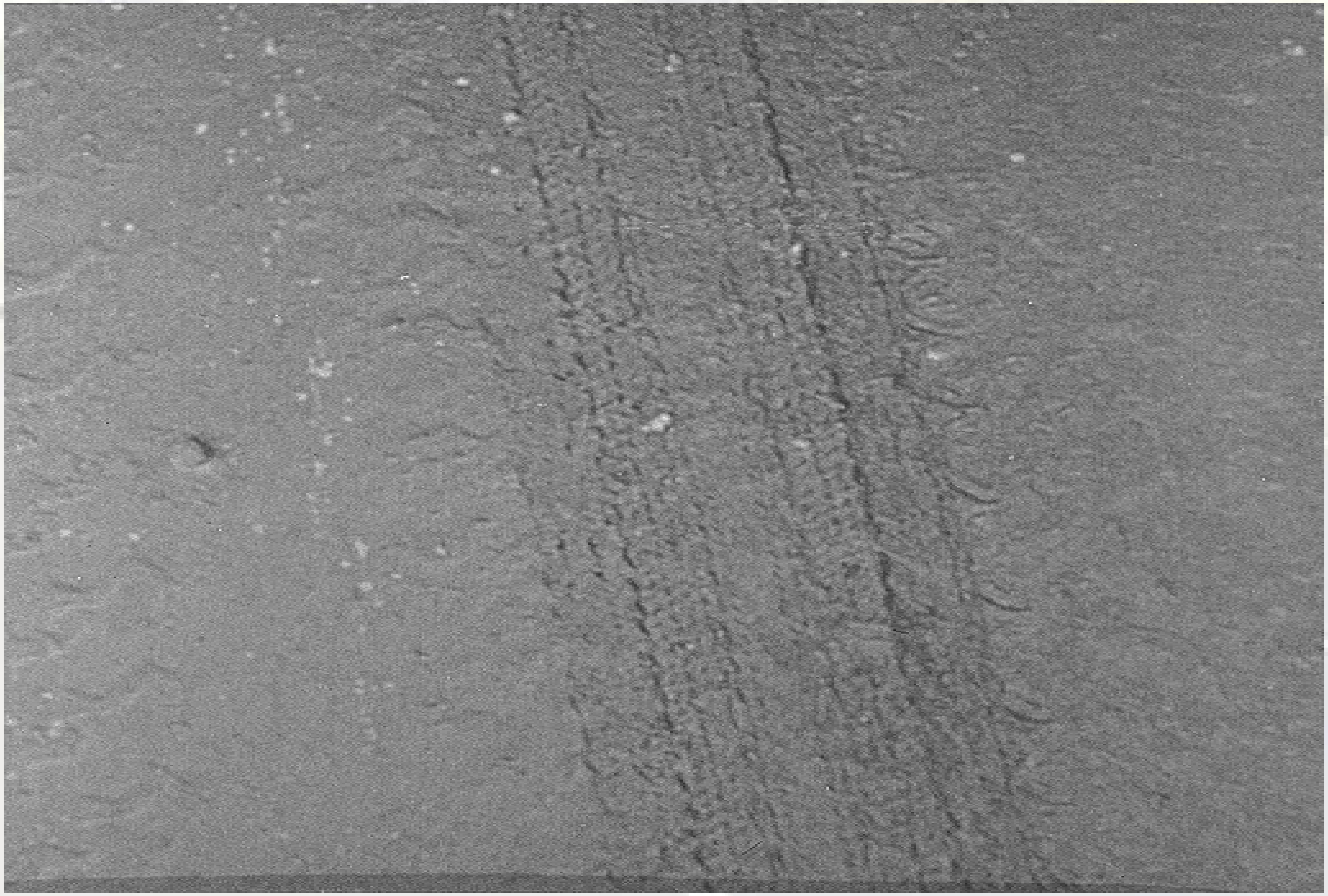
Specifications must include the correct mixture parameters for the anticipated secondary compaction and the correct grade of asphalt cement for your traffic and climate.

- **Use an established JMF when possible**
- **Use the maximum amount of RAP**
- **Require Rut Susceptibility Testing per AASHTO T 340**

Require the Contractor to provide timely QC on mixture and density.

- **It should take reasonable compactive effort to achieve density. (4 to 12 passes with appropriate rollers)**

FLUSHING



CAUSES OF FLUSHING

- **Flushing is generally a mixture problem**
  - **The mixture is “over-oiled”**
    - **May appear as a precursor to rutting**
    - **Commonly associated with a drop in asphalt absorption**
    - **May be associated with moisture damage (stripping)**
  - **Poor Quality Control during production**
    - **Improper Gradation**
    - **High Asphalt Cement Content**

CAUSES OF RUTTING OR FLUSHING

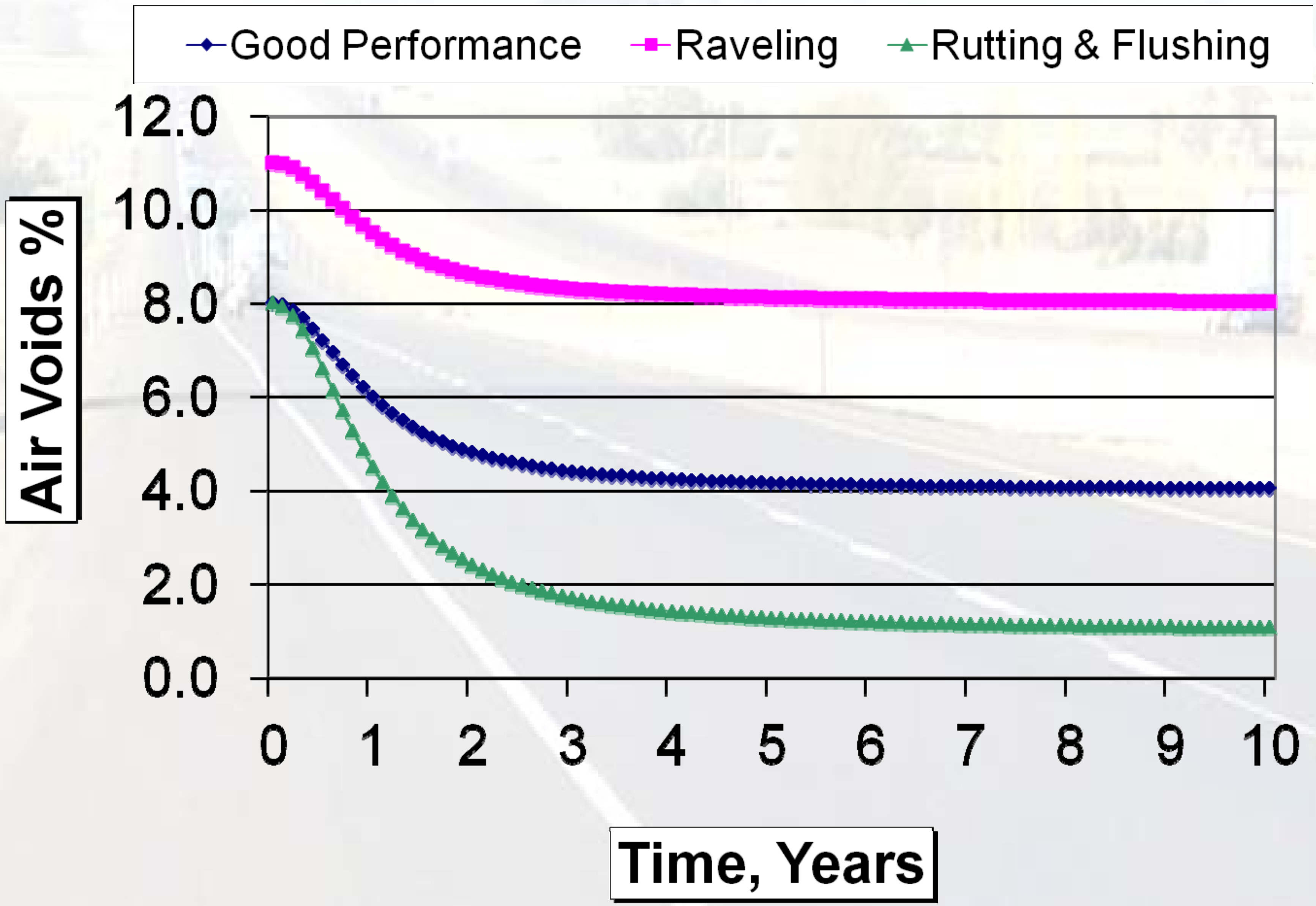
A classic case for creating a pavement that ruts or flushes is to use a mixture designed for a low traffic application and putting it on a high volume roadway.

e.g. – Using a Level 1 (Parking Lot) mix on a Level 3 main arterial street or truck bypass.

ASPHALT IS DESIGNED TO FURTHER COMPACT UNDER INITIAL SERVICE LOADS

Failure to understand the dependence of mixture performance on "Secondary Compaction" is a significant contributor to premature failures in asphalt pavements.

Note: **Applications that will never receive significant secondary compaction (e.g. – bike paths, private driveways, some parking lots, etc.) are more dependent on construction compaction to achieve desired voids. These mixes should be designed to lower air void targets to achieve 94 – 96% construction density.**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Time, Years

CRACKING

Construction Related:

- Longitudinal Joint
- Base Repairs (or lack thereof)
- Bonding

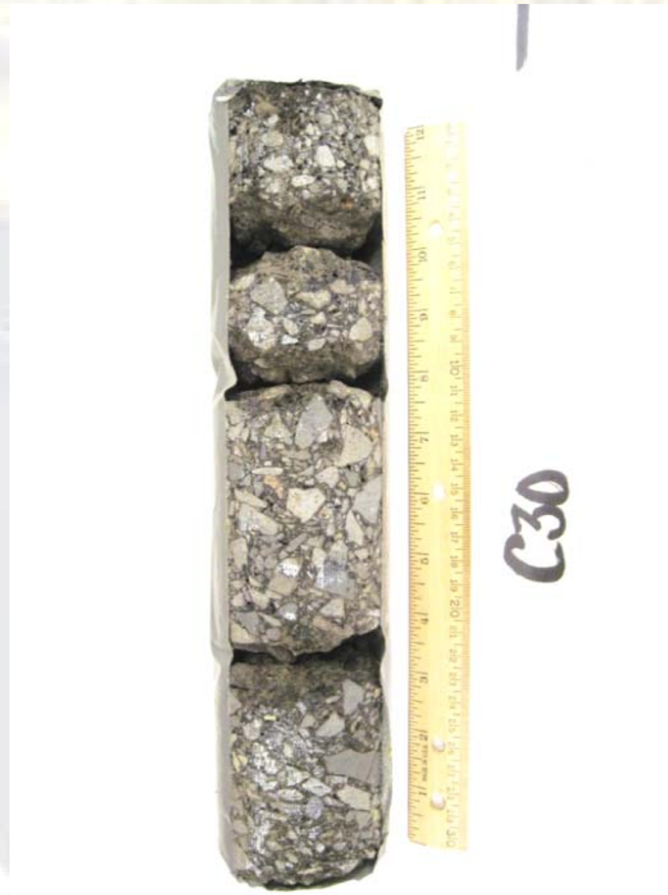
Load Related:

- Thickness (Fatigue)
- Reflective

Environmental:

- Thermal (Low Temperature)
- Aging (Brittleness)

MOISTURE DAMAGE



CAUSES OF MOISTURE DAMAGE

Engineering term for incompatibility between the Aggregate and Asphalt Cement:

- **Usually requires the presence of water**
- **Exacerbated by heavy loads.**
- **Will usually appear in the wheel path**

Test during mix design and production per AASHTO T 283.

CURES FOR MOISTURE DAMAGE

There is no means to mitigate stripping after the mix is in-place.

Treat Aggregate during production:
- Lime
- Polymer

Treat Asphalt Cement:
- Liquid Anti-Strip

SUMMARY

- **To be successful:**
  - **Recognize the interaction of asphalt materials and traffic (secondary compaction)**
  - **Volumetrics will change over the first one to three years of service**
  - **Match your mix to your traffic**

QUESTIONS?