Asphalt Performance for a Lifetime

MAPA
Missouri Asphalt Pavement Association

LUNCH & LEARN
The APA is a partnership of the Asphalt Institute, National Asphalt Pavement Association, and the State Asphalt Pavement Associations.
Five regional councils focused on what works in the field to the benefit of the asphalt pavement industry locally and nationally.
Perpetual Pavements

Structure and materials are designed to provide a long service life (50 years +)
Perpetual Pavement

An asphalt pavement that is designed for a service life of 50 years or more without requiring major structural rehabilitation or reconstruction.
Introduction

• Not a new concept
  – Full-Depth
  – Deep Strength
  – Long Life Pavements
Load Bearing by Flexible v. Rigid Pavement
Performance Goals - Avoid These

Repeated Bending Leads to Fatigue Cracking

Repeated Deformation Leads to Rutting
Empirical

- **1993 AASHTO Flexible Equation**

\[
\log_{10}(W_{18}) = Z_R \times S_o + 9.36 \times \log_{10}(SN + 1) - 0.20 + \frac{\log_{10}\left(\frac{\Delta PSI}{4.5 - 1.5}\right)}{1094} + 2.32 \times \log_{10}(M_R) - 8.07
\]

- **1993 AASHTO Rigid Equation**

\[
\log_{10}(W_{18}) = Z_R \times S_o + 7.35 \times \log_{10}(D + 1) - 0.06 + \frac{\log_{10}\left(\frac{\Delta PSI}{4.5 - 1.5}\right)}{1+1.624 \times 10^{7.35}} + (4.22 - 0.32 p_i) \times \log_{10}\left(\frac{(S'_c) (C_d) (D^{0.75})}{1.132}\right)
\]

\[
215.63 (J) \left(\frac{D^{0.75}}{E/k^{0.35}}\right)
\]
Mechanistic Performance Criteria

Defined: Design method that is based on models/inputs to calculate the reaction of a pavement to traffic loads. Similar to buildings and bridges.
Bottom-up Design and Construction

- Foundation
  - Stable Paving Platform
  - Minimize Seasonal Variability
- Fatigue Resistant Lower Asphalt Layer
- Rut Resistant Upper Asphalt Layers
Subgrade

- Existing materials quality based on strength, gradation & drainage capacity
  - **Good soils** will retain most of their load-bearing capacity when wet
  - **Poor soil** (e.g., swelling soils);
  - Remove to reach better soils below
  - Replace with better material
  - Stabilize to increase stiffness
- Compaction of subgrade materials is key
Base Course

- **Structure**
  - Part of Pavement Thickness Design
  - Typical Aggregate Base
  - Minimum Thickness 4”
Typical Cross Section

Pavements requiring only periodic surface renewal

- SMA, OGFC or Superpave
- Zone Of High Compression
- High Modulus Rut Resistant Material
- Max Tensile Strain
- Flexible Fatigue Resistant Material

Pavement Foundation
Rut Resistant Upper Layers

- Aggregate Interlock
  - Crushed Particles
  - Stone-on-Stone Contact

- Binder
  - High Temperature PG
  - Polymers
  - Fibers

- Air Voids
  - Avg. 4% to 6% In-Place

- Surface
  - Renewable
  - Tailored for Specific Use

Core from 10mm SMA
Example Top Down Cracking
Shear Stress Within an Asphalt Pavement

$E_{\text{HMA}} = 500 \text{ ksi}$

$E_{\text{SG}} = 10 \text{ ksi}$

$>35 \text{ psi}$

$>25 \text{ psi}$
Example = 1 Million ESALs
References

Software

TRB Circular No. 503
On-line at www4.nas.edu
This award honors asphalt pavements that were designed and built with outstanding care and exceptional quality. The result is a long-lasting pavement, one that serves the traveling public well, provides true value to the taxpayers, and demonstrates both the convenience and the quality of asphalt pavements.
Criteria:

• 35+ years old

• 13+ years between overlays (average)

• No increase > 4"
Missouri

2007

U.S. Route 54
Camden County

U.S. 54 traverses central Missouri and serves as the primary corridor for the regional tourism destination of Lake of the Ozarks.

The approximately 12.5-mile section was built in 1970 with an 8-inch base topped by 3 inches of HMA. In 1983, it received a 1.25-inch HMA overlay. The state has also performed some minimal maintenance during these 30 years.

Temperatures in the area range from below freezing in winter to above 90 degrees in the summer. Snow and ice removal operations often take place in the winter months. Traffic on the road has continued to grow, starting with an average daily traffic count of 2,583 vehicles in 1970 and increasing to 7,390 vehicles by 2007.

Missouri Department of Transportation
US 63, Texas County

A wet/tresco climate and an accumulated travel load of over 7 million equivalent single axle loads (ESALs) have not destroyed the integrity of this stretch of US 63. Running 20.3 miles, this Perpetual Pavement is located in Texas County and extends from the Phelps County line to Houston.

The pavement was built in 1963. It consists of a 7-inch rolled stone base and a 6-inch bitumen base, followed by a 1.75-inch binder course of Type B asphalt (a mix that contains aggregates of 1-inch minimum size). The surface course consisted of Type C asphalt (a mix that contains aggregates of 0.75-inch minimum size).

The road received a 1.25-inch overlay in 1978, and a seal and chip treatment in 1996. Small sections of the road were resurfaced in 1997 because of turn lane upgrades. It has required no other maintenance.
2017
Perpetual City Streets

West Broadway
Council Bluffs, IA
Layer Coefficient Considerations

Average values of layer coefficients for materials used in the AASHO Road Test were as follows:

- **Asphalt Surface Course**: 0.44
- **Crushed Stone Base Course**: 0.14
- **Sandy Gravel Subbase**: 0.11

Keep in mind that these values were empirically derived from a road test with one climate, one soil type, and one asphalt mix type.

The asphalt layer coefficient used for the Road Test was actually a weighted average of values ranging from 0.33 to 0.83.

More recent studies at the NCAT Test Track found that for Alabama, an asphalt layer coefficient of 0.54 better reflected actual performance.
AMERICA RIDES ON US

TODAY
94% of U.S. roads are surfaced with asphalt.1
Asphalt contractors are in every community.
3,500 asphalt plants operate in the U.S.
More than 400,000 jobs connected to asphalt across the country.2

FUTURE
18 years the average service life for new asphalt pavements.4
∞ the structural life of a properly designed, constructed and maintained Perpetual Pavement.7

TOMORROW
12+ year gain in service life from a thin asphalt overlay at an annualized cost as low as 25¢ per square yard
A 2-inch asphalt overlay can improve IRI by up to 100 in/mi

When it comes to long-term value, Asphalt Performs

Asphalt’s superior performance and value make it today’s pavement of choice across America. With local producers in every community, road owners have a competitive marketplace for the smooth, long-lasting pavements drivers demand. Asphalt is the best choice for value and performance, today, tomorrow and into the future.

APA | Asphalt Pavement Alliance
DriveAsphalt.org
Can’t all be wrong

94% of U.S. roads are surfaced with asphalt.

Asphalt contractors are in every community:

≈ 3,500 asphalt plants operate in the U.S.

More than 400K jobs connected to asphalt across the country.

Smooth is Customer Satisfaction

TOMORROW

12+ year gain in service life from a thin asphalt overlay at an annualized cost as low as 35c/

A 2 inch asphalt overlay can improve IRI by

More than 100 in/mi
Performance demands sustainability.
Asphalt pavements are designed, produced, constructed and maintained to conserve natural resources, reuse materials and deliver the smooth ride drivers demand. This makes asphalt the best choice for sustainability and performance, today, tomorrow and into the future.

When it comes to sustainability

ASPHALT PERFORMANCE

TODAY

79.6M TONS
of reclaimed asphalt pavement is used annually in new roads and parking lots.

$2.2B
is saved every year by using recycled asphalt — making the pavement not just environmentally sustainable but economically sustainable as well.¹

TOMORROW

$1.300
in maintenance costs is saved every year for each lane-mile of smooth asphalt.⁴

4.5%
less fuel is consumed by vehicles driving on smooth asphalt surfaces² ...

... which saves drivers about

13¢
per gallon.⁸

FUTURE

100%💡
of an asphalt pavement is reusable and contains the raw materials for the next generation of roads, runways, trails or parking lots.¹

$3.5B
in energy will be saved by 2020 by using warm-mix asphalt, according to U.S. Department of Transportation estimates.⁵
FHWA Definition Sustainability

“Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”
ASPHALT PERFORMS

79.6M TONS

of reclaimed asphalt pavement is used annually in new roads and parking lots
Performance demands sustainability.

Asphalt pavements are designed, produced, constructed and maintained to conserve natural resources, reuse materials and deliver the smooth ride drivers demand. This makes asphalt the best choice for sustainability and performance, today, tomorrow and into the future.

100% of an asphalt pavement is reusable and contains the raw materials for the next generation of roads, runways, trails or parking lots.¹

$2.2B is saved every year by using recycled asphalt — making the pavement not just environmentally sustainable but economically sustainable as well.¹
Resiliency

- Resilience:
  - the capability of a deformed body to recover its size and shape after being deformed especially caused by a compressive stress
  - an ability to recover from or adjust easily to misfortune or change
Damage Happens
IOWA DOT NEWS RELEASE

SEVERAL IOWA ROADS INCLUDING INTERSTATES 29 AND 680 REMAIN CLOSED DUE TO FLOODING

POSTED ON: MARCH 16, 2019

AMES, Iowa – March 16, 2019 – 10AM – Multiple flood closures remain in place for Interstates 29 and 680 as well as several surrounding roads and others throughout Iowa. Travel in Missouri and Nebraska is also being impacted by flooding.

Interstate closures include:

- I-680 in both directions
  between the Nebraska border and I-29 near Crescent (Mormon Bridge)
  The North portion of I-680 between I-80 and I-29 remains open for northbound traffic.
- I-29 in both directions
  between the I-680 interchange (near Loveland) and North 25th Street in Council Bluffs
- Northbound I-29
  between U.S. 136 in Missouri (near Rock Port, MO) and U.S. 34 in Iowa (near Pacific Junction)
- Southbound I-29
  between the I-80 interchange in Iowa (near Council Bluffs) and U.S. 136 in Missouri (near Rock Port, MO)

The following multi-state detour remains in effect for Interstate 29 travelers:

Northbound I-29 traffic is being detoured at I-35 in Kansas City, where travelers will continue north on I-35 into Iowa. From Des Moines, travelers will drive west on I-80 and continue onto I-680 to connect back with I-29 in Iowa.

Southbound I-29 traffic will be detoured at Loveland onto eastbound I-680 where travelers will continue on to eastbound I-80 to Des Moines. From Des Moines, travelers will head south on I-35 into Missouri where travelers can connect with I-29 in Missouri. (See map below.)

Travelers should be aware that westbound I-680 on the detour route in Iowa is reduced to one lane due to damage...
I 29 Iowa 2019
The Iowa Department of Transportation has announced that I-29 between US 34 and the Missouri border will be opening at 10 am today! Congratulations and thank you to CJ Mouva & Sons, Henningsen Const. Inc. and the Iowa DOT for getting this record job of reconstructing this road in record time.

#IOWASTRONG #ASPHALT

I-29 is now open to limited traffic between U.S. 34 and Missouri. The Iowa 2 Interchange (Exit 10) is open for traveler services and eastbound access. Remember to slow down, follow signs, and don’t drive around barricades.

For current information on adjacent roadways, visit www.511ia.org, www.511.nebraska.gov and http://traveler.modot.org/map

PLEASE NOTE: 12’ maximum vehicle width and length is recommended for this section of I-29.
When it comes to **flexibility** **ASPHALT PERFORMS**

From 2 wheels to 18 wheels, asphalt pavements can be built to meet every project and community need. Its flexible design and specialty mixes scale to meet local traffic volumes and climate conditions while making use of locally available materials. In addition, asphalt is smooth and quick to construct, improving ride quality and fuel efficiency, while decreasing user delay. This flexibility means asphalt pavements offer cost-effective, versatile performance for today, tomorrow, and into the future.

---

**FUTURE**

- **4.5%** the percentage decrease in fuel consumption when driving on smoother pavements.\(^1\)
  - Asphalt's smoothness conserves resources for the future.
- **50** the number of states where you can find the aggregates that make up 95% of asphalt pavement.\(^2\)

---

**TOMORROW**

- **3× FASTER** how quickly asphalt roads can be built and repaired, compared to other pavement materials, saving drivers time in traffic.\(^3\)
- **8 hrs** how long warm-mix asphalt mixtures can be hauled without affecting compaction, supporting disaster zones for emergency and recovery efforts.\(^4\)

---

**TODAY**

- **7B GALLONS** the average amount of fuel Americans save annually by driving on smoother roads — the equivalent of taking more than 10 million vehicles off the road every year.\(^5\)
- **6.7 INCHES PER HOUR** the amount of rainfall that is filtered off the road by using porous asphalt.\(^6\)
Flexibility

Definition of flexible / flexibility
1: capable of being flexed
2: yielding to influence:
3: characterized by a ready capability to adapt to new, different, or changing requirements
Deterioration is caused by many different forces that affect pavement performance. However, pavements deteriorate predominantly due to the vehicle loads and environmental elements they are exposed to over their lifetime.

Why this Matters!

- Easy to say and EXTREMELY difficult to do!
- New FHWA Guidance
- FHWA EDC-4
  - [http://goaspha.lt/2qBfTSt](http://goaspha.lt/2qBfTSt)
- Optimizing our infrastructure
- Agencies requirements for Funding
  - Doing More with less

The Holy Grail!
The Asphalt Impact

Versatility
Speed
Results

With asphalt pavements, maintenance and improvements that help traffic flow freely are made quickly outside of rush hour.

ASPHALT PERFORMS

3x FASTER

how quickly asphalt roads can be built and repaired, compared to other pavement materials. saving drivers time in traffic.
In summary, results from the past studies clearly indicate the adverse effect of increased in-place air voids on the fatigue performance of asphalt pavements. Table 1 summarizes these results. Depending on the mix type and experiment, a 1% decrease in air voids was estimated to improve the fatigue performance of asphalt pavements between 8.2 and 43.8%.

<table>
<thead>
<tr>
<th>Study</th>
<th>Lab/Field Experiment</th>
<th>Mix Type</th>
<th>Air Voids Evaluated</th>
<th>Increase in Fatigue Life for 1% Decrease in Air Voids</th>
</tr>
</thead>
<tbody>
<tr>
<td>UCB (Epps and Monismith 1969)</td>
<td>Lab</td>
<td>British Standard</td>
<td>4 - 14%</td>
<td>20.6%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>California Fine</td>
<td>5 - 8%</td>
<td>43.8%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>California Coarse</td>
<td>2.5 - 7%</td>
<td>33.8%</td>
</tr>
<tr>
<td>UCB (Harvey and Tsai 1996)</td>
<td>Lab</td>
<td>California Dense-Grad</td>
<td>1 - 3%</td>
<td>43.8%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4 - 6%</td>
<td>15.1%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>7 - 9%</td>
<td></td>
</tr>
<tr>
<td>WestTrack (Epps et al. 2002)</td>
<td>Lab</td>
<td>Fine</td>
<td>4, 8, 12%</td>
<td>13.5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fine-Plus</td>
<td>4, 8, 12%</td>
<td>13.3%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coarse</td>
<td>4, 8, 12%</td>
<td>9.0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Field</td>
<td>4, 8, 12%</td>
<td>21.3%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8.2%</td>
</tr>
<tr>
<td>AI (Fisher et al. 2010)</td>
<td>Lab</td>
<td>9.5 mm Dense-Grad</td>
<td>4 - 11.5%</td>
<td>9.2%</td>
</tr>
</tbody>
</table>

1% = Conservatively improves LCCA savings by 10%
Review of Initial Service Life Determination in LCCA Procedures and In Practice – NCAT Report

Summary of Middle 90% of Pavement Ages at Time of 1st Rehab

<table>
<thead>
<tr>
<th>Pavement Type</th>
<th>No.</th>
<th>Avg</th>
<th>Min</th>
<th>Max</th>
<th>Std Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC</td>
<td>206</td>
<td>17.68</td>
<td>7.09</td>
<td>28.93</td>
<td>5.51</td>
</tr>
<tr>
<td>PCC</td>
<td>121</td>
<td>23.84</td>
<td>12.88</td>
<td>35.44</td>
<td>5.79</td>
</tr>
</tbody>
</table>

Ride Quality (IRI) Prior to Rehabilitation

<table>
<thead>
<tr>
<th>Pavement Type</th>
<th>Percent of Total Pavement Sections</th>
<th>Very Good**</th>
<th>Good</th>
<th>Fair</th>
<th>Poor</th>
<th>Very Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>&lt; 60</td>
<td>61 – 95</td>
<td>96 – 120</td>
<td>21 – 170</td>
<td>&gt; 170</td>
</tr>
<tr>
<td>AC Pavements</td>
<td></td>
<td>9.6%</td>
<td>34.3%</td>
<td>24.1%</td>
<td>17.5%</td>
<td>14.5%</td>
</tr>
<tr>
<td>PCC Pavements*</td>
<td></td>
<td>1.1%</td>
<td>23.3%</td>
<td>26.7%</td>
<td>34.4%</td>
<td>14.4%</td>
</tr>
</tbody>
</table>
America rides on us

Asphalt is constantly innovating.

Modern roads take full advantage of scientific and engineering innovations. Through education, research, and applied knowledge, the asphalt industry delivers the best performance and cutting-edge innovation for today, tomorrow and into the future.

Today
Since 1994, the asphalt industry has invested over $30M in product research.


When it comes to innovation

Asphalt performs

Tomorrow
+2,200 students have been awarded industry scholarships, totaling more than $5.1M in scholarships granted since 1994.

Future
Visionary engineers are developing asphalt mixes to meet the needs of future cities.

8M autonomous vehicles expected to be on the road by 2025 to "see" asphalt roadways.
Visionary engineers are developing asphalt mixes to meet the needs of future cities.\(^3\)

8M autonomous vehicles expected to be on the road by 2025 to “see” asphalt roadways.\(^4\)
This tech could allow self-driving cars to see the road during snowstorms
Innovation - Materials

- Ground Tire Rubber
- Polymer Enhancements
- Fibers
- Bio Science
  - Polymers
  - Rejuvenators
  - Extenders
Which Picture Represent WMA Construction Sites?
Innovation in Testing

Example of Balance Mix Design Approaches

Balancing Rutting and Cracking Requirements

Zhou, et. al, Rejuvenator Characterization, Blend Characteristics, and Proposed Mix Design Method; AAPT 2015

Managing Performance of High Recycle Asphalt Mixtures

AMERICA RIDES ON US
Innovation—Techniques

• Joint Construction
Innovation—Equipment

- Intelligent Compaction
- Temperature Monitor
- Autonomous
We create a safe and comfortable driving environment!