Test Result Relationships and

- What do we mean by Test Result Relationships?
- What are they?
- Why is it important to be able to identify trends in test results?
- What type things can effect test results?
Test Result Relationships

Accurate, Repeatable and Comparable
Test Result Relationships

Consistency
Test Result Relationships

- Aggregates
- Binder
- VMA
- Rice Values – Max. Density or Max. Specific Gravity
- Compaction - Temperatures
- Air Voids
Test Result Relationships

Key Factors

- Specific Gravity of aggregates individual/combined
- Short Term Aging
- Gradation of mix (samples)
HMA Test Result Relationships

Binder Content and Rice Value
(Theoretical Maximum Specific Gravity)
Example

Design = 5.1% A.C. and 2.507 Max. Sp. Gr.

Percent Asphalt Cement

<table>
<thead>
<tr>
<th>Test #</th>
<th>%A.C.</th>
<th>Max Sp.Gr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5.30</td>
<td>2.480</td>
</tr>
<tr>
<td>2</td>
<td>5.11</td>
<td>2.488</td>
</tr>
<tr>
<td>3</td>
<td>5.25</td>
<td>2.477</td>
</tr>
<tr>
<td>Average</td>
<td>5.22</td>
<td>2.481</td>
</tr>
</tbody>
</table>

\[
G = \frac{100 - 5.22}{2.481 - 1.03} = 2.690 \\
G_{se} = 2.690 @ 5.1 A.C. \\
G_{max} = 100 \left( \frac{94.9}{2.690} + \frac{5.1}{1.03} \right) \\
G_{max} = 2.486 @ 5.1 A.C. \\
\]

CDOT Design  ● Field Results  ● Maximum Spec.


Field Sheet #
Summary of Test Relationships:

- As the asphalt content increases, the rice value will decrease.
- As the asphalt content decreases, the rice value will increase.
Does the GRADATION of a sample affect the results for Asphalt Binder Content or Rice?

- Effects AC content.
- Effects Rice value results.
How does Gradation Affect Test

- Coarse sample will result in a lower AC content.
- Fine sample will result in a higher AC content.
- Remember the trend of AC ver Rice.
- Due to splitting?
- A too coarse or too fine gradation will also affect the rice results. If the gradation is unrepresentative, then the rice result on that sample is not going to be correct to be used on the roadway!
HMA Test Result

Relationships

High Asphalt Binder Content
Low Asphalt Binder Content
Low Binder Contents

- Dryness / raveling
- Impermeability
- Oxidation
- Fatigue Cracking
- Lack of compaction
- Flexibility
- Durability
High Binder Contents

- Durability
- Stability
- Rutting
- Flushing
- Bleeding
High and Low Asphalt Content

Test result relationships:

* Low asphalt content = high air voids
* Low asphalt content = higher maximum specific gravity (rice)
* High asphalt content = low air voids
* High asphalt content = lower maximum specific gravity (rice)
Summary

Low %AC
• Higher % Air Voids
• Higher Rice value

High %AC
• Lower % Air Voids
• Lower Rice value
HMA Test Result Relationships

Rice (Theoretical Maximum Specific Gravity) / Maximum Density and Roadway Density
Maximum Specific Gravity

Key measurement
Percent Compaction or Density

94% +/- 2%
Rice Value & Density

Air Voids
Rice Value & Density

- Percent compaction is actually telling us the percent of air voids in the mat.
- In order to have a durable long lasting pavement, there needs to be between 8 & 4% air voids (92% - 96% compaction).
- Hence, the need for accurate rice values to monitor the compactive effort.
Accurate rice value for mix that is being placed.

Ex: Field Sp G of 2.380(gauge) / 2.507 (Mix Design) = 94.9%
     Field Sp G of 2.380(gauge) / 2.482 (New Target Rice) = 95.9%

Wet Density: (convert Sp G to wet density - 62.4 x Sp G)
     148.5 / 156.4 (Mix Design) = 94.9%
     148.5 / 154.9 (adjusted New Target) = 95.9%
Rice Value & Density

Rice or maximum density **not representative of the mix being placed:**

- Causes either an over or under-compacted mat.
- Calculated percent compaction becomes just a number that is not accurate or a true reflection of the density of the mat.

What happens to the pavement quality.

- **Over compaction** can lead to rutting, flushing or bleeding, resulting in a shortened pavement life and even dangerous driving conditions.
- **Under compaction** can lead to pavement susceptibility to moisture and air damage, shortening the life & durability of
Rice Value & Density

Summary of Test Relationships:

- Using a rice value that is too high will result in a calculated density that is actually lower than what the density of the roadway really is. This could result in over compaction of the mat.

- Using a rice that is too low will result in a calculated density that is actually higher than what the density of the roadway really is. This could result in under compaction of the mat.
Correction Factors to correlate gauge to the mat result in more accurate density test results
Gauge Settings and Density

* Check the settings in your gauge MA for asphalt.
* Correct maximum density input into the gauge.
* Using the correct Correction Factors?
* Correction Factors correlate gauges to mat for accurate compaction.
Volumetric Calculations

- VMA & Air voids, most important mix properties being measured in process control testing (all based on physical tests)
- Complying with volumetric criteria ...is the best assurance the mixture will be long lasting & a well performing HMA pavement.

Asphalt Institute IS-210

- Also, along with quality comes incentive pay.
Change in Rice value may indicate a change in the Bulk Specific Gravity of the Aggregate.

When the Rice value changes, the VMA changes, but still has to meet the minimum specified requirements.

VMA – what is it and how does it affect the durability of the pavement?

VFA – what is it?
HMA Test Result Relationships

Air Voids and Gradation
Air Voids and Gradations

Air voids:

- The durability of an asphalt pavement is a function of the air void content.
- Air voids = compaction = durability
- Aggregate gradation is what makes the strong stone skeleton to enhance resistance to permanent deformation and allows for sufficient void space to enhance mixture durability.
Voids and Gradation

• High % of 200 (esp. natural sands) = low % air voids in the compacted specimen.
• Addition of Crusher Fines (minus 3/8” angular shape) can increase VMA.
• Aggregate texture & shape also play into void content.
• Sampling, splitting & testing procedures.
Gradation and VMA

- VMA is affected by gradation
- Greater VMA values for smaller Nominal Max Aggregate size (greater inter-granular void space)

Leads to more about aggregate absorption and the importance of the aging process
Aggregate Absorption

- Effective Binder
- Proper aging
- Rice values
- Bulk Specific gravities of compacted mix
- Air voids
Absorption of Binder

Affected by:

- Viscosity of binder
- Aggregate type / pore size
- Time
- Temperatures
HMA Test Result

Relationships

What affects a Rice Value?
What Effects a Rice Value...

Sampling, splitting, temperatures, cure times for aggregate absorption, and testing equipment.
Cure Times of the Mix

Standard practice for cure times or aging periods, is two-hours @ at compaction temperature, minus anytime sample has already had to age or cure.
Volumetric Testing / Lab

Should be at correct compaction temp before compacting for at least 15 minutes.

Samples should never be kept at compaction temperature longer than 4 hours.
Aged mix versus mix that has not been short term aged.

Volumetric measurement:
Aged – Expected percent of asphalt binder has absorbed into the aggregate.
Not aged – At time of testing, asphalt binder still coating outside of aggregate, but will be lost due to absorption.
The Importance of Monitoring Temperature during Compaction
Even a good mix, if not compacted properly will not result in a long lasting durable asphalt pavement.
Temperature & Compaction

As binder cools it becomes stiffer and bonds the aggregates to provide a durable structure.
The temperature of a mixture is perhaps the most important property in obtaining density, since the viscosity of an asphalt binder is controlled by its temperature.

Obtaining density is perhaps the most important process for a durable long lasting asphalt pavement.
In Conclusion

- Even a good mix that meets all the mix design criteria in the lab, then has to be properly compacted to have an end result of a durable long life pavement.
Information

Information used has been compiled from the following Asphalt Institute sources:

- Superpave Mix Design Series No. 2 (SP-2)
- Mix Design Methods (MS-2) Sixth Edition
- Procedures to Improve the Precision of HMA Volumetric Calculations IS-210