Test Result Relationships
Importance of identifying trends.

- Help identify erroneous test results.
- Quality of pavement
- Encourage paying attention to test results.
What is the end result we are looking for when involved in producing and placing an asphalt pavement?

How do we as technicians effect the end result product?
Lab testing:
- Rice
- AC Contents
- Gradations
- Bulk Specific Gravities of cores

Field testing:
- Rice value
- Gauge Settings
- Temperatures
Mix design

Production:
Rice changes
Gradation
AC

These changes can only be made after representative samples are acquired and properly tested.

Accurate, comparable and repeatable test results, performed in an efficient manner and then communicated to the proper people.
Where it Starts

It all begins with **proper field sampling techniques and field sample sizes that are adequate.**

Next, the field sample must be **split down to test size and still remain representative of the material being produced.**
What Effects in the Lab?

- **Rice value**: Splitting, %AC & gradation, water temp, vibration, rodding.
- **%AC**: Splitting, gradation, % moisture, area around & in AC gauge, Correction Factors for Ignition Ovens.
- **Gradations**: Sampling, splitting, care in running the test.
- **All effected by condition of testing equipment**
Percent Compaction: Rice value used, gauge settings, correction factors.

Compaction: Temperature, roller pattern.

Quality: Compaction
Lab test results effect the roadway density, which effects the quality of the pavement. Lab test results are effected by the field sampling.
Responsibility as materials technicians is the quality of the material that is produced and that it is placed properly.

Even a good mix that meets all the mix design criteria, can still be poorly placed and have a disastrous end result.
HMA Test Result Relationships

Theoretical Maximum Specific Gravity or Unit Weight versus Roadway 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.
Theoretical Maximum Specific Gravity (rice) is the key measurement during both laboratory mix design and quality control procedures.

- Density can be calculated using Theoretical Maximum Specific Gravity commonly called the Rice. Ex: 2.500
- Density can be calculated using Maximum Density (Unit Weight)/Wet Density which is the weight of a mix in pounds per cubic foot. Ex. 156.0 pcf
- Converting back and forth is done by: Ex: 2.500 X 62.4 = 156 pcf or 
  156 / 62.4 = 2.5000
- 62.4 being the unit weight of water
- Either method can be used to calculate a density.
- Using Maximum Density / Wet Density of the mix is now the more common method when using M/D nuclear gauges out in the field performing mat densities.
Pavement is to be compacted to 94% +/- 2% density to achieve a durable pavement. That is 94% +/- 2% of the Theoretical Maximum Specific Gravity (rice) or maximum density (pcf) of the mixture.
We are looking for 8% air voids (92% compaction) to 4% air voids (96% compaction) and preferably 6% air voids (94% compaction) in the completed mat.

A certain percent of air voids are necessary in the finished HMA.
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 the asphalt pavement.
Check the settings in your gauge MA for asphalt.
Correct maximum density in-put into the gauge.
Using the correct Correction Factors?
Correction Factors correlate gauges to mat for accurate compaction.
HMA Test Result Relationships
Rice ver. Asphalt Content
Rice ver. Asphalt Content

Summary of Test Relationships:

- As the asphalt content increases, the rice value will decrease.
- As the asphalt content decreases, the rice value will increase.
The aggregate must be coated with the percent binder as per determined in the mix design.

- Too much binder, unstable mat resulting in rutting
- Too little binder, uncoated aggregate – open to moisture susceptible & stripping or a dry mix that does not compact well and is unstable.

**Amount of binder effects the rice value:**

- Inconsistent compaction.
- Effects quality of pavement.
Example

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

<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>
</tbody>
</table>

Average = 5.22

\[ G = \frac{100}{5.22} \]

\[ G = 19.1 \]

\[ G_{max} = \frac{100}{94.9} \]

\[ G_{max} = 1.06 \]

\[ G = 2.486 \text{ @ 5.1 A.C.} \]

Maximum Specific Gravity

→ CDOT Design  ⋆ Field Results  ⋆ Minimum Spec.


Field Sheet #
The Rice value changed with the plant produced material.

Adjust the rice for field produced material, so that the rice value being used is correct for accurate % compaction.

Ex: Field Sp G of 2.380 / 2.507 (Form 43) = 94.9%

Field Sp G of 2.380 / 2.482 (New Target Rice) = 95.9%

Difference of 1%

% Compaction
Change in the Bulk Specific Gravity of the Aggregate.

New Rice = New VMA, that still has to meet the minimum requirements.

VMA – what is it

New Mix design
Does the GRADATION of a sample affect the results for AC or Rice?

- Effects AC content.
- Effects Rice results.
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 sampling or 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!
Use a representative rice value to ensure that proper compaction takes place on the roadway and that no densities are failing or passing as the result of using rice values that are not representative of the mix being placed.

It is a good practice to always have a copy of the mix design handy and check what the rice value should be for that mix @ that % AC whether you are a lab tech or the field tech.

Also, have a copy of the daily average rice values along with the AC contents of each rice, if on a CDOT project. Try to pay attention to the relationships.
HMA Test Result Relationships

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

- Temperatures, aggregate absorption, cure times, sampling, splitting, testing equipment.
- Rice values change as the asphalt absorbed into the aggregate varies with a given mixture
- Cure times
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.
- A sample of mix taken at the plant, and immediately taken to the lab for testing, needs to be aged before the rice testing begins. (CDOT – 2hrs @ temp above 200’ F)
Field samples have aged by the time they reach the lab.

As per CDOT, if a sample cannot be tested & compacted in the agreed upon conditioning time, it should be allowed to cool and reheated.

Samples should never be kept at compaction temperature longer than 4 hours.
Each sample should be vibrated and rodded the same throughout production.

One other important item that needs to be mentioned, is the water for the test sample needs to be the same temperature used when calibrating the flask or adjusted.
HMA Test Result Relationships

Air Voids versus Gradation
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.
HMA Test Result Relationships

High Asphalt Content ver. 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)
How the quality of HMA is affected by low asphalt contents because of a higher percentage of air voids:

- Susceptible to dryness or raveling
- **Impermeability** is decreased - causing susceptible to moisture damage and stripping
- Thin film coating on the aggregate which can increase the speed at which oxidation takes place, causing early aging and loss of roadway life.
- Low asphalt content can lead to **fatigue cracking**. Fatigue cracking is a result of the pavements lack of resistance to repeated bending under wheel loads (traffic).
- Whether by design or **lack of compaction**, fatigue resistance is also drastically reduced by high percentage of air voids which can be caused from low asphalt content.
- **Flexibility** of an asphalt pavement is affected by low asphalt content (fatigue cracking)
- Maximizing the asphalt film thickness increases **durability**, so low asphalt content will decrease the durability.
How the quality of HMA is affected by high asphalt contents because of a lower percentage of air voids:

- Pavement can become unstable at a high asphalt content resulting in rutting, wash boarding, flushing or bleeding.
- Bleeding can cause low skid resistance.
- The higher the asphalt content, the lower the air voids.
- Increases the VFA (voids filled with asphalt) and takes the space for air voids.
- VMA (voids in the mineral aggregate) will generally decrease slightly to a minimum value then increase with increasing asphalt contents becoming unstable.
- Unit weight (density) of the total mix generally rises with increased asphalt content and then falls and becomes unstable, low air voids.
HMA Test Result Relationships

The Importance of Temperatures and Compaction
Even a good mix, if not compacted properly will not result in a long lasting durable asphalt pavement.

The lab testing will show what the mix is capable of in it’s performance, but the actual compaction process will determine the life and durability of the roadway.

Proper temperatures during the compaction.

Asphalt binder is a thermoplastic, temperature susceptible material.
As binder cools it becomes stiffer and bonds the aggregates to provide a durable structure.

Compaction needs to be complete before the mixture temperature falls below the recommended range for the type of PG binder being used.

Continuing to compact can damage the pavement.
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.
What all is involved in obtaining density?

- Field sampling - representative
- Splitting to test size - representative
- Lab tests for AC, gradation, rice value – accurate, representative – Quality Control
- Gauge settings – max. density, corr. factors - accurate
- Compaction – temperatures, rice values
- Quality pavement