CONCRETE MIX DESIGN ADJUSTMENT PROCEDURES

Because of some of the data and questions received in this Office, it is apparent that there is some confusion about the procedures for making adjustments to ODOT PCC Concrete mixes. Recent changes in the specifications have most likely and unknowingly increased the number of improper adjustments. Procedures that were correct in the past now need to be changed; and procedures that were incorrect in the past are still incorrect. Some of the confusion may be due to lack of communication from this office, but hopefully this message will be helpful in clearing up any problems that may exist.

FACTORS THAT MAY BE CAUSING CONFUSION

I. **Dry weights -vs- SSD weights.** The use of Dry weights have been the standard with ODOT for many years. SSD weights started being used in the High Performance Concrete mixes, and more recently all of the mixes in the 2002 spec book. This affects how adjustments are made in two ways:

1. Which Specific Gravity to use when making the adjustment.
   a. **Bulk Dry Specific Gravity**
   b. **Bulk SSD Specific Gravity**

2. How the moisture adjustments are made.
   a. When using **DRY** weights
   b. When using **SSD** weights
   c. Adjustments to the **mix water**
   d. Automated plant adjustments
   e. Reporting on a TE-45

II. **JMFs** - There are PCC Job Mix Formulas for each class and each aggregate combination of concrete. An updated list of the JMFs can be found on the website under OMM’s information list.

1. How to determine the JMF Number
2. What weights are represented on the JMF
3. What specific Gravities are on the JMF.
CLARIFICATION OF THE PROCEDURES

In order to remedy confusion when making adjustments, please take the following into consideration:

I. Mix Designs:

1. There are two different specific gravities reported by the Aggregate section, DRY and SSD. The specific gravity should match the design weights as follows:

   a. Bulk Dry Specific Gravity should be used when making adjustments to mix designs using DRY weights. This consists of concrete mix design weights from the 1997 Construction and Materials Specifications book, as well as the Supplemental Specification 847 and 848.

   b. Bulk SSD Specific Gravity should be used when making adjustments to mix designs using SSD weights. This consists of mix design weights from the 2002 Construction and Materials Specifications book and Supplemental Specification 844.

2. Even though the actual design weight and design specific gravity values have not changed from the 1997 specifications, they need to be handled differently as follows:

   a. Use the appropriate specific gravity when adjusting the mix. This will change the theoretical adjusted design weight, but the batch weights should be the same after making the moisture adjustment.

      i. The Specific Gravity List 2002 for specific gravities and absorptions is on the ODOT website, on the Office of Materials Management page, under Information list. This list contains both the Bulk Dry and Bulk SSD specific gravities. Make sure that you chose the correct one.

   b. The moisture adjustments to the aggregate batch weights are done differently when using SSD weights than when using DRY weights. The differences are:

      i. **Dry weights** - multiply the adjusted (for sp.gr.) DRY design weights by the total moisture correction factor to determine the batch weight.

      ii. **SSD weights** - The adjusted (for sp.gr.) SSD design weight needs to be taken back to the theoretical adjusted dry condition by dividing by the absorption correction factor; then multiplied by the total moisture correction factor in order to determine the batch weight.
iii Correction Factor - this is a way of making adjustments for moisture or absorption. In order to determine the correction factor, divide the value(%) by 100 then add 1.

\[ 1 + \left( \frac{x\%}{100} \right) \]

**Example:** The coarse aggregate in a class C - limestone mix has a design weight of 1630 lbs/yd³ which is based on a specific gravity of 2.65. Moisture tests show that the stone has a moisture content of 2.5%. The aggregate source has the following information:

- DRY Specific Gravity: 2.594
- SSD Specific Gravity: 2.640
- Absorption: 1.77%

Determine the **batch weight**:

**USING 1997 PROCEDURES**

- **CORRECT** -
  \[ 1630 \times \frac{2.594}{2.65} = 1596 \text{ (adj. DRY wt.)} \]
  \[ 1596 \times 1.025 = 1636 \text{ (batch wt)} \]

**USING 2002 PROCEDURES**

- **CORRECT** -
  \[ 1630 \times \frac{2.640}{2.65} = 1624 \text{ (adj. SSD wt.)} \]
  \[ 1624 \times \frac{1.025}{1.0177} = 1636 \text{ (batch wt)} \]

Working this correctly either way will result in the same answer. But, if the wrong specific gravity is used or the wrong or the moisture calculations are not done correctly, the following can be the result:

**1997 PROCEDURE USING SSD SP. GR.**

- **INCORRECT** -
  \[ 1630 \times \frac{2.64}{2.65} = 1624 \]
  \[ 1624 \times 1.025 = 1664 \text{ (batch weight)} \]

**2002 PROCEDURE USING DRY WEIGHT MOISTURE ADJUSTMENT PROCEDURE**

- **INCORRECT** -
  \[ 1630 \times \frac{2.64}{2.65} = 1624 \]
  \[ 1624 \times 1.025 = 1664 \text{ (batch weight)} \]

This illustrates that using the correct adjustment procedure with the correct material values will result in the same batch design regardless of whether DRY or SSD designs are used. It also illustrates that using the wrong specific gravity or method of determining the moisture adjustment can result in a significant error for the batch weights.

c. Next, an adjustment to the **water added to the mixer** needs to be made. This is done in two different ways depending on whether the DRY or SSD methods were used.

i. **Dry method:** Determine the total moisture in the aggregate; determine the amount of water that is absorbed; subtract the absorbed moisture from the total moisture to find the adjustment needed to mix water.

  \[ \begin{align*}
  \text{Total Moisture} & = 1630 \times 0.025 = 41 \text{ lbs of water} \\
  \text{- Absorbed Moisture} & = 1630 \times 0.0177 = -29 \text{ lbs of water} \\
  \text{Free Moisture} & = 12 \text{ lbs of water}
  \end{align*} \]
ii. **SSD method**: Subtract the Design weight from the Batch weight of the aggregate.

<table>
<thead>
<tr>
<th>Batch weight</th>
<th>1636 lbs of water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design weight</td>
<td>1624 lbs of water</td>
</tr>
<tr>
<td>Free Moisture</td>
<td>12 lbs of water</td>
</tr>
</tbody>
</table>

iii. For both methods, the Free Moisture value was a positive value. This means that there is free moisture on the surface of the aggregate and that water is being added to the mix from the aggregate. Water, therefore, needs to be taken out of the Mix Water in order to maintain the desired water/cement ratio. If on the other hand the value were negative, the aggregates would be dry and would be absorbing some of the mix water. In that case, water would have to be added to the Mix Water in order to maintain the desired water/cement ratio.

d. The weights used by the producer will depend on how automated the plant is. Typically, fully automated plants use SSD weights. If the producer has moisture probes and is allowed to use them, then the weights used (programmed into the computer) by the producer should be the adjusted design weight. Heed the following precautions if the producer has an automated plant:

i. Do not make the moisture adjustments of the sand if the moisture probes are turned on.

ii. If the computer automatically makes adjustments for moisture content manually entered into the computer, again, just provide adjusted SSD design weights.

iii. If your district allows the use of moisture probes, make sure that they are calibrated regularly to assure accuracy. If they haven’t been calibrated or you don’t allow their use, make sure they are turned off when the concrete is being batched. Otherwise there will be double adjustments being made.

iv. If the computer makes batch adjustments based on a aggregate moisture manually entered into the program, make sure that the actual moisture contents are determined regularly and are accurate for that particular days mixing.

v. If the plant computer has “ODOT mix designs” stored, make sure the correct weights and absorptions are in the system. The correct weights are not necessarily the weights that are in the spec book. Those weights need to be manually adjusted for specific gravities prior to entering in the system.
e. A new TE-45 form is available on the Intranet on the OMM page, under TE FORMS. There is a TE-45 and a TE-45 REV form. The TE-45 REV is the new form and is designed for using the SSD weights. Step by step instructions are also provided in another attachment. The next Manual of Procedures for Concrete will have those instructions. The TE-45 form is still the old one.

II. JMF consistency.

1. The JMF number can be determined by going to the OMM page on the website under Information List, and Concrete JMFs
   a. Make sure that you have the right sources for the aggregates
   b. Search by:
      – Material Code - for the class of concrete
      – Sand source
      – Coarse aggregate source
   c. Can then look JMF up on CMS if needed.
   d. If a JMF number is not available for the combination of aggregates that you have, contact Klaire Mason @ (614) 275-1326 or by e-mail.

2. Weights on the JMFs are the design weights specified in the Spec Book, Supplemental Spec, Proposal Note or Plan Note. Adjustments are not made for variances from the design specific gravities of the aggregates.
   a. Exceptions to the to this are mix designs such as MS or FS designs that are developed by the Ready Mix Concrete Producer.
   b. In the future, QC/QA mix designs will be developed by the ready mix producer and will be plant specific and will therefore be unique designs that are not in any ODOT tables.

3. What is not consistent is how the specific gravities and absorptions are reported on the PC CONCRETE JMF screen in CMS. The values are reported in the following manner:
   a. All class C, F, S, MSC and SDC report the design specific gravity values from which the weights are based. For instance, 2.62 for all natural sands and gravels and 2.65 for limestone. The absorptions have a value of 0.01 simply because the CMS fields require a number.
   b. All Option and HPC mixes have specific gravity and absorption values that are source specific. The weights however remain the design weights from the tables in the specifications. The specific gravity values are SSD specific gravities so if those values are used for adjustments, they will only be accurate using the SSD and 2002 procedures shown above. They will
not work properly when using DRY weights and procedures

- We may be taking the source specific gravities and absorptions out of the JMFs in the future. In the mean time, If you notice that the specific gravities do not match the design specific gravities, verify the value and that you are using the right specific gravity (bulk dry or bulk SSD).

c. The weights have not been adjusted for the indicated specific gravity.

d. If there is a question as to whether the specific gravity is the design or the actual specific gravity, look at the absorption value. If it has a number other than 0.01, it is the actual number for that source.

e. Double check any specific gravity or absorption values in the JMF. Those were the value at the time that the JMF was created. Those numbers may have changed. The updated values for specific gravities and absorption can be found on the OMM web page under Information List - Specific Gravities List for 2002.

f. The JMFs that are on the web site are "state general" mixes. In other words, the combination of aggregates are not specific to any one producer and therefore competing companies can have identical JMF numbers.

g. There are, however, JMFs that are not "state general" that are plant specific that can only be found on CMS. Those are basically mix designs that the plant developed, and are therefore proprietary mixes.

Misc. The “state general” JMFs do not list the cement, flyash, GGBF slag source on the JMF. Properly fill in that information when a sample ID is made.