INTRODUCTION TO WEIGHT MEASUREMENTS

Numerous road and bridge construction pay items are measured by weight -- usually tons or pounds.

METHODS

Several different techniques can be employed for weight measurement. Let's look at some of these methods.

CERTIFIED SCALES

This is the most obvious method of determining weights for final quantities. Simply weigh the material on a scale. But there are a few things we have to remember about correct procedures.

First of all, we don't use just any old scale. Scales must meet the requirements for accuracy and condition established by the Division of Weights and Measures of the Florida Department of Agriculture. These scales must be recertified every six months either by the Division of Weights and Measures or by a registered scale technician.

In addition, periodic checks may be directed by the engineer. The contractor is requested to load a truck, weigh it on his scales, and then weigh it on another set of certified truck scales. When the difference exceeds the allowance of the Division of Weights and Measures, the scales must be adjusted and recertified.

Tabulation Forms are used to record the weight of each load weighed on a certified scale. But they are not required in the case of an asphalt plant equipped with an automatic printer system which records the weights of aggregates and liquid asphalt delivered to the pug mill, as well as the total weight of the batches contained in each truckload.

Automatic printer system batch scales must be certified for accuracy every six months. They must be checked for accuracy at the beginning of production for the Department and at least once a week during production. The allowable difference between the printed total weight and that obtained from commercial certified scales is four pounds per thousand pounds of load. If the difference is greater, a recheck is made on a second set of certified scales. If it is confirmed that the batch scales are out of tolerance, the contractor must have the scales adjusted and recertified.

Certain shipments by rail, such as bulk cement, may be weighed on state-certified scales and documented with certified weight tickets.
STANDARD WEIGHT TABLES

Reinforcing steel and structural steel items usually are paid for on the basis of computed weights. The weights of rolled shapes, bars, plates and pipe railings are computed on the basis of nominal weights as given in the manufacturer's handbook and the dimensions shown on the plans. For reinforcing steel, the unit weights to be used are the Concrete Reinforcing Steel Institute (CRSI) Standard Reinforcing Steel Bar Weights.

The weights of bolts, including nuts and washers, are to be computed in accordance with the following table (based on average lengths) found in the Standard Specifications:

<table>
<thead>
<tr>
<th>Diameter of Bolt:</th>
<th>3/4&quot;</th>
<th>7/8&quot;</th>
<th>1&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight per 100 bolts:</td>
<td>50 lbs.</td>
<td>100 lbs.</td>
<td>150 lbs.</td>
</tr>
</tbody>
</table>

For example, the weight of 300 3/4-inch bolts (with nuts and washers) would be:

\[
\left(\frac{300 \text{ bolts} \times 50 \text{ pounds}}{100 \text{ bolts}}\right) = 150 \text{ pounds}
\]

VOLUME CONVERSIONS

The weight of some structural shapes may be determined by calculating the volume and then converting to a weight using standard weights per cubic foot.

Typical assumed weights per cubic foot are:

- Structural Steel: 490 lbs.
- Steel Castings and Forgings: 490 lbs.
- Gray-Iron Castings: 450 lbs.
<table>
<thead>
<tr>
<th>Material</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malleable Iron</td>
<td>480 lbs.</td>
</tr>
<tr>
<td>Phosphor Bronze</td>
<td>562 lbs.</td>
</tr>
<tr>
<td>Wrought Iron</td>
<td>485 lbs.</td>
</tr>
<tr>
<td>Lead</td>
<td>706 lbs.</td>
</tr>
</tbody>
</table>

### Weight Measurements

Indicate which of the following statements about scales are true.

A. Must meet accuracy and condition requirements established by the Division of Weights and Measures.

B. Must be recertified every eight to ten months.

C. Certified on Florida and Georgia scales only.

D. Must indicate the volume of each loaded truck.

E. None of the above.

### Weight Measurements

Indicate which of the following statements about automatic system scales are true.
A. Must have a degree of error no greater than 40 pounds per thousand pounds.

B. Must be checked for accuracy at the beginning of production for the Department and at least once a week during production.

C. Must be checked for accuracy at least once a month during production for the Department.

D. Automatic printer system batch scales must be certified for accuracy every six months.

E. Both B and D.

6 Weight Measurements

CRSI stands for Concrete Reinforcing Steel Institute. True or False?

A. True

B. False

6 Weight Measurements

According to the Standard Weight Table, what is the TOTAL weight of the following quantities of bolts? 450 pieces of 3/4 " bolts, 290 pieces of 7/8 " bolts and 638 pieces of 1” bolts.
A. 1,472 Lbs
B. 1,545 Lbs.
C. 1,704 Lbs.
D. 1,789 Lbs
E. None of the above.

<table>
<thead>
<tr>
<th>Diameter of Bolt</th>
<th>3/4”</th>
<th>7/8”</th>
<th>1”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight per 100 bolts</td>
<td>50 Lbs</td>
<td>100 Lbs</td>
<td>150 Lbs</td>
</tr>
</tbody>
</table>

6 Weight Measurements

Determine the weight of the structural steel shape shown below. Structural Steel = 490 Lbs. per cubic foot. Convert inches to feet and calculate answers to the nearest pound.

A. 375 Lbs.
B. 413 Lbs.
C. 357 Lbs.
D. 434 Lbs.

E. None of the above.

WEIGHT MEASUREMENT EXAMPLES

Let's go through some step-by-step procedures for pay quantity weight measurement for several typical pay items.

ASPHALTIC CONCRETE

Asphaltic concrete pavement usually is measured and paid for by the ton. There is need for careful documentation of the tons of mix delivered and actually used in the work.

When the asphaltic concrete is weighed on conventional truck scales, the original documentation is by delivery tickets.
Asphalt plants have fully automatic setups in which batch scales are equipped with an automatic recording system. Delivery tickets from such an approved system are acceptable as documentation. Let's go through the procedures for this situation.

1. Be sure that the batch scales and automatic printer have been certified within the past six months.
2. Before accepting the first load, check the accuracy of the scales and printer by weighing the load on a set of certified commercial truck scales. (Periodic checks should be made at least once a week thereafter.)
3. Delivery tickets provided by the plant will have preprinted numbers. See example Figure-1
4. Original delivery tickets are retained by the plant verification technician. Copies are distributed to (1) Plant QC Technician (2) the road quality control technician and (3) the road verification technician.
5. As tickets are collected, they should be bound in daily bundles. For each bound set of tickets, an invoice cover sheet is provided. This is called the Computer Summary of Quantities for Asphalt Concrete (the form is available on the Construction website under Site Source record forms). This invoice shows the following: (1) Financial Project ID number, (2) date, (3) design Mix #, (4) type of material, (5) Total no. of invoices or tickets in this bundle (6) total No. of Tons for this bundle, (7) Sample numbers with pay items numbers, Lot , Tons and waste; (8) Plant Inspector, and (9) Remarks. See example Figure -2. Separate books should be bound for materials of different Design Mix type.

FIGURE – 1

AUTOMATIC PRINTER TICKET
**Eagle Asphalt Company**  
**Somewhere FL**  
**1-800-555-5555**

<table>
<thead>
<tr>
<th>ACCOUNT</th>
<th>MIX</th>
<th>TRUCK</th>
<th>TONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>S-1</td>
<td>573</td>
<td>22.46</td>
</tr>
</tbody>
</table>

**Tons**

- **GROSS:** 35.75
- **TARE:** 13.29
- **NET:** 22.46

**MIX TEMPERATURE:** 325°

**LOAD NO.:** 10

**ACC. TOTAL:** 196.11 TONS

**DATE/TIME:** 07/01/06 12:00 PM

Received by

---

**FIGURE – 2**

**COMPUTER SUMMARY OF QUANTITIES FOR ASPHALT CONCRETE INVOICE**
6  **Weight Measurements**

As an asphalt plant technician, you should verify that:
A. The scales are being checked once a month.
B. A supplementary numbering system has been established.
C. The scales and printer have been certified within the last six months.
D. All the above.
E. None of the above.

6 Weight Measurements

When should you check the accuracy of the scales and printer on a set of commercial truck scales?

A. Before accepting the first load and at least once a week after.
B. Every month.
C. Each morning and afternoon.
D. Every three months.
E. None of the above.

6 Weight Measurements
The cover for each bound set of delivery tickets for Asphalt Concrete should show: (Only one correct answer)

A. Tare weight of each truck, total quantity of material, type of material and number of tickets in bundle.

B. Book number, Type of Material, Financial Project ID Number and Driver’s Name.

C. Driver’s Name, Tare Weight of each Truck, Type of Material and Distance from Plant to Project.

D. An invoice cover sheet that has the following: Financial Project ID Number, Design Mix #, type of material, Total no. of invoices or tickets in this bundle, total no. of Tons for this bundle, Sample numbers with pay item numbers including Lots, tons and waste, Plant Inspector, and Remarks

E. None of the above.

6 Weight Measurements

Separate books should be bound for:

A. Each different method of payment.

B. Materials of different Design Mix type.

C. Each week’s run.
D. Materials wasted or used in private work.
E. None of the above.

**REINFORCING STEEL**

The second pay item that requires pay quantity weight measurement is Reinforcing Steel. Reinforcing Steel is measured and paid for by the pound. But, we don't have to weigh the bars. The specifications accept calculated weights based on the detailed lengths of bars as shown in the plans and the standard weights per linear foot for the various sizes of bars. Let's go through some typical calculations.

The following table shows a bill of material for reinforcing steel on a project.

<table>
<thead>
<tr>
<th>Bar Mark</th>
<th>Bar Size</th>
<th>No. Required</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>W 401</td>
<td>4</td>
<td>66</td>
<td>4'-2&quot;</td>
</tr>
<tr>
<td>W 402</td>
<td>4</td>
<td>10</td>
<td>32'-6&quot;</td>
</tr>
<tr>
<td>W 403</td>
<td>5</td>
<td>6</td>
<td>6'-10&quot;</td>
</tr>
<tr>
<td>W 404</td>
<td>6</td>
<td>19</td>
<td>1'-6&quot;</td>
</tr>
<tr>
<td>W 405</td>
<td>8</td>
<td>5</td>
<td>13'-8&quot;</td>
</tr>
<tr>
<td>W 406</td>
<td>9</td>
<td>2</td>
<td>10'-8&quot;</td>
</tr>
</tbody>
</table>

Remember how to convert inches to decimals of a foot? To calculate the weight of reinforcing bars, you must first convert the bar lengths from feet and inches to feet and decimals of a foot. You may accomplish this using your calculator. When you are ready to proceed, select continue or press alt N.

Once you've made these conversions, the calculations would look like the following, with each bar mark extension rounded to the pound.

\[
\# \text{ Bar} \times \text{ Lbs./Ft} \times \text{ No. Required} \times \text{ Length} = \text{ Lbs.}
\]
Reinforcing steel quantities normally are summarized separately for the various components of structures (each end bent, pier, median wall, etc.). These same breakdowns of pay quantities should be recorded in the computation book along with the total pounds of reinforcing steel for the project.

Note: The bar size number indicates the diameter of the bars in eights of an inch through bar size B. For example: #4 = 4/8" = (1/2") and #6 = 6/8" = (3/4"). From bar size 9 and up, the equivalent square dimensions increases in 1/8" increments.

### 6 Weight Measurements

Compute the pay quantity of reinforcing steel indicated in the Bill of Reinforcing Steel Table.

_ROUND each extension to the nearest pound, by also referring to the conversion tables provided._

(Bar Size: #9 = 3.4; #8 = 2.67; #6 = 1.502; #4 = 0.668 Lbs/Ft.) (round to the nearest Lbs.)

<table>
<thead>
<tr>
<th>MARK</th>
<th>SIZE</th>
<th>No. Req’d</th>
<th>LENGTH</th>
<th>POUNDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>B901</td>
<td>9</td>
<td>1</td>
<td>15'-8&quot;</td>
<td></td>
</tr>
<tr>
<td>B902</td>
<td>9</td>
<td>1</td>
<td>14'-5&quot;</td>
<td></td>
</tr>
<tr>
<td>B801</td>
<td>8</td>
<td>13</td>
<td>41'-11&quot;</td>
<td></td>
</tr>
<tr>
<td>B802</td>
<td>8</td>
<td>5</td>
<td>15'-8&quot;</td>
<td></td>
</tr>
<tr>
<td>B803</td>
<td>8</td>
<td>6</td>
<td>13'-6&quot;</td>
<td></td>
</tr>
<tr>
<td>B804</td>
<td>8</td>
<td>1</td>
<td>12'-5&quot;</td>
<td></td>
</tr>
<tr>
<td>B601</td>
<td>6</td>
<td>15</td>
<td>1'-6&quot;</td>
<td></td>
</tr>
<tr>
<td>B401</td>
<td>4</td>
<td>24</td>
<td>9'-8&quot;</td>
<td></td>
</tr>
</tbody>
</table>

A. 2,819 Lbs.

B. 2,557 Lbs.

C. 2,560 Lbs.

D. 3,426 Lbs.
6  Weight Measurements

The reinforcing steel quantities for the individual end bents and piers of a bridge should be summarized separately on the item computation sheet and not just entered as a total weight of the reinforcing steel for the project. True or False?

True
False

6  Weight Measurements

Reinforcing Steel quantities normally are summarized separately for various components such as end bents and piers. True or False?

True
False
STRUCTURAL STEEL DEDUCTS

To determine the pay quantities of concrete in certain structures, the volumes of the structural steel embedded in the concrete must be deducted to obtain a net pay volume.

Usually, the weight of the steel is determined first and then converted to cubic feet. This procedure is the opposite of the one discussed in the volume conversions section, where we talked about converting volumes of structural shapes to pounds.

Although the pay quantity we want to obtain is a volume measurement rather than a weight measurement, the procedure for steel deducts is included in this chapter because of its use of standard weights from the plans and specifications.

Let's go through a typical procedure for deducting the volume of steel piling from a concrete bridge footing. Since the procedures are the same, we will not show the calculations for deductions from the seal concrete.

1. Determine the total length of steel in feet embedded in the footing. To do this, check the elevation and footing details in the plans -- as shown in Figure 6-3 below. (NOTE: Student is able to zoom view of Figure 6-4 if needed.) The elevation view shows how far the piles extend into the footing -- in this case, 1 foot. The plan of footing indicates the number of piles -- 20. Therefore, the total length of piling in the footing is 20 piles x 1 foot per pile = 20 feet.

2. Multiply the total length by the weight per foot of the piling found in the plan notes -- as shown in the lower right corner of Figure 6-3 (arrow). This identification (14BP75) for the steel “H” piling indicates that the piling weighs 75 pounds per linear foot. So we have:

   \[ 20 \text{ feet} \times 75 \text{ pounds per foot} = 1,500 \text{ pounds} \]

3. Divide the weight obtained in Step 2 by the weight per cubic foot shown in the specifications (as shown on page 6-3) for structural steel – 490 pounds.
1,500 pounds ÷ 490 pounds per cubic foot = 3.061 cubic feet (This is the amount of deduct from the total footing.)

4. Refer to the plan dimensions of the footing and determine its volume in cubic feet (Figure 6-3):

   28 feet x 19 feet x 5 feet = 2,660 cubic feet

5. Subtract the deduct from the footing volume to determine the pay quantity of concrete for the footing:

   2,660 cubic feet – 3.061 cubic feet = 2,657 cubic feet

Although the preceding method is generally the simplest and most preferred method, there is an alternative way of determining structural steel deducts from concrete volumes. Instead of computing the total weight of the embedded steel and then converting the weight to a volume, you sometimes can determine the volume of steel directly.

To compute the cubic feet of deduct, you multiply the distance the steel protrudes into the concrete (in inches) by the cross-sectional area of the steel shapes in square inches (which is 22.039) by the number of steel members involved.

Using our example problem from the other method, we would have:

\[
\frac{12\text{ in.} \times 22.039\text{ in.}^2 \times 20}{1728\text{ in.}^3\text{ per ft.}^3} = 3.061
\]

\[
(2,660\text{ cubic feet} - 3.061\text{ cubic feet} = 2,657\text{ cubic feet})
\]

This is the same answer we calculated using the other method.

Note: The cross-sectional areas for various steel shapes can be found in the tables shown in the Manual of Steel Construction of the American Institute of Steel Construction. This alternative method is just for the student’s information. The student is not required to memorize this equation.
# FIGURE 6-3

<table>
<thead>
<tr>
<th>MARK</th>
<th>SIZE</th>
<th>No. Req'd</th>
<th>LENGTH</th>
<th>POUNDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>B901</td>
<td>9</td>
<td>1</td>
<td>15'-8&quot;</td>
<td></td>
</tr>
<tr>
<td>B902</td>
<td>9</td>
<td>1</td>
<td>14'-5&quot;</td>
<td></td>
</tr>
<tr>
<td>B801</td>
<td>8</td>
<td>13</td>
<td>41'-11&quot;</td>
<td></td>
</tr>
<tr>
<td>B802</td>
<td>8</td>
<td>5</td>
<td>15'-8&quot;</td>
<td></td>
</tr>
<tr>
<td>B803</td>
<td>8</td>
<td>6</td>
<td>13'-6&quot;</td>
<td></td>
</tr>
<tr>
<td>B804</td>
<td>8</td>
<td>1</td>
<td>12'-5&quot;</td>
<td></td>
</tr>
<tr>
<td>B601</td>
<td>6</td>
<td>15</td>
<td>1'-6&quot;</td>
<td></td>
</tr>
<tr>
<td>B401</td>
<td>4</td>
<td>24</td>
<td>9'-8&quot;</td>
<td></td>
</tr>
<tr>
<td>B402</td>
<td>4</td>
<td>2</td>
<td>7'-4&quot;</td>
<td></td>
</tr>
<tr>
<td>B403</td>
<td>4</td>
<td>38</td>
<td>11'-4&quot;</td>
<td></td>
</tr>
<tr>
<td>B404</td>
<td>4</td>
<td>10</td>
<td>8'-2&quot;</td>
<td></td>
</tr>
</tbody>
</table>

**TOTAL**
FIGURE 6-3

GENERAL NOTES:

DESIGN SPECIFICATIONS: Designed in accordance with the AASHTO Specifications for Highway Bridges & Approved Revisions.

LOADING: H2 20' - 40' TON.

ANCHOR BOLTS: SET ANCHOR BOLTS FOR TYPE VI BEAMS BEARING SHOE ASSEMBLIES AS SHOWN ON SHEET NO. 9 - 3P AND SET ANCHOR BOLTS FOR TYPE IV BEAMS BEARING PLATES (EFT BEAMS ONLY) AS SHOWN ON SHEET NO. 9 - 3P. ANCHOR BOLTS SHALL CONFORM TO A.S.T.M. SPECIFICATIONS A-307 OR A-35.

PILES: ALL PILES SHALL BE STEEL "H" PILING (14 BP 73) BEAM SEATS: ALL BEAM SEATS SHALL BE FINISHED PARALLEL TO THE BOTTOM OF THE BEAM.
The footing for one pier of a bridge has 24 steel “H” piles 12BP53 that extend 1 foot into the footing. Determine the amount of “Deduct” from the total footing volume. (round to the nearest Cubic Foot)

A. 3.0 Cubic Feet
B. 3.3 Cubic Feet
C. 3.6 Cubic Feet
D. 3.7 Cubic Feet
E. None of the above.
Delivery Tickets provided by the plant will have preprinted numbers. True or False?

True

False

6 Weight Measurements

According to the standard weight table, what is the TOTAL weight of the following quantities of bolts? There are 350 pieces of 3/4" bolts, 200 pieces of 7/8" bolts and 800 pieces of 1" bolts.

A. 1,875 Lbs
B. 1,575 Lbs
C. 2,395 Lbs
D. 2,475 Lbs
E. None of the above.
STANDATD WEIGHT TABLE

Diameter of Bolt:  3/4"  7/8"  1"
Weight per 100 bolts  50 Lbs  100 Lbs.  150 Lbs.

6 Weight Measurements

Determine the weight of the structural steel shape shown below. Structural steel = 600 Lbs. per cubic foot. Convert inches to feet and calculate answer to the nearest pounds.

A.  31 Lbs.
B.  4,500 Lbs.
C.  375 Lbs.
D.  600 Lbs.
6 Weight Measurements

The cover for each bound set of delivery tickets for Asphalt Concrete should show: (Only one correct answer).

A. An invoice cover sheet that has the following: Financial Project ID Number, Design Mix #, type of material, Total no. of invoices or tickets in this bundle, total no. of Tons for this bundle, Sample numbers with pay item numbers including Lots, tons and waste, Plant Inspector, and Remarks.

B. Tare weight of each truck, total quantity of material, type of material and number of tickets in bundle.

C. Book number, Type of Material, Financial Project ID Number and Driver's Name.

D. Driver's Name, Tare Weight of each Truck, Type of Material and Distance from Plant to Project.

E. None of the above.