MODULE 6 - WEIGHT MEASUREMENTS

Slide 1 WELCOME

Welcome to the Florida Department of Transportation’s computer-based training series on Final Estimates, Level 1 Training. This is Module 6, Weight Measurements. This CBT contains audio and interactive elements. An alternate version is available on the resources page. To begin, select the start button or press Shift+N on your keyboard.

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Numerous road and bridge construction pay items are measured by weight, usually tons or pounds. Several different techniques can be used for weight measurement. Let's look at some of these methods.

Slide 3 CERTIFIED SCALES

Scales are the most obvious method of determining weights of pay items. This method is straightforward and can be obtained by simply weighing the material on a scale. But there are a few things to remember to measure weights correctly.

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First of all, scales must meet the requirements for accuracy and condition established by the Bureau of Weights and Measures of the Florida Department of Agriculture. These scales must be recertified every six months by either the Bureau of Weights and Measures or by a registered scale technician.

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In addition to the certification of the scales, periodic checks are also required. The contractor must weigh a loaded truck on their scales, and then weigh it on another set of certified truck scales which is not owned by the Contractor. When the difference in weight exceeds 8 pounds per ton of load, then a recheck on a second set of certified scales must be done. If both the check and recheck indicate that the printed weight is out of tolerance, then the scales must be adjusted and recertified. This check must be done once asphalt production has begun and at least every 30 days during production.

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Although tabulation forms are typically used to record the weight of each load weighed on a certified scale; they are not required for a plant equipped with an automatic printer system which records the total weight of the batches contained in each truckload.

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

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Another example of this is asphaltic concrete pavement which is paid for by the ton. Asphalt plants have fully automatic setups in which batch scales are equipped with an automatic recording system. When the asphaltic concrete is weighed on conventional truck scales prior to leaving the plant site, the delivery tickets are printed for the project personnel. Delivery tickets from such an approved system are acceptable as documentation.

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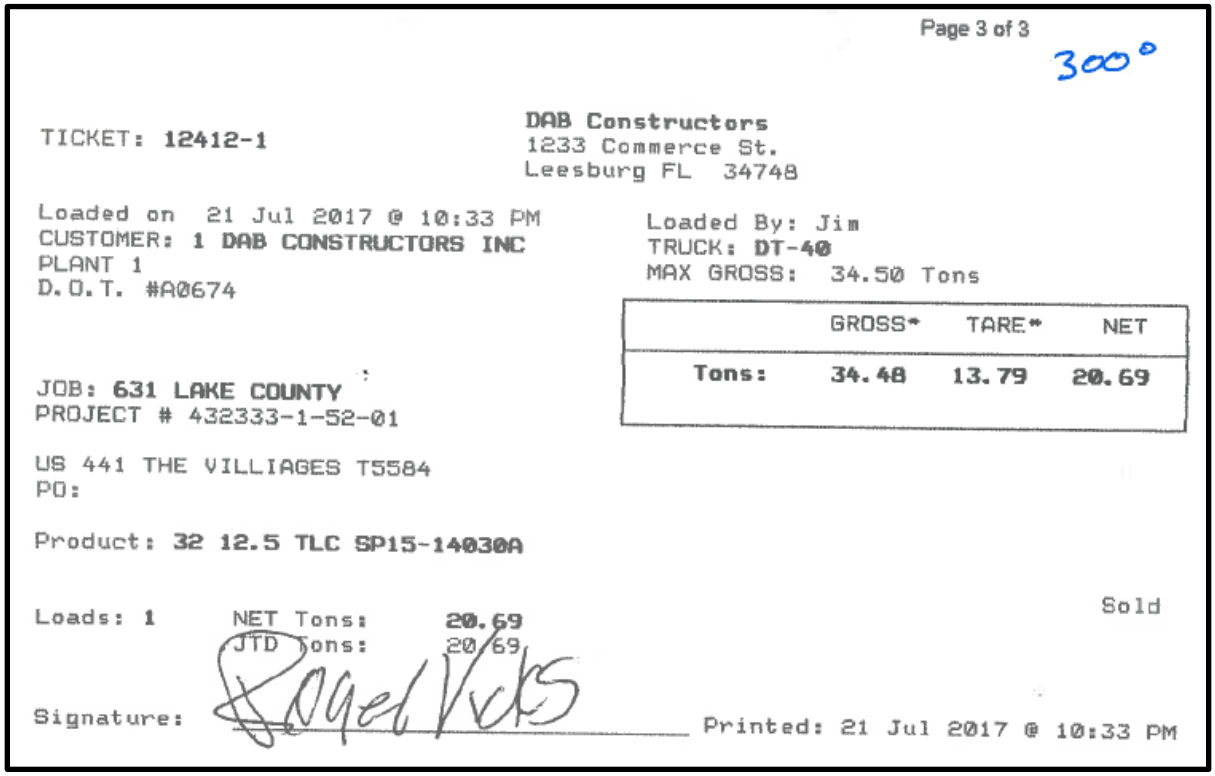
Let's go through the procedures for this situation.

1. Verify 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 both the plant scales and a certified truck scale.
3. Delivery tickets provided by the plant should include a minimum of the load number, project number, date, name & location of the plant, mix design number, gross, tare and net tonnage per truck, and the daily total tonnage of mix for the mix design.



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300°

TICKET: **12412-1**

DAB Constructors
1233 Commerce St.
Leesburg FL 34748

Loaded on 21 Jul 2017 @ 10:33 PM
CUSTOMER: **1 DAB CONSTRUCTORS INC**
PLANT 1
D.O.T. #A0674

Loaded By: Jim
TRUCK: **DT-40**
MAX GROSS: 34.50 Tons

	GROSS*	TARE*	NET
Tons:	**34.48**	**13.79**	**20.69**

JOB: **631 LAKE COUNTY**
PROJECT # 432333-1-52-01

US 441 THE VILLIAGES T5584
PO:

Product: **32 12.5 TLC SP15-14030A**

Loads: 1 NET Tons: **20.69**
JTD Tons: 20.69

Sold

Signature: Roger Vicks

Printed: 21 Jul 2017 @ 10:33 PM

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4. Original delivery tickets are retained by the Plant Verification Technician and inputted into EDMS as part of the LOT submittal package. One copy is kept by the Roadway Verification Technician.
5. As tickets are collected, they should be inputted into PDF format separately by date. Tickets should be inputted separately for materials of different Design Mix types.

Slide 10 KNOWLEDGE CHECK

Now let's test your knowledge.

1) Which of the following statements about scales is true?
   A. Scales must meet accuracy and condition requirements established by the Bureau of Weights and Measures.
   B. Scales must be recertified every eight to ten months.
   C. Certified on Florida, Alabama and Georgia scales only.
   D. Scales must indicate the volume of each loaded truck.
   E. None of the above.

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2) Which of the following statements about automatic system scales is true?
   A. Scales must have a degree of error no greater than 40 pounds per thousand pounds.
   B. Scales must be checked for accuracy at the beginning, at the mid, and end of production.
   C. Scales must be checked for accuracy at least once a year during production for the Department.
   D. Automatic printer system batch scales must be certified for accuracy every six months.

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3) Each asphalt plant technician should verify that:
   A. The scales are being checked once a year.
   B. A supplementary numbering system has been established.
   C. The original delivery tickets are retained for the LOT submittal package.
   D. All the above.
   E. None of the above.

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4) When should you check the accuracy of the scales and printer on a set of commercial truck scales?
   A. Before accepting the first load.
   B. At least every 30 days during production.
   C. Each morning and afternoon.
   D. Every three months.
   E. Both A and B.

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5) Tickets should be collected for:
   A. Each week's run.
   B. Materials of different Design Mix type.
   C. Each day's production of material.
   D. Both B and C.
   E. All of the above.

Slide 15 STANDARD WEIGHT TABLES

Another method of determining weight is the 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 provided by the manufacturer and the dimensions shown on the plans.

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Reinforcing steel, which is most commonly referred to as rebar, contains a unit weight in pounds per feet for each size of reinforcing steel. These unit weights are issued by the Concrete Reinforcing Steel Institute Manual of Standard Practice. The weight for sizes for #3 through #9 rebar is shown in the table. Using the length of rebar used and the unit weights we can easily calculate the total weight. Note that the bar size number indicates the diameter of the bars in eights of an inch through bar size B. Notice in the table that the diameter of the bar is the same as bar number divided by 8. For example, a number 4 bar has a diameter of ½ inches, which is 4/8.

Rebar Size and Weights		
Industry Size	*Diameter (inches)*	*No. of Bars*
3	3/8	0.376
4	1/2	0.668
8	5/8	1.043
6	3/4	1.502
7	7/8	2.044
8	1	2.670
9	1 1/8	3.400

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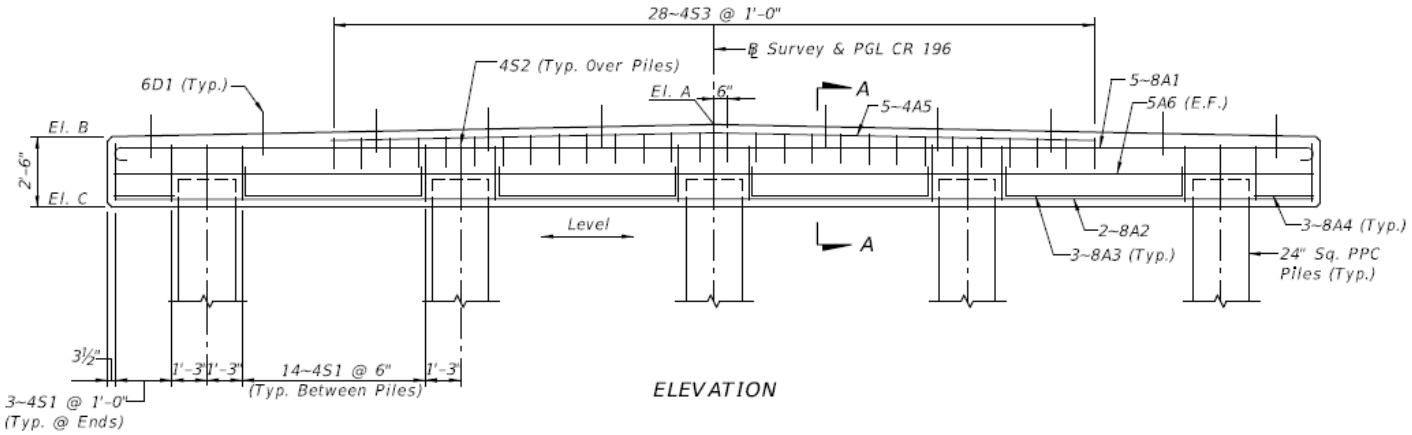
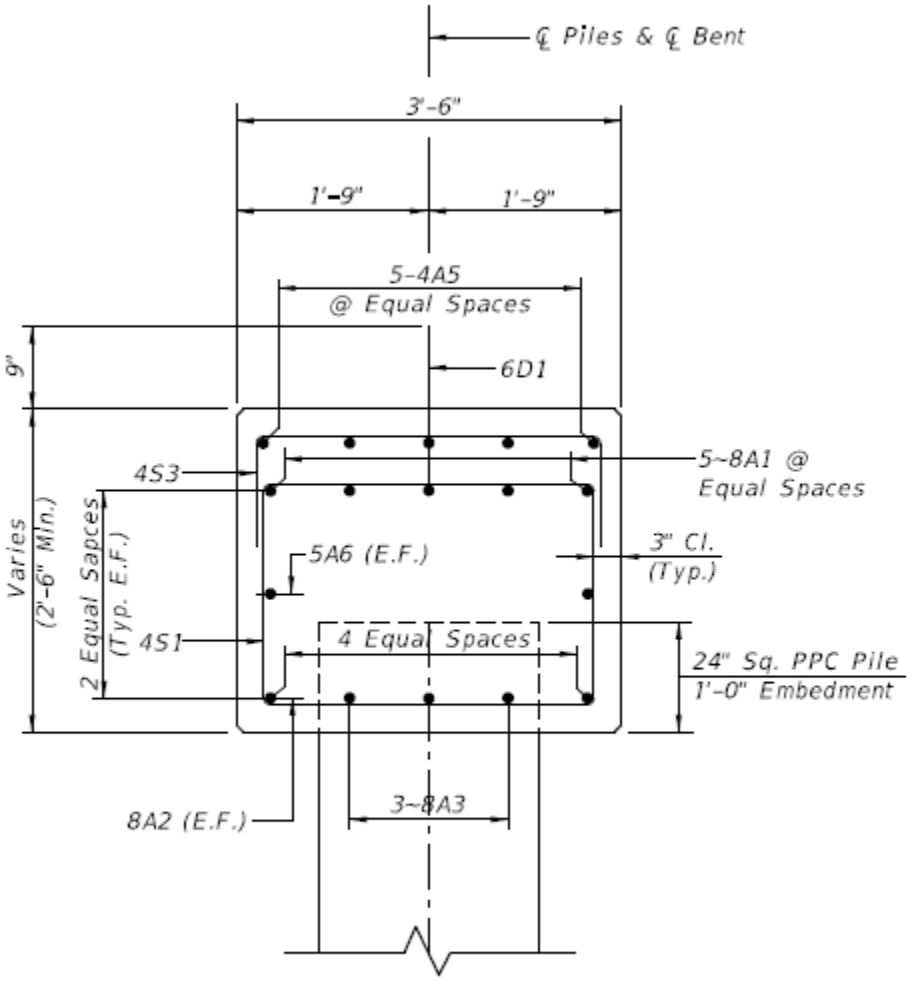
To do this, we must use the plan sheets to obtain the elevations and details used to calculate the steel lengths.





SECTION A-A

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Another place that reinforcing steel is documented is in the Reinforcing Steel tables located in the plans. In this table, the rebar size, length, spacing and quantity is documented by the Engineer.

MARK		LENGTH	NO	TYP	STYLE		B	C	D	E	F	H	J	K	N	O
SIZE	DES	FT IN	BARS	BAR	A	G	FT IN	FT IN	FT IN	FT IN	FT IN	FT IN	FT IN	FT IN	NO	ANG
LOCATION: END BENT 1 OR 6											NO. REQUIRED = 2					
8	A1	45 - 10	5	18	1	1	44 - 0									
8	A2	44 - 0	2	1			44 - 0									
8	A3	9 - 2	12	11			6 - 6	1 - 4	1 - 4							
8	A4	2 - 9	6	1			2 - 9									
4	A5	27 - 2	5	1			27 - 2									
5	A6	44 - 0	2	1			44 - 0									
6	D1	1 - 6	11	1			1 - 6									
4	S1	10 -7	68	4	4	4	1 - 11	3 - 0								
4	S2	7 - 4	5	5			1 - 11	3 - 0	0 - 3	0 - 3						
4	S3	5 - 0	28	11			3 - 0	1 - 0	1 - 0							
5	W1	4 - 6	12	1			4 - 6									
5	W2	3 - 5	12	1			3 - 5									

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For example, using the Reinforcing Steel tables located in the plans for End Bent 1 & 6, we can see that there are 4 different designations for the #8 rebar. This includes the A1, A2, A3 and A4 designations and each has a different length. If we multiply the length of each of these designations by their respective number of bars, we can calculate the total length for the following designations.

MARK		LENGTH	NO	TYP	STYLE		B
SIZE	DES	FT IN	BARS	BAR	A	G	FT IN
LOCATION: END BENT 1 OR 6							
8	A1	45 - 10	5	18	1	1	44 - 0
8	A2	44 - 0	2	1			44 - 0
8	A3	9 - 2	12	11			6 - 6
8	A4	2 - 9	6	1			2 - 9
4	A5	27 - 2	5	1			27 - 2
5	A6	44 - 0	2	1			44 - 0
6	D1	1 - 6	11	1			1 - 6
4	S1	10 -7	68	4	4	4	1 - 11
4	S2	7 - 4	5	5			1 - 11
4	S3	5 - 0	28	11			3 - 0
5	W1	4 - 6	12	1			4 - 6
5	W2	3 - 5	12	1			3 - 5

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For A1, we see that the length of this designation is 45 feet - 10 inches and there are 5 of these bars. This gives us a total length of 225 feet – 50 inches or in decimal form, this is 229.17 feet. This same calculation can be repeated for A2, A3 and A4.

Designation	***Length (ft. – in.)***	***No. of Bars***	***Total Length (ft.)***
A1	45’ – 10”	5	225’ – 50” or 229.17’
A2	44’ – 0”	2	88.00’
A3	9’ – 2”	12	110.00’
A4	2’ – 9”	6	16.50’

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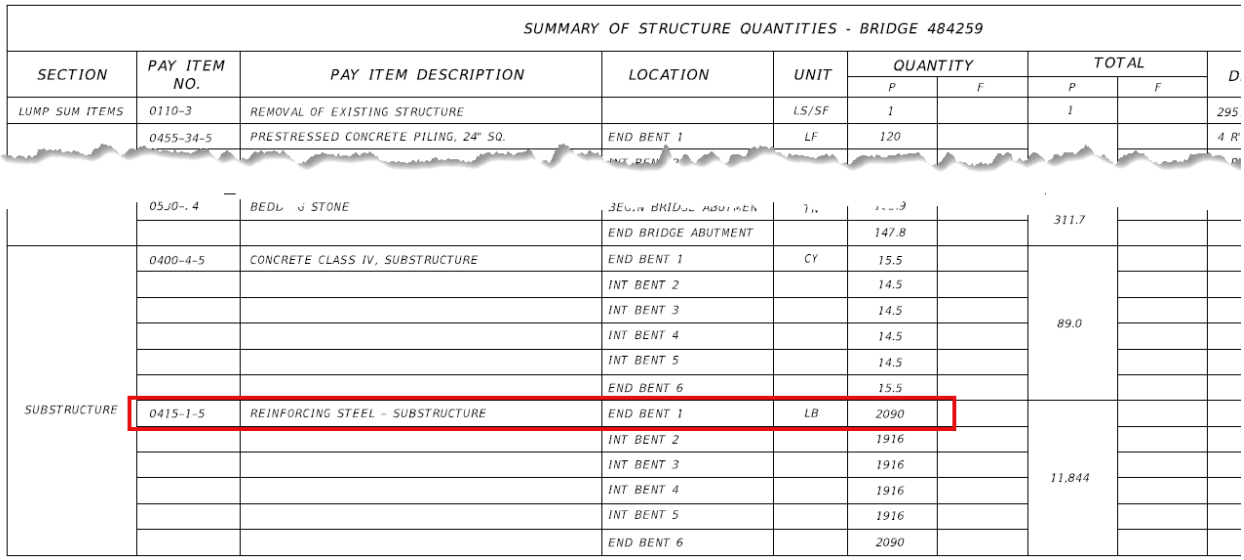
Once the length of each size of rebar or reinforcing steel is determined, the lengths can then be summed together and multiplied by the corresponding unit weight. This will give us the total weight of reinforcing steel similar to what is shown in the plan summary boxes.



SUMMARY OF STRUCTURE QUANTITIES - BRIDGE 484259

SECTION	PAY ITEM NO.	PAY ITEM DESCRIPTION	LOCATION	UNIT	QUANTITY P	QUANTITY F	TOTAL P	TOTAL F	D
LUMP SUM ITEMS	0110-3	REMOVAL OF EXISTING STRUCTURE		LS/SF	1		1		295
	0455-34-5	PRESTRESSED CONCRETE PILING, 24" SQ.	END BENT 1	LF	120				4 R
			INT BENT 2						
	0530-.4	BEDL .3 STONE	SECT'N BRIDGE ABUTMENT	TN	163.9		311.7		
			END BRIDGE ABUTMENT		147.8				
	0400-4-5	CONCRETE CLASS IV, SUBSTRUCTURE	END BENT 1	CY	15.5				
			INT BENT 2		14.5				
			INT BENT 3		14.5		89.0		
			INT BENT 4		14.5				
			INT BENT 5		14.5				
			END BENT 6		15.5				
SUBSTRUCTURE	0415-1-5	REINFORCING STEEL - SUBSTRUCTURE	END BENT 1	LB	2090				
			INT BENT 2		1916				
			INT BENT 3		1916		11,844		
			INT BENT 4		1916				
			INT BENT 5		1916				
			END BENT 6		2090				

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Let’s look at an example. Reinforcing Steel is measured and paid for by the pound, but we don't have to weigh the bars. The specifications accept the Concrete Reinforcing Steel Institute’s standard weights per linear foot for the various sizes of bars. Let's go through some typical calculations.
The following table shows the required reinforcing steel on a project.

Bar Mark	Bar Size	No. Required	Length (ft. & in.)	Length (feet)
W 401	4	66	4’-2”	
W 402	4	10	32’-6”	
W 403	5	6	6’-10”	
W 404	6	19	1’-6”	
W 405	8	5	13’-8”	
W 406	9	2	10’-8”	

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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.

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Once you've made these conversions, the calculations would look like the following. Note that the sum of the rebars are rounded to the pound. It is important to round at the end of the calculation so accuracy is retained.

Bar Size & Mark	Unit Weight (lbs./ft.)	No. Required	Length (ft. & in.)	Length (ft.)	Calculated Weight (lb.)
(#4) W 401	0.668	66	4'-2"	4.1667	183.7
(#4) W 402	0.668	10	32'-6"	32.50	217.1
(#5) W 403	1.043	6	6'-10"	6.8333	42.8
(#6) W 404	1.502	19	1'-6"	1.50	42.8
(#8) W 405	2.670	5	13'-8"	13.6667	182.4
(#9) W 406	3.400	2	10'-8"	10.6667	72.5
				Total (Rounded)	741.3 **741 lbs.**

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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 Summary of Quantities sheets within the Final As-Built Plans along with the total pounds of reinforcing steel for the project.

SUMMARY OF STRUCTURE QUANTITIES - BRIDGE 484259

SECTION	PAY ITEM NO.	PAY ITEM DESCRIPTION	LOCATION	UNIT	QUANTITY P	QUANTITY F	TOTAL P	TOTAL F	D
LUMP SUM ITEMS	0110-3	REMOVAL OF EXISTING STRUCTURE		LS/SF	1		1		295
	0455-34-5	PRESTRESSED CONCRETE PILING, 24" SQ.	END BENT 1	LF	120				4 R
	0530-.4	BEDD[illegible] STONE	[illegible]	TN	[illegible]		311.7		
			END BRIDGE ABUTMENT		147.8				
	0400-4-5	CONCRETE CLASS IV, SUBSTRUCTURE	END BENT 1	CY	15.5		89.0		
			INT BENT 2		14.5				
			INT BENT 3		14.5				
			INT BENT 4		14.5				
			INT BENT 5		14.5				
			END BENT 6		15.5				
SUBSTRUCTURE	0415-1-5	REINFORCING STEEL - SUBSTRUCTURE	END BENT 1	LB	2090		11,844		
			INT BENT 2		1916				
			INT BENT 3		1916				
			INT BENT 4		1916				
			INT BENT 5		1916				
			END BENT 6		2090				

Slide 26 KNOWLEDGE CHECK

Now let's test your knowledge.

1) Which of the following is the pay quantity for the reinforcing steel shown in the Table below?

Bar Mark	Bar Size	Unit Weight (lb./ft.)	No. Required	Length (ft. & in.)	Weight (lbs.)
W 901	9	3	1	15'-8"	
W 902	9	3	1	14'-5"	
W 801	8	2.670	13	41'-11"	
W 802	8	2.670	5	15'-8"	
W 803	8	2.670	6	13'-6"	
W 804	8	2.670	1	12'-5"	
W 601	6	1.502	15	1'-6"	
W 401	4	0.668	24	9'-8"	
W 402	4	0.668	2	7'-4"	
W 403	4	0.668	38	11'-4"	
W 404	4	0.668	10	8'-2"	
			Total		

A. 2,819 lbs.
B. 2,545 lbs.
C. 2,560 lbs.
D. 3,426 lbs.
E. None of the above.

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2) The reinforcing steel quantities for the individual end bents and piers of a bridge should be summarized separately in the Plan Summary Boxes within the Final As-Built plans and not just entered as a total weight of the reinforcing steel for the project.
A. True
B. False

Slide 28 STANDARD WEIGHT TABLES

Another pay item which uses the standard weight tables is the High Strength Fastener Assemblies (including nuts and washers). These items are to be computed in accordance with the table found in the Standard Specifications, Section 460-8.5, Table 460-9 shown below.

Diameter of High-Strength Fastener, inch	***3/4 in.***	***7/8 in.***	***1 in.***	***1-1/8 in.***	***1-¼ in.***
Weight per 100 bolts	52 lbs.	100 lbs.	135 lbs.	182 lbs.	238 lbs.

For example, the weight of 300 3/4-inch bolts (with nuts and washers) would be 300 bolts times 52 pounds divided by 100 bolts which is equal to 156 pounds.

$$\text{Weight (lbs.)} = 300 \text{ bolts} \times \frac{52 \text{ lbs.}}{100 \text{ bolts}} = 156 \text{ lbs.}$$

Weight (in pounds) equals 300 bolts times 52 pounds divided by 100 bolts, which is equal to 156 pounds.

Slide 29 KNOWLEDGE CHECK

Now let's test your knowledge.

1) According to the Standard Weight Table, what is the total weight for the following quantities of High Strength Fasteners? 450 pieces of ¾" bolts, 290 pieces of 7/8" nuts and 638 pieces of 1" nuts.

Diameter of High-Strength Fastener, inch	***3/4 in.***	***7/8 in.***	***1 in.***
Quantity of Bolts	450	290	638
Weight per 100 bolts	52 lbs.	100 lbs.	135 lbs.

A. 1,385 lbs.
B. 1,545 lbs.
C. 1,704 lbs.
D. 1,789 lbs.
E. None of the above.

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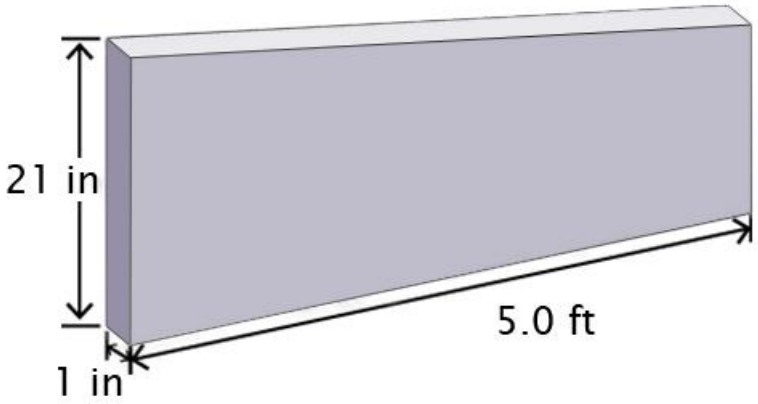
2) Determine the weight of the structural steel shape shown, Note Structural Steel = 490 lbs. per cubic foot (as an example). Convert inches to feet when calculating answer. Calculate answer to the nearest pound.

A. 375 lbs.
B. 413 lbs.
C. 357 lbs.
D. 434 lbs.
E. None of the above.



Slide 31 STRUCTURAL STEEL DEDUCTS

Now let's discuss another way to use the standard weight tables. 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. It is important to note that according to the Standard Specifications, all materials embedded in concrete such as structural steel or pile heads must be deducted when computing the volume of concrete volume to be paid for. Reinforcing bars or welded wire mesh are not deducted from concrete volumes since the area they occupy in concrete structures is minimal.

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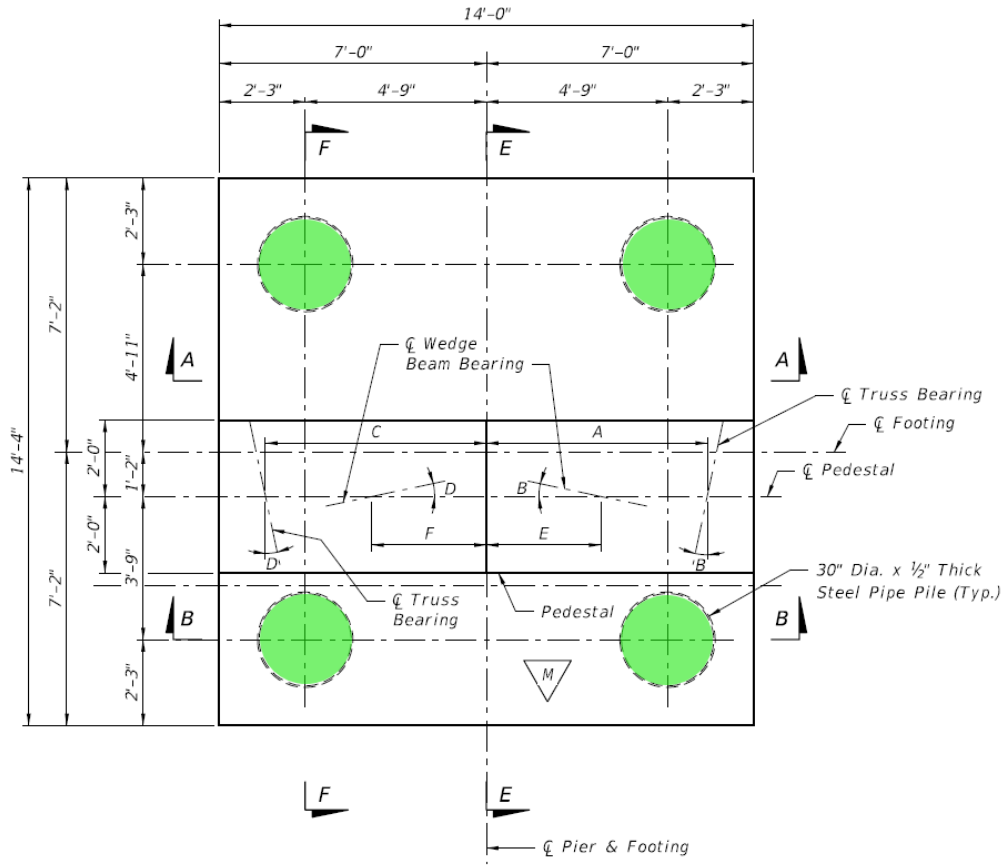
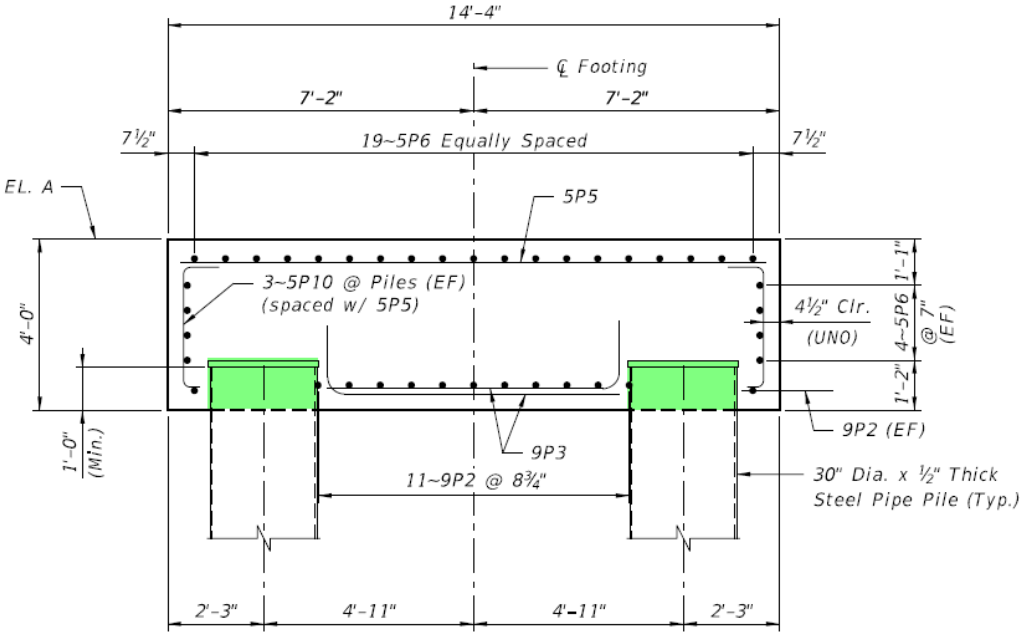
Let's go through a typical procedure for deducting the volume of steel within the end bent of a concrete bridge.

Step 1: Determine the total length of steel in feet embedded in the end bent.
In this example, there are four 30" diameter steel pipe piles that intrude in the end bent. Each of the piles have a wall thickness of ½ inch and extend in the bent a minimum of 1 foot. Therefore, since there are 4 piles extended 1 foot in the bent, the total length of steel is 4 feet.



PLAN - Pier 3 Right Footing
(For Pier 3 Left Footing, see Typical Plan)



SECTION F-F
(Pedestals not shown)

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Step 2: Multiply the total length of structural steel shown in the plans by the unit weight per foot for each steel pipe pile.

From the manufacturer's data sheet, we know that 30" diameter steel piles, with ½" thick walls, weight 157.68 pounds per foot. It is important to note that most manufacturers of structural steel shapes create data sheets that contain both the dimensions and weight so it does not need to be re-calculated by Engineers or contractors.

Since the unit weight is 157.68 pounds per foot, when this is multiplied by the total length 4 feet, we calculate a weight of 630.72 lbs.

$$4 \text{ feet} \times 157.68 \text{ lbs./ft.} = 630.72 \text{ lbs.}$$

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Step 3: Convert the total weight to volume.

Divide the weight obtained in Step 2 by the unit weight for structural steel which is 490 pounds per cubic foot.

630.72 pounds divided by 490 pounds per cubic foot equals 1.29 cubic feet.

$$\frac{630.72 \text{ pounds}}{490 \text{ pounds per cubic foot}} = 1.29 \text{ cubic feet}$$

(This is the amount of deduct from the total footing.)

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Step 4: Refer to the plan dimensions of the end bent and determine its volume in cubic feet. Subtract the steel volume from the footing volume to determine the pay quantity of concrete for the footing.

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.

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

$$\text{Volume} = (\text{Length into Concrete Member}) \times (\text{Cross Sectional Area}) \times (\text{No. of Steel Members})$$

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

$$\text{Volume} = \text{Length into Concrete Member} \times \left(\frac{\pi(r1^2)}{4} - \frac{\pi(r2^2)}{4} \right) \times \text{No. of Steel Member}$$

Where r1 represents the Outer Diameter and r2 represents the Inner Diameter:

$$\text{Volume} = 12'' \times \left(\frac{\pi(30''/12'')^2}{4} - \frac{\pi(29/12)^2}{4} \right) \times 4$$

$$\text{Volume} = 1.29 \text{ cubic feet}$$

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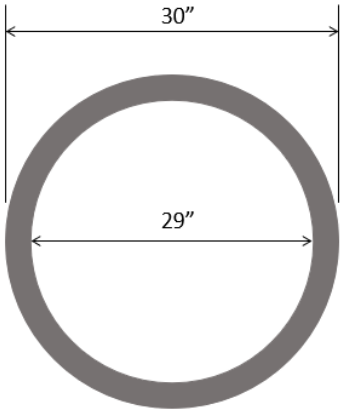
So, the piles protrude 12 inches into the end bent times the area of the outer diameter minus the area of the inner diameter all multiplied by 4 since there are four piles in the bent. This equals 1.29 cubic feet which is the same answer we calculated using the other method.

Note: The cross-sectional areas for various steel shapes can be found in the tables shown in the Steel Construction Manual by the American Institute of Steel Construction.



Slide 38 KNOWLEDGE CHECK

Now let’s test your knowledge.

1) The footing for one pier of a bridge has 24 steel “H” piles 12BP53 that extend 1 foot into the footing. The unit weight for one pile is 53 pounds per foot. The weight of Structural Steel is 490 lbs per cubic foot. Which of the following is the amount of “Deduct” from the total footing volume 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.

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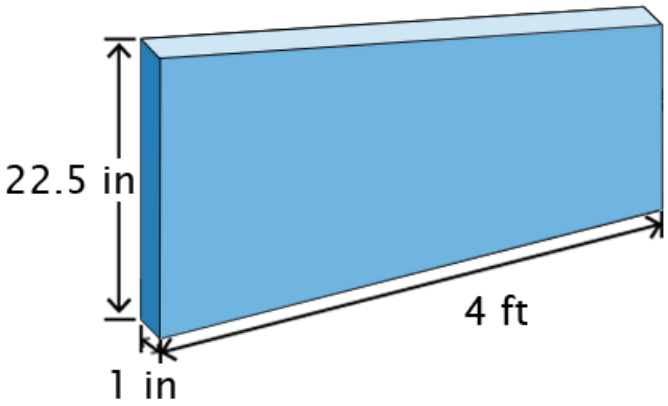
3) Which of the following is the weight of the structural steel shape? Note: Structural steel = 490 lbs. per cubic foot. Convert inches to feet.

A. 278 lbs.
B. 306 lbs.
C. 2,658 lbs.
D. 3,675 lbs.



Slide 40 CONCLUSION

This is the end of Module 6. Thank you for your time and attention.