Chapter 5
Quantities Calculations

Introduction

Quantity calculations are computed for each bid item listed in the Table of Estimated Quantities on the Title Sheet. Estimated quantities allow the Bridge Program and other programs to project, track, and justify costs and the amount and type of work to be done through various stages of a project.

General Information

Two individual sets of quantity calculations shall be completed for each project. Each set of calculations shall have a cover sheet listing all the bridge related bid items and the total quantities (a copy of the Table of Estimated Quantities may be used). Computations shall be separated, totaled, and labeled by bid items. Show all numbers used and all steps or calculations. Most Lump Sum bid items require estimates of components to determine an estimated cost (i.e., reinforcing steel, concrete, etc. in Expansion Device Modification). Components within a bid item (i.e., girders, bearings, field splices, etc. within Structural Steel) shall be grouped together, subtotaled, and labeled. Sketches may be included within the quantities to support numbers used in calculations.

Errors on the plans that are discovered during the quantity process should be noted and brought to the attention of the detailer or checker.

Unless otherwise noted, the numbers used to compute quantities shall be the numbers shown on the plans, rounded to two decimal places. Geometric angles shall be accurate to four decimal places.

Unless otherwise noted, all quantities shall be rounded up to the next unit of accuracy.

An example table of Estimated Quantities follows. The example project has two structures, both of them have removal of concrete, class B concrete, and new strip seal expansion devices. The quantities for Removal of Concrete and Class B Concrete are 21.5 CY for Site A and 21.2 CY for Site B when taken to the tenth of a cubic yard (0.1 CY) but the Removal of Concrete quantity is rounded up.

ESTIMATED QUANTITIES						
ITEM NO.	ITEM	UNIT	TOTAL QUANTITY	ESTIMATE		
				SITE A	SITE B	TOTAL
202.03465	REMOVAL OF CONCRETE	CY	44	22	22	
512.01012	EXPANSION JOINT (GLAND)	LF	78	40	38	
513.00015	CLASS B CONCRETE	LS	LUMP SUM	21.5 CY	21.2 CY	42.7 CY

Special Instructions by Bid Item

Estimated quantities for the more common bridge associated bid items shall be based on the units and accuracy shown in the following table. An asterisk (*) indicates that additional information and suggested formulas to be used in quantity calculations follow the table.

Reference the Standard Specifications and Standard Plans for further information on bid items.

Standard Specification Section	Item	Accuracy	Unit
100	Performance Bond	-----	LS
	Railroad Insurance	-----	LS
	Force Account Work*	$100	$
	Mobilization	-----	LS
	Controls for Lead Paint Removal*	Whole SF	LS

Standard Specification Section	Item	Accuracy	Unit
202-Removal	Removal of Structures and Obstructions	EA	LS
	Removal of Sign Structures	EA	LS
	Removal of Bridges	EA	EA
	Removal of RC Box Culverts	EA	LS
	Removal of Bridge Railing	Whole FT	FT
	Removal of Pedestrian Rail	Whole FT	FT
	Removal of Curb	Whole FT	FT
	Removal of Concrete*	Whole CY or Whole SY	LS
			SY
			CY
206-Excavation and Backfill for Culverts	Trench Subexcavation	10 CY	CY
	Culvert Subexcavation	10 CY	CY
211-Culvert Cleaning	Culvert Cleaning	EA	EA
212-Structure Excavation and Backfill	Dry Excavation*	10 CY	CY
	Wet Excavation	10 CY	CY
	Pervious Backfill Material	10 CY	CY
		Whole TON	TON
217-Geotextiles	Geotextile*	Whole SY	SY
501-Structural Steel	Structural Steel*	200 LB	LS
502-Precast Concrete	Precast Concrete Members	0.1 CY	LS
	Precast Box Culverts	Whole FT	FT
	Prestressed Precast Concrete I- Girders	Whole FT	FT
	Prestressed Precast Concrete Bulb T	Whole FT	FT
	Prestressed Precast Concrete Tri-Deck	Whole FT	FT

Standard Specification Section	Item	Accuracy	Unit
503-Bridge Railing	Bridge Railing	Whole FT	FT
	Bridge Railing Modification	Whole FT	FT
		Whole FT	LS
	Reset Bridge Railing	Whole FT	FT
		Whole FT	LS
	Pedestrian Railing	Whole FT	FT
	Pedestrian Railing Modification	Whole FT	FT
		Whole FT	LS
504-Bearing Piles and Sheet Piling	Predrilled Holes	Whole FT	FT
	Pile Splices	EA	EA
	Steel Piling HP	Whole FT	FT
	Steel Sheet Piling	Whole SF	SF
505-Concrete Barrier	Concrete Barrier	Whole FT	FT
506-Drilled Shaft Foundations	Drilled Shaft Foundation	Whole FT	FT
507-Reinforced Bridge Approach Fills and Reinforced Concrete Approach Slabs	Reinforced Concrete Approach Slabs*	Whole SY	SY
	Bridge Approach Backfill*	Whole CY	CY
508-Reinforced Concrete Slope Paving	Reinforced Concrete Slope Paving	Whole SY	SY
	Slope Paving Repair/Modification	Whole SY	SY
511-Riprap and Gabion Erosion Protection	Gabions*	Whole SY	SY
		10 CY	CY
	Filter Aggregate	10 CY	CY
	Machine-Placed Riprap	10 CY	CY

Standard Specification Section	Item	Accuracy	Unit
512-Expansion Joints	Expansion Joint Repair/Mod	Whole FT	FT
	Bearing Device Mod	EA	LS
	Expansion Joint (Gland)	Whole FT	FT
	Compressed Joint Material	Whole FT	FT
	Elastomeric Compression Joint Seal	Whole FT	FT
513-Structural Concrete	Concrete (Class A, Class B, & Class S)*	0.1 CY	LS
514-Reinforcing Steel	Mechanical Splices	EA	LS
		EA	EA
	Reinforcing Steel*	10 LB	LS
	Reinforcing Steel (coated)*	10 LB	LS
515-Silica Fume Modified Concrete Bridge Deck Repair	Bridge Deck Repair Class I-A*	Whole SY	SY
	Bridge Deck Repair Class I-B*	Whole SY	SY
	Bridge Deck Repair Class II-A*	Whole SY	SY
	Bridge Deck Repair Class II-B*	Whole SY	SY
	Silica Fume Modified Concrete*	0.1 CY	CY
516-Paint Repair	Paint Repair (Bridge Railing)	Whole FT	FT
		Whole FT	LS
	Paint Repair (Steel Piling & Structural Steel)*	Whole SF	LS
		Whole SF	SF
605-Underdrains	Gravel for Drains	Whole CY	CY
		Whole TON	TON
	Underdrain Pipe (perforated or non-perforated)	Whole FT	FT
612-Siphons	Siphon Pipe	Whole FT	FT
	Siphon Fixed Ends	EA	EA

Standard Specification Section	Item	Accuracy	Unit
617-Cut-Off Walls and Head Walls	Cut-Off Wall (Conc)	0.1 CY	CY
	Head Wall (Conc)	0.1 CY	CY
618-Precast Reinforced Concrete Stock Passes	RC Stock Pass	Whole FT	FT
	RC Stock Pass FE Sect	EA	EA
622-Structural Plate Pipe	Structural Plate Pipe	Whole FT	FT
	Structural Plate Stock Pass	Whole FT	FT
627-Epoxy Resin Injection	Epoxy Resin Injection	Whole FT	LS
		GAL	GAL
		Whole FT	FT
701 - Electrical Devices	Conduit System – X	Whole FT	LS
	Bridge Lighting System	Whole FT	LS
702-Signs, Delineators, and Reference Markers	Steel Overhead Sign Support*	200 LB	LS
	Sign Structure Repair	LS	LS
	Reset Overhead Sign Structure	LS	LS
	Splash Boards*	Whole FT	FT

Force Account Work - Usually determined by field personnel.

Controls for Lead Paint Removal - Estimate the area of steel requiring spot cleaning for each element. Include the estimate for each item in a note or, on projects with several structures, in a table on the Title Sheet. In the "Estimate" column of the quantity block, show the accumulated sum of all areas requiring spot cleaning.

Removal of Concrete - The unit used for this bid item will depend on the situation and the preference of the Squad Team Leader. If Lump Sum is used, calculate volume.

Excavation - All excavation except for that involved with riprap must be calculated. The equations and figures shown below are useful for calculating excavation quantities. Culvert and trench excavation shall be calculated as shown in the Standard Plans. Subexcavation shall be calculated as specified in the Standard

Plans and Standard Specifications. The General Notes will explain excavation limits when the existing ground line is above or below finished grade.

The following equation shall be used for determining approach slab excavation quantities.

Notes: 1) Use dimensions and elevations from plans at centerline bridge roadway.
2) Do not compensate for grade or slope.
3) Do not add or subtract small areas (i.e. corbels, sleeper slabs, etc.).
4) Dimensions A, C, and D shall be to natural ground line for new bridges on fill and to finished grade for all other structures.

For elephant ear wingwalls:

Shallow configuration

$$V = (W + WL)\left(B\left(\frac{A+C}{2} \right) + \frac{A^2}{2} \right)$$

Deep configuration

$$\mathrm{V} = (\mathrm{W} + \mathrm{WL})\left(10\left(\frac{C+D}{2} \right) + B\left(\frac{D+A}{2} \right) + \frac{A^2}{2} \right)$$

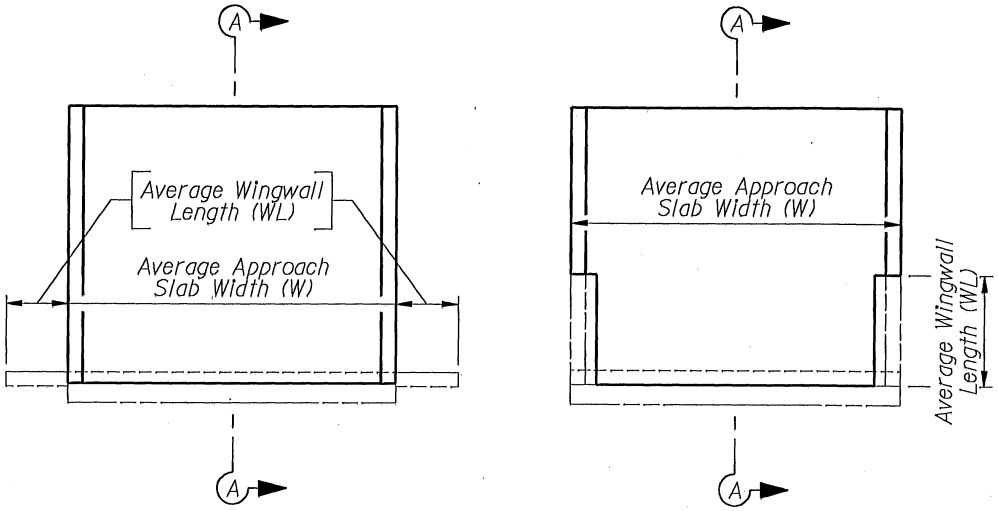
For sweptback wingwalls:

Shallow configuration

$$V = WL(W)\left(C - \left(\frac{C-A}{4} \right) \right) + \left(W + A + \left(\frac{C-A}{4} \right) \right) x \left((B - WL)\left(A + \left(\frac{C-A}{4} \right) \right) + \frac{A^2}{2} \right)$$

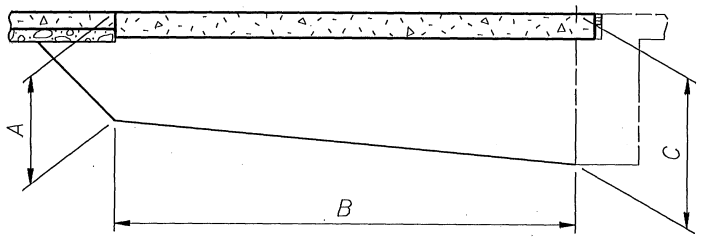
Deep Configuration

$$V = WL(W)\left(\frac{C+D}{2} \right) + \left(W + \left(\frac{D+A}{2} \right) \right) x \left((10.0 + B - WL)\left(\frac{D+A}{2} \right) + \frac{A^2}{2} \right)$$

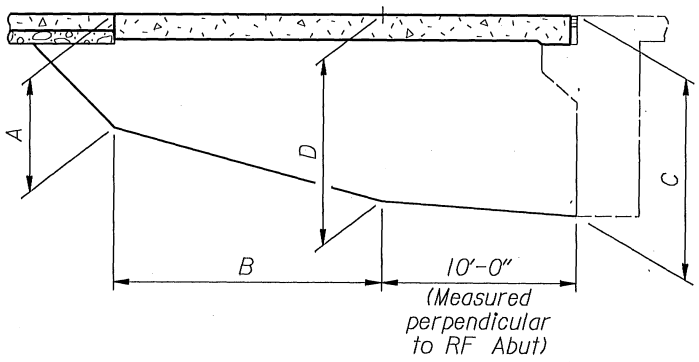


PLAN
(Elephant ear wingwalls)

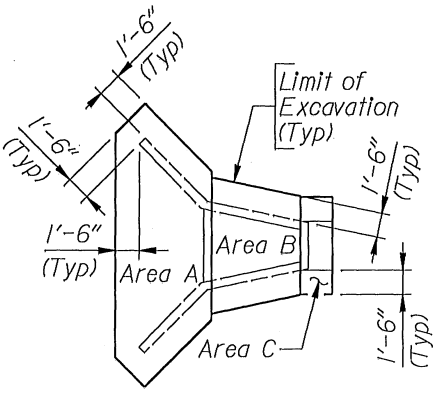
PLAN
(Sweptback wingwalls)



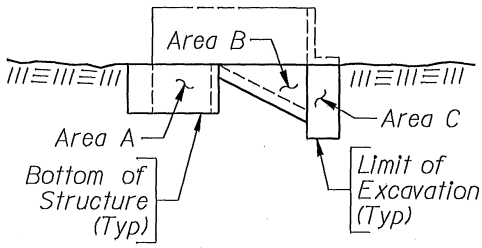
SECTION A-A
(Shallow approach slab configuration)



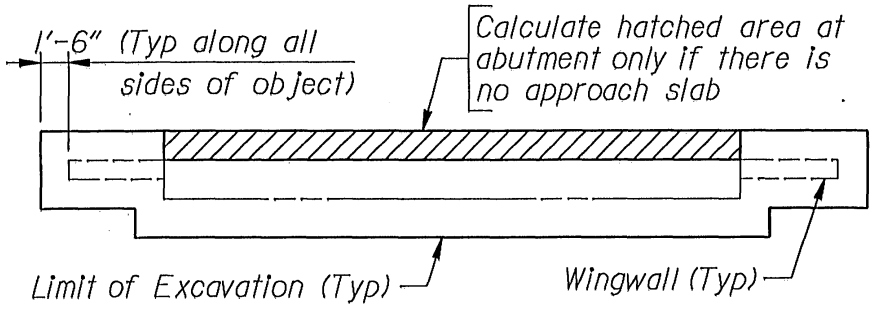
SECTION A-A
(Deep approach slab configuration)



PLAN OF INLET OR OUTLET

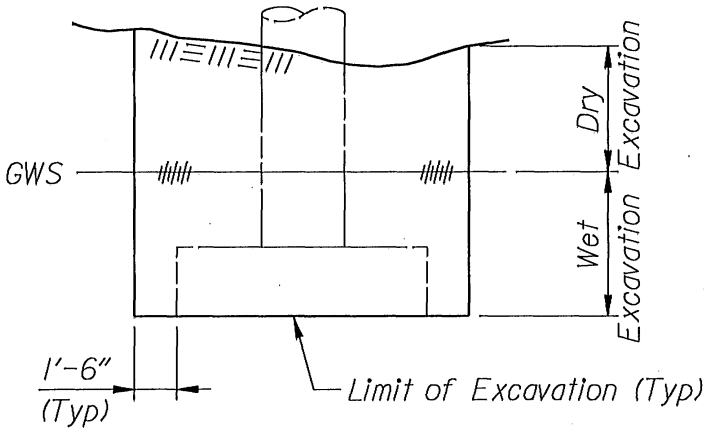


ELEVATION OF INLET OR OUTLET



PLAN

(Elephant ear wingwall abutment shown, sweptback wingwall abutment, piers, and bents similar)



ELEVATION AT FOOTING

(Showing Wet Excavation versus Dry Excavation)

Geotextile - For approach slabs, use the average lengths and widths shown in excavation figures with the addition of 7'-0" for each wrap location. Do not subtract any area for wrap overlaps in the corners. Do not forget the fabric layer that lines the bottom of the excavation.

Shallow Elephant Ear Wingwall Abutment

$$Area(SY) = \frac{(W + WL + (2x7')) \, x \left(B + \frac{A}{2} + 7' \right) x \, NL}{9}$$

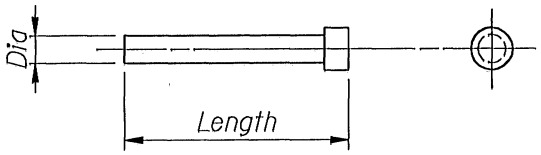
Deep Elephant Ear Wingwall Abutment

$$Area(SY) = \frac{(W + WL + (2x7')) \, x \left(10 + \left(\frac{A + B}{2} \right) + 7' \right) x \, NL}{9}$$

Where NL = number of layers, including the bottom layer

Structural Steel - Includes all steel and related items on structures with the exception of reinforcing steel, most steel piling, railing, snow plow plates, and strip seal and conduit anchorages. On bridges or culverts with a minor amount of structural steel, the steel may be subsidiary to other bid items. Some of the commonly overlooked steel components are deck drains and drain systems, elastomeric bearing pads, fabric bearing pads, bearing anchor bolts, cutwater angles, shear connectors, and pile bracing on steel bents. Use the call-out dimension for beveled plates and plates with large holes when used for sole or splice plates in sign structures. The weight of steel plates and bars, based on the plate or bar call-out dimensions, shall be determined by multiplying the volume of the steel by 490 pounds per cubic foot (pcf). The length multiplied by the weight given in the tables of AISC's Manual of Steel Construction shall be used for standard shapes (i.e. rolled beams, channels, angles, pipe, tubing, etc). The weights for round pipe exceeding the pipe sizes listed in the AISC manual can be found under A 53 in ASTM's Annual Book of ASTM Standards, Volume 01.01, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless. Add 2% of total calculated weight for miscellaneous nuts and bolts before rounding to the nearest 200 pounds.

Table Of Shear Connector Weights						
Dia	Length					
	3"	4"	5"	6"	7"	8"
2"	.210	.270	.330	.390	.450	.510
e"	.336	.432	.528	.624	.720	.816
:"	.490	.615	.740	.865	.990	1.115
f"	.640	.810	.980	1.150	1.320	1.490

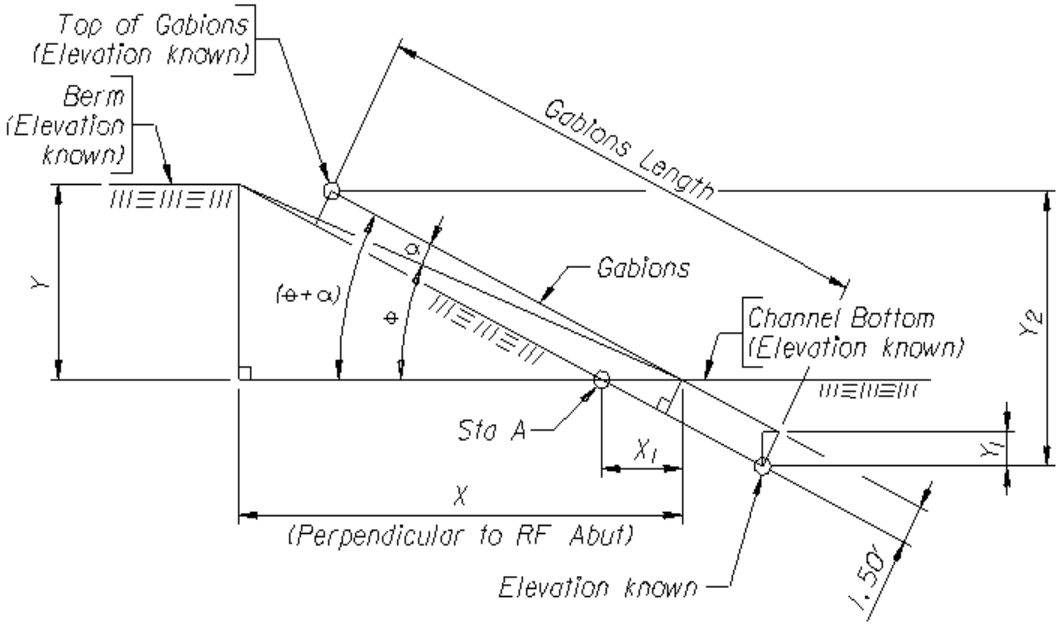


Reinforced Concrete Approach Slabs - Estimate the area of concrete. Do not include the area of compressed joint material.

Bridge Approach Backfill - Use the volume obtained from the approach slab excavation calculations and subtract the approach slab volume. See excavation formulas and diagrams.

Gabions (riprap) - Calculate slope length of gabions based on the

following formulas and diagrams.

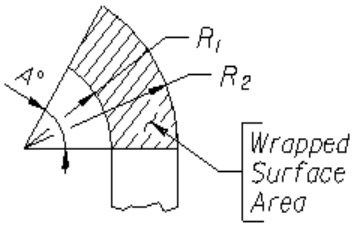


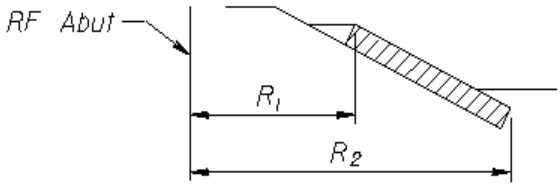
$$\tan\theta = \frac{Y}{X} \qquad \sin\alpha = \frac{1.50}{\sqrt{X^2+Y^2}} \qquad Y_1 = 1.50 \times \cos(\theta+\alpha) \qquad \text{Gabions Length} = \frac{Y_2 - Y_1}{\sin(\theta+\alpha)}$$

If top of gabions elevation and berm elevation are the same, $\alpha = \theta$.

Calculations for Sta A required on GP&E sheet

$$X_1 = \frac{1.50}{\sin(\theta+\alpha)} \qquad \text{Sta A} = (\text{Sta at } \mathbb{C} \text{ Channel}) \pm \frac{(\text{Channel Bottom Width} / 2) \pm X_1}{\cos \text{ Skew Angle}}$$





$$R_1 = \text{Berm Width} + \left[\frac{(\text{Berm Elev}) - (\text{Top of Gabions Elev})}{\tan(\theta+\alpha)}\right] + \left[\frac{1.50}{\sin(\theta+\alpha)}\right]$$

$$R_2 = R_1 + \frac{Y_2 - Y_1}{\tan(\theta+\alpha)}$$

$$\text{Wrapped Surface Area} = \pi \frac{A}{360} (R_2+R_1) \sqrt{(R_2-R_1)^2 + Y_2^2}$$

Concrete - If a Slab Thickening Diagram is needed, use the total average thickness. Soffit dimensions shown for precast girders shall be assumed to run full length of the girders for Class A Concrete quantity.

Reinforcing Steel - Each component (i.e., abutment, bent, etc.) shall have its reinforcing steel calculated and totaled based on the groupings shown in the Bill(s) Of Reinforcement. These totals shall be rounded up to the next whole pound. The total given in the "Estimate" column(s) of the Table of Estimated Quantities shall be the sum of the individual totals rounded up to the next whole 10 pounds. Use the average bar length, as shown on the plans, in the calculation of set bars. The weights listed in the tables in Section 4.19 - Reinforcing Steel shall be used to three decimal places.

The following table can be used to calculate the weight of spiral reinforcing steel per vertical foot of column or drilled shaft.

Table of Spiral Reinforcement Weight (lb/ft)

Core Dia	Pitch - #5 bar					Pitch - #4 bar					Pitch - #3 bar					
	2"	2 1/4"	2 1/2"	2 3/4"	3"	2"	2 1/4"	2 1/2"	2 3/4"	3"	1 3/4"	2"	2 1/4"	2 1/2"	2 3/4"	3"
12"	19.7					12.6					8.1	7.1				
18"	29.5	26.2	23.6	21.4	19.7	18.9	16.8	15.1	13.7	12.6	12.1	10.6	9.4	8.5	7.7	7.1
21"	34.4	30.6	27.5	25.0	22.9	22.0	19.6	17.6	16.0	14.7	14.2	12.4	11.0	9.9	9.0	8.3
27"	44.2	39.3	35.4	32.2	29.5	28.3	25.2	22.7	20.6	18.9	18.2	15.9	14.2	12.7	11.6	10.6
33"	54.1	48.1	43.1	39.3	36.1	34.6	30.9	27.7	25.2	23.1	22.3	19.5	17.3	15.6	14.2	13.0
39"	63.9	56.8	50.9	46.4	42.7	40.9	36.5	32.8	29.8	27.3	26.3	23.0	20.4	18.5	16.8	15.4
45"	73.8	65.5	58.7	53.6	49.2	47.3	42.2	37.8	34.4	31.5	30.3	26.6	23.6	21.3	19.4	17.7

The weights given in the preceding table include wire for regular loops only. Weight must be added for the one and one-half turns top and bottom required for embedment. The weight of the combined top and bottom embedments is equivalent to one-half the tabular weight for a 2" pitch. The weight of spiral spacers will not be calculated. For core diameters not shown in the table, the following equation can be used to determine the weight of the spiral:

$$Weight\,(lb) = \pi\left(\frac{Core}{12}\right)(N_t)(W_b)$$

Where: Core = Core diameter (in)
N_t = Number of turns
W_b = Bar weight (lb/ft)

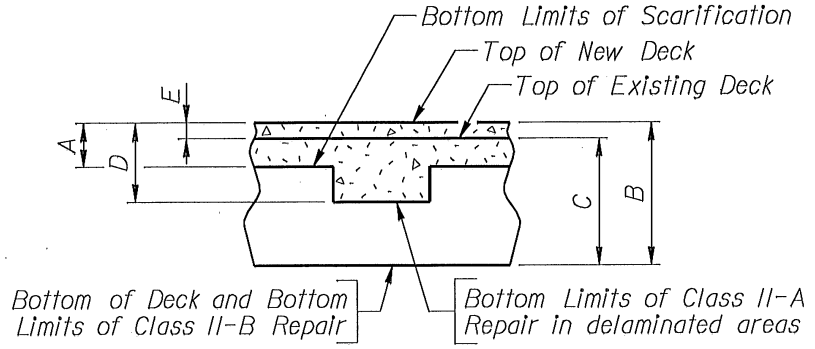
Bridge Deck Repair (Modified System) - All classes of repair are defined in the Standard Specifications. If a bridge deck evaluation is available, it shall be used to figure the delaminated areas requiring Class II-A Repair. If a bridge deck evaluation is not available or if the deck has an existing overlay, the amount of Class II-A Repair shall be determined by the Squad Team Leader. Multiple passes of Class I-B Repair must be stated on the plans.

Class II-B Repair = 5 SY or 10% of SY of delaminated areas (whichever is greater)

Class II-A Repair = SY of delaminated areas with reduction for Class II-B Repair

Class I-B Repair = SY of taper or removal of existing overlays. This SY is multiplied by 2 (2 passes) for tapers of overlays with an average depth greater than 13".

Class I-A Repair = SY of deck. If the deck is to receive longitudinal tapers, Class I-A Repair = SY of entire deck minus SY Class I-B Repair (1 pass).



Modified Concrete - Based on using the Bridge Deck Repair (Modified System) quantities to be shown in the Table of Estimated Quantities. Thickness of the new concrete shall be to four decimal places. Dimensions A, B, C, D, and E should be input in feet to four decimal places in the following formulas.

A = Thickness of new concrete (ft)

B = Thickness of new deck (Outside of taper area) (ft)
C = Thickness of existing deck (ft)
D = (One-half of C) plus E (ft)
E = B minus C
F = Avg. thickness of Class I-B Repair
G = Avg. thickness of new concrete

$$\text{Class I-A Volume} = \left[Area(SY)_{Class\,I-A}\right]\left(\frac{1}{3}A\right)$$

$$\text{Class I-B Volume} = \left[Area(SY)_{Class\,I-B}\right]\left(\frac{1}{3}G\right)$$

$$\text{Class II-A Volume} = \left[Area(SY)_{Class\,II-A}\right]\left(\frac{1}{3}(D-A)\right)$$

$$\text{Class II-B Volume} = \left[Area(SY)_{Class\,II-B}\right]\left(\frac{1}{3}(B-A)\right)$$

For Class II-A repairs with in a taper

$$\text{Class II-A Volume} = \left[Area(SY)_{Class\,II-A}\right]\left(\frac{1}{3}(D-F)\right)$$

Paint Repair - Estimate the area of structural steel, bridge railing, or piles to be painted and include this area in the "Estimate" column of the Title Sheet quantity block for this item. Use of the AISC Manual may be helpful for determining surface areas of wide flange beams.

Steel Overhead Sign Support - Do not include any steel not specifically billed on the Bridge Program sheets (i.e., luminaire mast arms are not included, but luminaire support arms usually are). Some of the commonly overlooked steel components are field splice flanges, cap plates, stiffeners, luminaire support plates, anchor rings, and anchor bolts. Refer to the publications mentioned in Structural Steel for pipe weights. Field splice flanges may utilize 150 lb slip-on flanges (See following table for weights), otherwise, calculate from dimensions shown on the plans. Use plate or bar call-out dimensions for determining weights. Add 2% of total calculated weight for miscellaneous nuts and bolts before rounding up to the nearest 200 pounds.

Table Of 150 Lb Slip-On Flange Weight													
Nominal Pipe Dia (In)	3	32	4	5	6	8	10	12	14	16	18	20	24
Weight (Lb)	9	11	13	15	17	28	40	61	83	106	109	148	204

Splash Boards - This item should be present where railroad switching or frequent railroad activity is performed for new railroad overpass structures or major rehabilitations of existing structures over a railroad.

Doweled Anchor Joints - The linear foot measurement of this bid item is based on the linear feet of joint face regardless of the number of rows of doweled anchor joints.

Bridge Deck Membrane - The area of membrane can be determined from the following formula:

$$Area\,(SY) = \frac{[CRW + (2 \times AD)] \times L}{9}$$

Where:
- CRW = clear roadway width in feet (ft)
- AD = asphalt depth in feet (ft)
- L = bridge length in feet (ft)