

SECTION 602 - REINFORCING STEEL

602.01 Description. This work includes furnishing, storing, and placing reinforcing steel (also rebar or bar) according to the contract.

602.02 Materials. Reinforcing steel shall conform to Subsection 709.01 - Reinforcing Steel.

602.03 Order Lists and Bending Diagrams. The Contractor shall submit two (2) copies of the reinforcing steel order lists and bending diagrams to the Engineer. The Contractor shall be wholly and completely responsible for the accuracy of the lists and diagrams.

602.04 Storage, Surface Condition and Protection of Reinforcement. The Contractor shall store reinforcing steel above the surface of the ground upon platforms, skids, or other supports. The Contractor shall protect the reinforcing steel from mechanical damage and surface deterioration caused by exposure to conditions producing rust. Reinforcement shall be free of mortar, oil, dirt, excessive mill scale, scabby rust, and other coatings that would destroy or reduce the bond. Reinforcement shall also be free from injurious defects such as cracks and laminations.

602.05 Bending. The Contractor shall bend the reinforcing steel cold. Bars partially embedded in concrete shall not be field bent except shown in the contract or permitted by the Engineer. The Contractor shall use only competent workers for cutting and bending. The Contractor shall provide the proper appliances for such work.

The Contractor shall bend or straighten the bars according to the contract. The Contractor shall not use bars having cracks or splits.

602.06 Placing and Fastening. The Contractor shall place the reinforcing steel accurately. During the placing of concrete, the Contractor shall hold the reinforcing steel firmly by accepted supports in the position shown in the contract. The Contractor shall fasten the reinforcing steel securely together. The Contractor shall tie the bars at the intersections. If the spacing is less than one (1) foot in each direction, the Contractor shall tie alternate intersections. The Engineer will inspect and accept the reinforcing steel placed before the Contractor places concrete. The Contractor shall weld according to Section 501 - Steel Structures. This includes shop welding, field welding, and temporary welding.

The Contractor shall maintain the distances from the forms by stays, blocks, ties, hangers or other accepted supports.

The Contractor shall maintain the proper clearance between the reinforcing steel and the boundaries of the concrete by:

- (1) precast mortar blocks: *|
 - (a) of equal compressive strength as the surrounding concrete that *|
the Contractor will place and *|
 - (b) accepted shape and dimensions or *|
- (2) by accepted metal chairs. *|

Steel wire bar supports that will be in contact with the exterior of the concrete shall conform to Class 1 bar supports specified in CRSI "Manual of Standard Practice".

The Contractor shall separate the layers of bars by precast mortar blocks *| or by equally suitable devices. The Engineer will not permit the use of *| pebbles, pieces of broken stone or brick, metal pipes or wooden blocks. *|

The Contractor shall straighten the mesh reinforcement shipped in rolls *| into flat sheets before the Contractor places the mesh. *|

The practices and procedures followed in placing and fastening *| reinforcing steel shall conform to the current CRSI editions of "Placing Reinforcing Bars" and "Manual of Standard Practice".

The Contractor shall tie bundled bars together at not more than six (6) *| feet centers. The Contractor shall limit the maximum number of bars in a *| bundle to two (2) effective bars for No. 14 and No. 18 and three (3) effective *| bars for other sizes. The Engineer will not permit tack welding on *| reinforcing bars. *

(A) Splicing. The Contractor shall furnish bars in full lengths shown *| in the contract except the following reinforcing bars: |

- (1) The Contractor shall splice bars longer than commercially *| available lengths by lapping or butt-joining the ends of the bars, |
- (2) The Contractor shall splice bars smaller than No. 14 in size by *| lapping or by butt-joining the ends of the bars, and |
- (3) The Contractor shall splice Nos. 14 and 18 bars by butt- *| joining. *

The Contractor shall avoid splicing of bottom reinforcement at or *| near the centerline of the span and splicing of top reinforcement at or *| near continuous support. *

The Contractor shall submit the location of splices for acceptance *| by the Engineer. The Contractor shall locate splices in areas of low *| stresses whenever feasible. The Contractor shall stagger the splices as *| far as possible. Splices shall be at least forty (40) bar diameters. The *|

member of bars spliced at sections normal to the axis of the member shall not exceed thirty-three (33) percent of the total main reinforcement in the member. If bars cross construction joint, the Contractor shall anchor each end of the reinforcing steel forty (40) bar *| diameters each side of the joint. *

(B) **Lapped Splices.** The length of lapped splices for Grade 40 bar reinforcement shall conform to Table 602-I. The lengths of lapped *| splices for Grade 60 bar reinforcement shall be fifty (50) percent *| greater than the lengths required for Grade 40. The Contractor shall *| increase the length of lapped splice of each bar of a bundled bar set *| twenty (20) percent over the requirements of the individual bar. *

The Engineer will not permit lapped splices at locations where the *| concrete section is not sufficient to provide: *

(1) a minimum distance of one and a half (1-1/2) bar diameters or *|

(2) one and a half (1-1/2) times the size of the maximum aggregate *|

whichever is larger, between the splice and the nearest adjacent *| bar. *

The Contractor shall not impair the required clearance to the *| surface of the concrete. *

In lapped splices, the Contractor shall place the bars in contact *| and wire the bars together. The Engineer will not permit non-contact *| lapped splices. *

TABLE 602-I - LENGTH OF LAPPED SPLICES*		
Bar Size	Minimum Lap Top Bars ¹	Length, Inches Other Bars
3	14	12
4	19	14
5	24	17
6	31	22
7	42	30
8	55	39
9	70	50
10	88	63
11	109	78
14, 18	Lap splices not permitted	-

* Table based on $f'_c = 3,000$ psi and $f_y = 40,000$ psi.

¹ Horizontal bars with more than twelve (12) inches of concrete below in a pour.

(C) **Butt-Jointed Splices.** The Contractor shall butt-weld or connect the butt-jointed splices mechanically. The Contractor shall not locate splices on bent portions of bars. Butt-jointed splices shall resist the flexural and other load effects due to handling and placing of the reinforcement, and during construction. Completed butt splices shall develop not less than ninety (90) percent of the specified tensile strength of the unspliced bars.

(1) **Welded Splices.** The Contractor shall splice reinforcing steel by welding according to "Reinforcing Steel Welding Code," AWS D1.4, with modifications and additions as specified below. If the contract refers to AWS D1.1 "Structural Welding Code", the Contractor shall modify the requirements in Section 501 - Steel Structures.

When the Contractor uses an arc welding process, the Contractor shall join the bar sizes No. 6 and larger only with direct butt splices according to AWS D1.4. The Contractor may join bar sizes No. 5 and smaller by the splices recommended by AWS D1.4.

The Contractor shall measure the temperatures by temperature showing crayons or other means.

Electrodes for the shielded metal-arc process shall be the low hydrogen classifications according to AWS D12.1. The electrodes manufacturers shall furnish to the Engineer the certificates of Compliance according to the contract.

The Contractor shall dry the low hydrogen electrodes for at least two (2) hours between four hundred fifty (450) and five hundred (500) degrees Fahrenheit before the Contractor uses the electrodes. The Contractor shall store the electrodes immediately after drying in a storage oven held at a temperature of at least two hundred fifty (250) degrees Fahrenheit. The Contractor shall redry the electrodes that the Contractor will not use within four (4) hours after removal from a drying or storage oven before use. The Contractor shall not use wet electrodes.

If the Contractor uses gas metal-arc process with carbon dioxide shielding, the Contractor shall weld according to "Special Ruling, Gas Metal-Arc Welding with Carbon Dioxide Shielding," AWS SR1, and as modified by Section 501 - Steel Structures. The qualification of procedures and welders shall be as specified below. The classification of electrode used shall be as specified in AWS D1.4 Certificates of Compliance. The Contractor shall furnish to the Engineer specifications from the electrode manufacturer.

On direct butt splices, the Contractor shall gouge, chip, or remove the root of the initial weld to sound metal before the Contractor starts welding on the second side.

The Contractor shall prepare the welding procedure, welder and welder operator qualifications as specified by AWS D1.4. The tensile specimens for welding procedure, welder and welder operator qualifications shall develop ninety (90) percent of the minimum tensile strength as specified for the reinforcing steel. The weld quality shall meet the requirements of AWS D1.1 and as modified by Section 501 - Steel Structures. The joint penetration shall be complete.

Costs for welding procedure, welder, and welder operator qualifications, including radiography, shall be at no cost to the State.

The Engineer will do and assume the cost of radiographic inspection of the weld splices. The Contractor shall pay for the cost of retesting corrected defective welds.

The Contractor shall schedule the fabrication so that the Contractor can test no less than ten (10) percent of the total number of welds at each inspection. The Contractor shall notify the Engineer at least twenty-four (24) hours before the welds are ready for radiographic inspection.

The Engineer will reject defective welds. The Contractor shall correct the welds by accepted methods at no cost to the State.

For radiographing of qualification specimens and production splices, the direction of radiation shall be normal to the length of the root of the weld. The Engineer will establish the adequacy of the radiographic technique by placing a square carbon steel bar, of suitable length, next to the reinforcing bar, and including both bars in the radiograph. The square bar size, shall be the nearest standard size, within one-sixteenth (1/16) inch, to the dimension that is ninety (90) percent of the diameter of the reinforcing bar inspected. The Engineer will place a penetrometer on the square bar next to the location of the weld. The number of the penetrometer will be as required by the thickness of the square bar. The Engineer will consider the technique for radiography satisfactory if the penetrometer number and smallest hole are visible on the radiograph.

(2) Mechanical Butt Splices. Mechanical butt splices may be the sleeve-filler metal type or the sleeve-threaded type at the option of the Contractor.

The mechanical butt splices used shall be of accepted design. The Engineer will base acceptance of a new design upon technical data. This includes test results, proof of satisfactory performance submitted by the manufacturer, results of tests by the Engineer on sample splices, and splice material furnished by the manufacturer. The Contractor shall resubmit a design for acceptance if changes in the details or materials occurs.

Completed mechanical butt splices shall develop not less than ninety (90) percent of the specified minimum ultimate tensile strength of the unspliced reinforcing steel.

The total slip of the reinforcing steel within the splice sleeve after loading in tension to thirty thousand (30,000) pounds per square inch and relaxing to approximately zero (0) load shall not exceed the following, measured between gage points clear of the splice sleeve:

- (a) 0.01-inch for bars No. 14 or smaller and
- (b) 0.03-inch for bar No. 18.

The dimensions and type of steel used in the manufacture of the splice sleeve shall be such that the ultimate tensile strength of the sleeve is greater than the other components of the completed mechanical butt splice.

Splicing procedures shall be according to the manufacturer's recommendations, except as modified in this section. The Contractor shall make splices using manufacturer's standard equipment, jigs, clamps, and other required accessories.

The Contractor shall cut the ends of reinforcing steel nominally square.

Splice sleeves shall have a clear coverage of not less than one and three-quarters (1-3/4) inches measured from the surface of the concrete to the outside of the sleeve. The Contractor shall adjust or relocate the stirrups, ties, and other reinforcement. The Contractor shall place additional reinforcement if necessary to provide planned clear coverage to reinforcement.

The Contractor shall submit a certificate of compliance to the Engineer for each shipment of splice material with the following:

- (a) The type or series identification of the splice material and for sleeve-threaded type sleeves, the heat treatment lot number.
- (b) The reinforcing steel grade and size number to be spliced by the material.
- (c) A copy of the manufacturer's catalog giving complete data on the splice material and procedures.
- (d) A statement that the splice material will develop not less than ninety (90) percent of the specified minimum ultimate tensile strength of the unspliced reinforcing bar. Also, the Contractor shall comply with the total slip requirements and other requirements in this contract.

(e) A statement that the splice material conforms to the details and materials of a specific accepted design.

The sleeve-filler metal type mechanical butt splice includes a steel splice sleeve. The steel splice sleeve shall fit closely over the reinforcing steel with ferrous filler metal in the annular space between the rebars and the sleeve and between the ends of the rebars. The Contractor shall melt the filler metal by an exothermic reaction. The splicing process shall not fuse the filler metal with the rebars nor heat the rebars to their melting point. The Contractor may heat the ends of the rebars to their nominal melting point at mid-length of the splice sleeve.

The Contractor shall remove oversize projections and distortions of the rebars within the sleeve by grinding.

The Contractor shall clean the surfaces of the rebars within the sleeve and for two (2) inches beyond the end of sleeve of slag, mill scale, rust and other foreign materials. The Contractor shall clean by an oxyacetylene torch followed by power wire brushing or by abrasive blasting.

Immediately before adding filler material to the splice sleeve the Contractor shall preheat the entire splice sleeve to three hundred (300) degrees Fahrenheit \pm fifty (50) degrees Fahrenheit. The Contractor shall not direct the flame inside the splice sleeve.

In the completed splice, sound, non-porous filler metal shall be visible at both ends of the splice sleeve and at the tap hole in the center of the sleeve. The Contractor may recess the filler metal as established by the packing ring. Void limits shall conform to Table 602-II - Void Limits.

The sleeve-threaded type of mechanical butt splices includes a steel splice sleeve with tapered interior threads that joins the rebars with matching tapered threads. The Contractor shall taper the threads so that cross threading will not occur during assembly.

The Contractor shall mark each splice sleeve with the heat treatment lot number.

After completion of assembly, the Contractor shall tighten the splice to a torque value of not less than two hundred (200) foot-pounds.

The Contractor shall submit mechanical splice procedures in rebars for acceptance that the Contractor will use. The Contractor shall qualify the operators employed to make such splices in rebars by tests done on sample splices of the type the Contractor will use. The Contractor shall have the above accepted before the Contractor makes the actual splices.

The Engineer may accept mechanical splice procedures and operators based upon acceptance of previous tests done on sample splices. *

Completed sample splices shall be at least forty-two (42) inches long with the splice at mid-length.

The Contractor shall make and test the sample splices in the presence of the Engineer. When a commercial agency tests the samples, the Engineer will witness the test. *

The testing on sample splices shall conform to the contract.

The Contractor shall submit an operator qualification test for each mechanical splicing position and procedure that the operator will use on the work. *

Each operator qualification test for mechanical splices includes two (2) sample splices in the largest bar size that the operator will splice. The operators may qualify for splicing No. 18 bars by test on No. 14 bars. *

The Contractor shall consider each qualified operator test for mechanical splicing bars to also qualify the same operator on bar sizes smaller than those used in making the tests. *

Each operator applying for qualification shall make mechanical splices, without assistance and shall use bars with the same:

- (a) ASTM designation,
- (b) manufacturer's series of sleeves,
- (c) filler metal cartridges, and
- (d) equipment that the operator will use during the work. *

The Contractor shall consider the operator qualified if the operator makes mechanical splices for the procedure qualification test. The Contractor may provide simultaneous operator and procedure qualification tests. *

Each mechanical butt splice procedure qualification test includes two (2) sample splices in the largest bar size that the Contractor will splice with the procedure. *

The Contractor shall test the sample mechanical splices made *|
for qualifying mechanical splicing procedures and operators in *|
tension.

The Engineer will make job control tests during the progress *|
of the work. Job control tests include physical testing of sample *|
mechanical butt splices fabricated and tested by the Contractor and
nondestructive testing done by the Engineer.

The Contractor shall make sample mechanical butt splices for *|
job control tests including other sample splices for qualification. *|

The Contractor shall fabricate the sample mechanical butt *|
splices for job control tests at the jobsite. *|

Sample mechanical butt splices for job control tests shall be *|
of the two (2) types described herein. *|

The Contractor shall fabricate the special control sample *|
splices from short lengths of reinforcing bar resulting in a total *|
length of forty-two (42) inches. Cut-out control sample splices
include completed splices cut to a total length of forty-two (42) *|
inches from full length reinforcing bars placed in the work. The *|
Contractor shall test both types of control sample splices *|
according to the provisions for Mechanical Splicing. |

The Contractor shall furnish and test the special control *|
sample splices as follow: *|

(a) The Contractor shall furnish sufficient lengths of rebar. *|
The Contractor shall fabricate not less than three (3) special |
control sample splices for each one hundred (100) splices or
fraction that the Contractor will make in each size of rebar *|
for the work. |

(b) The Engineer will designate the lot of splices made for
the work represented by each set of three (3) special control
sample splices.

(c) The operator shall fabricate the special control sample *|
splices. At the time designated by the Engineer, the operator *|
shall use the same splice materials, position, location, *|
equipment, and procedures that the operator will use on the *|
work site. *|

(d) The Contractor shall remove, identify, and test the *|
special control sample splices from their temporary positions. *|

(e) If the special control sample splice in the group of three (3) samples fail to meet the test requirements, the Contractor shall furnish and test cut-out control sample splices as ordered by the Engineer. The Contractor may submit other evidence to the Engineer to prove that the lot of splices represented by the above specified samples complies with the contract. The Engineer shall be the sole judge of the compliance of the lot of splices with said test requirements. *

When the Engineer orders in writing that the Contractor requires cutout control sample splices, the Contractor shall furnish and test cut-out control sample splices. This splice is an addition to cut-out control sample splices because of failure of special control sample splices. The Engineer will designate the lot of splices made for the work represented by the cut-out control sample splices. The designated lot will not include splices in a previously accepted lot. *

The Contractor shall furnish and test cut-out control sample splices cut from full length rebars placed in the work according to the following: *

(a) The Contractor shall remove, identify, and test the two (2) cut-out control sample splices from each lot in question from their location in the job. *

(b) The Contractor shall either: *

1. replace the full length rebars cut for furnishing cut-out control sample splices or *

2. furnish additional lengths of rebars and resplice the said cut rebars as required to restore the reinforcing bars to the full length shown in the contract. *

If the cut-out control sample splice cut from rebars placed in the work fail to meet the test requirements, the Engineer will reject the entire lot of splices represented by the cut-out control sample splices according to Subsection 106.07 - Unacceptable Materials. *

Mechanical splicing may be subject to nondestructive testing according to the contract. *

If the contract requires nondestructive testing, the Contractor shall provide sufficient access facilities to permit the Engineer to do the tests. *

For sleeve-filler metal type splices, the voids of the filler metal in the annular space between the rebars and the splice sleeve shall not exceed the following: *

(a) Voids are those voids that the Engineer may measure by a probe inserted in each end of the splice sleeve. *

(b) The Contractor shall establish: *

1. the void area from the void end width measured next to the end of the splice sleeve and *

2. the void depth measured from the deepest point of the void to the end of the splice sleeve.

3. The Contractor shall compute the void area from the formula: *

$$\text{Void Area} = \text{void width} \times (\text{void depth} - 3/16 \text{ inch}).$$

4. The Contractor shall decide the low filler metal around the full circumference by the average depth measured from the bottom of the void to the end of the splice sleeve. *

5. Voids shall not exceed the limits given in Table 602-II - Void Limits. |

TABLE 602-II - VOID LIMITS		
Bar Size No.	Void Area Within 1/2 of Sleeve Square Inches	Vertical Splice, only, Full Circumference Low Inches
8	1.02	1/2
9	1.02	1/2
10	1.03	7/16
11	1.53	9/16
14	2.15	5/8
18	3.00	5/8

The Engineer will do nondestructive testing, except access facilities, without charge to the Contractor. *

(B) Lapping. Sheets of mesh or bar mat reinforcement shall overlap each other sufficiently to maintain a uniform strength. The Contractor shall fasten the sheets of mesh or bar mat reinforcement securely at the ends and edges. The edge lap shall not be less than one (1) mesh in width. *

602.07

602.07 **Method of Measurement.** The Engineer will not measure reinforcing steel when contracted on a lump sum basis. *|
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The Engineer will base the weights calculated upon Table 602-III. *

TABLE 602-III - BAR DESIGNATION, WEIGHT AND AREA		
Bar No.	Weight Per Linear Foot Pounds	Area Square Inches
3	0.376	0.11
4	0.668	0.20
5	1.043	0.31
6	1.502	0.44
7	2.044	0.60
8	2.670	0.79
9	3.400	1.00
10	4.303	1.27
11	5.313	1.56
14S	7.650	2.25
18S	13.600	4.00

The Engineer will not make allowance for clips, wire or other material used for fastening reinforcement in place. *|
*|

The Engineer will not measure mesh reinforcement. *

602.08 **Basis of Payment.** The Engineer will pay for the accepted reinforcing steel on a lump sum basis. *|
*|

The price shall be full compensation for furnishing and testing sample splices and completed splices cut from rebars placed in the work, including replacing or resplicing rebars to the length shown in the contract; furnishing access facilities to permit the Engineer to do the tests, and for losses or delays to the Contractor resulting from the sampling and testing specified herein; furnishing labors, equipment, materials, tools and incidentals necessary to complete the work. *|
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The Engineer will make payment under:

*|

Pay Item	Pay Unit
Reinforcing Steel in Bridges (___ pound)	Lump Sum
Reinforcing Steel other than in Bridges (___ pound)	Lump Sum
Reinforcing Steel for _____ (___ pound)	Lump Sum

The Engineer will not pay for mesh reinforcement. The Engineer will *|
consider them incidental to the various contract items. *|