

**SECTION 415**  
**REINFORCING FOR CONCRETE**

**415-1 Description.**

Furnish and place steel and fiber reinforced polymer (FRP) reinforcing of the quality, type, size, and quantity designated. Obtain all FRP reinforcing bars from a producer on the Department's Production Facility Listing.

**415-2 Materials.**

Meet the following requirements:

Steel Bar Reinforcement .....	931-1.1
Steel Welded Wire Reinforcement .....	931-1.2
FRP Bar Reinforcement .....	932-3

**415-3 Protection of Material.**

**415-3.1 Steel Reinforcing:** Store steel reinforcement above the surface of the ground, upon platforms, skids, or other supports, and protect it from mechanical injury and surface deterioration. Ensure that the steel reinforcement is free from loose rust, scale, dirt, paint, oil, and other foreign material prior to incorporation into the work.

**415-3.2 Fiber Reinforcing Polymer (FRP) Reinforcing:** Store FRP reinforcement above the surface of the ground, in boxes or upon platforms, skids, or other supports, and protect it from mechanical injury and direct exposure to UV light. Ensure that the FRP reinforcement is free from dirt, paint, oil, and other foreign material prior to incorporation into the work.

**415-4 Bending, Splicing, and Cutting.**

**415-4.1 Steel Reinforcing:** Fabricate reinforcing bars as prescribed in the CRSI Manual of Standard Practice. Shop bend the reinforcement cold to the shapes indicated in the Plans. Do not bend the reinforcement to shape in the field. Minor bending adjustments may be performed in the field with the approval of the Engineer.

Do not hot bend or straighten, weld, or thermal cut reinforcing steel.

**415-4.2 Fiber Reinforcing Polymer (FRP) Reinforcing:** No field fabrication of FRP reinforcing bars is permitted except tying and field cutting per ACI 440.5. Do not bend or straighten, couple, thermal cut, or shear cut FRP reinforcing bars.

**415-5 Placing and Fastening.**

**415-5.1 General:** Unless otherwise specified in the Contract Documents, the tolerance for bar spacing is plus or minus 1 inch from the plan position and the tolerance for concrete cover is minus 1/4 inch or plus 1/2 inch from the plan dimensions. Construct all tie patterns referenced by this Section in accordance with the CRSI Manual of Standard Practice.

**415-5.2 Concrete Blocks for Spacing:** Use precast concrete blocks to space and support the reinforcing bars. Use concrete blocks with a strength equal to or greater than the concrete in which they are to be placed and have wires cast into them for fastening to the reinforcing bars. Moist-cure the blocks for at least three days.

Submit a certification verifying the class of concrete used to fabricate the concrete blocks, and identifying the batch and load of concrete from which the concrete blocks were cast.

**415-5.3 Tying:**

**415-5.3.1 Steel Reinforcing:** Tie steel reinforcing using pliable steel wire that readily bends and twists without breaking and that provides a tie of sufficient strength to hold the steel reinforcing in its proper position. Tie stainless reinforcing steel using plastic, polymer, or nylon coated pliable steel wire; or stainless steel wire meeting the requirements of ASTM A276, UNS S31600.

**415-5.3.2 Fiber Reinforcing Polymer (FRP) Reinforcing:** Tie FRP reinforcing using plastic, polymer, or nylon coated pliable steel wire that readily bends and twists without breaking and that provides a tie of sufficient strength to hold the FRP reinforcing in its proper position.

**415-5.4 Splices:** Where splices are authorized, rigidly clamp the bars or tie them in a manner meeting the Engineer's approval. Use the lap splice length as shown on the Plans.

**415-5.4.1 Steel Reinforcing:** Do not use welded splices for steel reinforcing except as specifically authorized by the Engineer and meeting the requirements of AWS D 1.4 Structural Welding Code - Reinforcing Steel.

Use mechanical couplers or splice devices for steel reinforcing that are listed on the Department's Approved Product List (APL).

**415-5.4.2 Fiber Reinforcing Polymer (FRP) Reinforcing:** Do not use mechanical couplers for FRP reinforcing. Use lap splices only.

#### **415-5.5 Footings:**

**415-5.5.1 Supports:** Support footing mat reinforcing with concrete blocks having dimensions not greater than 4 by 4 inches by plan clearance. Fasten concrete blocks to the steel using the cast-in wires.

**415-5.5.2 Tolerances:** Place footing mat reinforcing within 1/2 inch vertically from the plan bottom clearance and within 1 inch from the plan side clearance.

**415-5.5.3 Tying:** Tie footing mat reinforcing with a double-strand single tie at all intersections on the periphery and at alternate intersections within the mat.

#### **415-5.6 Dowel Bars for Columns and Walls:**

**415-5.6.1 Supports and Positioning:** Position dowel bars projecting into columns and walls so as to allow splicing of the vertical bars to the dowels and to tie the dowel bars in their plan position. Support the dowel bars by a rigid template such that concrete placement does not disturb their position. Support the reinforcing prior to placement of the footing concrete and do not insert dowel bars into the plastic concrete.

**415-5.6.2 Tolerances:** Place the dowels within 1/2 inch of their plan position and with a side clearance tolerance not exceeding 1/4 inch.

#### **415-5.7 Verticals and Hoops for Columns:**

**415-5.7.1 Spacing-off from Side Forms:** Space column reinforcing bars from the side forms by concrete blocks of dimensions not exceeding 2 inches by 2 inches by clearance dimension. Securely fasten each block to the reinforcing.

##### **415-5.7.2 Tolerances and Clearance:**

1. Column Verticals: Place column verticals within 1/2 inch of their plan position. Ensure that the side form clearance is within 1/4 inch of the specified clearance.

2. Column Hoops: Place every hoop within 1 inch of the plan position for the specific hoop, with no accumulation of such tolerance caused by the spacing between any two hoops. Ensure that side form clearance for any hoop is within 1/2 inch of its specified clearance.

**415-5.7.3 Tying:** Tie the column hoops to the column verticals at each intersection, by a cross tie or figure 8 tie.

**415-5.8 Wall Reinforcing (Not Including Dowel Bars):**

**415-5.8.1 Supports:** Space wall reinforcing bars from the side forms by concrete blocks of dimensions not greater than 2 inches by 2 inches by clearance dimensions. Fix the spacing between wall mats by means satisfactory to the Engineer.

**415-5.8.2 Tolerance:** Except when necessary to clear a fixture, place reinforcing bars within 1 inch of plan position. Ensure that the number of bars in any affected unit is as specified, and place the remainder of the bars (not thus affected) within 1 inch of plan location.

**415-5.8.3 Tying:** Tie retaining wall reinforcing bars with a cross tie or figure 8 tie at each intersection on the periphery and at every third intersection within the mat. If workmen use the reinforcing as a ladder, provide additional ties as directed by the Engineer.

Tie noise and perimeter wall reinforcing bars with a single tie at each intersection on the periphery and at every third intersection within the mat.

**415-5.9 Beams and Caps:**

**415-5.9.1 Supports:** Maintain bottom clearances by approved heavy beam bolsters. Support additional layers of main longitudinal reinforcing bars from the lower layers by heavy upper-beam bolsters, placed directly over low supports.

Begin the spacing of beam bolsters at not more than 2 feet from the end of the beams or caps and space the additionally required bolsters at not more than 4 feet.

Use concrete blocks, having dimensions not greater than 2 inches by 2 inches by specified clearance, fastened to the reinforcing bars by the cast-in wires, for spacing the upper main longitudinal bars below the top bars. Maintain the side clearance by concrete blocks, having dimensions not greater than 2 inches by 2 inches by required clearance, fastened to the reinforcing bars by the cast-in wires.

**415-5.9.2 Tolerances:** Place the main longitudinal reinforcing bars so as to provide a bottom and top clearance within 1/4 inch of the plan vertical dimensions for all layers. Space the bars from side forms within 1/2 inch of the specified spacing.

Place stirrups within 1 inch of the plan position for each individual stirrup and do not allow the tolerance to accumulate.

**415-5.9.3 Tying:** Tie all intersecting bars with a double-strand single tie.

**415-5.10 Deck Slabs:**

**415-5.10.1 Supports:**

1. Bottom Mats: Support the bottom mat of reinforcing bars using slab bolsters or concrete blocks. Use one row of slab bolsters placed 6 inches from the edge of the slab and two rows down each deck section between beams. Do not allow the spacing between rows to exceed 4 feet, measured center to center.

Use concrete blocks 2 inches by 2 inches by clearance dimensions. Space concrete blocks 4 feet on center as a maximum.

2. Top Mats: Support the top mats of reinforcing bars by either continuous or individual high chairs. Provide high chairs along both sides of each beam and approximately 6 inches back from the edge of the beam. Place the outside row of high chairs 6 inches from the edge of the slab. If using individual high chairs, do not allow the longitudinal spacing to be greater than 4 feet.

As an alternate to the above, on prestressed beam construction, the Contractor may support the top mat of reinforcing bars on the shear connectors bent to the proper elevation with one line of high chairs centered between the beams.

3. Truss Bars: Support truss bars at each end of the top bends by continuous high chairs or by individual high chairs spaced longitudinally at not more than 4 feet.

**415-5.10.2 Tolerances:** Ensure that top and bottom clearances are within 1/4 inch from those shown in the Plans.

Ensure that end and bottom clearances are within 1/4 inch from those shown in the Plans.

Ensure that end and edge clearances are within 1/4 inch of the clearance specified.

Place curb bars within 1/4 inch in any direction of the plan position.

**415-5.10.3 Tying:** Tie all reinforcing bars in each layer with a double-strand single tie at every intersection on the periphery and at every third intersection in the interior area. If encountering difficulty in maintaining the reinforcing bars in position during the placing of concrete, tie additional intersections as necessary to hold the reinforcing bars secure.

#### **415-5.11 Box Culverts:**

##### **415-5.11.1 Supports:**

1. Bottom Slabs: In the bottom slabs of box culverts, provide supports for single-mat reinforcing bars and for bottom-mat reinforcing bars, including placement and spacing, as specified for footing mat steel in 415-5.5. In addition, where the Plans call for more than one mat of reinforcing bars in the bottom slab of the culvert, support the top mat away from the bottom mat, either by upper beam bolsters or by other means satisfactory to the Engineer.

2. Walls: Place, space and support the reinforcing bars in walls of box culverts in accordance with the requirements of 415-5.8.

3. Top Slabs: In the top slabs of box culverts, support the bottom mats of reinforcing bars by a row of slab bolsters 12 inches from the inside face of the walls and with additional rows of bolsters at spacings not exceeding 4 feet, center to center. As an exception, unless the Engineer deems the use of the slab bolsters as necessary to obtain proper support, the Contractor may use concrete blocks as the supporting device. Use blocks of dimensions not greater than 2 inches by 2 inches by the required clearance, with spacings not exceeding 4 feet in any direction. Fasten blocks to the reinforcing steel by the cast-in wires.

4. Truss Bars: Support truss bars as specified in 415-5.10..

**415-5.11.2 Tolerances:** Use tolerances in placing the reinforcing bars in box culvert slabs as specified for deck slabs in 415-5.10. Use tolerances for placing bars in walls as specified in 415-5.8.

**415-5.11.3 Tying:** Tie reinforcing bars in box culverts as specified for deck slabs in 415-5.10.

**415-5.12 Cleaning:** Before placing any concrete, clean all mortar from the reinforcement.

##### **415-5.13 Bar Supports:**

**415-5.13.1 General:** Provide reinforcing bar supports manufactured in accordance with all requirements of the CRSI Manual of Standard Practice. Use bar supports of adequate strength to withstand a 300 pound concentrated load without permanent deformation or breakage, with deflection less than 5% of the support height.

Ensure that no more than 5% of the reinforcing bar supports exhibit unsatisfactory performance, breakage, or permanent deformation during bar tying and/or concrete placement operations. If a bar support does not achieve this level of performance, reduce the average spacing between bar supports by 15%, or remove that product from use on the job.

Ensure that bar supports do not move during concrete placing operations. To prevent movement, tie supports to the reinforcing bars.

When using bar supports on corrugated metal stay-in-place forms, use supports specifically designed for the form being used.

For structural elements located in extremely aggressive environments, do not use metal bar supports in contact with removable forms or floor surfaces to support reinforcing bars.

**415-5.13.2 Metal Bar Supports:** For metal bar supports in contact with removable forms, provide supports constructed with molded plastic legs or plastic protected metal legs or bolster rails. Do not allow any portion of the bar support other than the molded plastic leg or plastic protected portion of the metal leg or bolster rail to be closer than 1/2 inch from the removable form surface for concrete to be cast.

Submit certification verifying that all metal bar supports meet the following requirements:

1. That they are manufactured from cold drawn steel wire in accordance with the wire sizes and geometrical dimensions shown in the CRSI Manual of Standard Practice, Chapter 3.

2. That the plastic used for protection of the steel legs or bolster rails has a thickness of 3/32 inch or greater at points of contact with the form work.

Provide plastic protection by a dipping operation, by adding premolded plastic tips to the legs of the support or by molding plastic to the top wire of the support. Ensure that the plastic material used for protection of steel legs does not chip, crack, deform, or peel during use.

Do not use metal bar supports to support FRP reinforcing bars.

**415-5.13.3 Plastic Bar Supports and Spacers:** Use non-stackable plastic bar supports and spacers. Bar supports shall be able to meet the concentrated load requirements of 415-5.13 within a working temperature range of 20 to 150°F. Spacers shall be able to provide sufficient strength to support reinforcing steel in the required position without deformation and relaxation under job conditions. For drilled shafts, use wheel spacers with a smooth perimeter surface.

Submit protection from sunlight until placed in the form and mold in a configuration which does not restrict concrete flow and consolidation.

All plastic bar supports and spacers shall have a maximum water absorption of 0.5% at 7 days as per ASTM D570. Plastic bar supports and spacers made of recycled plastic products must meet the additional requirements of Section 972.

Submit to the Engineer independent lab test data and certification verifying that the plastic spacers meet the requirements specified herein.

Use plastic bar supports listed on the Department's APL. Provide each individual bar support with an identification number unique to the particular model permanently marked on the surface as included in the APL. Manufacturers seeking evaluation of products for inclusion on the APL must submit an application in accordance with Section 6 and include

certified test reports from an independent laboratory showing that the plastic bar supports meet all the requirements specified herein.

#### **415-6 Welded Deformed Steel Wire Reinforcement.**

**415-6.1 General:** Provide welded deformed steel wire reinforcement as shown in the Plans or as a substitute for deformed bar reinforcement when approved on the shop drawings. Propose substitutions of welded deformed steel wire reinforcement in a manner that provides a cross-sectional area per foot of welded deformed steel wire equal to that provided in the Plans for deformed bar reinforcement. Orient the deformed wires of welded deformed steel wire reinforcement in the same position as bar reinforcement detailed in the Plans. Cross wires of welded deformed steel wire reinforcement may be deformed or smooth and must have a cross-sectional area at least 35% greater than the area of the deformed wire.

**415-6.2 Design:** When welded deformed steel wire reinforcement is substituted for deformed bar reinforcement, ensure that the development length, splices, shear reinforcement, and distribution meet the requirements of the AASHTO LRFD Bridge Design Specifications.

#### **415-7 Method of Measurement.**

**415-7.1 Reinforcing Steel:** The quantity to be paid for will be the plan quantity, in pounds, of reinforcing steel, stainless reinforcing steel, or low carbon chromium reinforcing steel incorporated into the completed work and accepted, subject to any changes approved by the Engineer. The quantity will not include the reinforcing steel (all types) in any item of work for which the basis of payment already includes the steel reinforcement. No additional payment will be made for substitutions of welded deformed wire reinforcement proposed by the Contractor. No separate payment will be made for reinforcing steel (all types) in pipe endwalls. No deduction will be made from reinforcing steel (all types) quantities for encroachment of inlets and pipes in box culverts. The lengths to be used in the calculation will be the detailed lengths of bars as shown in the Plans.

**415-7.2 Unit Weights of Steel Bars:** The unit weights used will be CRSI Standard Reinforcing Steel Bar Weights.

**415-7.3 Welded Wire Reinforcement:** Where welded wire reinforcement is to be paid for by weight, the quantity to be paid for will be the product of the area, in square feet, of the welded wire reinforcement incorporated into the completed work and accepted, multiplied by the manufacturer's standard weight per square foot.

When welded deformed steel wire reinforcement is substituted for deformed bar reinforcement, the quantity to be paid for will be the quantity which would be paid for if bar reinforcement as detailed in the Plans were utilized, based on plan quantity.

**415-7.4 Fiber Reinforcing Polymer (FRP) Reinforcing:** The quantity to be paid for will be the plan quantity, in linear feet, of bar incorporated into the completed work and accepted, subject to any changes approved by the Engineer. The quantity will not include the FRP bar in any item of work for which the basis of payment already includes the FRP bars. The lengths to be used in the calculation will be the detailed lengths of bars as shown in the Plans.

#### **415-8 Basis of Payment.**

Price and payment will be full compensation for all work specified in this Section, including all welding, all clips, spacers, ties, mechanical couplers, etc., and wire or other material used for fastening the reinforcement in place.

If spliced bars are used when full length bars might reasonably be required, the weight paid for will be only that which would be obtained if full length bars were used, with no allowance for lap.

Payment will be made under:

- Item No. 415- 1- Reinforcing Steel - per pound.
- Item No. 415- 2- Stainless Reinforcing Steel – per pound.
- Item No. 415- 3- Low Carbon Chromium Reinforcing Steel – per pound.
- Item No. 415- 10- Fiber Reinforced Polymer Reinforcing Bar – per linear foot.