CHAPTER 8 REINFORCING STEEL

8.1 Table of Contents

8.2 Overview

The purpose of this chapter is to provide you with a solid introduction to reinforcing steel. There are a couple of acceptable approaches to reinforcing detailing. There are also some important habits, practices, and techniques that will help your detailing of rebar go much smoother. What follows this overview is a recommended method that ought to give you a starting point and a sense of perspective.

> ⓘ **Remember that your primary goals are accuracy, clarity, organization and consistency. It is critical to get the reinforcing steel drawn and scheduled correctly. It is important to clearly communicate the design intent to the Contractor. Finally, it is helpful to everyone if the reinforcing steel is organized and the plans are detailed in a consistent way, job to job and sheet to sheet.**

8.2.1 Why Reinforce Concrete?

Concrete is a relatively inexpensive material that is both resistant to corrosion and strong in compression but unable to resist strong tensile forces. You could say that concrete resists being pushed, but fails when it is pulled. Reinforcing steel helps resist those tensile or “pulling” forces.

♬ Reinforcing steel in columns, unlike most reinforcing steel, acts not only to resist tensile forces, but also compression.

Reinforced concrete gets its strength from the two materials, steel and concrete, working together. To get them working together, it is critical that the steel be adequately bonded to the concrete. Achieving this bond is called **developing** the bar, and many aspects of reinforcing design are geared toward achieving development.

8.2.2 Types of Reinforcing

8.2.2.1 Main Reinforcing

Main reinforcing are the bars that are in place to resist the forces that would otherwise pull the concrete apart.

[insert graphic to demonstrate where tensile forces occur, typical main reinforcement]

8.2.2.2 Shrinkage and Temperature Reinforcing

A shortcoming of concrete is that it tends to crack as it cures and as it expands and contracts with change of temperature. Shrinkage and temperature reinforcing minimizes this cracking and typically runs perpendicular to the main reinforcing.

8.2.2.3 Distribution Reinforcing

Distribution reinforcing takes a concentrated load and spreads it over more area to engage more of the structure to carry the load. This reinforcing typically runs perpendicular to the main reinforcing.

8.2.2.4 Shear Reinforcing

Shear reinforcing typically runs perpendicular to the main reinforcing and is generally concentrated around points where the concrete is being supported. The combination of forces at these locations tends to break the concrete diagonally. Shear reinforcing resists that diagonal breakage.

- Shear reinforcing would be most efficiently placed diagonally, perpendicular to the direction of cracking. It is placed normal to the main steel chiefly for constructability reasons.

Typical places you would find shear reinforcing would be in a superstructure where it is supported at abutments and piers or in a pier cap where it is supported by columns.

8.2.2.5 Superstructure Over Pier

There is also reinforcing steel in some superstructures in the area over the pier. This "Additional Distribution Reinforcement" minimizes cracking over the pier.

- Technically, this steel also resists bending in the negative moment region as well, though this is not the reason the steel is placed here.

8.2.3 Some Reinforcing Concepts

8.2.3.1 Developing a Bar

The strength of reinforced concrete comes from the composite action of the two materials. Developing a bar means creating the necessary bond between the steel and the concrete. A properly developed bar will yield before it pulls out of the concrete.

8.2.3.2 Cover

Steel rusts, concrete doesn't. "Cover" is how much concrete is required to cover the steel to help keep it from rusting. It is measured from the face of concrete to the face of steel.

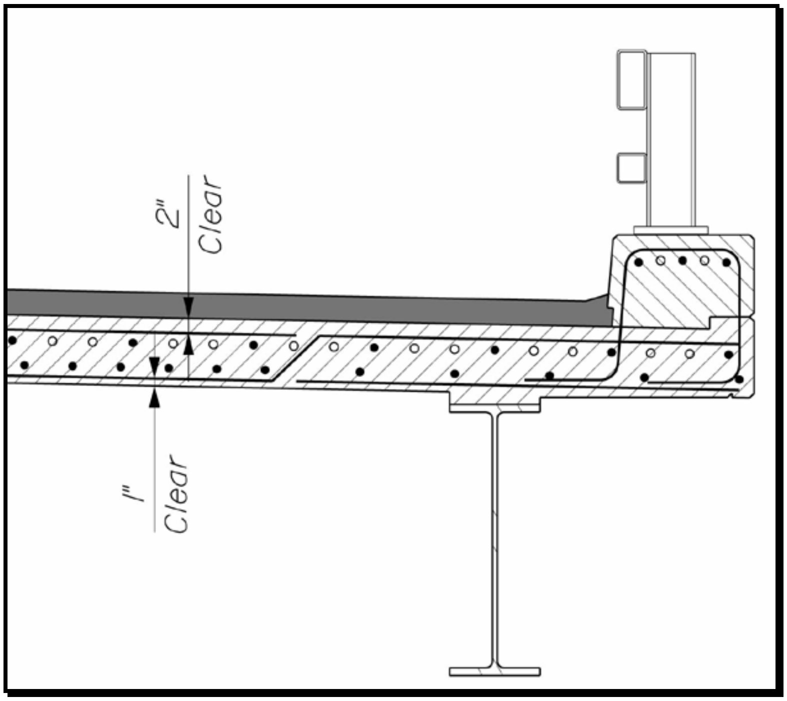


Figure 8-1 Cover Requirements in Superstructure

Cover varies depending on how much environmental exposure a surface gets. Tops of superstructures require more cover than bottom sides, abutment footings require more cover than breastwalls. Salt-water structures require more cover.

Cover also varies with constructability issues. Concrete surfaces cast against soil or ledge require more cover, due to the irregularity of the surface.

Cover is specified by the designer according to AASHTO.

♬ Cover is always specified as a minimum. Bars placed with too little cover may end up rusting, so why not bury the bars deeper? That might reduce the strength of the structure. Think of the bars on opposite sides of a slab as being the flanges of a beam. Burying the bars too deep is like reducing the depth of that beam.

8.2.3.3 Embedment

Rebar gets its strength by bonding to concrete. Embedment is the minimum length of steel that has to be encased in concrete to develop the required strength. Embedment length varies with bar size, pullout strength, concrete strength, and structural requirements.

You will often deal with embedment lengths when looking at how far bars need to extend into a footing, or between two separate placements of concrete.

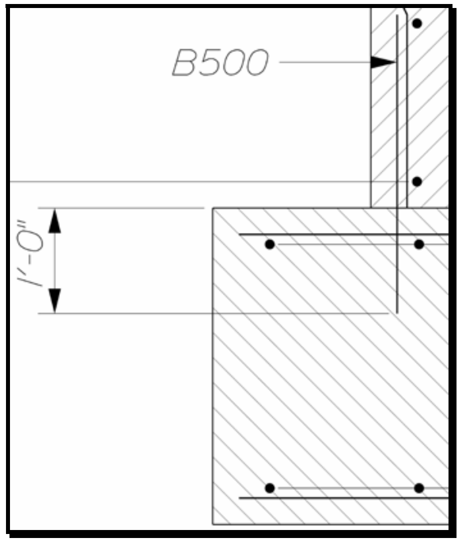


Figure 8-2 Dowel Embedment

8.2.3.4 Hooks

Sometimes there isn't enough depth of concrete to provide enough embedment to develop strength. Another way to develop strength of the bar is to bend the end of the bar into a hook. Hooks can be of different angles, and the bend radius varies both with hook type and with size of steel.

♬ Hooked bars can develop more strength in less space than straight bars.

One common use of hooked bars is to force a contractor to place certain bars prior to placement of concrete, i.e. vertical steel coming out of an abutment footing. A straight dowel might be pushed into freshly placed concrete, which weakens the bond around the bar.

Hooks can be enclosed or non-enclosed. The enclosure of a hook affects the embedment required.

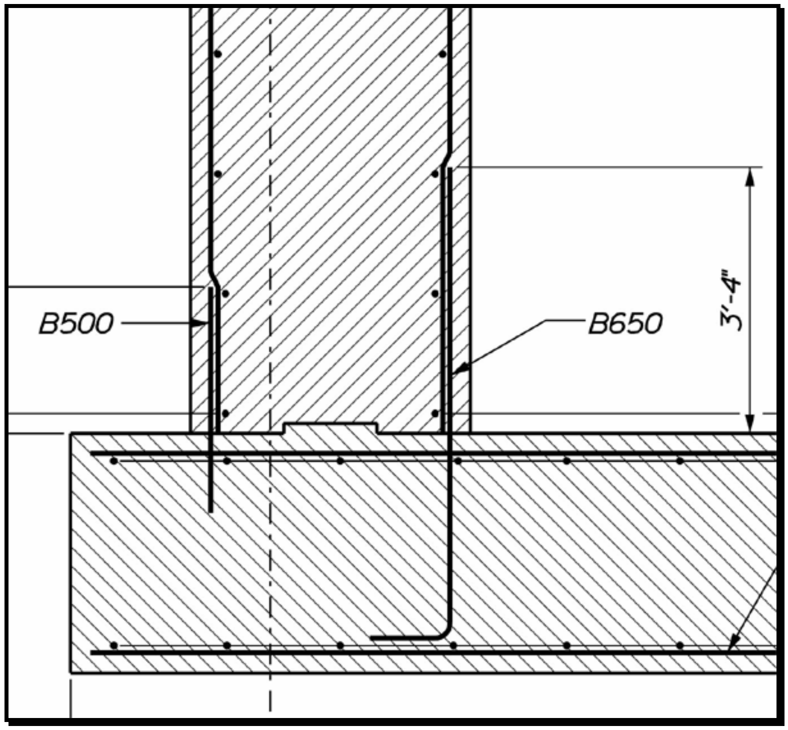


Figure 8-3 Unenclosed Hook

(Note that there are no longitudinal bars directly over the hook.)

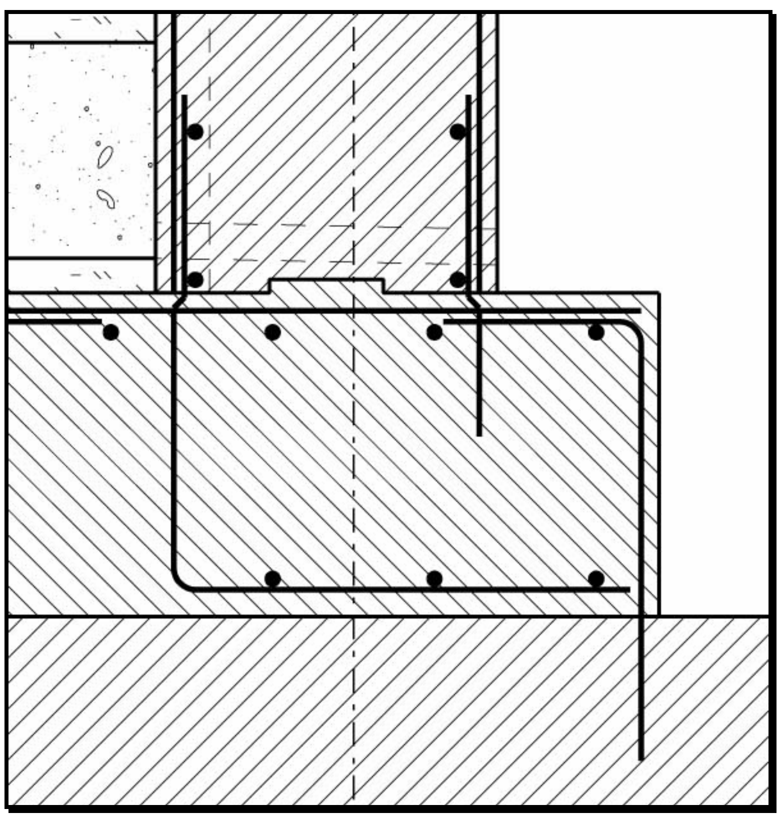


Figure 8-4 Enclosed Hook

8.2.3.5 Splices

Splicing is required when a bar isn't long enough or a joint is required. Bars may be deliberately left short for constructability and transportation concerns.

A. Lap Splices

The preferred method of splicing two bars together is a lap splice, where the two bars overlap each other for some minimum distance. This distance is the splice length.

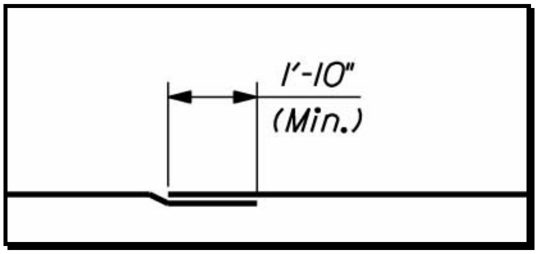


Figure 8-5 Splice Length

♬ The "kink" in the bar on the left of Figure 8-5 is a symbol to indicate that the two bars are in physical contact and wired together. It does not represent an actual bend in the bar.

Tie wires on splices are used to hold the bars in position. The strength of the lap splices comes from the bond of the bars to the surrounding concrete, not from the tie wire.

The splice length varies depending on the size of the bars, epoxy coating, strength of the concrete, and the structural requirements. Splice lengths should be specified by the designer.

B. Mechanical Couplers

It is sometimes necessary to attach bars together without the benefit of a lap splice. This requirement may arise due to geometric or constructability constraints. In cases where a splice is required, but a lap splice cannot be fit, a mechanical coupler may be used.

Mechanical couplers provide a physical connection between two bars. This is shown diagrammatically as in Figure 8-6 Mechanical Coupler.

Refer to Standard Specifications Section 503.07 for more information on splicing.

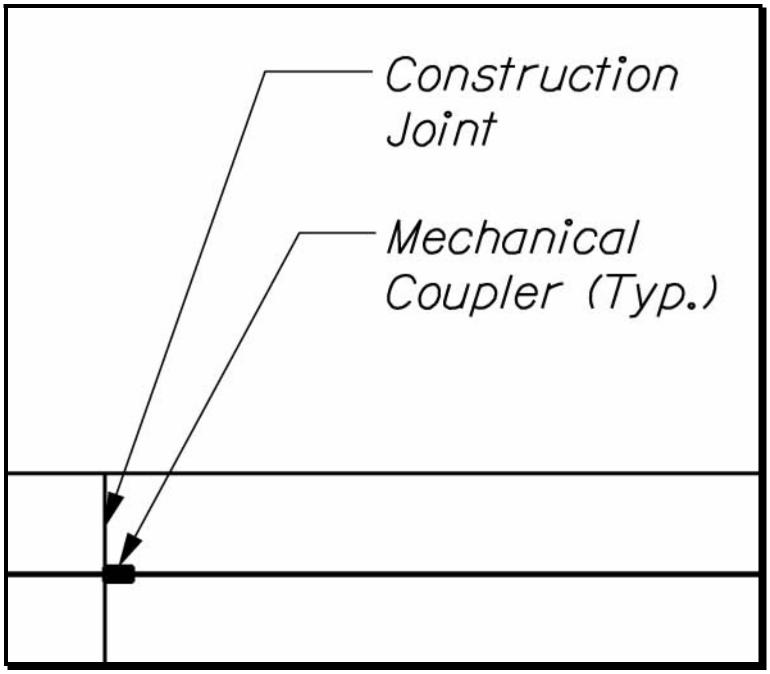


Figure 8-6 Mechanical Coupler

C. Welded Splices

In cases where neither a lap splice nor a mechanical coupler can fit, it is acceptable to specify a welded connection between bars. Generally this occurs with especially large bars, where the lap splice length is long and mechanical couplers are exceptionally large.

8.2.3.6 Projection

Projection occurs at concrete joints. Bars that extend through a joint have some length sticking out before the final placement of concrete. This length is called the projection length.

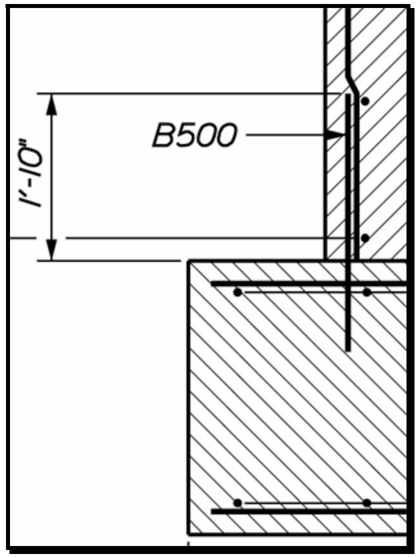


Figure 8-7 Dowel Projection

8.2.3.7 Joints

↳ Refer to *Bridge Design Guide* Section 5.2.4 for more detailed information on concrete joints.

A. Contraction

Concrete cracks, particularly due to shrinkage during curing. Contraction joints are used to control the location of these cracks. Reinforcing steel is not generally carried through contraction joints, except in rigid frames and integral abutments.

B. Expansion

Expansion joints allow adjacent placements of concrete some freedom to expand and contract with changes in temperature without crushing or moving each other. Expansion joints may occur where these expansion forces change direction, for instance a wingwall turn. Reinforcing steel is not carried through an expansion joint.

C. Construction

Construction joints are used between concrete placements when the sequence of construction requires more than one placement. These joints may be designed to coincide with contraction or expansion joints. If not functioning as a contraction or expansion joint, reinforcing steel is normally carried through the joint.

8.2.3.8 Top Bars

Top bars are horizontal bars with more than 12” depth of concrete cast below the reinforcement. It is suggested that multiple horizontal bars in a single vertical plane such as column ties or horizontal bars in walls need not be considered top bars. Bars considered “top bars" require longer splice lengths. An example of top bars would be the top mat of reinforcing steel in a footing.

8.2.3.9 Some Common Bar Types

A. *Dowels*

Dowels are short straight bars usually joining two placements of concrete, for example between a footing and a wall. The length of the bar will be determined by embedment, splice and projection requirements.

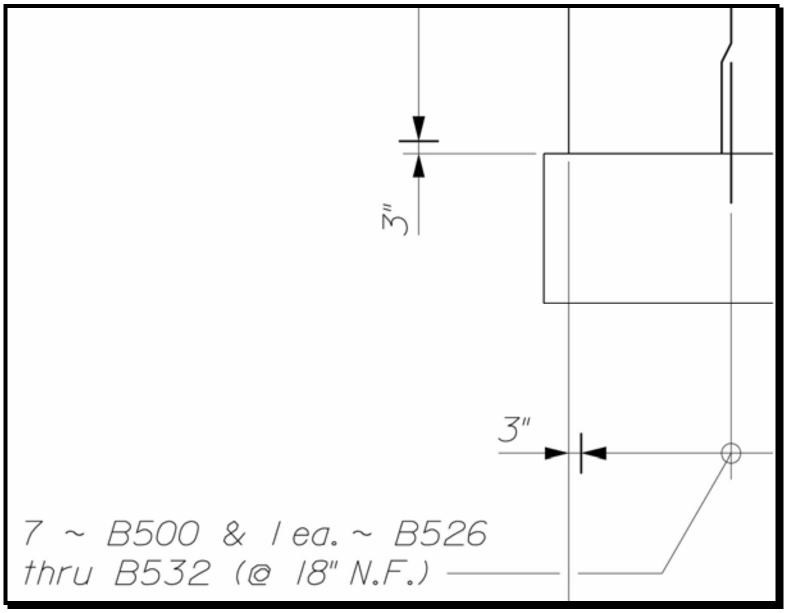


Figure 8-8 Dowel Callout

B. *Stirrups*

Stirrups are bent bars, usually found in curbs, precast voided slabs, and superstructure haunches. Stirrups usually form a U shape, with or without additional legs, and have at least three straight legs.

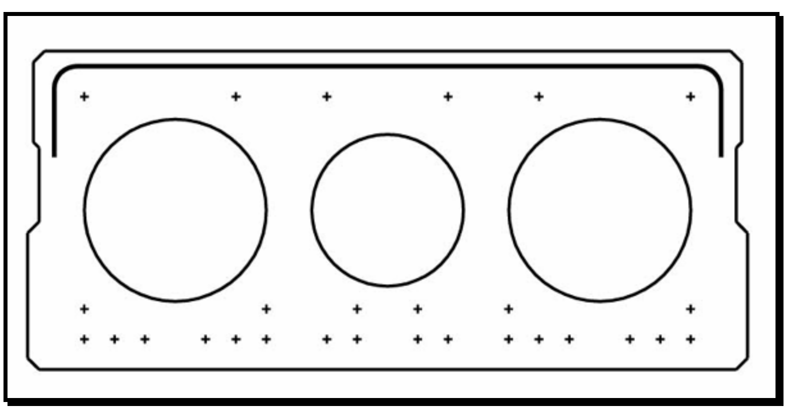


Figure 8-9 Simple Stirrup

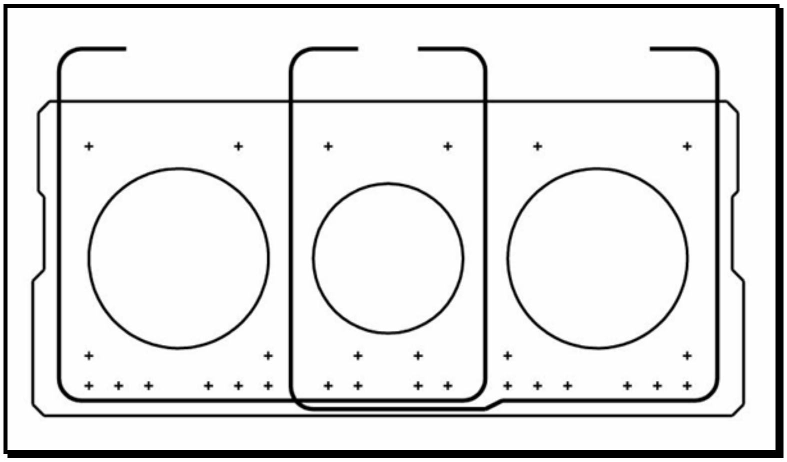


Figure 8-10 Stirrups With Legs

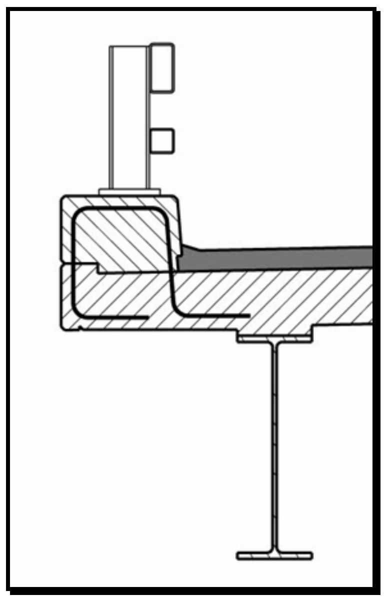


Figure 8-11 Curb Stirrup

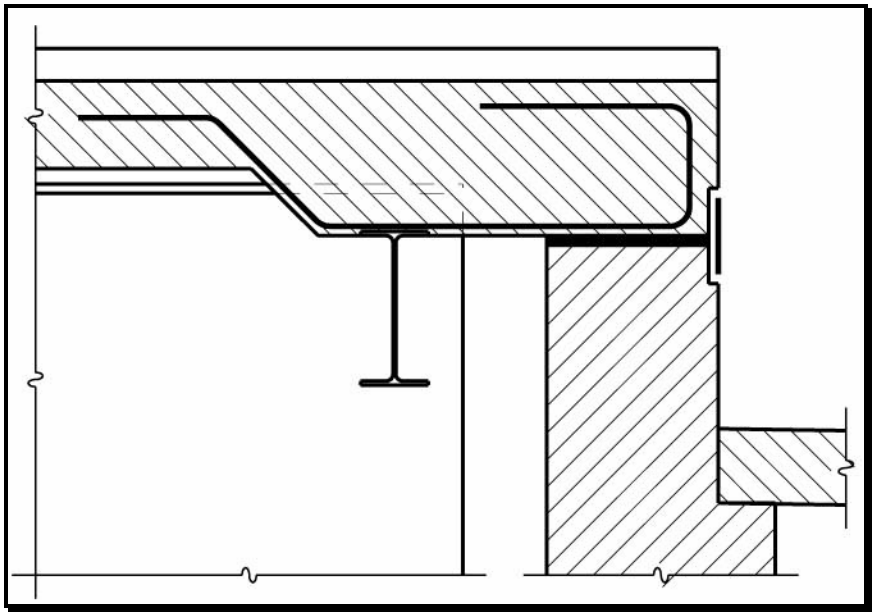


Figure 8-12 Superstructure Haunch Stirrup

C. Crank bar

Crank bars are usually transverse superstructure bars. The crank shape is the most efficient way to provide top steel and bottom steel where they are required (top steel over beams, bottom steel in spans between beams).

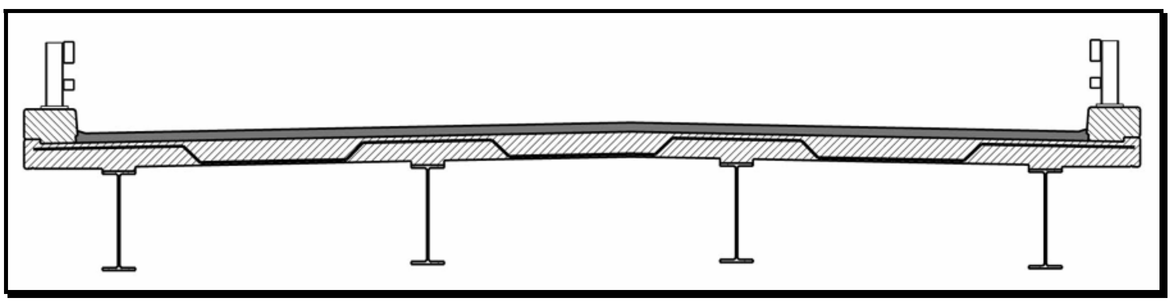


Figure 8-13 Crank bar

D. Hairpin

Hairpins are bent bars, typically found as transverse bars in superstructure fascia, concrete barriers and transition barriers. Hairpins have a 180-degree bend and at least two straight sections with or without additional legs.

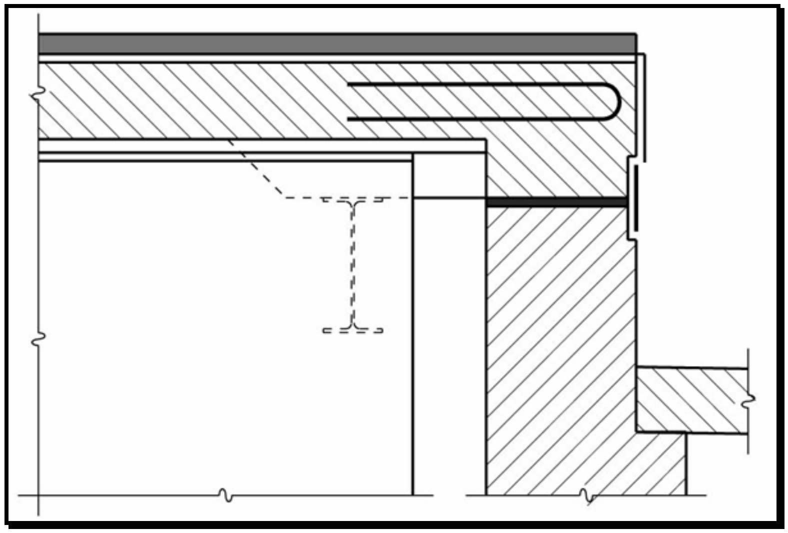


Figure 8-14 Simple Hairpin

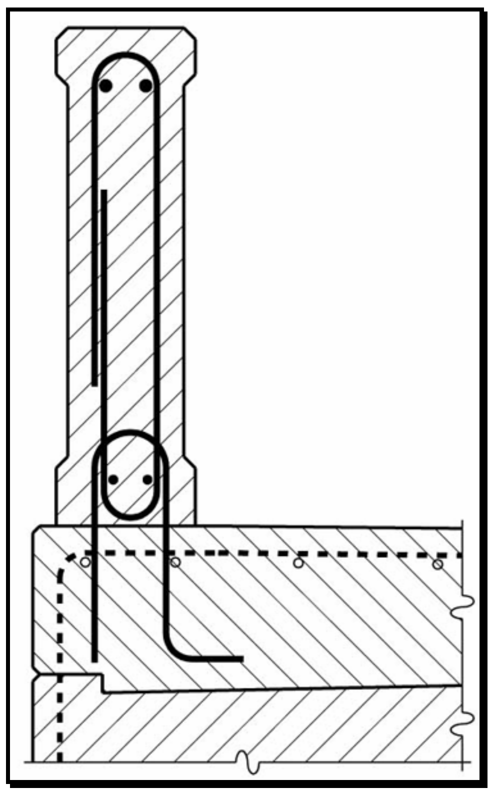


Figure 8-15 Rail Hairpins

8.2.4 Responsibilities of the Designer

The Engineer or Designer provides the following:

- Bar size and spacing
- Bar Cover requirements

- Projection
- Sketches that clarify design intent
- Splice lengths
- Embedment depths
- Location of Concrete joints
- Bend radii when required

The Detailer is encouraged to discuss all of these aspects of the reinforcing with the Designer before proceeding with work and as issues arise.

8.2.5 Detailer as Designer

8.2.5.1 Detailing as a Check for Design

Detailers are responsible for communicating the design to the Contractor. Detailers need to completely understand and visualize the geometry of the structure to accomplish this. Often, the Detailer comes to a more complete and detailed understanding of aspects of the structure than the Designer, and is able to offer the Designer insights that may help either improve the design of the structure or solve unexpected problems with the structure or constructability of the structure.

ⓘ **Detailing is an important check for many aspects of Design. Keep on the lookout for interferences and always try to understand the reason for every line you put on the drawing.**

8.2.5.2 Design by Experienced Detailers

With experience, the Detailer begins sharing Design responsibility. A Detailer with knowledge of standard practices can accomplish many elements of design.

ⓘ **An experienced Engineer should check all Design work, particularly Design performed by a non-Engineer.**

Detailers typically will not design main reinforcement – it is up to the Designer to determine the size and spacing of bars. However, there are certain properties of reinforcing steel that can be preliminarily set by the Detailer. These might include:

- Splice Lengths
- Embedment Lengths (enclosed vs. unenclosed hook embedment)
- Hook and Bend Geometry
- Projection
- Clearances
- Cover Requirements (chart of cover)

- Temperature Steel

8.2.6 List of References

8.2.6.1 Specifications

It is important to start by reading the MaineDOT Standard Specifications. Some important sections are:

- 502 Structural Concrete
- 503 Reinforcing Steel
- 518 Structural Concrete Repair
- 535 Precast, Prestressed Concrete Superstructure
- 709 Reinforcing Steel and Welded Steel Fabric

8.2.6.2 Bridge Design Guide

- Concrete Joints: 5.2.4
- Concrete Cover: 6.1.4.1, 5.4.1.5,
- Drill and anchoring: 6.2.3
- Splices
- Reinforcing Steel 6.2.1.2
- Concrete Slab on Steel Girders 6.2.2.1

8.2.7 Standard Drilled & Anchored Bolts and Reinforcing Steel Notes

(The following note is used for Type 1 anchors when bolts are size 7/8" or greater.)

1) For drilling and anchoring bolts size 7/8" or greater, the anchor material chosen from the Maine DOT prequalified list shall be submitted to the Resident for approval.

(The following note is used for Type 3 anchors when reinforcing bars are size #9 or greater.)

For drilling and anchoring reinforcing bars size #9 or greater, the anchor material chosen from the Maine DOT prequalified list shall be submitted to the Resident for approval.

8.2.7.1 CRSI Manual of Standard Practice

This manual is a wealth of information about reinforcing steel. For example, there is information on hook and stirrup bending criteria, as well as a chart for weight per foot of bars that can be used for estimating purposes.

It is highly recommended that a new detailer peruse this book prior to their first reinforcement detailing project.

8.2.7.2 Standard Details

Become familiar with the standard details that show rebar, such as end posts, approach slabs, and construction joints.

8.3 Step One: Gathering Information

It is critical to familiarize yourself with the structure before you begin to put lines on paper. Putting lines on paper is the easy part of the job: it's putting the lines in your head that really takes effort. That is what this step is about.

8.3.1 Geometry

First, the concrete section should be completely designed and that design should be checked: there's nothing worse than having to reinforce a section 3 or 4 times because the geometry of the element keeps changing.

♬ Make certain that the concrete has been drawn to scale. Compare the dimensions and elevations as labeled to the actual length and location of lines in your CAD file. Pay particular attention to wing lengths and elevations, bridge seat elevations, parapet elevations, concrete joint locations, and seal elevations.

Check to be sure that the following elements have been included, where applicable. They may affect the shape of the structure you are reinforcing.

- Expansion joint material between the parapets and the superstructure fascia.
- Bearing material under precast boxes on abutments and piers. Make sure bearings have been designed and checked to the correct height.
- Make sure concrete joints have been located.

8.3.2 Design

Next, you should get the reinforcing scheme from the designer. Information should include:

- Bar size and spacing, for example: #5 @ 12" E.F. Many structures require multiple bar sizes and spacings. Size and spacing may be different on near face vs. far face, top vs. bottom, wing vs. breastwall, horizontal vs. vertical, etc.

♬ Spend some time with the designer's sketches before you begin to lay out the rebar and make sure you understand the scheme.

- Bar Layout, for instance, does the design require stirrups at the top or ends of the structure? This information will typically be communicated with a design sketch of a section and/or plan and/or elevation.

8.3.3 Application of Reinforcing Concepts

Once you have the specific design criteria for the project at hand, you must apply some reinforcing standards that will help you detail bars. Track down these standards by talking to the designer, experienced detailers and by referring to reference guides.

8.3.3.1 Cover

What distance must be maintained from the face of the concrete to the reinforcing steel? This number might be different from a breastwall to a footing, from an abutment to a pier and from the top to bottom of a superstructure slab. Check with the designer to determine what cover was used in the computations.

♬ Some of this information may be found in the *BDG* but the detailer should always double check with the designer.

Refer to 8.2.3.2 for more information.

8.3.3.2 Splices

It's likely that you'll require at least one splice in any reinforcing scheme. The splice length varies depending on bar size, bar location and bar type. For example, epoxy-coated bars require a different splice length than black bars.

When two bars with different splicing requirements are spliced together, the shorter of the two splice lengths governs.

Check with the designer if there is any question about what splice length is required.

Refer to Section 8.2.3.5 for more information.

8.3.3.3 Embedment

It's also likely that you'll need to use embedded bars, for instance in a footing. You should find the embedment distance, projection length, whether the bars need to be hooks or straight, etc. Again, this is a design decision.

Refer to 8.2.3.3 for more information.

8.3.3.4 Hooks

You may also be dealing with some hooked bars. Standard hook dimensions are easily found in reference guides, discuss any exceptions and variations with the designer.

Refer to 8.2.3.4 for more information.

8.4 Step Two: Layout

There is no disguising the fact that laying out reinforcing steel is a time-consuming and complicated process. The best approach is to take your time and be as systematic as possible. You are well on your way if you have gathered the information as we discussed in Step One.

The goal of this step is to determine the location, number of bars, and length of bars required to reinforce the structural element. To achieve this you'll start with the structural details and apply clearances, splice lengths, embedments, and hook geometries that you gathered in step one.

By the end of this step, you'll be ready to complete a plan, elevation and sections necessary to fully document each bar's number and location. You'll also be entering the bars' designations into the reinforcing schedule, along with the number of bars and bar size, bend type, and location.

As you lay out the reinforcing steel, try to consider how you will annotate the bars.

♬ Keep it Clear: focus on making the layout as straightforward and constructible as possible. Remember, it's cheaper to have a few extra pounds of steel on the project than to have such a complex rebar layout that it causes the Contractor to make a mistake.

8.4.1 Draw Clearance Lines

In your plan, elevation and section views, draw lines that represent the cover requirements. These lines will usually be either 2 or 3 inches inside the outer limits of the concrete and parallel with the surface.

These are construction lines that will help you locate and determine the correct length of bars.

8.4.2 Draw the Bars

Using plan, elevation and section views, draw single lines and solid circles to represent each bar.

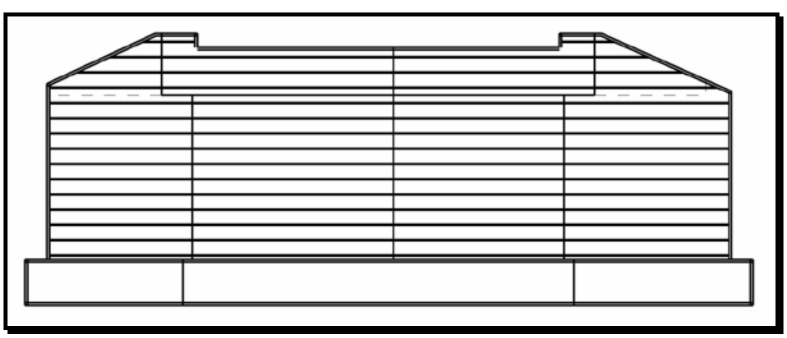


Figure 8-16 Working Sketch of Abutment Elevation

♬ Draw to scale – you may need to go back later and move lines around to make it read better, but right now you're detailing this to be measured and recorded, so draw to scale.

These are working sketches and the lines should either be construction elements or you should work with copies of your plans and elevations to avoid making unwanted changes to the documents.

Use multiple plans, elevations and sections as necessary to help you plan the reinforcing in the front and back, top and bottom and at various points along the structure.

♬ Note that these single-line representations aren't strictly accurate, as reinforcing bars obviously have a thickness to them. In some rare instances where clearances are tight (precast voided slabs and boxes, for instance) it may be necessary to draw up the bars completely and carefully showing the bar thicknesses. For the purpose of most reinforcing, however, it is safe to simply draw a single line.

8.4.3 Standard Practice

8.4.3.1 Design Clearance

Reinforcing can be a maximum of one-half the design spacing from any expansion or unreinforced joint or limit of concrete placement. For example, when placing an array of vertical bars in a wall with an expansion joint (no horizontal bars passing through), the bars must be no more than half the design spacing on either side of the joint.

8.4.3.2 Bar Lengths

Reinforcing steel is available in lengths up to 60 feet.

♬ When using long straight bars often times designers will use a minimum bar size of #5 because anything smaller is very flimsy and hard to handle in the field.

8.4.3.3 Substructure

A. Back Hooks

When reinforcing a wall section, always put a hook on the far face vertical bar that is enclosed in the footing to prevent the Contractor from placing the bar after the footing concrete has been poured.

B. Wing Steel

When laying out vertical steel in an abutment wing, start at the wing end and place the first vertical bar six inches in. Space the rest at the design spacing. This provides enough length to tie the vertical bars to the horizontal bars.

C. Interference

Piles and girders will occasionally interfere with the placement of reinforcing steel. Be sure to check for these interferences and figure your reinforcing steel accordingly. In some cases, girders and piles may be drilled to allow reinforcing steel to pass through. In other cases, bars may be spaced around the interference. Be sure to check with the Designer for a recommendation.

D. Vertical Bar Spacing

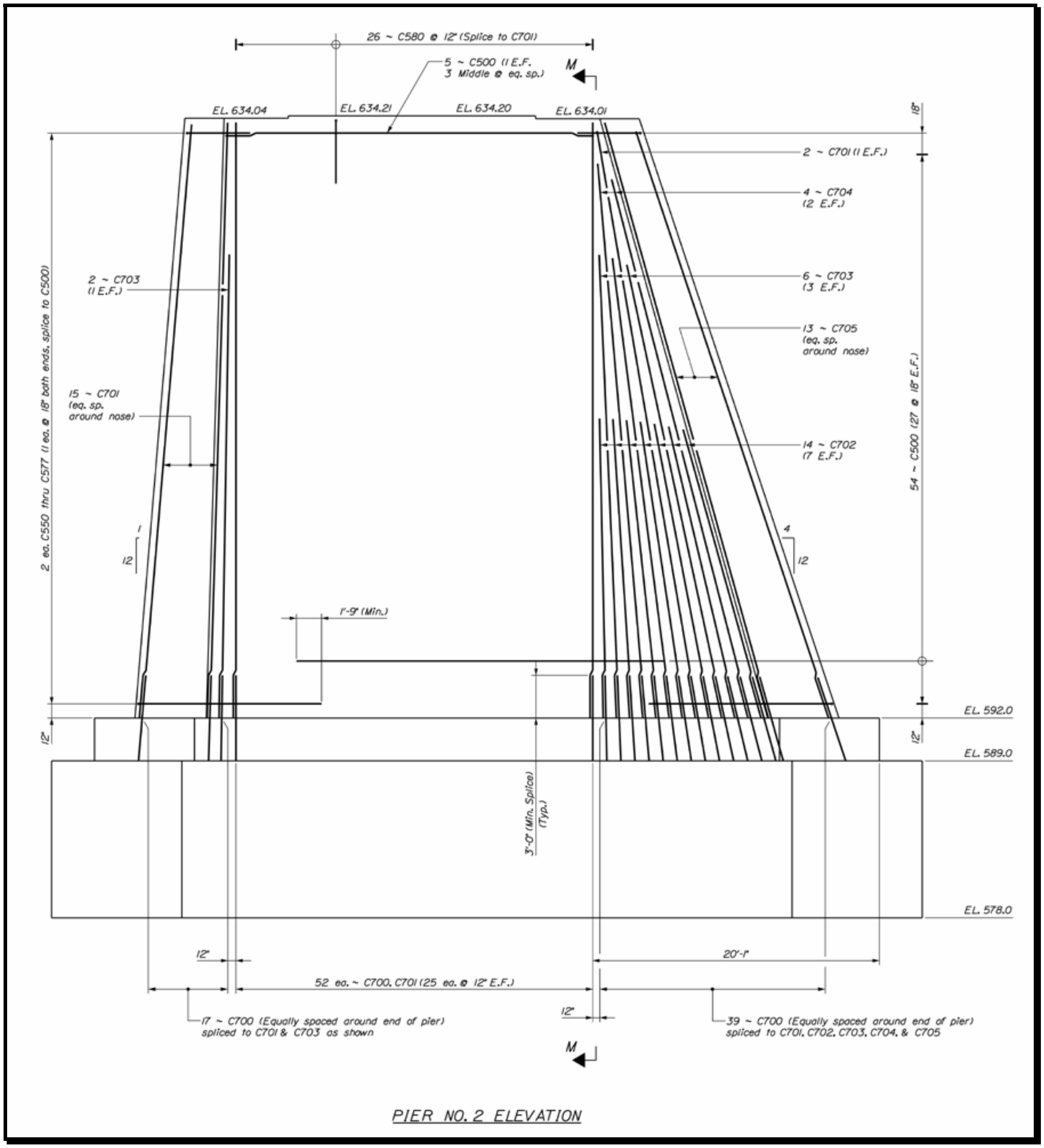


Figure 8-17 Pier Elevation

To call out the number of vertical bars in the nose of a pier, first lay out the bars exactly, using even bar spacing around the nose. Then call out the number of bars and designate the layout as "even spacing."

A large mass pier with battered faces has bars that get closer together. At the bottom of the shaft, vertical bars are spaced around the perimeter of the shaft at the design spacing. As those bars taper together, some can be left shorter. Look for the point at which the bars close to one-half bar spacing apart. At this point you can shorten every other bar while still maintaining the design spacing.

Work from the elevation view, in general the upstream end of the shaft where the nose is most sharply battered is going to be the most difficult area to work with.

8.4.3.4 Superstructure

A. Skew

Reinforcing steel in a superstructure should be parallel to the skew of the substructure up to a maximum skew of 25 degrees. Greater skews than this require reinforcing steel to be placed normal to the span. In either case, the spacing for the bars is measured along the centerline of the stringers.

B. Crank Bar

When precast concrete superstructure deck panels are not offered as an option to the contractor, the structural designer may use crank bars and straight bars as main reinforcement.

The BDG does not address crank bar layout. Use Figure 8-18 as a guide in crank bar detail development.

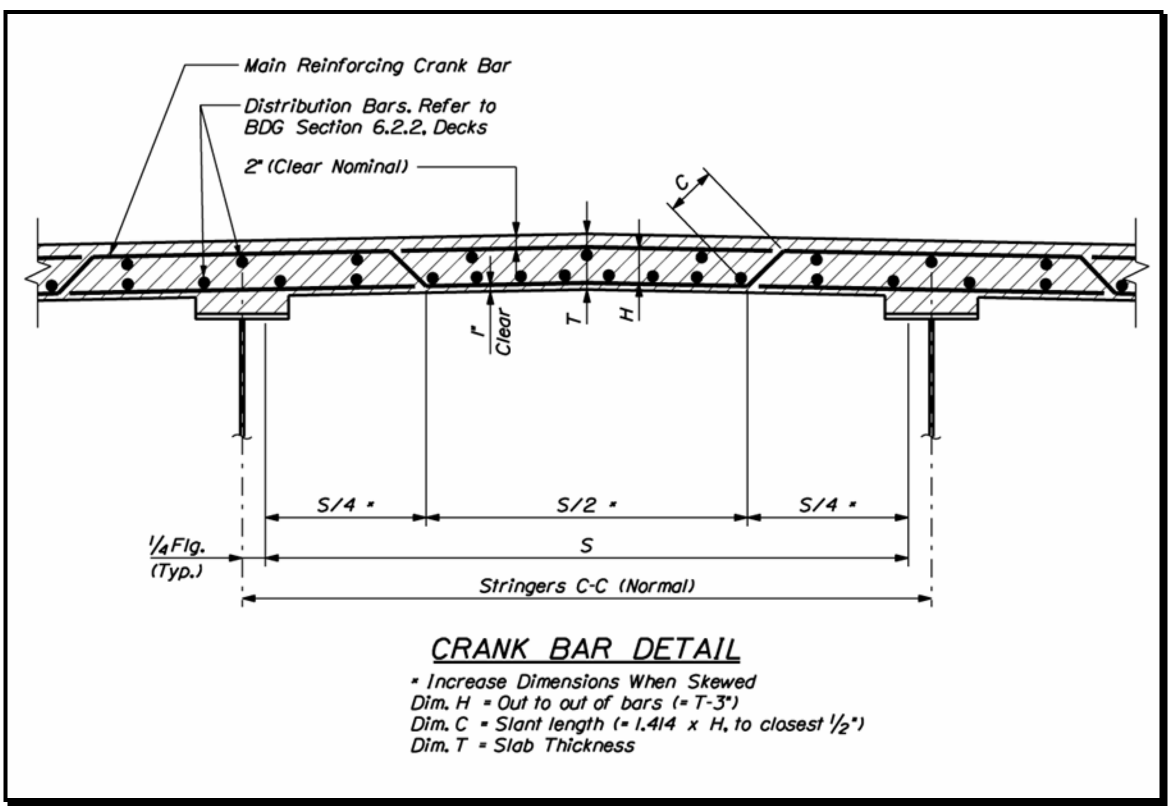


Figure 8-18 Crank Bar Detail

C. Splices

Longitudinal steel in structures more than 60 feet long will require splicing. Add a note to your superstructure plan that instructs the Contractor to stagger the splice locations.

D. Add'l Reinforcing

Curbs with curb-mounted rail systems require additional reinforcing under each rail post.

It is acceptable to call out these bar counts and designations with a note, shown under the "Plan" label, with a heading of "Additional Reinforcing Not Shown."

- ♬ Refer to Standard Detail Section 507 Curb Reinforcing Plan & Sidewalk Reinforcing Plan.

Extra longitudinal reinforcement may be added in the slab and curb in negative moment areas such as over piers.

E. Bridge Drains

It is unnecessary to lay out reinforcing steel to fit around bridge drains. There is a general note that covers adjusting steel around drains.

8.4.3.5 Precast Box Beams and Voided Slabs

Precast boxes and voided slabs require a great deal of precision when laying out reinforcing steel. Close work with the Designer is required, and the Detailer will often find it necessary to draw the bars completely to scale to insure a proper fit.

8.4.3.6 Welded Wire Fabric, Wire Mesh

Wire meshes and fabrics are mats of smooth steel used primarily in thin slabs. In bridge work they are typically found in precast deck panels.

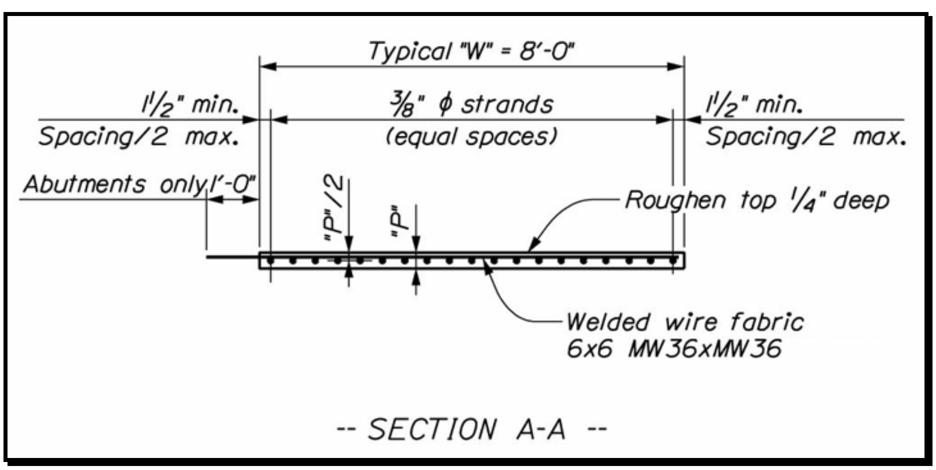


Figure 8-19 Welded Wire Fabric

8.4.3.7 Approach Slabs

Don't forget to include approach slab bars in your reinforcing steel schedule. Check the Standard Details for layout requirements.

8.4.4 Tactical Detailing

There are a few tricks of the trade that will help the detailer in situations where the design spacing of reinforcing doesn't fit for one reason or another.

Steel is designed by area – this means that the main reinforcing is designed such that a percentage of the cross-sectional area of the concrete is taken up by steel. Because of this, it typically doesn't matter if you have to shift bars one way or the other by a couple of inches.

Tying up reinforcing in the field is not an exact science. They'll make it work out in the field if you give them enough bars and a reasonable idea of where they'll fit.

8.4.4.1 Reduce Spacing

Rebar spacing given by the designer is a maximum spacing and can be closer if the structural geometry requires it.

In some cases, you'll find you can't place an array of bars in the structure, while meeting both cover requirements and using the design bar spacing. For short arrays, it is acceptable to space the bars equally, rather than using the design bar spacing.

It is also acceptable in some cases where the spacing is irregular to simply show each bar and label them "space as shown."

8.4.4.2 Flare

Another acceptable layout technique is to flare bars. Bars are often flared to provide reinforcing around a corner of a footing. It is important to maintain the minimum spacing as required by the design when laying out flared bars.

This is a common practice in abutment footings, as shown in Figure 8-20.

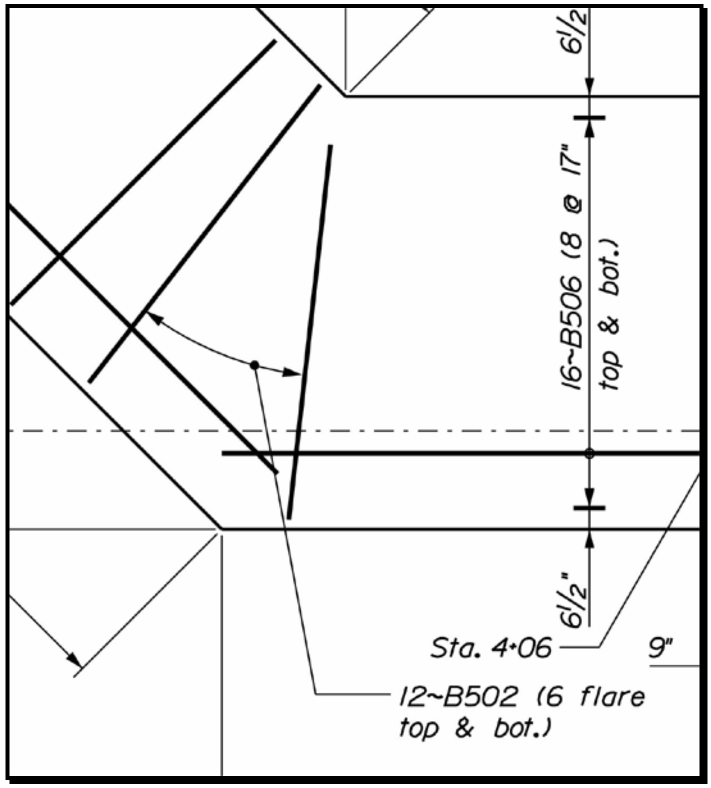


Figure 8-20 Flare Bars in Footing

8.4.4.3 Cut to Fit

In some rare instances it is useful to instruct the Contractor to cut reinforcing steel in the field to fit some particular geometry. An example of this is cutting the bars in a concrete collar around a pipe arch.

> ⓘ **This is a last-ditch effort type of solution. Do not make a habit of it and always ask an experienced Detailer for a second opinion on how to avoid specifying a "Cut to Fit."**

8.4.4.4 Bend in Field

Reinforcing steel bars of number 5 or smaller can be bent on the job site. There are rare occurrences where a bend cannot be specified on the rebar schedule, for instance, a bar that requires two bends that are non-planar.

> ⓘ **Epoxy-coated bars cannot be bent in the field.**

8.5 Step Three: Make a Draft Schedule

This step involves establishing a bar mark for every bar, then counting and measuring each bar and recording your results in a draft schedule.

At this stage you will also consider a couple of ways of reducing the number of different bar designations required.

8.5.1 Setting the Bar Mark

8.5.1.1 Overview

Bar Marks (i.e. A500, P550, S405) are made up of three parts: the letter, the size and the serial number.

The letter shows whether the bar is a superstructure bar ("S") or an Abutment No. 1 bar ("A") or a Pier bar ("P") etc.

Table 8-1 Bar Mark Letter Usage

Bar Letter	**Location**
A	Abutment Number 1
B	Abutment Number 2
P	Pier
S	Superstructure
PC	Precast
AS	Approach Slab

The next number is the bar diameter, i.e. a number 5 bar.

The second two numbers are a kind of "serial number" for the bar – each different bar needs a unique name, these last two numbers provide that.

♬ Bars numbered XX00 through XX49 are typically straight bars. Bars numbers XX50 through XX99 are typically bent bars.

8.5.1.2 Numbering Bars

There are some general rules of thumb to follow as you assign numbers to the bars in your structure.

- Bars numbered 00 through 49 are typically straight bars.
- Bars numbered 50 through 99 are typically bent bars.

- Reserve numbers 00 through 05 for dowels.
- Reserve numbers 50 through 55 for hooks.
- As much as possible, number bars by concrete placement, i.e. keep footing bars together, breastwall bars together, etc.
- Number bars in the order they will be used: footing bars should have lower numbers than the bars in the structure that rests on the footing.
- Consecutively numbered bars should be somewhere near each other in the structure, i.e. don't skip around from wing to breastwall.
- Label vertical bars first, because they have to go in first.
- Number bars left to right.
- Number bars bottom to top.
- Number near face before far face.

> ⓘ **Leave some spaces for numbers in between sets so you can add bars later.**
>
> ⓘ **If you have more than 100 bars, you can break it up so that Footing bars are designate as "F" bars.**

A. Abutment Bar Numbering Tips

Number the breastwall steel first, then the wings. With symmetrical wings, this will allow you to use the same numbering for both wings.

B. Superstructure Bar Numbering Tips

Start numbering from the longest bars. These are the longitudinal steel.

8.5.2 Scheduling Straight Bars

Fill in your temporary schedule. Start by organizing all the bar marks.

Next, count the number of each bar, and note the location. Refer to further documentation for specific terms to use in calling out bar location.

Next, measure the bars and note the length. All the bars that you have drawn in your working drawing should be drawn to scale, with the correct cover, the correct splice lengths, embedments, etc. Use the computer to measure the lengths of the bars.

8.5.3 Scheduling Bent Bars

Fill in your temporary schedule with all the bent bar marks.

Count the number of each bar and note the location.

Determine the bent type for each bar by referring to the reinforcing steel schedule.

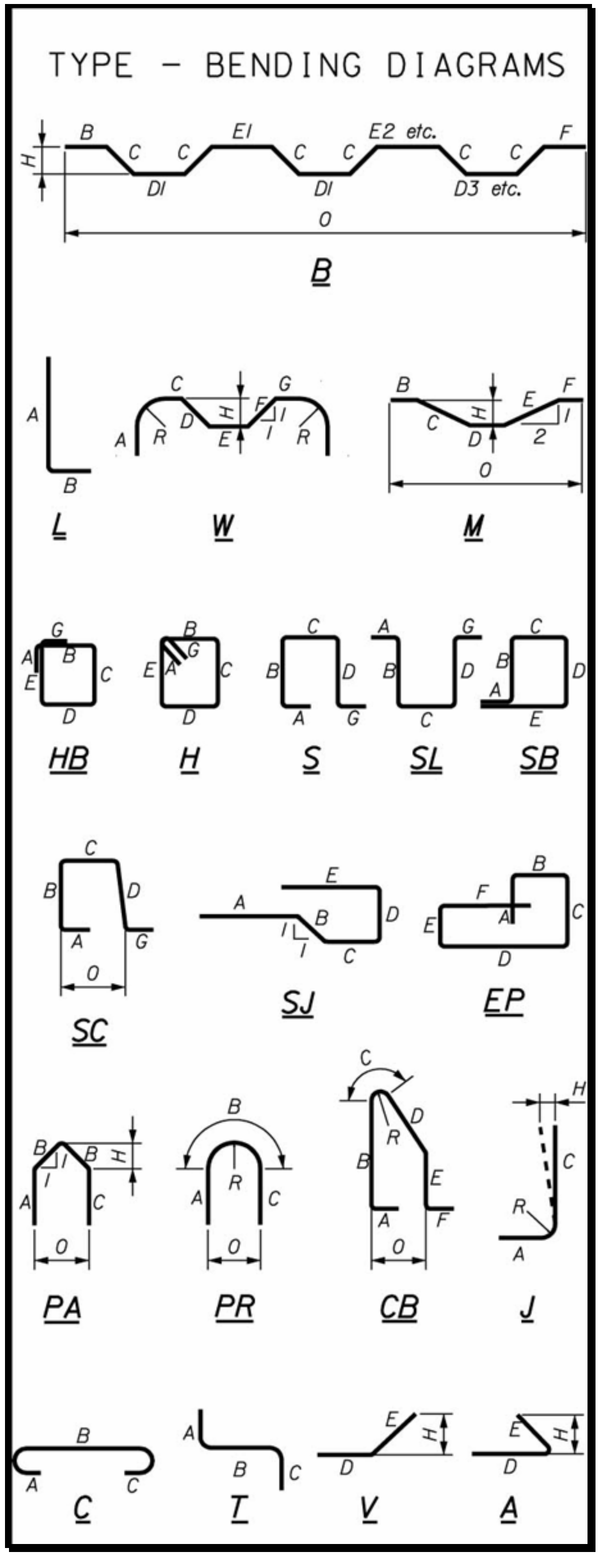
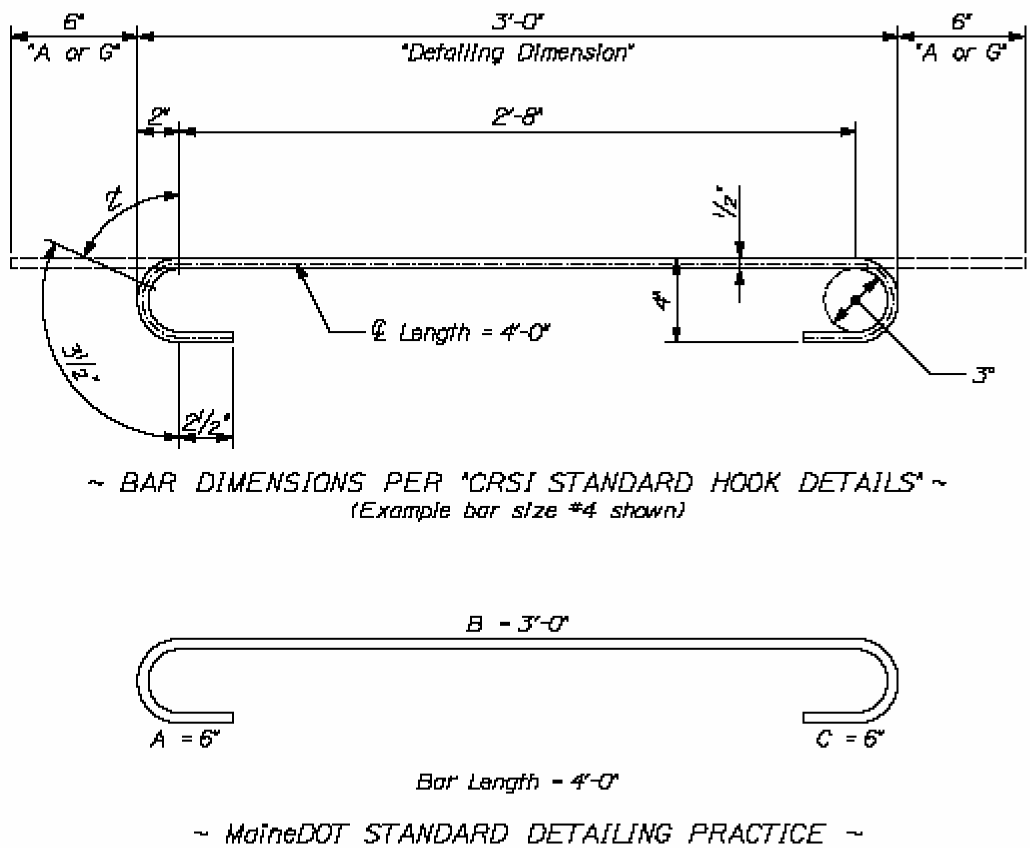


Figure 8-21 Bent Types

Note that each bent bar has more than one length to measure: often you have to measure not only the length of each leg, but also the overall height, width, and occasionally a radius. Each of these items is labeled with a letter, A-H, O or R. These designations are also shown on the reinforcing schedule.

- The Type C bar has radiuses at each end and this can create some confusion about how the dimensions are calculated for the Reinforcing Steel Schedule. The following illustrations show how the Type C bar lengths should be figured.



TYPICAL HOOK DIMENSIONING

- What if there is no bent type that matches your bar? First, ask a second opinion: there may be a way of cleverly using an existing bar type to show your bar – think of using a bar type with more legs than you need and setting some leg lengths to zero. If you do need a new bent type, simply give it a name and draw it on the rebar sheet. Label the legs, always starting with leg A, and ending with leg G. Use "R" for any radius, "H" for a height and "O" for an overall dimension.

Measure each leg, plus any overall dimensions that are required for the bent type and note them in your temporary schedule.

- Remember that in most cases, bent bars are dimensioned "out to out."

8.5.4 Rounding Lengths

Once you have measured and noted the bar lengths exactly, you're going to have to round them to a reasonable length.

What is a reasonable length? In general, we want to round to an even number of inches.

> ⓘ **Sometimes greater accuracy is required, i.e. a precast voided slab stirrup. Talk to the Designer if you have questions about rounding.**

Some bar lengths are going to need to be rounded up, some down. How can we tell which?

- In general, round the length of a bar or leg **down** only when both ends of the bar or leg are controlled by cover requirements.
- Round the length of a bar or leg **up** in all other situations.

Some examples:

- Round **up** if the bar is spliced onto another bar
- Round **down** if a bar is a stirrup that spans the width of the structure.
- Round **down** if a bar runs the entire length of the structure
- Round **up** if one end of the bar ends in the middle of the structure, far away from any joint.

8.6 Step Four: Annotation

Once you have assigned bar marks to every bar and have completed your draft reinforcing schedule, it's time to label, dimension, and schedule the bars.

There are basically four pieces of information that need to be provided for each bar.

1) Number of Bars. This "Count" should only be shown in one place on the drawings. Do not label the number of bars more than once.
2) Bar Designation, e.g. "A500." The letter is used to differentiate bars in different parts of the structure, "A" for abutment number 1, "B" for abutment number 2, "S" for superstructure, etc.
3) Spacing. You must specify the spacing of the bars, whether it is 18", 12", 6", etc. Make sure you only label the spacing once.
4) Location. Sometimes you must specify "EF" for "Each Face" or "NF" or "FF" for "Near Face" or "Far Face." This information is not required if the location of the bars is clarified in a section view.

♬ These abbreviations need to be defined on the plans in a legend.

8.6.1 Show the Bars

8.6.1.1 What to Show Where

Abutment bars should be shown in the elevations and sections. The count should be shown in the elevation. Sometimes it's easier to have two drawings of abutment, one for geometry one for reinforcing.

Pier bars should be shown in the elevation and section, count should be shown in the elevation.

Superstructure bars should be shown in the plan and transverse section. The count should be given on the plan.

8.6.1.2 Simplify the Scheme

Sometimes you can simplify your drawings with a simple change to the reinforcing scheme.

If two adjacent bars are almost the same length, consider eliminating one designation and leave one just a little short or a little long. Be sure to look at your cover, splice, and embedment requirements when deciding on a final length.

If a series of bars are to be spliced, consider using a single bar and varying the splice lengths. This is called "over-splicing." Again, be sure that minimum splice length is maintained.

♬ In general, don't call for over-splicing of more than half the bar's length.

8.6.1.3 Don't Show Every Bar

If you have 3 or more of any single bar, you should always show a single bar along with a dimension that shows the range of bar placement.

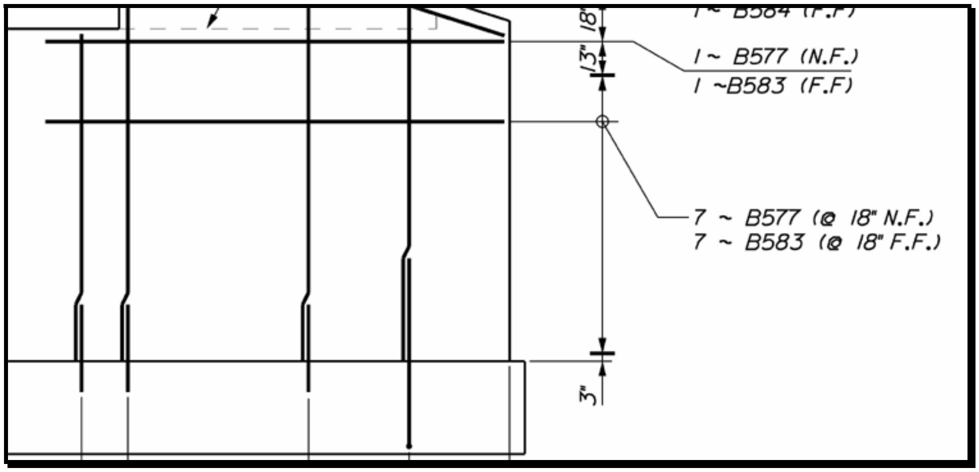


Figure 8-22 NF & FF at Multiple Locations

8.6.1.4 Pointing to Single/Double Bars

The simplest method of annotation is to simply point at the one or two bars being labeled.

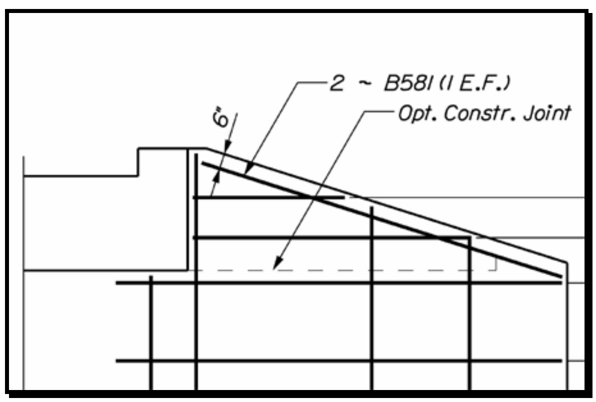


Figure 8-23 NF & FF at 1 Location

8.6.1.5 Showing Multiple Bars

Multiple placements of a single bar designation can be shown in a couple of ways.

A. Showing an Array of Multiple Bars

Sometimes the design calls for a range of bars that grow sequentially longer or shorter. This is similar to showing multiple placements of a single bar.

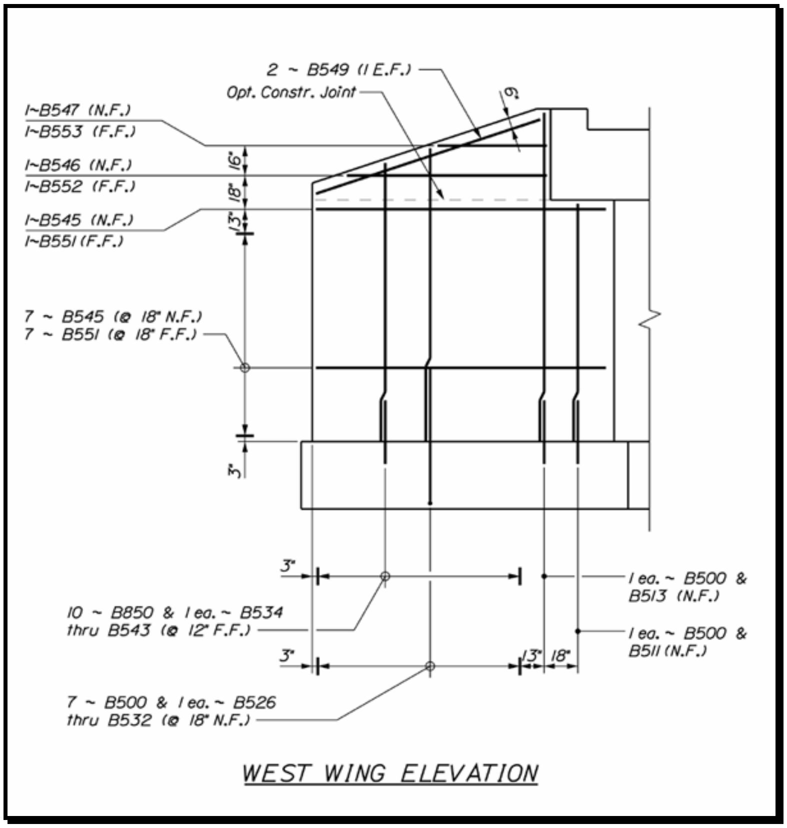


Figure 8-24 Spliced Arrays

B. *Multiple Sets of Bars*

Often you will be faced with annotating a series of bars that are tied together. An example would be in the breastwall of an abutment, you might have a hook tied to a vertical bar tied to a stirrup. These could be called out with a single array.

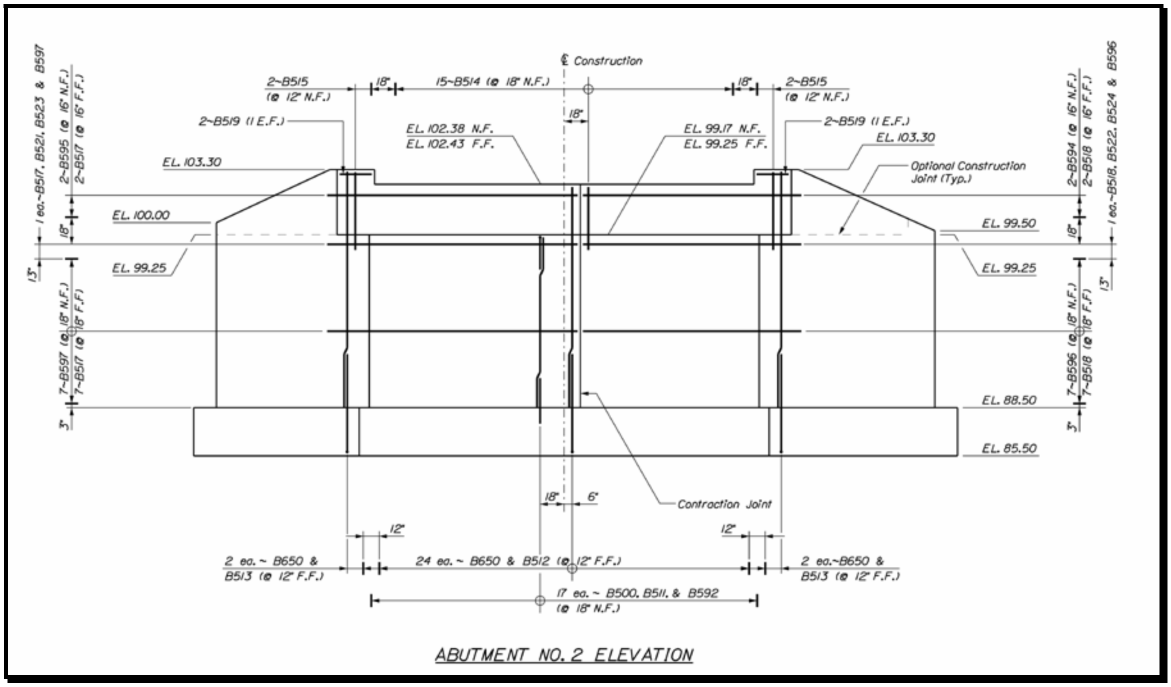


Figure 8-25 Spliced Sets at Multiple Locations

8.6.2 Label the Bars

Each bar needs to be labeled with a designation, spacing, location and count.

↳ Refer to Dimensioning section, below, for location annotation requirements.

In order to save room and provide a readable plan, you have to simplify your details as much as possible.

8.6.2.1 Standard Grammar

There are a number of acceptable ways to label. Here are some examples.

- 52~A500@18" N.F.
- 52 ea.~A500&A525 (26 of each @ 18" E.F.)
- 10~A500 (5@18" E.F.) spliced to 2 ea.~A511 thru A515 (1 of each E.F.)
- 8~A525 (4@18" E.F.)
- 2 ea.~A510 thru A515 (1 of each @12" top & bott)
- 4~A503 (2 flare top & bott.)

For Spacing, there are three acceptable ways to label.

- At a spacing – 10~A500 @ 18" N.F.
- Equal Spacing – 10~A500 @ Eq. Spacing N.F.
- Space as Shown – 10~A500, Space as Shown N.F.

8.6.2.2 Calling out Bar Locations

Call out bars per side, using either upstream/downstream or North/South/East/West or even Left/Right side (remembering that Abutment 1 "Left" bars will actually be shown on the right side of the abutment elevation.)

8.6.3 Dimension the Bars

All bars must be dimensioned off some reference; either centerline construction, reference line, construction joint, or an edge of concrete.

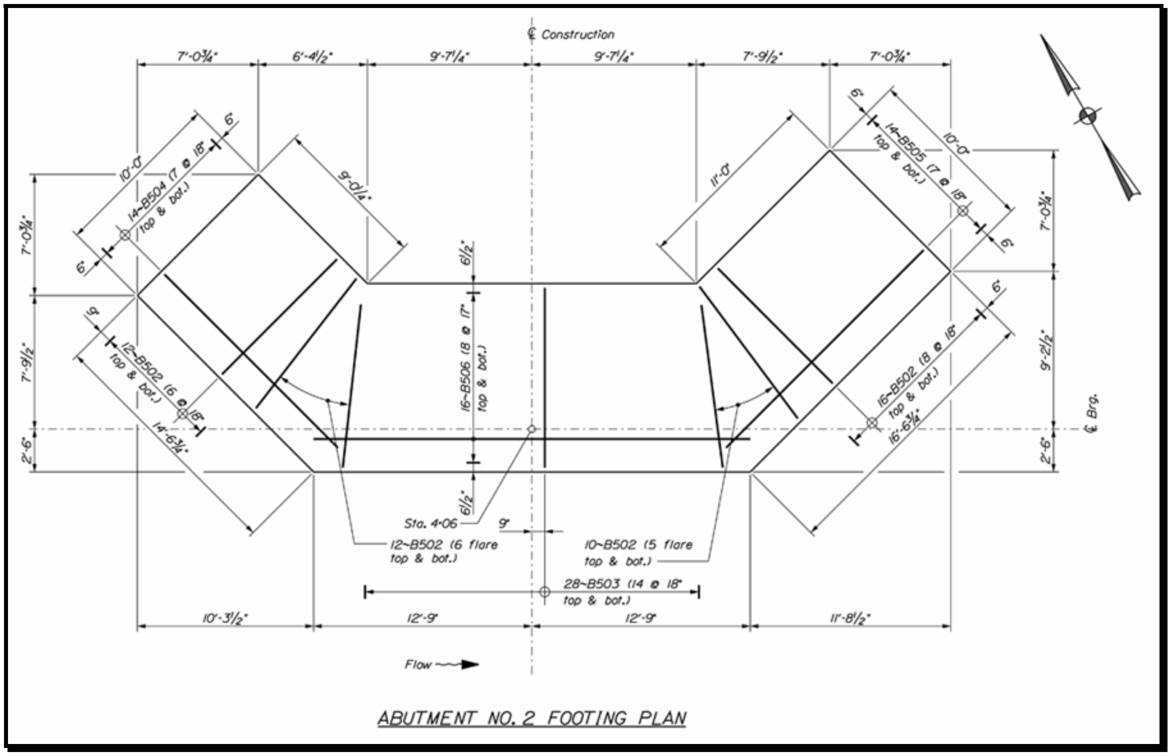


Figure 8-26

ⓘ **Reinforcing steel clearances are not a substitute for this reference.**

If an array of bars is spaced at a given distance, you only need to tie one end of that array to an acceptable reference. However, if bars are spaced either at equal spacing or "as shown" each end of the array needs to be tied to an acceptable reference.

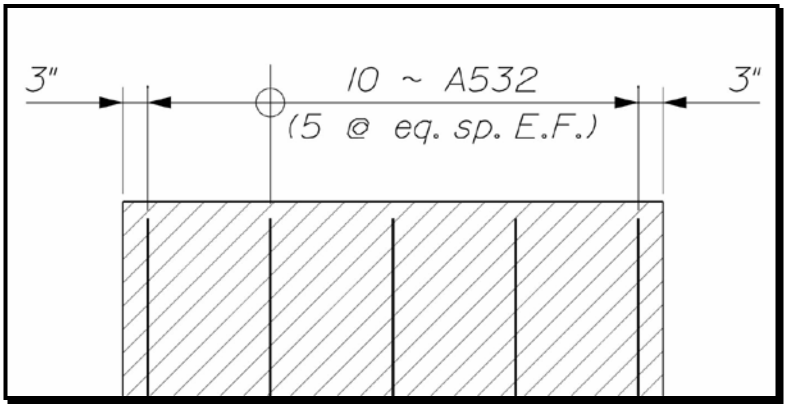


Figure 8-27

8.6.4 Schedule the Bars

The final step of annotation is to fill in the reinforcing steel schedule. With a completed draft schedule, simply copy your bars into the final schedule.

Some things to be sure to check when scheduling:

- Make sure every bent type called for is detailed on the sheet. If it is not shown in the Bending Diagrams, you can remove some unused bar types off the sheet to make room to draw your own bar type diagram for that specific bar.

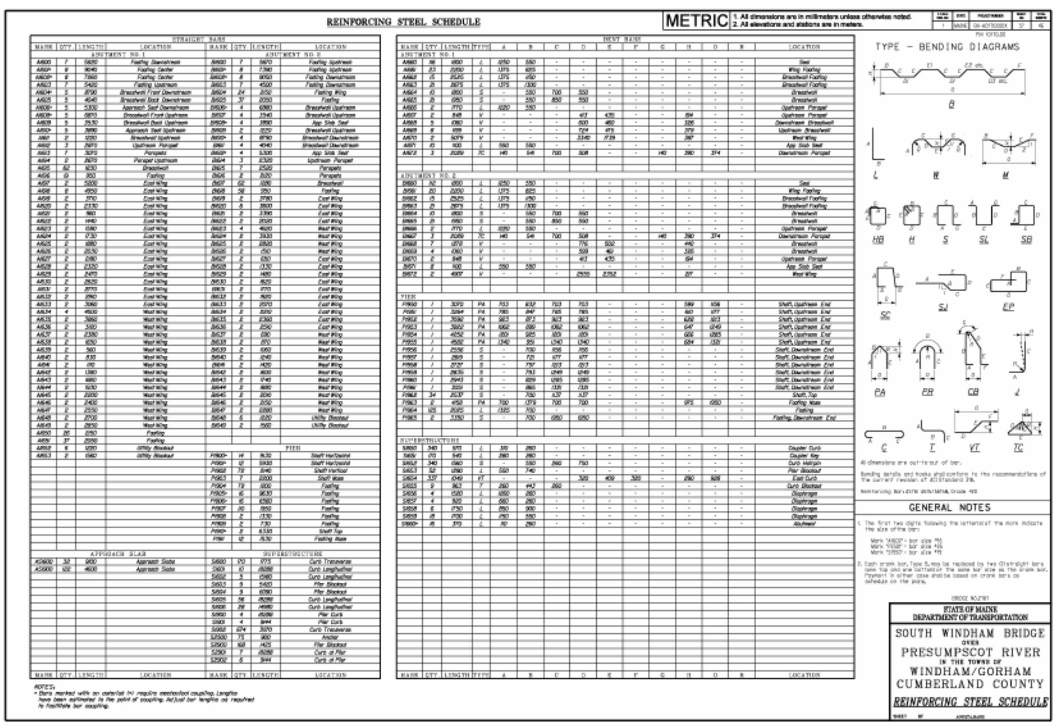


Figure 8-28 Reinforcing Steel Schedule

8.6.5 Typical Sheet Contents

Will Contain:

1) Schedule of Straight Bars
2) Schedule of Bent Bars
3) Type-Bending Diagram
4) General Notes

8.7 Step Five: Checking

Look in *Bridge Design Guide* to read about checking policy.

Verify quantity and length of main reinforcing.

Things to look for:

1) Check from paper instead of from the computer.
2) Look at rebar schedule and count bars
3) Make sure that any bars shown as typical or detailed in one place meant to apply to more than one location
4) Make sure you include your approach slab bars