SECTION 5 - REINFORCEMENT

5.1 - GALVANIZED REINFORCEMENT

Galvanized Reinforcement shall be used in all locations. Galvanizing provides corrosion resistance by adding a sacrificial coating of zinc to the reinforcement. The zinc is consumed by the movement of electrons and, therefore, does not expand to the same magnitude that bare metal expands as it corrodes. Therefore, concrete cracking and spalling due to reinforcement corrosion is delayed until the zinc coating has been fully consumed. Stainless steel and stainless steel clad reinforcing steel is also available. These types of steel should only be used in highly corrosive marine environments with approval from the **DSD**. Refer to the **NYSDOT** Standard Specifications for the mechanical requirements of stainless steel reinforcing. Also available is a high strength weathering reinforcing steel called MMFX. This steel has a design yield strength of 80 ksi. It is only used in locations where reinforcing congestion of 60 ksi needs to be reduced. This type of steel shall only be used with approval from the **DSD**. Refer to the Authority Special Specification for this product for additional information.

The advantages of using galvanized reinforcement as compared to epoxy-coated reinforcement include:

A. Better bond strength between the concrete and reinforcement.

B. Shorter lap lengths.

C. The galvanized coating is more durable during handling and installation requiring less touchup and repair of the galvanized coating.

D. The galvanized coating is chemically bonded to the bar, whereas an epoxy coating relies upon adhesion.

E. The coating coverage requirements are more stringent, resulting in higher fabrication quality.

F. Comparable unit cost.

G. Longer service life.

The following guidelines shall apply for galvanized reinforcement:

A. The lap lengths and imbedment lengths for galvanized reinforcement are the same as for uncoated reinforcement.

B. The out to out length of straight or shop bent galvanized bars should not exceed 40 feet.

C. Galvanized reinforcement may be used in conjunction with existing uncoated or epoxy-coated reinforcement when necessary.

5.2 - REINFORCEMENT GRADE

All new and replacement bar reinforcement shall be **ASTM** A 615, GRADE 60. (Billet steel only). Bars shall be galvanized and fabricated in accordance with **ASTM** A 767, and meet the requirements of **NYSDOT** Material Specification 709-11.

5.3 - SPACING

The spacing between parallel bars shall not be more than 18 inches or 1.5 times the wall or slab thickness, whichever is less. For cast-in-place concrete, the clear distance between parallel bars in a layer shall not be less than 1.5 times the nominal bar diameter, 1.5 times the maximum size of the coarse aggregate, or 1 ½ inches, whichever is greater. For precast concrete (manufactured under plant control conditions), the clear distance between parallel bars in a layer shall not be less than 1 bar diameter, 1.33 times the maximum size of the coarse aggregate, or 1 inch, whichever is greater.

When reinforcement is placed in beams and girders in two or more layers, the bars in the upper layers shall be placed directly above those in the bottom layer wherever possible. In concrete slabs, the reinforcing bars in separate mats shall be offset so that they are not directly over each other.

The clear distance between bars shall also apply to the clear distance between a splice and an adjacent splice or bar. For structural elements designed by the **LFD** method, the flexural reinforcement shall be distributed in accordance with **AASHTO 17th Edition** Subsection 8.16.8.4. For structural elements designed by the **LRFD** method, the flexural reinforcement shall be distributed in accordance with **AASHTO LRFD 4th Edition** Subsection 5.10.

5.4 - COVER

The concrete cover required between reinforcing steel and the outside face of a structural unit is dependent on the type of structure and outside environment. The following list indicates the minimum required cover for most circumstances.

Traditionally Reinforced Deck Slabs on Beams or Stringers:

Top of slab with separate wearing surface.. 2 in

Top of slab with integral wearing surface .... 2 ½ in

Bottom of slab.. 1 ½ in

Isotropically Reinforced Deck Slabs on Beams or Stringers:

Top of slab with separate wearing surface... 2 ½ in

Top of slab with integral wearing surface .... 2 ½ in

Bottom of slab.. 1 ½ in

Beams.. 2 in

Walls and piers above footings (including those adjacent to water) .... 3 in

Footings (including unformed bottom)... 3 in *

Face of culverts in contact with earth .... 2 in

Bottom of bottom slab of culvert .... 3 in

Bottom of top slab of culverts and low rise rigid frames... 1 ½ in

Arches, intrados and extrados .... 2 in

Precast and cast-in-place piles .... 2 in

Precast piles exposed to sea water .... 3 in

All concrete surfaces exposed to sea water .... 4 in

Top of sidewalk slabs .... 3 in

Pedestal (Top).. 3 in

Pedestal (Sides)... 3 in

* - When footings are placed on piles, the cover is normally measured from the top of the pile. However, if spacing allows, the designer may place the bottom mat of

reinforcement the cover distance above the bottom of footing. The concrete cover over seismic stirrups in substructure stems and footing where required shall be 2 ½ inches except in salt water environments where the cover shall be 3 ½ inches.

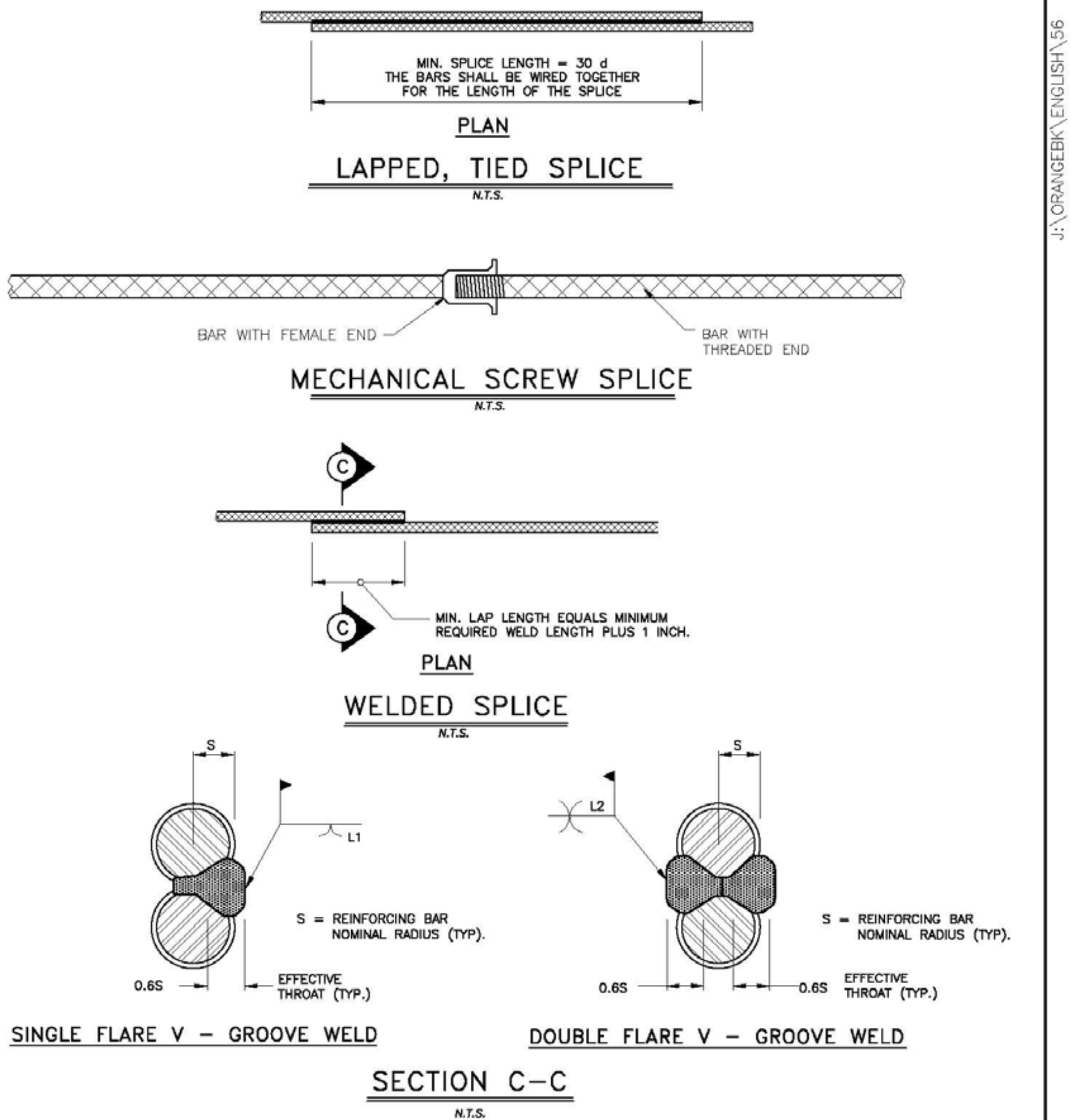
5.5 - MAXIMUM BAR LENGTHS

Specified bar lengths are limited due to fabrication and coating constraints and design considerations. This allows for the most economical price by increasing the number of competing bidders. Most reinforcing bar plants in the United States produce bars in a standard length of 60 feet. However, most galvanizing tanks are limited to 40 feet long. Therefore, the maximum length of a straight galvanized bar should not exceed 40 feet. Where bars can be shop bent prior to galvanizing, the 40 foot length limitation applies to the out to out dimension of the bent bar. Where shop bending is not allowed (typically only on projects in NY Division), all bar bending is done in the field after galvanization. In this case, the length limitation would apply to the overall length of the bar.

5.6 - SPLICING REINFORCEMENT

5.6.1 - GENERAL

During the design process, consideration must be given to splicing reinforcing bars. This is necessary due to limited bar lengths (40 feet max.) and construction practices (stage construction). Splice lengths and locations shall be shown on the contract plans. The Thruway Authority generally accepts three types of splices: Lap Splices, Mechanical Splices and Welded Splices. See Detail 5.6.



MINIMUM WELD LENGTHS

BAR SIZE	SINGLE FLARE L1 V–GROOVE WELD	DOUBLE FLARE L2 V–GROOVE WELD
5	4"	2 1/2"
6	4 1/2"	2 3/4"
7	5"	3"
8	5 1/2"	3 1/4"
9	6"	3 1/2"

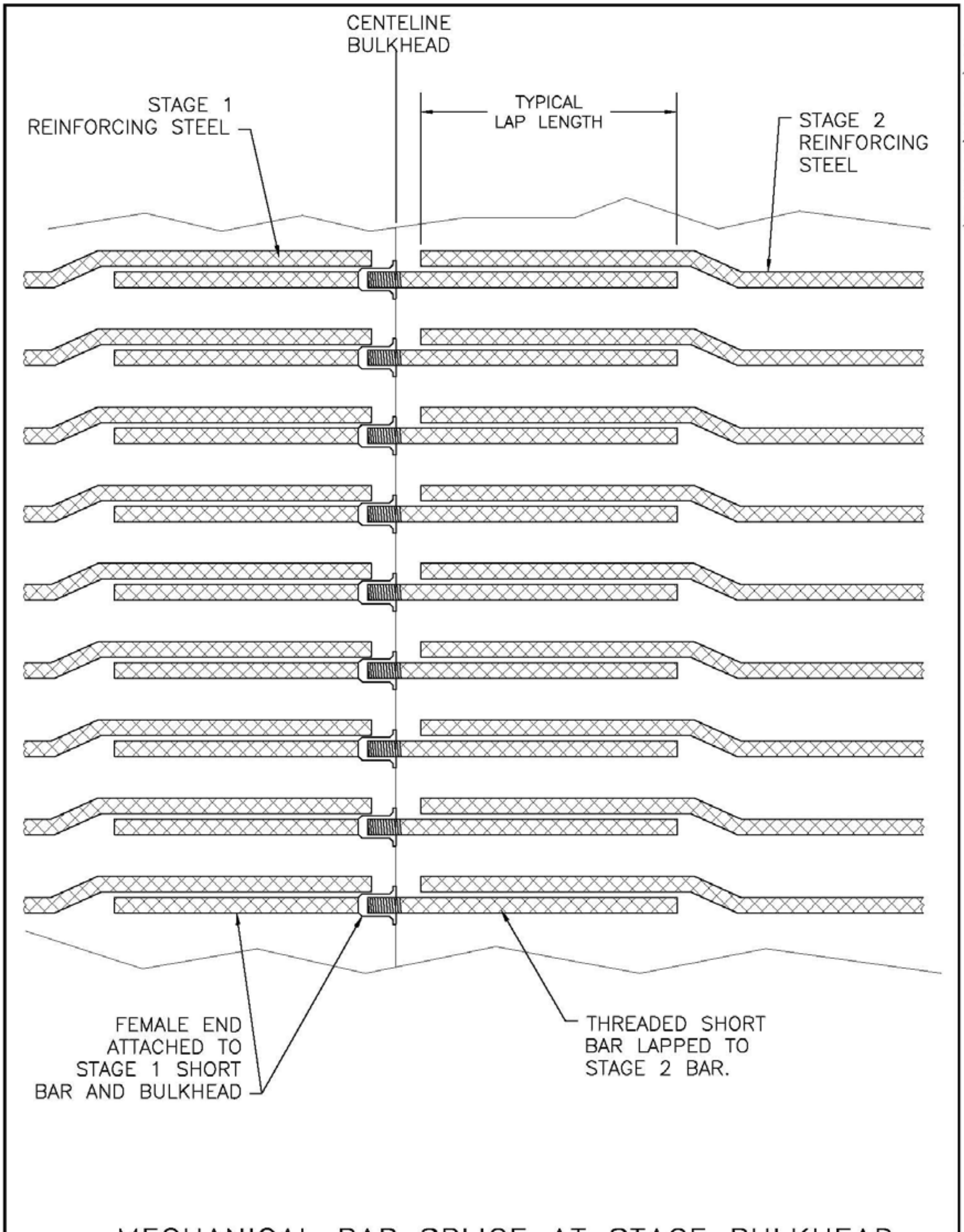
REINFORCING BAR SPLICE TYPES
DETAIL 5.6

N.T.S.

Of the three, lap splices are the most economical, and so, should be used whenever possible. Lap splices shall be wired together the full length of the splice. Allowable mechanical splices are limited to the "screw" type. These are used at construction joints where space is limited. When splicing a galvanized bar to an existing epoxy-coated bar, the epoxy-coated bar splice length shall be used. Mechanical splices are typically used at bulkheads of construction joints on staged construction projects. Space between the stages is usually limited. A bar that needs to be continuous between stages will end in Stage 1. A bar of the same diameter and appropriate lap length with a female flanged connection welded to the end is lapped to the Stage 1 bar and attached to the bulkhead at the flanged connection. During Stage 2, a second bar of appropriate lap length and a threaded end is screwed into the Stage 1 female connector. The appropriate Stage 2 bar is then lapped to this second bar. See Detail 5.6.1. Welded splicing of reinforcement shall be limited to spiral reinforcement in pier columns & CIP piles, and replacement reinforcement in concrete repair areas where the appropriate lap length of the existing bar cannot be exposed. See the Thruway Standard Detail Sheets for Class D and Deck Concrete Repair Details. Reinforcement shall not be tack welded. All welding of reinforcing bars shall be in accordance with the New York State Steel Construction Manual.

5.6.2 - SPLICING REINFORCEMENT IN DECKS

Splices of reinforcement in decks should be in compression zones wherever possible. Splices of transverse bars in the bottom mat should be directly over the beams or stringers. Transverse bars in the top mat should be spliced between the beams or stringers.



MECHANICAL BAR SPLICE AT STAGE BULKHEAD
DETAIL 5.6.1

N.T.S.

When stage construction is required, splicing of the transverse bars shall be within a closure pour between adjacent beams. A closure pour should never be directly over a beam. Where room is limited between stages, mechanical bar splices should be used as described in Subsection 5.6.1.

On simple span bridges, the placement of splices on longitudinal bars is not critical due to the deck being in longitudinal compression for its full length. Splices in both top and bottom mats should be placed to maximize bar lengths (40 feet maximum) and staggered where possible.

On continuous and rigid frame bridges, portions of the deck will be in tension due to superimposed dead loads and live loading. These areas must be identified during design and indicated on the contract plans. Splicing of longitudinal bars should be excluded from these areas. The longitudinal reinforcement in tension zones should have its ends anchored into adjacent compression zones whenever possible. In the case of a continuous structure where the tension zone over the pier is at or greater than 40 feet, the bars should be spliced away from the pier, closer to the dead load point of contraflexure. At no time should the longitudinal reinforcement be spliced directly over the pier.

5.6.3 - SPLICING REINFORCEMENT IN WALL STEMS

Splices of vertical bars shall be made in accordance with the seismic criteria found in **AASHTO 17th Edition** Division IA Subsection 6.6 and **AASHTO LRFD 4th Edition** Subsection 5.10.11.

Splices between main vertical wall reinforcement and the reinforcement emerging from the footing shall be made in the wall stem. The steel emerging from the footing shall extend up into the wall stem the full development length of the bar. The wall stem steel shall be lapped to the steel from the footing. The lap length required for these splices shall be that required for the smaller bar. In some cases, it may be practical to eliminate splices by extending the bars emerging from the footing to the top of wall stem.

Horizontal reinforcing steel in wingwalls, retaining walls and conventional abutment stems are for temperature only. However, the splices of these bars shall be of the tension type, recognizing that soil loads will be translated along the length of the structure. Horizontal reinforcing in abutment stems of integral abutment bridges and rigid frame bridges is tension steel designed for the soil loading between piles and the confinement of the core concrete and vertical reinforcing steel during seismic activity. See **AASHTO 17th Edition** Division IA Subsections 6.6 &7.6 and **AASHTO LRFD 4th Edition** Subsection 5.10.11.4.1d. All splices shall be the tension type and staggered where possible.

5.6.4 - SPLICING REINFORCEMENT IN PIER STEMS AND COLUMNS

Splices of vertical bars shall be made in accordance with the seismic criteria found in **AASHTO 17th Edition** Division IA Sections 6.6 &7.6 and **AASHTO LRFD 4th Edition** Subsection 5.10.11.4. When a plinth is provided at the base of a column or stem, the design vertical reinforcement for the column or stem shall extend through the plinth and into the footing its full development length. Lap splices in the design vertical reinforcement shall be provided (if necessary) within the center half of the column's height. Splices should be staggered wherever possible. In some cases, it may be practical to eliminate splices by extending the bars emerging from the footing to the top of the stem or column. Vertical design reinforcement shall extend into the cap beam of column piers for the full imbedment length, bent or hooked as required.

Horizontal reinforcing in pier stems is tension steel designed for the confinement of the core concrete and vertical reinforcing steel during seismic activity. See **AASHTO 17th Edition** Division IA Sections 6.6 &7.6 and **AASHTO LRFD 4th Edition** Subsection 5.10.11.4. All splices shall be the tension type and staggered where possible.

5.7 - MARKING OF BARS

Bars shall be marked consecutively, beginning with the number one (1), through each structural unit. A structural unit, such as an abutment, includes all concrete subdivisions (abutment footing, abutment stem, wingwall footing, wingwall stem, etc.) which together comprise the entire unit. In the bar list, structural units are to be identified by a general heading, e.g., South Abutment. Appropriate subheadings shall also precede the listing of bars in each subdivision, e.g., Southeast Wingwall stem. When a subdivision is still further divided into more than one pour, the listing of bars in each pour shall also be preceded by appropriate identification, e.g., Abutment Stem, Pour 1. A typical bar marking might be 7AG20. This bar mark represents a #7 size galvanized bar in the abutment that is the 20th different type to be placed in the abutment. The letter G following the structural unit letter (A) in the bar mark indicates that the bar is galvanized.

When a bar is imbedded in two or more subdivisions (such as a dowel), the subheading under which the bar is listed shall be the subdivision in which the bar is initially imbedded. The same bar mark may be reused throughout the same structure unit provided the bar is identical each time it is used.

In applying the sequential bar number where two or more structure units are involved, such as two or more similar abutments, piers, spans etc., it is desirable that the same bar number be applied to bars in similar locations in the structure unit. The fact that two bars lying in different structure units may have the same bar number but have different lengths, or they may have the same length but have different sizes or different shapes, or any combination of these factors will not be confusing to the fabricator due to our practice of providing a separate bar list, properly titled, for each structure unit.

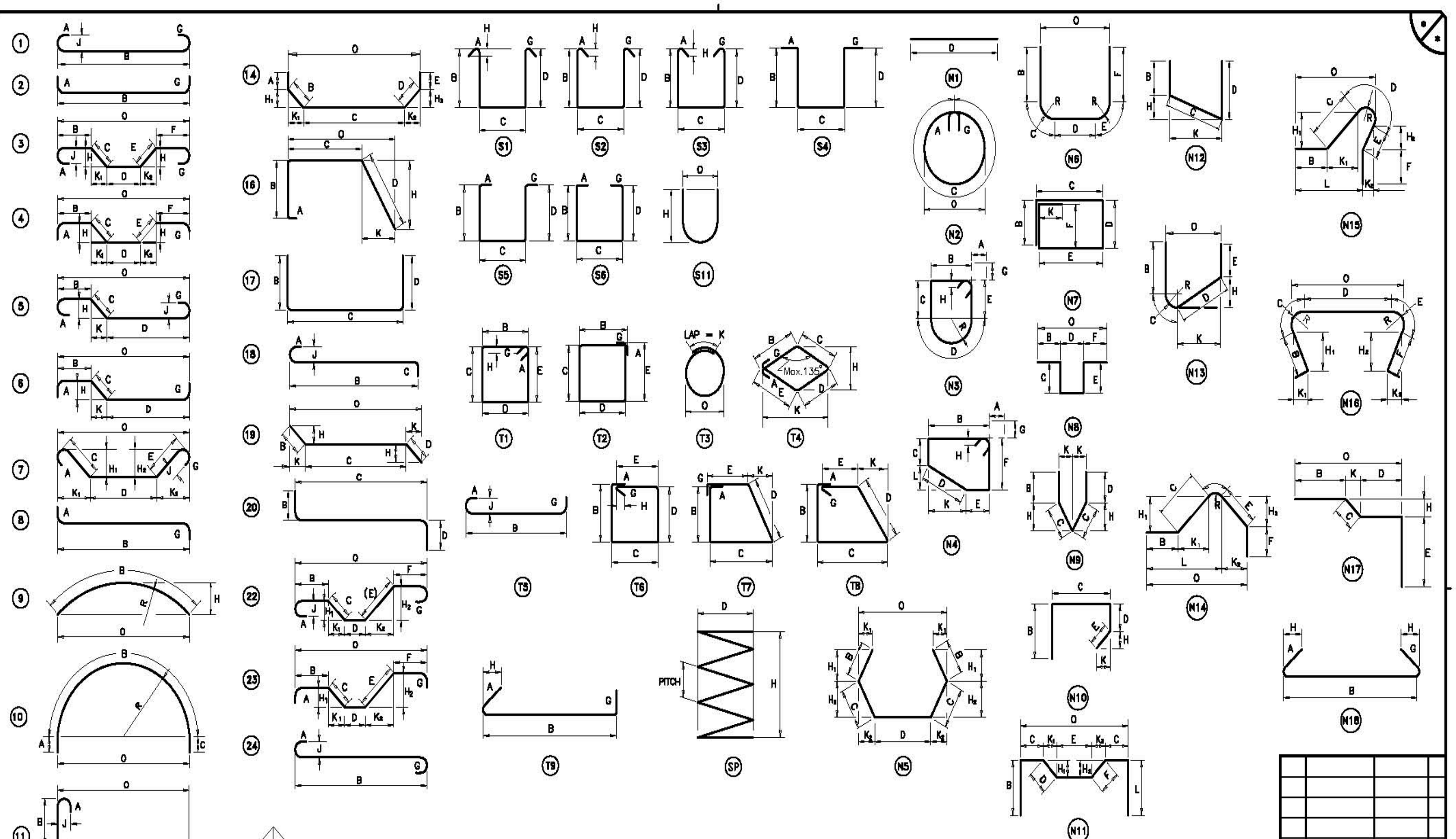
For varying length bars, give minimum, maximum and average lengths of bars. Give number of sets of bars even if the number of sets is one. All the bars within a set will have the same bar mark. If the length varies by less than 4 inches between the minimum and maximum length of the set, rather than vary the bar length, use the length of the shortest bar. Deviations from the above system of marking bars must have the approval of the **DSD**.

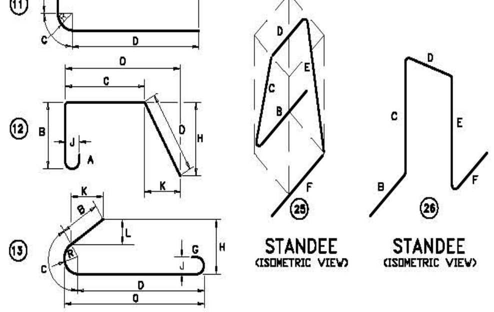
5.8 - BAR BENDING DIAGRAMS & STANDARD HOOKS

In order to conform to practices used in the reinforcing bar industry, the Authority has adopted the bar bending diagrams and standard hook dimensions found in the Manual of Standard Practice (first printing) of the **Concrete Reinforcing Steel Institute (CRSI)**. These diagrams, as well as several additional diagrams commonly required in our structures, are shown on the following pages. The drawing of bar bending diagrams should be inserted into the contract plans. These diagrams shall be used in all in-house and consultant designs prepared for the Authority. All dimensions on these diagrams are measured from out-to-out of bar bends. Any additional bar configurations required for a project shall be added manually to the contract plans. As noted in the **CRSI** Manual, the stirrup (Type "S") and tie bars (Type "T") have tighter fabrication tolerances than other bars. Since this will increase costs, the designer should choose these bar types with care. Lengths for each leg of the bars should be rounded to the nearest ½ inch. The direction of rounding shall be such that minimum cover and minimum lap lengths are maintained. The average length of a set of bars shall also be rounded to the nearest ½ inch.

5.9 - DRILLING AND GROUTING REINFORCING BARS

Three approved items for drilling and grouting of reinforcing bars exist. Which item number to use depends on the application. Refer to Section 586 of the **NYSDOT** Standard Specifications for guidance. In general, bars in tension will require pullout testing. Bars in compression will not.





ALL DIMENSIONS ARE OUT-TO-OUT DIMENSIONS EXCEPT HOOKS A & G

STEEL REINFORCEMENT NOTES

1. UNLESS OTHERWISE DESIGNATED, ALL BAR REINFORCEMENT FOR CONCRETE IN SIZES UP TO AND INCLUDING NO. 55 SHALL CONFORM TO THE REQUIREMENTS OF THE "SPECIFICATIONS FOR DEFORMED BILLET-STEEL BARS FOR CONCRETE REINFORCEMENT", ASTM A615. ALL BARS SHALL BE GRADE 60, UNLESS OTHERWISE DESIGNATED.
2. FOR TYPICAL BENDING DETAILS, RECOMMENDED P.I.N. DIAMETER "D" OF BENDS HOOKS AND OTHER STANDARD PRACTICES SEE ACI-318 & THE CONCRETE REINFORCING STEEL INSTITUTE (CRSI) "MANUAL OF STANDARD PRACTICES" (MSP).
3. BARS WHICH REQUIRE MORE ACCURATE BENDING THAN STANDARD PRACTICES SHOULD HAVE LIMITS INDICATED ON THE BARLIST.
4. ALL DIMENSIONS ARE OUT TO OUT OF BAR EXCEPT "A" AND "G" ON STANDARD 180° AND 135° HOOKS.
5. DIMENSIONS "A", "G" AND "J" ARE STANDARD BENDING DIMENSIONS PER EACH SIZE OF BAR. REFER TO C.R.S.I. – M.S.P. FOR DETAILS.
6. WHERE SLOPE DIFFERS FROM 45°, DIMENSIONS "H" AND "K" MUST BE SHOWN ON BARLIST.
7. Δ – INDICATES BARS TO CUT TO FIT IN THE FIELD.
8. ALL REINFORCING BARS SHALL BE FABRICATED AND GALVANIZED IN ACCORDANCE WITH ASTM A767 AND MEET THE REQUIREMENTS OF NYSDOT MATERIAL SPECIFICATION 709-11.
9. FIELD CUT ENDS OF GALVANIZED REINFORCING STEEL SHALL BE REPAIRED AS PER SUBSECTION 556-3.03B2 OF THE N.Y.S. STANDARD SPECIFICATIONS. THE COST FOR THIS WORK SHALL BE INCLUDED IN THE PRICE BID FOR ITEM 556.0203.
10. ITEMS FOR REINFORCINCING STEEL ARE AS FOLLOWS:
    556.0201 – UNCOATED BAR REINFORCEMENT FOR CONCRETE STRUCTURES.
    556.0203 – GALVANIZED BAR REINFORCEMENT FOR STRUCTURES.
11. BAR MARK PROCEDURE IS AS FOLLOWS:
    6SAG03
    - SEQUENTIAL BAR NUMBER.
    - INDICATES BAR COATING (G=GALV., BLANK=BLACK)
    - INDICATES STRUCTURE TYPE (IE. A=ABUTMENT, P=PIER ETC.)
    - INDICATES BAR LOCATION (IE. S=SOUTH, N=NORTH ETC.) (OPTIONAL).
    - INDICATES BAR SIZE (IE. 5,6,7,ETC.)
12. BAR MARKS SHOULD NORMALLY INCREASE IN SEQUENTIAL NUMBER AND SIZE FROM SMALLEST TO LARGEST AT EACH LOCATION.
13. "*" – INDICATES BAR MARK IS OUT OF SEQUENCE.

DATE	DESCRIPTION	BY	SYM.

REVISIONS

NEW YORK STATE THRUWAY AUTHORITY
DEPARTMENT OF ENGINEERING SERVICES
200 SOUTHERN BLVD., ALBANY, N.Y. 12209

TITLE OF PROJECT: *

LOCATION OF PROJECT: *

TITLE OF DRAWING: STANDARD BARBEND DETAILS

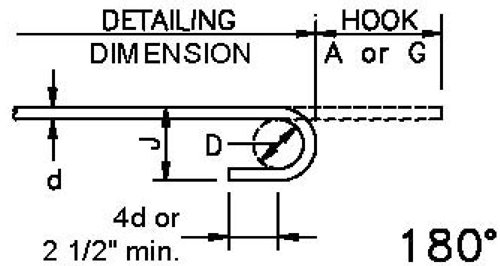
CONTRACT NUMBER: *

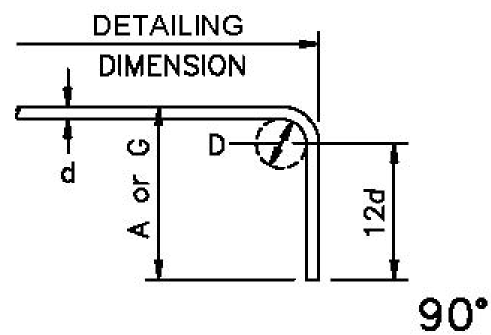
DATE: 1/06

DRAWING NUMBER: *

STANDARD HOOKS

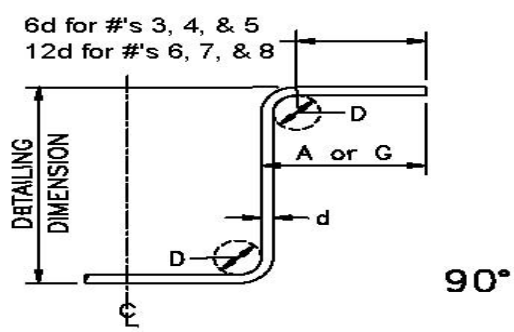
BAR SIZE	180° HOOKS			90° HOOKS
	D	A or G	J	A or G
#3	2 ¼”	5”	3”	6”
#4	3”	6”	4”	8”
#5	3 ¾”	7”	5”	10”
#6	4 ½”	8”	6”	1’-0”
#7	7”	10”	8 ¾”	1’-2”
#8	8”	11”	10”	1’-4”
#9	9”	1’-3”	11 ¼”	1’-7”
#10	10”	1’-5”	12 ½”	1’-10”
#11	11”	1’-7”	1’-1	2’-0”
#14	1’-5 ½”	2’-3”	1’-9”	2’-7”
#18	1’-10 ½”	3’-0”	2’-3”	3’-5”

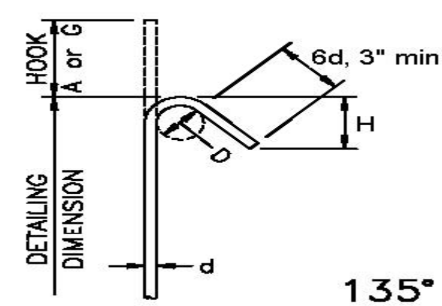




SEISMIC STIRRUPS AND TIE HOOKS

BAR SIZE	D	90° HOOK	135° HOOK	
		A or G	A or G	H
#3	2 ¼”	4”	4”	3”
#4	3”	5”	4”	3”
#5	3 ¾”	6”	5”	3 ¾”
#6	4 ½”	1’-0”	8”	4 ½”
#7	7”	1’-3”	9”	5 ¼”
#8	8”	1’-5”	10”	6”





5.10 - MINIMUM REINFORCEMENT REQUIREMENTS

The minimum reinforcement requirements for various structural elements are presented in the following subsections.

5.10.1 - FOOTINGS - ABUTMENTS AND PIERS

The minimum top reinforcement for individual pier footings shall not be less than 50% of the design bottom reinforcement, but not less than #6 bars at 12 inch centers (both directions). The minimum top reinforcement for continuous pier footings shall be #6 bars at 12 inch centers (both directions).

The minimum transverse and longitudinal reinforcement required for bottom reinforcement in continuous pier footings and for top and bottom reinforcement in abutment and wingwall footings shall be #5 bars at 18 inch centers (both directions). In all cases, these bars shall be either hooked at both ends, or a hooked bar shall be lapped to both ends of these bars. In abutment spread footings, additional transverse reinforcement may be required by design (generally in the bottom of toe and top of heel). See Subsection 5.12 for suggested placement details. In spread footings of piers having columns, additional transverse and longitudinal reinforcement may be required by design. In pile-supported footings of abutments and piers, additional transverse and longitudinal reinforcement may be required by design.

All reinforcing steel extending into stems or columns shall be bent or hooked in the footing. Vertical stirrups (Type N18), #4's at a maximum 4 foot (both directions) grid, shall be provided to connect the top and bottom mats of pier, abutment and wingwall footings. The footing stirrups shall have 135º hook on one end and a 90º hook at the other end. Stirrups shall be placed alternately so that a 135º hook is next to a 90º hook.

5.10.2 - WALLS, STEMS AND SOLID PIERS

The vertical reinforcement for the tensile face of walls, stems and solid piers shall be that required by design, but in no case less than #5 bars at 12 inch centers. Vertical reinforcement for the compression face of walls and stems shall be a minimum of #5's at 12 inch centers. Horizontal stirrups, #4's at 12 inch centers (both directions), shall be provided to connect the front and rear mats of reinforcement in abutment stems, solid piers, and plinths. These stirrups shall have a 135º hook on one end and a 90º hook at the other end. Stirrups shall be placed alternately so that a 135º hook is next to a 90º hook. Walls that do not support a vertical load, such as retaining walls and wingwalls do not require stirrups connecting the front and rear reinforcing steel

The minimum horizontal reinforcement for walls, stems and solid piers shall be #5 bars at 18 inch centers. This minimum amount of reinforcing is included to help prevent shrinkage cracking of the concrete. More reinforcement may be required by design. Cases of this condition include but are not limited to horizontal wall flexure and pier stem vertical steel containment requirements.

The tops of pier and abutment stem bridge seats shall have #8 bars at 6 inch centers longitudinally full length with hooked ends. The front and back of the bridge seats shall be tied together with "U"-

shaped #8 bars at 12 inch centers.

<u>5.10.3 - COLUMNS</u>

When a plinth is provided at the base of a column, the design vertical reinforcement for the column shall extend through the plinth and into the footing.

Vertical reinforcement shall consist of at least four (4) #5 bars or larger, placed at the corners of rectangular sections or equally spaced for circular sections.

Vertical design reinforcement shall extend into the cap beam for the full imbedment length (bend or hook as required). Continuous #5 ties shall surround the vertical reinforcement in rectangular columns. For circular columns, the ties shall be a minimum #3 spiral.

The spacing of ties shall not exceed the least dimension of the column or 12 inches. Additional ties shall be provided at 6 inch centers at the top and bottom of the column over a length equal to the greater of:

A. The maximum dimension of the column.

B. 17% of the column height.

C. 18 inches.

Refer to See **AASHTO 17th Edition** Division IA Subsection 6.6.2(B) and **AASHTO LRFD 4th Edition** Subsection 5.10.11.4d. The ties shall continue for a distance equal to 50% the maximum column dimension but not less than 15 inches from the face of the column connection into the adjoining cap beam or footing.

5.10.4 - STIRRUPS AND TIES

All stirrups and ties shall be provided with 135º hooks on one end and 90º hooks on the other. The minimum cover requirements of Subsection 5.4 do not apply to stirrups. They do however apply to column ties. Stirrups and ties shall be placed to encompass all other reinforcement. For minimum spacing requirements see Subsection 5.3.

5.11 - REINFORCEMENT DEVELOPMENT LENGTHS AND LAP LENGTHS

The basic development length and lap lengths provided in Tables A through F are based on the data provided in Subsections 8.25 through 8.32 of the **AASHTO 17th Edition**.

The assumed rebar yield strength (f_y) is 60ksi, and the assumed compressive strength of the concrete (f′c) is 3,000psi. The classes of tension lap splices are defined in Table 5.11.

TENSION LAP SPLICE CLASS

	Percent of A_s Spliced Within Required Lap Length		
A_s Provided/A_s Required	**50%**	**75%**	**100%**
≥ 2	Class A	Class A	Class B
< 2	Class B	Class C	Class C

TABLE 5.11

As an example, if the area of steel required by the design moments is $A_{sR} = 2in^2$/l-ft and the area provided is $A_{sP} = 2.5in^2$, $A_{sP}/A_{sR} = 1.25$. If 50% of the bars are spliced in the same line then a Class B splice would be required.

Top reinforcement is defined as any horizontal reinforcement with more than 12 inches of fresh concrete cast below it. When the area of steel provided is greater than that required to develop the ultimate moment capacity of the section, the basic development length and splice lengths indicated in the tables may be reduced by the ratio: A_{sR}/ A_{sP}. However, basic development length and splice lengths shall not be less than 12 inches as specified in the **AASHTO 17th Edition** Subsection 8.25.4.

The development length and lap lengths for reinforcement encompassed by spirals, assumes the spiral reinforcement has at least a 4 inch pitch.

The modification factor for cover and spacing is 1.0 if either the cover (in line with the spacing) is less than 3 inches, or the spacing is less than 6 inches. If the cover is at least 3 inches and the spacing is at least 6 inches, the modification factor is 0.8.

DEVELOPMENT AND LAP LENGTHS UNCOATED AND GALVANIZED REINFORCEMENT

TABLE A

TENSILE REINFORCEMENT
COVER AT SPLICE < 3 in OR
SPACING < 6 in

TOP REINFORCEMENT

(Cover is measured in the direction of the spacing)

BAR SIZE	Ld (in)	LAP LENGTH (in) CLASS A	CLASS B	CLASS C
3	13	13	17	22
4	17	17	22	29
5	21	21	28	36
6	27	27	35	46
7	37	37	48	63
8	49	49	63	83
9	62	62	80	105
10	78	78	102	133
11	96	96	125	163
14	131	*	*	*
18	169	*	*	*

* LAPS NOT ALLOWED PER AASHTO 8.32.1.1

TABLE B

TENSILE REINFORCEMENT
COVER AT SPLICE < 3 in OR
SPACING < 6 in

OTHER THAN TOP REINFORCEMENT

(Cover is measured in the direction of the spacing)

BAR SIZE	Ld (in)	LAP LENGTH (in) CLASS A	CLASS B	CLASS C
3	12	12	12	16
4	12	12	16	21
5	15	15	20	26
6	20	20	25	33
7	27	27	35	45
8	35	35	45	59
9	44	44	57	75
10	56	56	73	95
11	69	69	89	117
14	94	*	*	*
18	121	*	*	*

* LAPS NOT ALLOWED PER AASHTO 8.32.1.1

DEVELOPMENT AND LAP LENGTHS
UNCOATED AND GALVANIZED REINFORCEMENT

TABLE C

TENSILE REINFORCEMENT
COVER AT SPLICE ≥ 3 in AND
SPACING ≥ 6 in

TOP REINFORCEMENT

(Cover is measured in the direction of the spacing)

BAR SIZE	Ld (in)	LAP LENGTH (in) CLASS A	CLASS B	CLASS C
3	12	12	14	18
4	14	14	18	23
5	17	17	22	29
6	22	22	28	37
7	30	30	39	50
8	39	39	51	66
9	49	49	64	84
10	63	63	81	106
11	77	77	100	131
14	105	*	*	*
18	135	*	*	*

* LAPS NOT ALLOWED PER AASHTO 8.32.1.1

TABLE D

TENSILE REINFORCEMENT
COVER AT SPLICE ≥ 3 in AND
SPACING ≥ 6 in

OTHER THAN TOP REINFORCEMENT

(Cover is measured in the direction of the spacing)

BAR SIZE	Ld (in)	LAP LENGTH (in) CLASS A	CLASS B	CLASS C
3	12	12	12	13
4	12	12	13	17
5	12	12	16	21
6	16	16	20	27
7	21	21	28	36
8	28	28	36	47
9	35	35	46	60
10	45	45	58	76
11	55	55	71	93
14	75	*	*	*
18	97	*	*	*

* LAPS NOT ALLOWED PER AASHTO 8.32.1.1

DEVELOPMENT AND LAP LENGTHS
UNCOATED AND GALVANIZED REINFORCEMENT

TABLE E

COMPRESSION REINFORCEMENT

BAR SIZE	Ld (in)	MINIMUM LAP LENGTHS W/O TIES (in)	MINIMUM LAP LENGTHS WITH TIES (in)
3	9	12	12
4	11	15	13
5	14	19	16
6	17	23	19
7	20	27	22
8	22	30	25
9	25	34	28
10	28	39	32
11	31	43	36
14	37	*	*
18	50	*	*

* LAPS SHALL FOLLOW PROVISIONS OF AASHTO 8.32.4.1

TABLE F

COMPRESSION REINFORCEMENT WITH SPRIALS
4 in MAXIMUM PITCH

BAR SIZE	Ld (in)	MIN LAP LENGTH (in)
3	8	12
4	9	12
5	11	14
6	13	17
7	15	20
8	17	23
9	19	26
10	21	29
11	24	32
14	28	*
18	37	*

* LAPS SHALL FOLLOW PROVISIONS OF AASHTO 8.32.4.1

5.12 - SUGGESTED REINFORCEMENT PLACEMENT DETAILS

Refer to details in Section 3 – Deck Systems, and Section 4 – Substructures, for examples of various placement schemes.

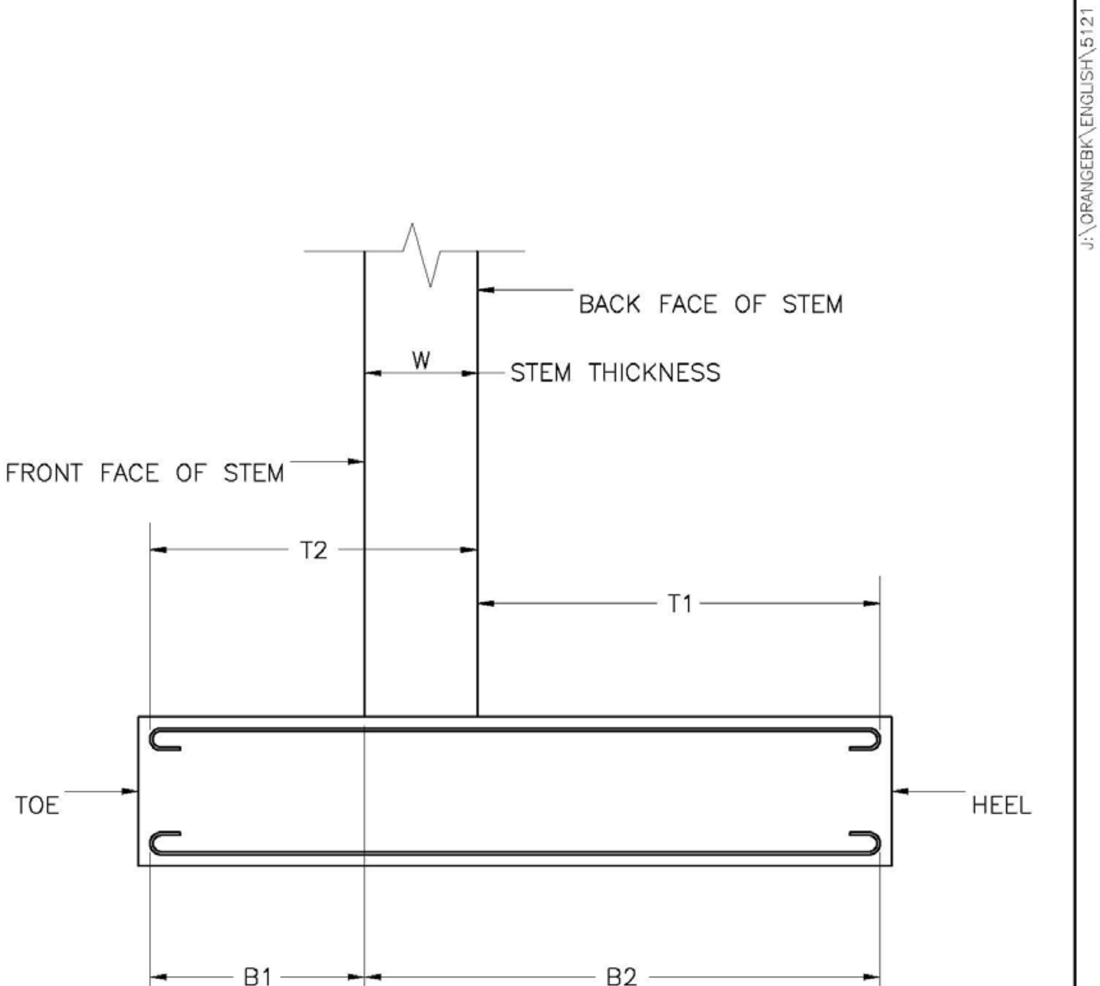
5.12.1 - DESIGN REINFORCEMENT - SPREAD FOOTINGS

5.12.1.1 - TOE STEEL

Tensile reinforcement is required in the bottom of the toe. The length of the bar from the front face of the wall to the front end of the bar (dimension "B1") must be equal to or greater than the minimum development length for tensile reinforcement other than top bars as shown in the tables (see Detail 5.12.1). The remaining length of bar, "B2", should extend to the footing heel as shown. All bottom tensile reinforcement shall be hooked 180º at both ends.

5.12.1.2 - HEEL STEEL

Tensile reinforcement is required in the top of the heel. The length of the bar from the rear face of the wall to the rear end of the bar (dimension "T1") must be equal to or greater than the minimum development length for tensile reinforcement ("top bars"). The remaining length of the bar, "T2", should extend to the footing toe as shown. All top tensile reinforcement shall be hooked 180º at both ends.



DETAIL 5.12.1

N.T.S.

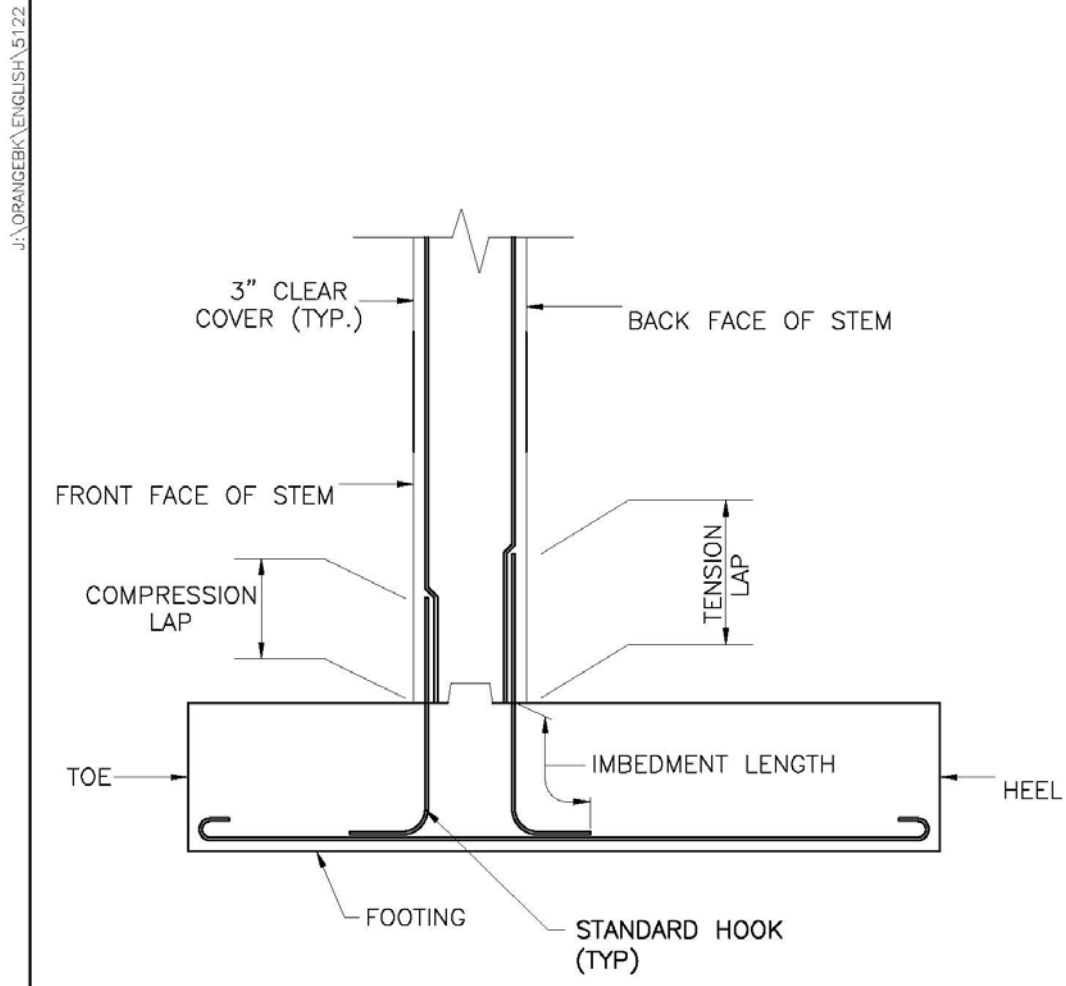
5.12.2 - DOWEL PLACEMENT – FOOTING INTO STEM

Hook all footing dowels 90º. Place dowels so that a minimum of three inches of clear cover is provided (see Detail 5.12.2). Typically, the hook end is placed on top of the bottom matt of footing reinforcing. The required lap lengths for compression and tension laps are shown in the tables. When all the wall tensile reinforcement is lapped to the footing dowels at the base of the wall, the lap length must satisfy the requirements of a class "C" splice. Splice locations in pier stems shall be as required in the **AASHTO 17th Edition** Division IA Subsection 7.6.2(F).

5.12.3 - POSSIBLE DOWEL COMBINATIONS

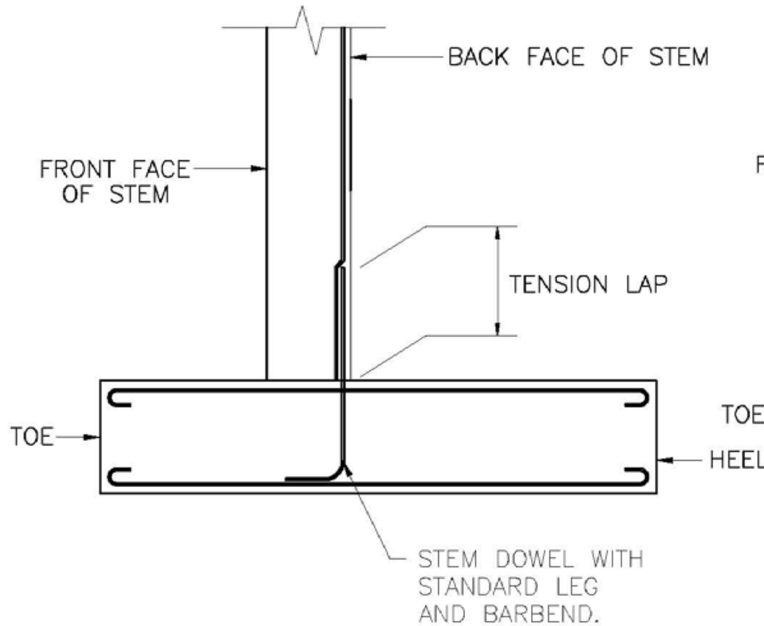
It may sometimes be desirable to bend some of the transverse bottom steel up into the wall and use it as the dowel to the tensile reinforcement in the stem. One reason for doing this is if the footing is too shallow to develop the strength of the standard doweled hook.

The designer should keep in mind that bottom transverse reinforcement should extend to the back of the footing at a maximum spacing of 12 inches. See Details 5.12.3.a and 5.12.3.b. The designer should also remember that the lap length at the base of the stem is controlled by the size of the vertical stem steel, not the size of the dowel.



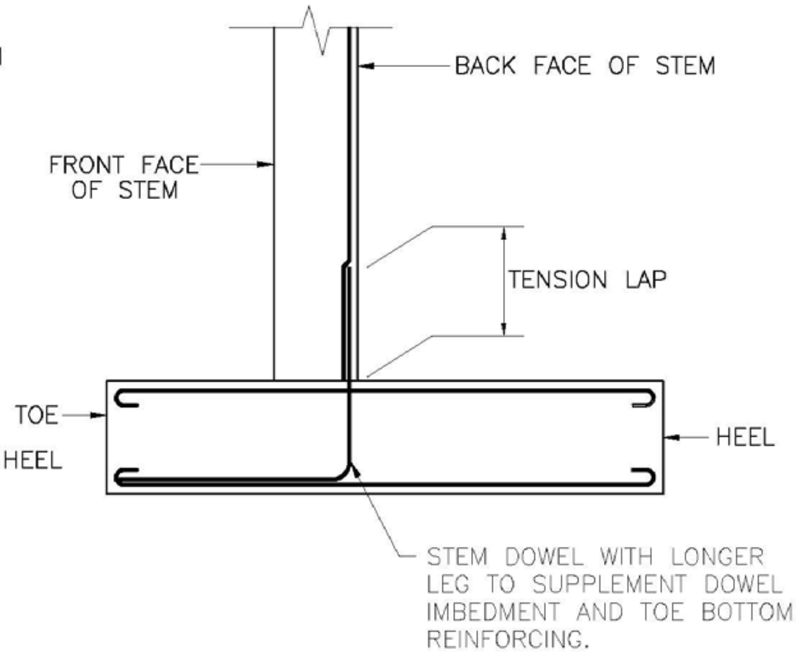
DETAIL 5.12.2

N.T.S.



DETAIL 5.12.3.a

N.T.S



DETAIL 5.12.3.b

N.T.S.

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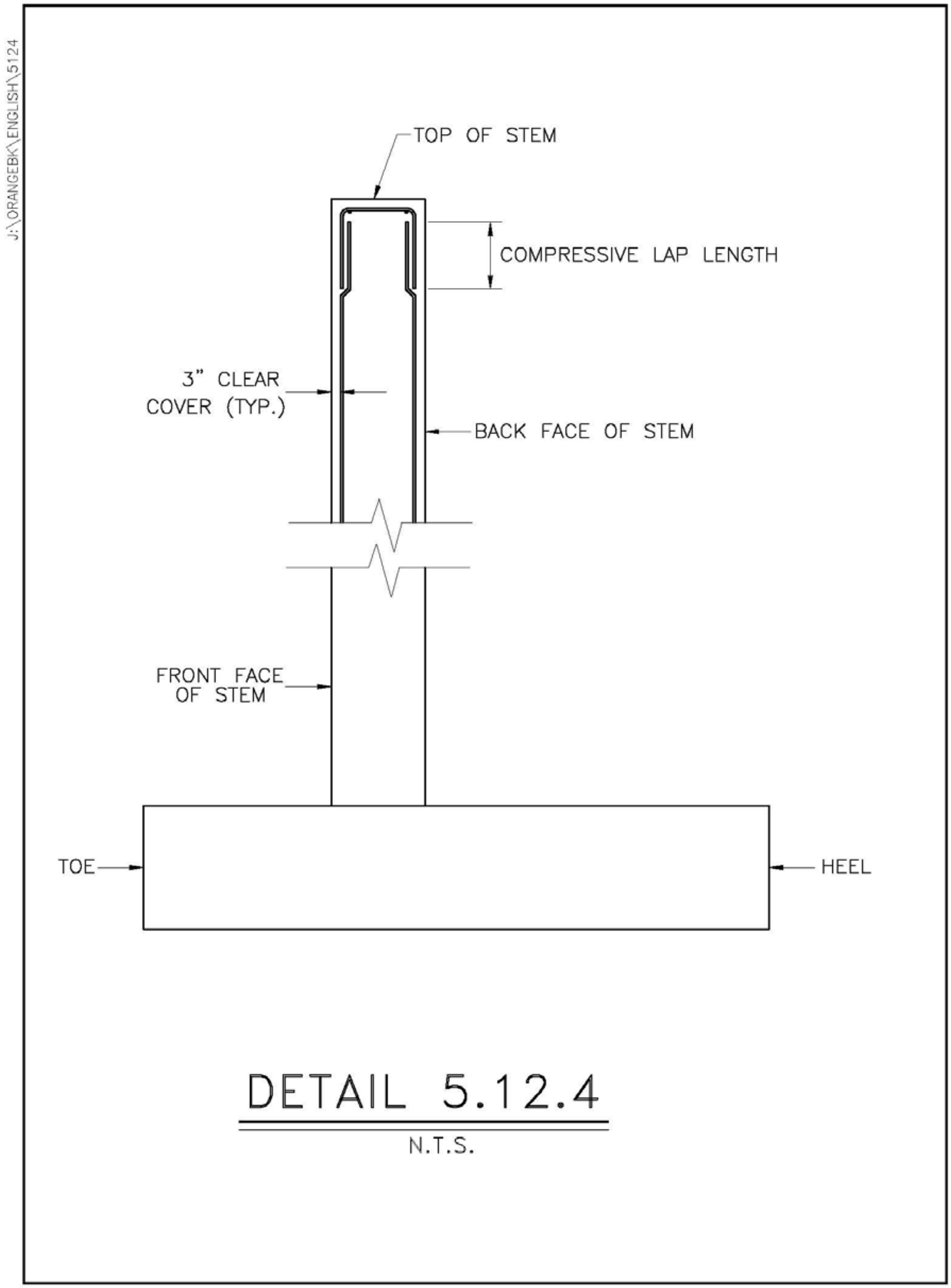
5.12.4 - COMPRESSION BARS

Use lap lengths for compression bars for the following situations:

1. Longitudinal (distribution/temperature) reinforcement in footings.
2. Longitudinal (distribution/temperature) reinforcement in structural slabs (compression zones, not in tension zones over piers).
3. Longitudinal reinforcement in the top of bridge seats and the top of solid piers.
4. Lapping U-shaped stirrups in sidewalks, backwalls, wingwalls and retaining walls. See Detail 5.12.4.

For situations that include compressive and tensile zones, such as pier caps on multi-column piers and decks on multi-span continuous bridges, the designer shall identify all stress reversal zones. Tensile reinforcement shall be anchored beyond this zone into the compression zone using lap lengths for tensile reinforcement. Compressive (distribution/temperature) reinforcement shall be anchored to the tensile reinforcement. The lap length will be that required for the tensile reinforcement.


J:\ORANGEBK\ENGLISH\5124
TOP OF STEM
COMPRESSIVE LAP LENGTH
3" CLEAR
COVER (TYP.)
BACK FACE OF STEM
FRONT FACE
OF STEM
TOE
HEEL
DETAIL 5.12.4
N.T.S.