

CFRP/GFRP SHEET PILE DESIGN CRITERIA AND NOTES

DESCRIPTION:

This Design Standard includes details for six types of piles with two thicknesses. Type "A" is prestressed concrete construction with CFRP strands. Types "B1", "B2", "C1" and "C2" piles (corner piles) are reinforced concrete construction. Type "H" is prestressed concrete construction with carbon-steel strands. Manufacture, cure and install Sheet Piles in accordance with the requirements of the contract documents.

MATERIALS: (for materials not listed refer to the Specifications)

CONCRETE

Class: V (Special) with silica fume, metakaolin or ultra-fine flyash for Type "H" Sections. V (Special) for all other sections.  
 Unit weight: 145 pcf  
 Modulus of Elasticity: Based on the use of Florida limerock aggregate concrete

REINFORCING BARS

Glass Fiber Reinforced Polymer (GFRP) bars meeting the requirements of Specification Section 932.

PRESTRESSING STRAND

Carbon Fiber Reinforced Polymer (CFRP) strand meeting the requirements of Specification Section 933.  
 Carbon-Steel strand meeting the requirements of Specification Section 931.

DESIGN PARAMETERS:

Type "A"

Concrete Compressive Strength at release of prestressing: 4000 psi minimum  
 Uniform compression after prestressing losses: 700 psi minimum  
 Pick-up, Storage and Transportation: 450 psi tension with 1.5 times pile self weight for single-point pick-up at  $f'c \geq 6000$  psi

Types "B1", "B2", "C1" & "C2"

Pick-up, Storage and Transportation: Minimum compressive strength  $f'ci \geq 4000$  psi required for two-point pick-up;  $f'c \geq 6000$  psi for single-point pick-up.

Type "H"

Concrete Compressive Strength at release of prestressing: 4000 psi minimum  
 Uniform compression after prestressing losses: 800 psi minimum  
 Pick-up, Storage and Transportation: 0 psi tension with 1.5 times pile self weight for single-point pick-up at  $f'c \geq 6000$  psi

PLASTIC FILTER FABRIC:

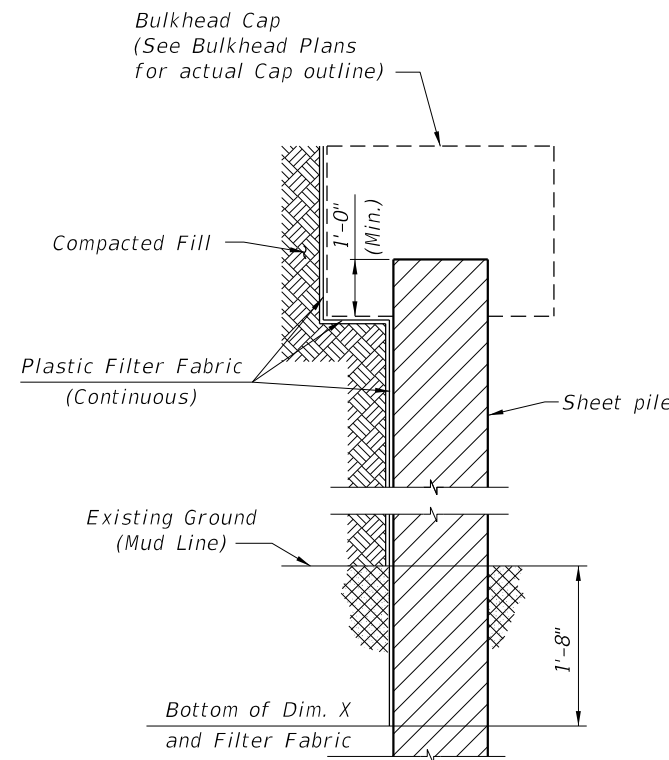
The plastic filter fabric shall extend to the bottom of the "X" dimension.

PILE PICK-UP AND HANDLING:

Two-point pick-up for lifting out of forms & two-point support for storage & transportation.  
 Single-point pick-up for installation only.

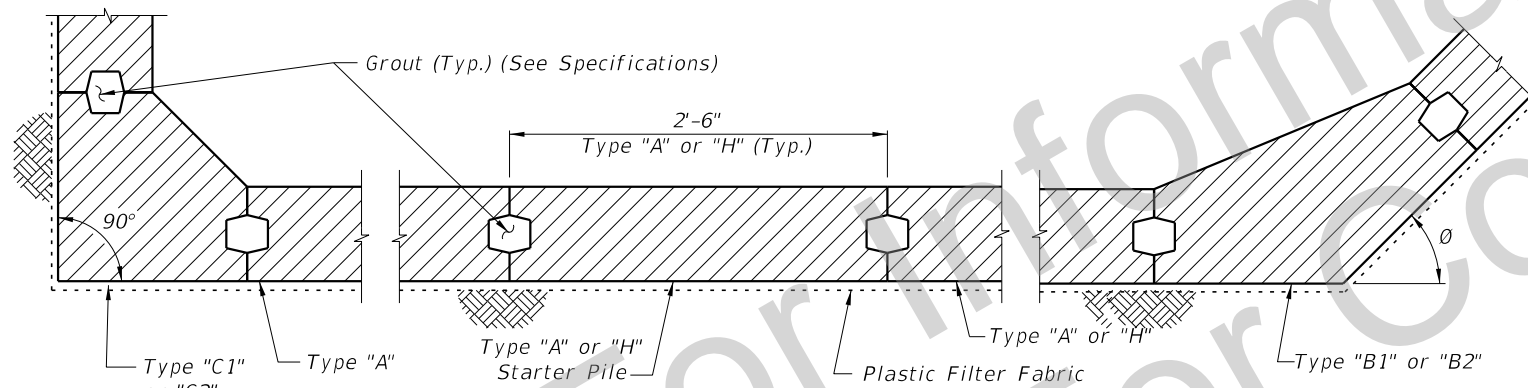
PILE FIT-UP:

The 2'-6" Sheet Pile dimension is nominal. This dimension may be shortened by the Manufacturer up to 1/2" to allow for Sheet Pile fit-up in its final position. Minimum Sheet Pile width is 2'-5 1/2". No changes shall be made to the tongues or grooves.



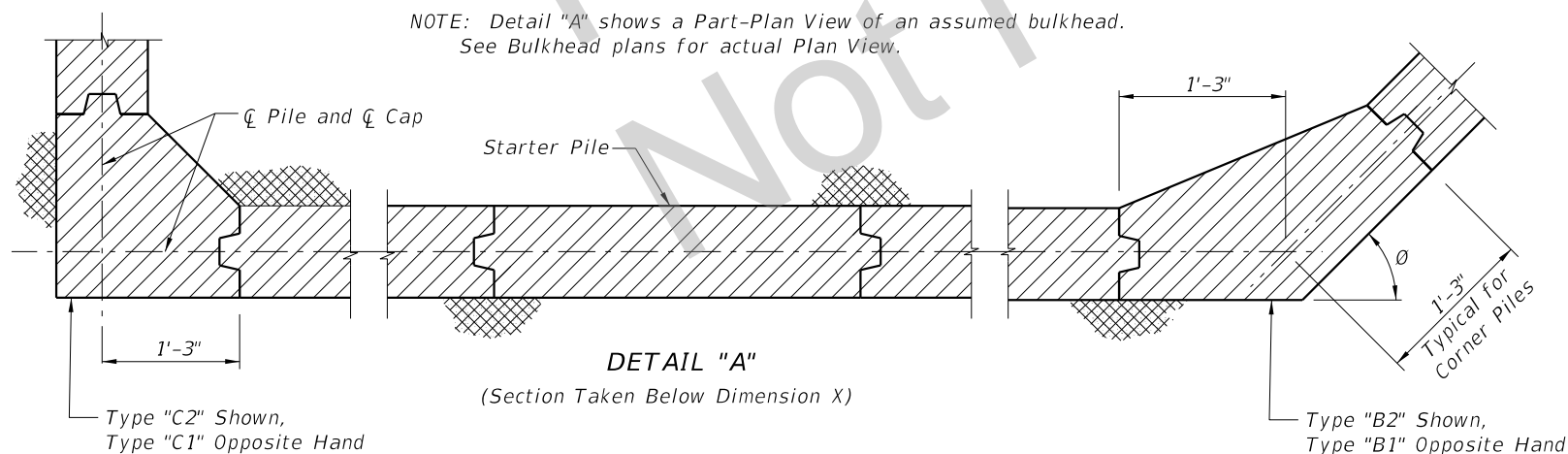
SECTION THRU BULKHEAD  
 (Showing Plastic Filter Fabric)

CROSS REFERENCES:  
 For Dimensions L and X see Sheet Pile Wall Data Table in Structures Plans.

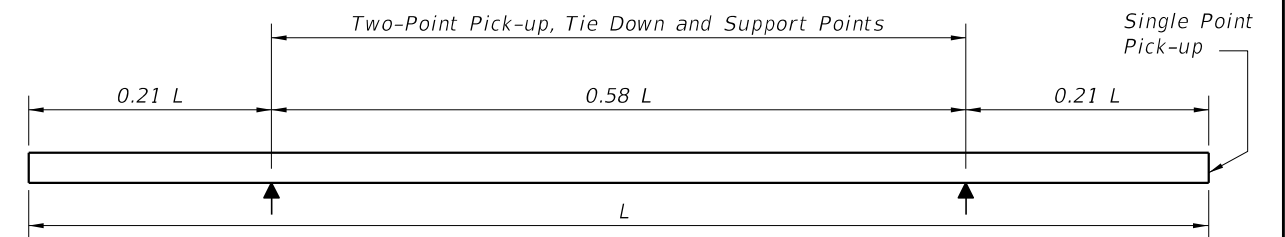


DETAIL "A"  
 (Cap and Anchoring System Not Shown)  
 (Section Taken Above Dimension X)

NOTE: Detail "A" shows a Part-Plan View of an assumed bulkhead. See Bulkhead plans for actual Plan View.



DETAIL "A"  
 (Section Taken Below Dimension X)



PILE STORAGE AND TRANSPORTATION SUPPORT DETAILS

NOTES AND DETAILS

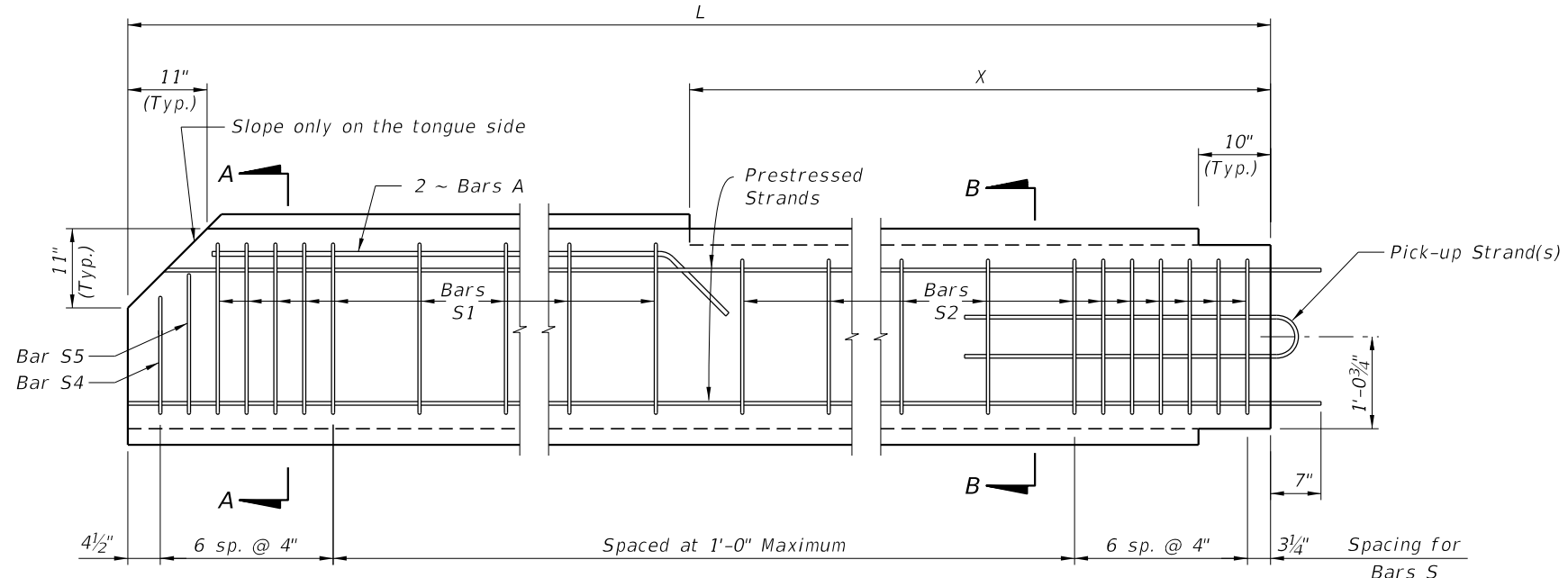
LAST REVISION 09/01/16	DESCRIPTION:
---------------------------	--------------



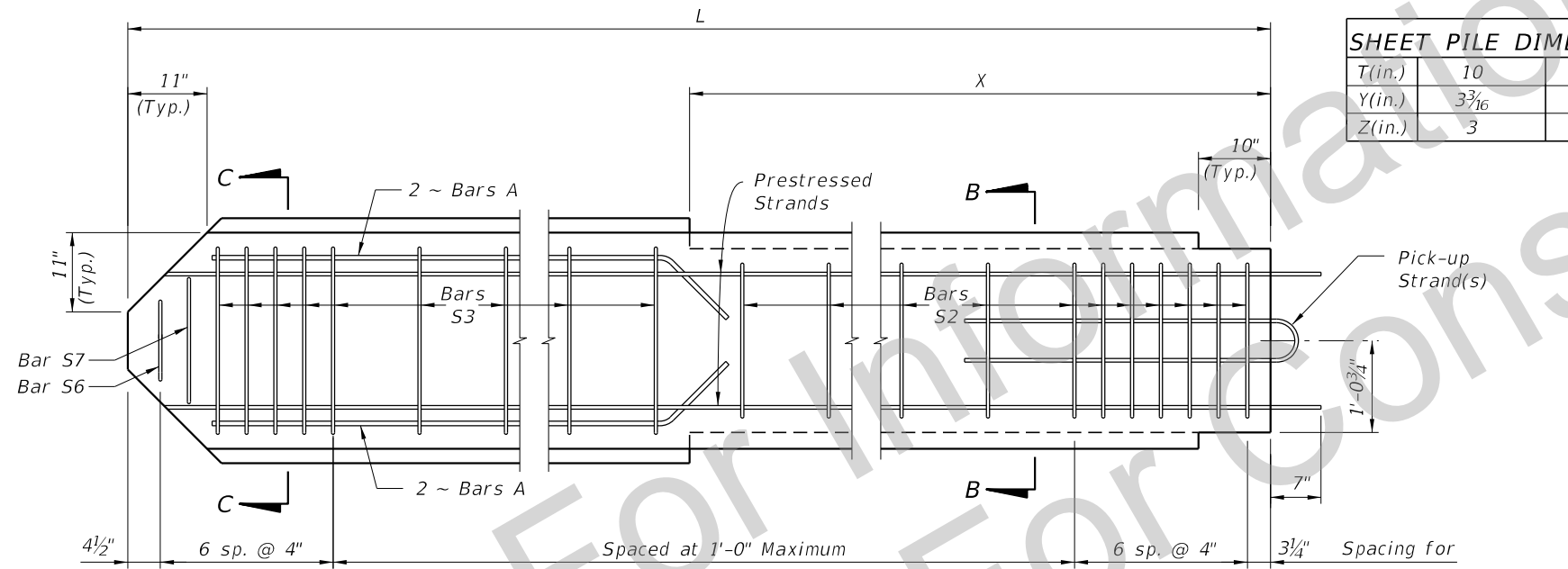
PRECAST CONCRETE CFRP/GFRP SHEET PILE WALL

INDEX NO. D22440	SHEET NO. 1 of 5
---------------------	---------------------

SDATES



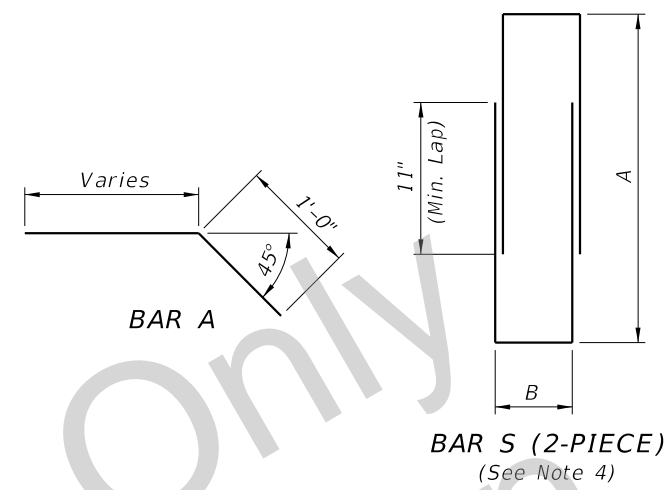
TYPICAL PILE



STARTER PILE

SHEET PILE DIMENSIONS		
T(in.)	10	12
Y(in.)	3 7/16	4 3/16
Z(in.)	3	4

BAR BENDING DIAGRAMS

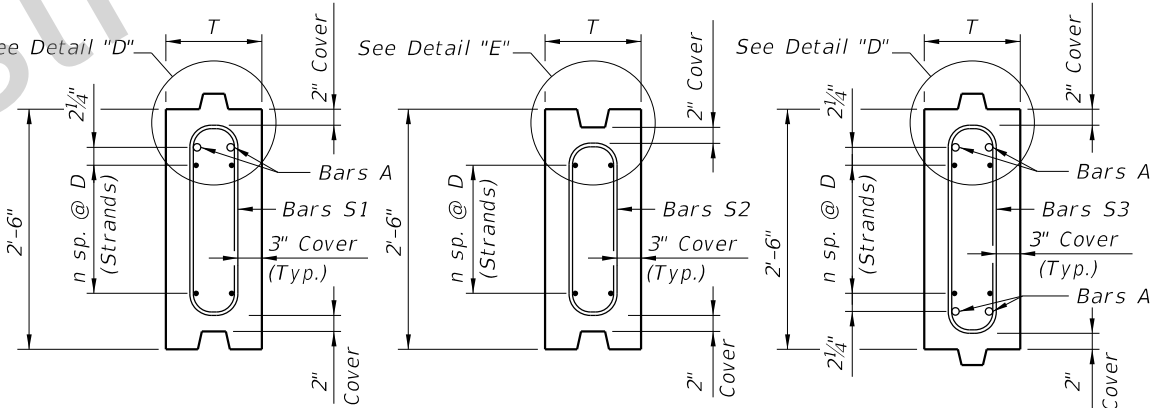


DIMENSION A	
S1	1'-11 3/4"
S2	1'-9 1/2"
S3	2'-2"
S4	1'-6 3/4"
S5	1'-10 3/4"
S6	11"
S7	1'-7 1/4"

DIMENSION B	
T=10 in.	4"
T=12 in.	6"

NOTES:

1. Intermediate Prestress Strands not shown in Elevations and Sections.
2. All bar dimensions are out-to-out.
3. Bars A are GFRP #5
4. Bars S are GFRP #4 and may be a single closed bar (hoop) with equivalent area and tensile strength.
5. For Dimensions L and X see Sheet Pile Data Table in Structures Plans.



SECTION A-A

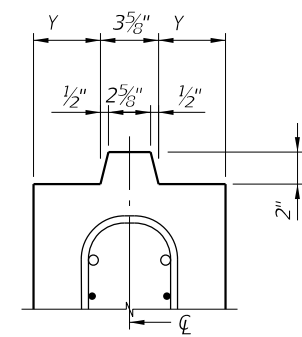
SECTION B-B

SECTION C-C

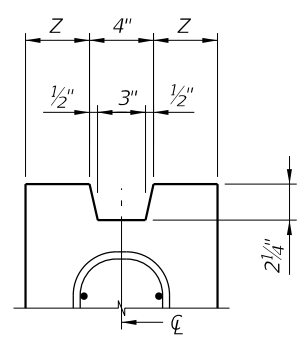
Wall Thickness	CFRP STRAND DIA. (in.)	MAXIMUM L **	n	D (in.)	TOTAL # OF STRANDS	SECTION MODULUS (in. <sup>3</sup> )	* STRESS (psi)
T=10 in.	0.49 (12.5mm)	26'-0"	4	4	10	500	730
	0.5 (12.7mm)	27'-0"	3	5 1/4 <sup>(2)</sup>	8	500	830
	0.6 (15.2mm)	27'-0"	3	5 1/4 <sup>(2)</sup>	8	500	840
T=12 in.	0.49 (12.5mm)	31'-0"	5	3 1/4 <sup>(1)</sup>	12	720	730
	0.5 (12.7mm)	31'-0"	3	5 1/4 <sup>(2)</sup>	8	720	700
	0.6 (15.2mm)	31'-0"	3	5 1/4 <sup>(2)</sup>	8	720	710

\* Unit Prestress after losses @ Section B-B.  
 \*\* Based on lifting using single point pick-up.

Alternate symmetrical strand patterns:  
 (1) 4 sp. @ 2" & 1 sp. @ 8"  
 (2) 2 sp. @ 4" & 1 sp. @ 8"



DETAIL "D" (Typical Tongue)



DETAIL "E" (Typical Groove)

TYPE "A" STANDARD SECTION

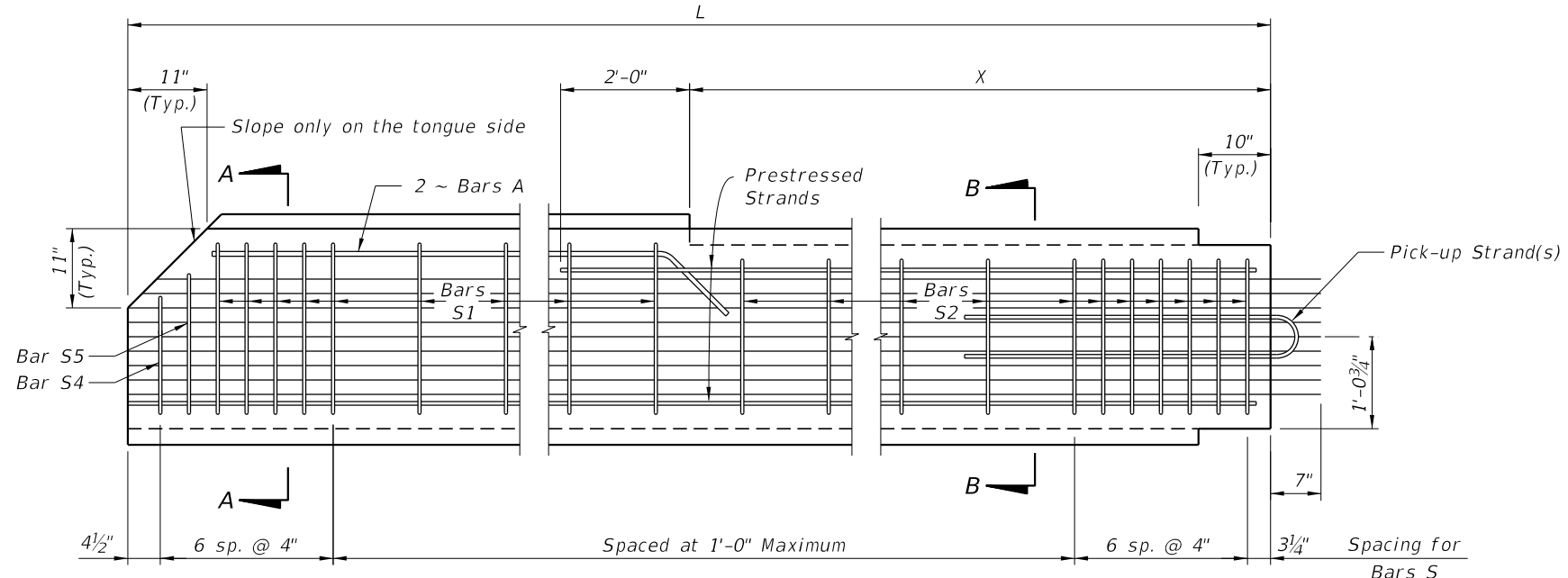
SDATES

LAST REVISION	DESCRIPTION:
09/01/16	

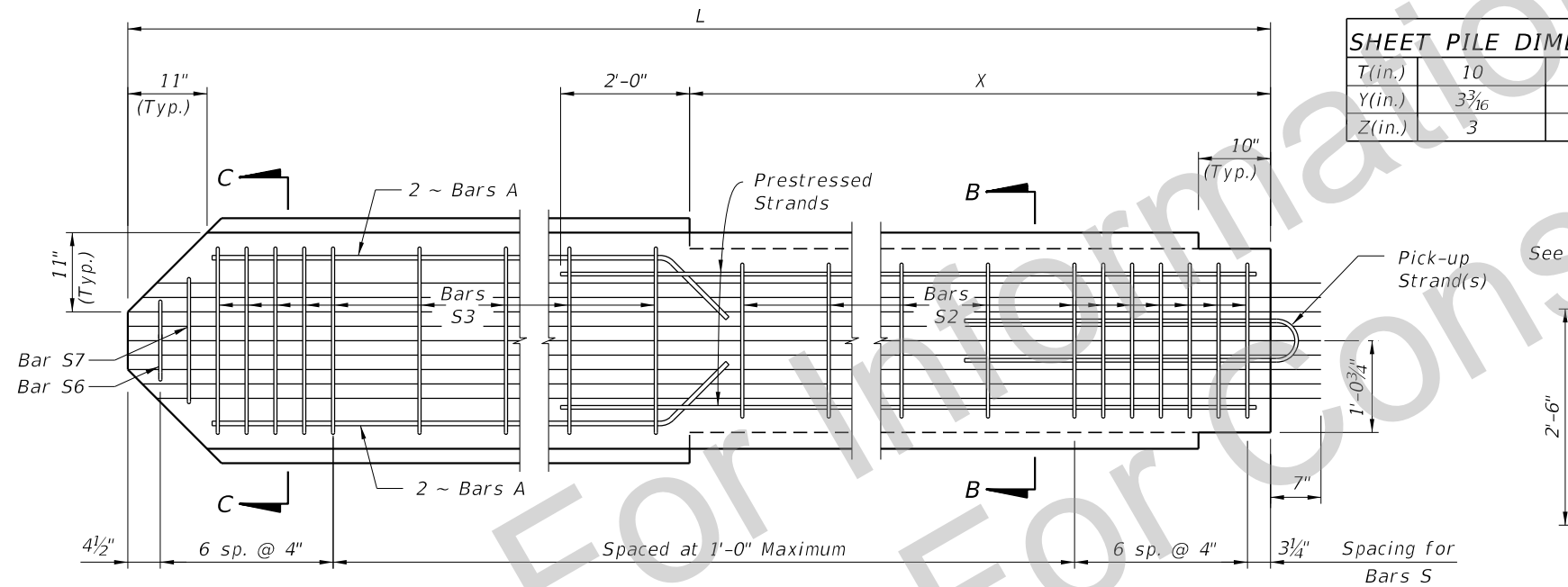


PRECAST CONCRETE CFRP/GFRP SHEET PILE WALL

INDEX NO.	SHEET NO.
D22440	2 of 5



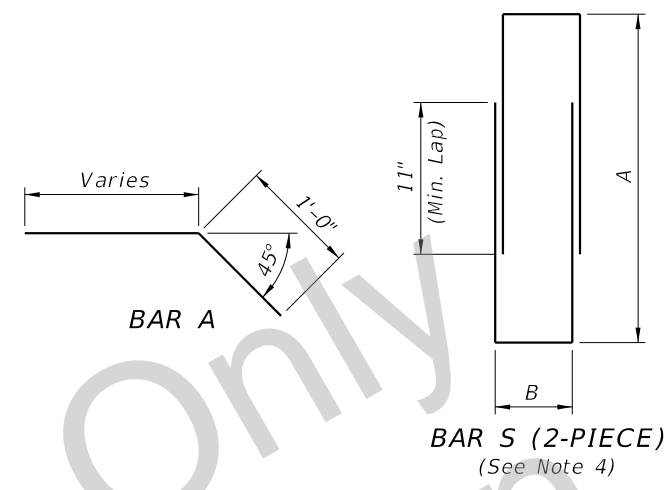
TYPICAL PILE



STARTER PILE

SHEET PILE DIMENSIONS		
T(in.)	10	12
Y(in.)	3 3/16	4 3/16
Z(in.)	3	4

BAR BENDING DIAGRAMS

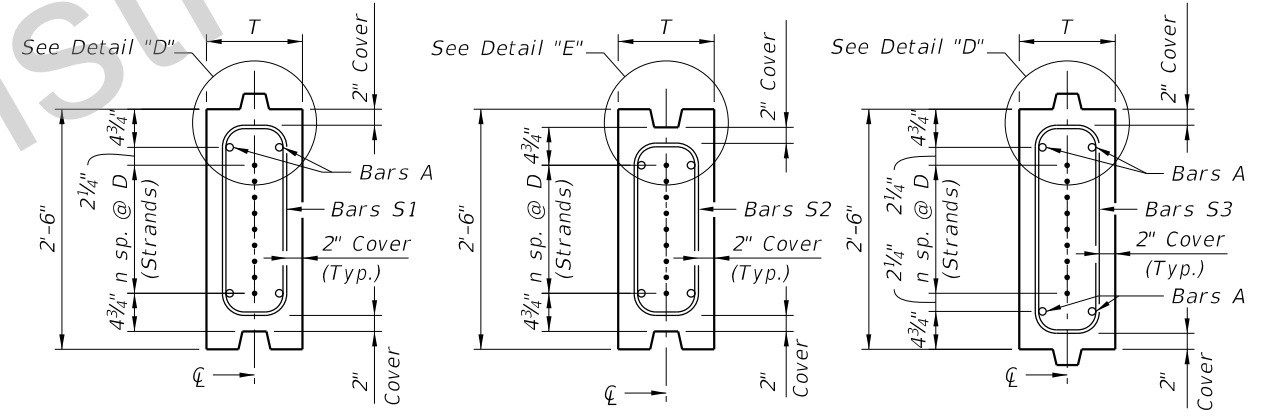


DIMENSION A	
S1	1'-11 3/4"
S2	1'-9 1/2"
S3	2'-2"
S4	1'-6 3/4"
S5	1'-10 3/4"
S6	11"
S7	1'-7 1/4"

DIMENSION B	
T=10 in.	6"
T=12 in.	8"

NOTES:

1. Intermediate Prestress Strands not shown in Elevations and Sections.
2. All bar dimensions are out-to-out.
3. Bars A are GFRP #5
4. Bars S are GFRP #4 and may be a single closed bar (hoop) with equivalent area and tensile strength.
5. For Dimensions L and X see Sheet Pile Data Table in Structures Plans.



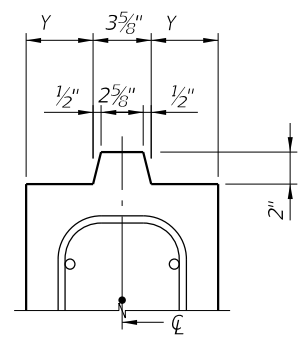
SECTION A-A

SECTION B-B

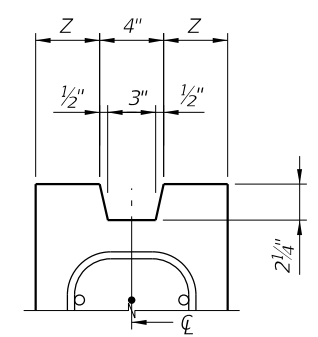
SECTION C-C

Wall Thickness	STEEL STRAND DIA. (in.)	MAXIMUM L**	n	D (in.)	TOTAL # OF STRANDS	SECTION MODULUS (in. <sup>3</sup> )	* STRESS (psi)
T=10 in.	0.6	26'-0"	8	2	9	500	920
T=12 in.	0.6	29'-0"	8	2	9	720	800

\* Unit Prestress after losses @ Section B-B.  
 \*\* Based on lifting using single point pick-up.



DETAIL "D"  
(Typical Tongue)



DETAIL "E"  
(Typical Groove)

TYPE "H" STANDARD SECTION

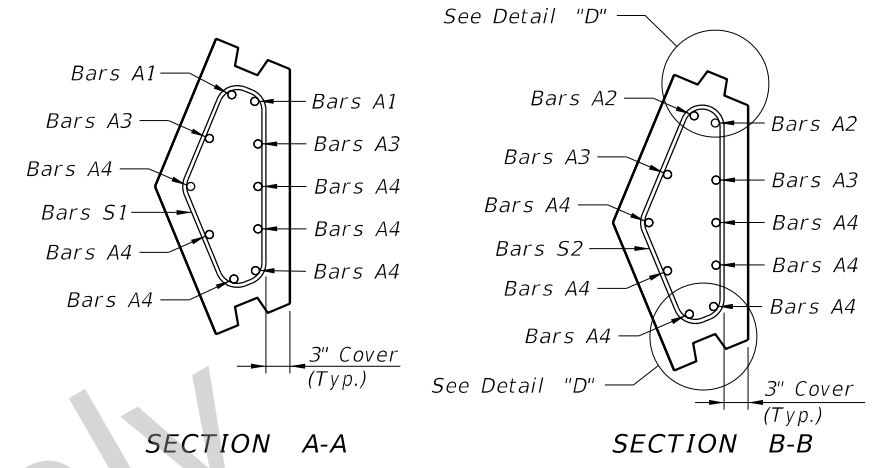
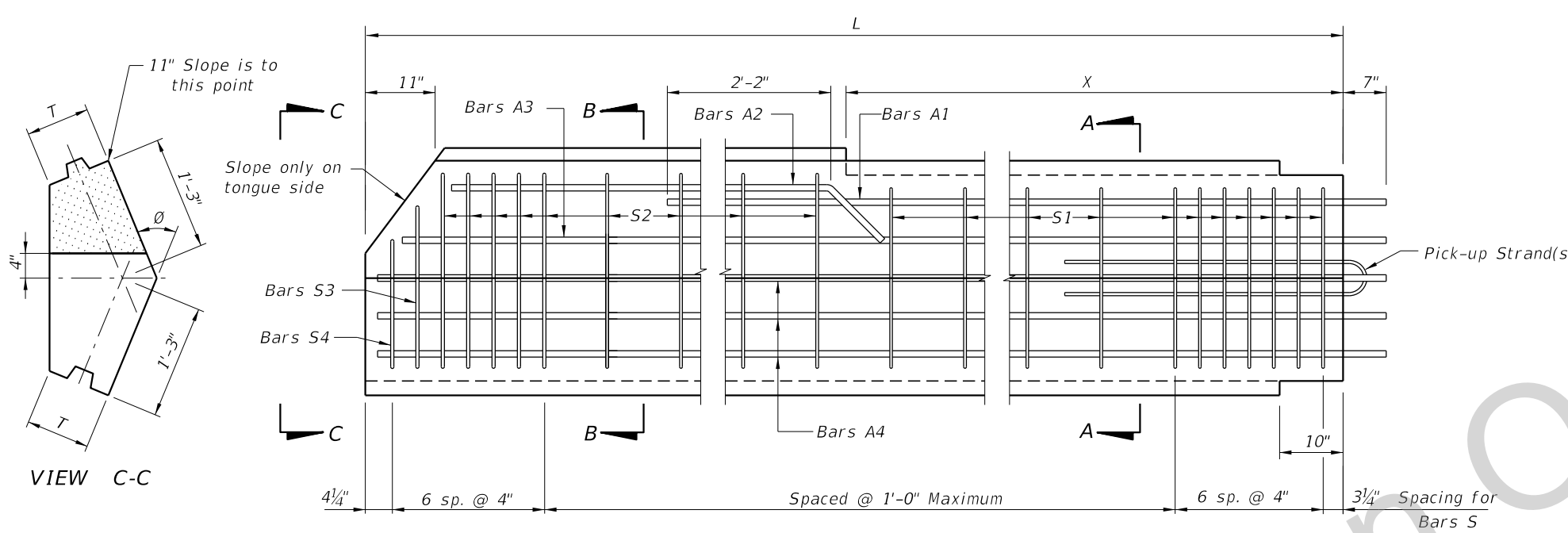
8/24/2016 5:40:26 PM

LAST REVISION 09/01/16	DESCRIPTION:
---------------------------	--------------



PRECAST CONCRETE CFRP/GFRP SHEET PILE WALL

INDEX NO. D22440	SHEET NO. 3 of 5
---------------------	---------------------



ELEVATION  
(TYPE "B1" PILE SHOWN, TYPE "B2" PILE OPPOSITE HAND)

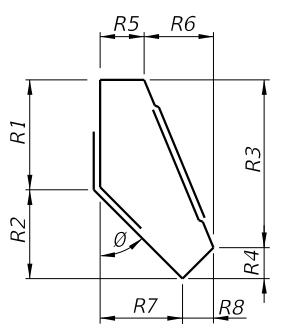
BAR BENDING DIAGRAMS

STIRRUP DIMENSIONS (T = 10")

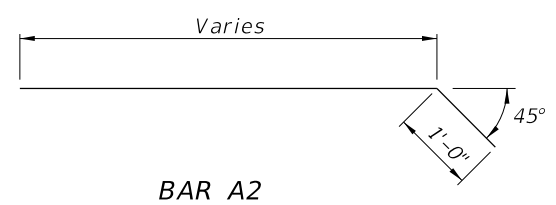
Ø	BAR MARK	R1	R2	R3	R4	R5	R6	R7	R8
30°	S1	11 1/4"	9 3/4"	1'-6 1/2"	2 1/2"	5"	4 3/4"	5 1/2"	4 1/4"
	S2	1'-1 1/2"	9 3/4"	1'-8 3/4"	2 1/2"	4 1/2"	5 1/2"	5 3/4"	4 1/4"
	S3	11 1/4"	8"	1'-6"	1 1/4"	5"	4 1/2"	4 1/2"	5"
	S4	11 1/4"	4 1/4"	1'-1 3/4"	1 3/4"	5"	3 3/4"	2 1/2"	6 1/4"
45°	S1	11 1/2"	8"	1'-4"	4"	5 1/2"	6 1/2"	8"	4"
	S2	1'-1 3/4"	8"	1'-5 3/4"	4"	4 1/2"	7 1/2"	8"	4"
	S3	11 1/2"	6 3/4"	1'-4"	2 1/4"	5 1/2"	6 3/4"	6 3/4"	5 1/2"
	S4	11 1/2"	3 1/2"	1'-0"	3"	5 1/2"	5"	3 1/2"	7"
60°	S1	1'-0"	6"	1'-0 3/4"	5 1/4"	6"	7 1/4"	10 1/4"	3"
	S2	1'-2"	6"	1'-2 3/4"	5 1/4"	4 3/4"	8 3/4"	10 1/2"	3"
	S3	1'-0"	4 3/4"	1'-1 1/2"	3 1/4"	6"	8"	8 3/4"	5 1/4"
	S4	1'-0"	2 1/2"	10"	4 1/2"	6"	5 3/4"	4"	7 1/2"

STIRRUP DIMENSIONS (T = 12")

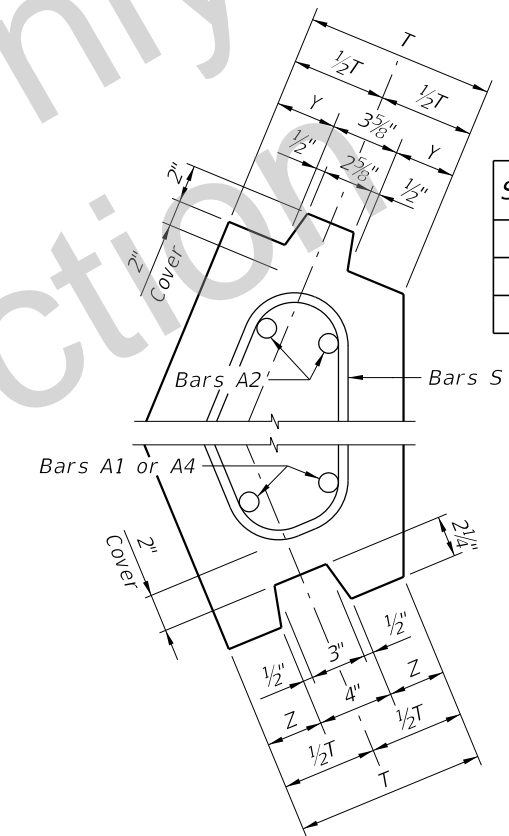
Ø	BAR MARK	R1	R2	R3	R4	R5	R6	R7	R8
30°	S1	11 1/2"	10"	1'-6"	3 1/2"	7"	4 3/4"	5 3/4"	6"
	S2	1'-1 3/4"	10"	1'-8 1/4"	3 1/2"	6 1/2"	5 1/4"	5 3/4"	6"
	S3	11 1/2"	8 1/4"	1'-5 3/4"	2"	7"	4 3/4"	4 1/2"	7 1/4"
	S4	11 1/2"	4"	1'-1 1/4"	2 1/4"	7"	3 3/4"	2 1/2"	8 1/4"
45°	S1	1'-0"	8 1/2"	1'-3 1/4"	5 1/4"	7 1/2"	6 1/4"	8 1/2"	5 1/4"
	S2	1'-2 1/4"	8 1/2"	1'-5 1/2"	5 1/4"	6 1/2"	7 1/4"	8 1/2"	5 1/4"
	S3	1'-0"	7"	1'-4"	3"	7 1/2"	6 3/4"	7"	7 1/4"
	S4	1'-0"	3 1/2"	11 3/4"	3 3/4"	7 1/2"	5"	3 1/2"	9"
60°	S1	1'-0 1/2"	6 1/4"	11 3/4"	7"	8"	6 3/4"	10 3/4"	4"
	S2	1'-2 3/4"	6 1/4"	1'-2"	7"	6 3/4"	8"	10 3/4"	4"
	S3	1'-0 1/2"	5"	1'-1 1/2"	4"	8"	8"	9"	7"
	S4	1'-0 1/2"	2 1/2"	9 1/2"	5 1/2"	8"	5 1/2"	4 1/4"	9 1/4"



BARS S1 & S2  
(2 - PIECE)



BAR A2



DETAIL "D"  
(TYPE "B1" PILE SHOWN, TYPE "B2" PILE OPPOSITE HAND)

SHEET PILE DIMENSIONS		
T (in.)	10	12
Y (in.)	3 3/16	4 3/16
Z (in.)	3	4

- NOTES:
- This drawing includes details for precast concrete corner piles for 10" and 12" thick sheet pile systems. The details apply equally to both thicknesses.
  - The bar configurations shown in Sections A-A and B-B shall be used for Ø angles between 15° and 75°. For Ø angles not shown, the reinforcing bar dimensions may be interpolated or extrapolated from the stirrup dimensions shown.
  - All bar dimensions are out-to-out.
  - Bars A are GFRP #8 and Bars S are GFRP #4.
  - Values for Stirrup Dimensions are shown for Ø equal to 30°, 45° & 60° only.
  - Bars S are fabricated as a 2 piece stirrup with a minimum lap length of 8", as shown in Bar Bending Diagrams, or a single closed bar (hoop) when approved by the Engineer.
  - If Type "B1" or "B2" pile is used as a Starter Pile show tongue on both sides of pile from Dim. X down. Show dimensions for Bars S2, S3 & S4 in shop drawings.
  - If tongue must be on the opposite side from that shown all dimensions and Bars A, S2, S3 and S4 will be the same but opposite hand.
  - For Dimensions L, X and Angle Ø, see Sheet Pile Data Table in Structures Plans.

TYPE "B1" AND "B2" - VARIABLE ANGLE CORNER PILE

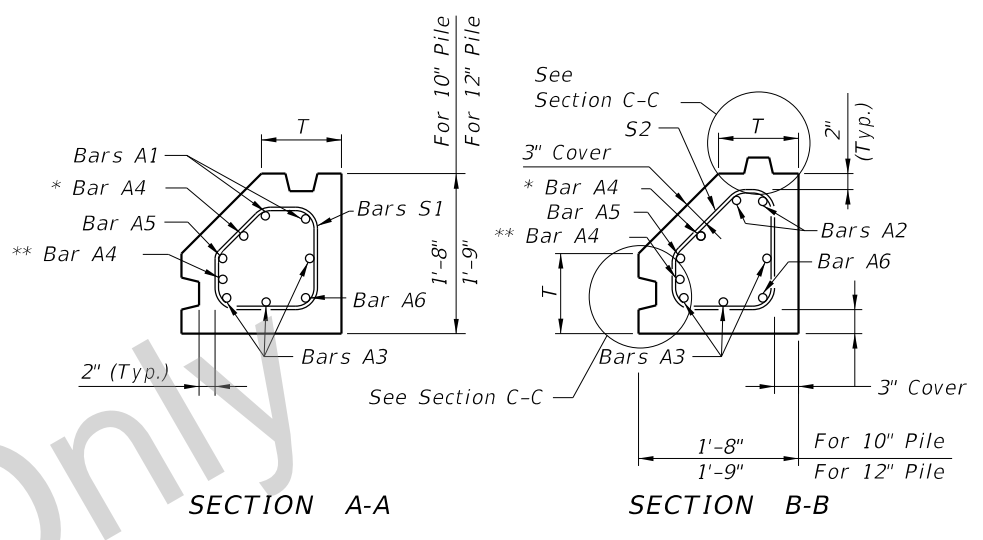
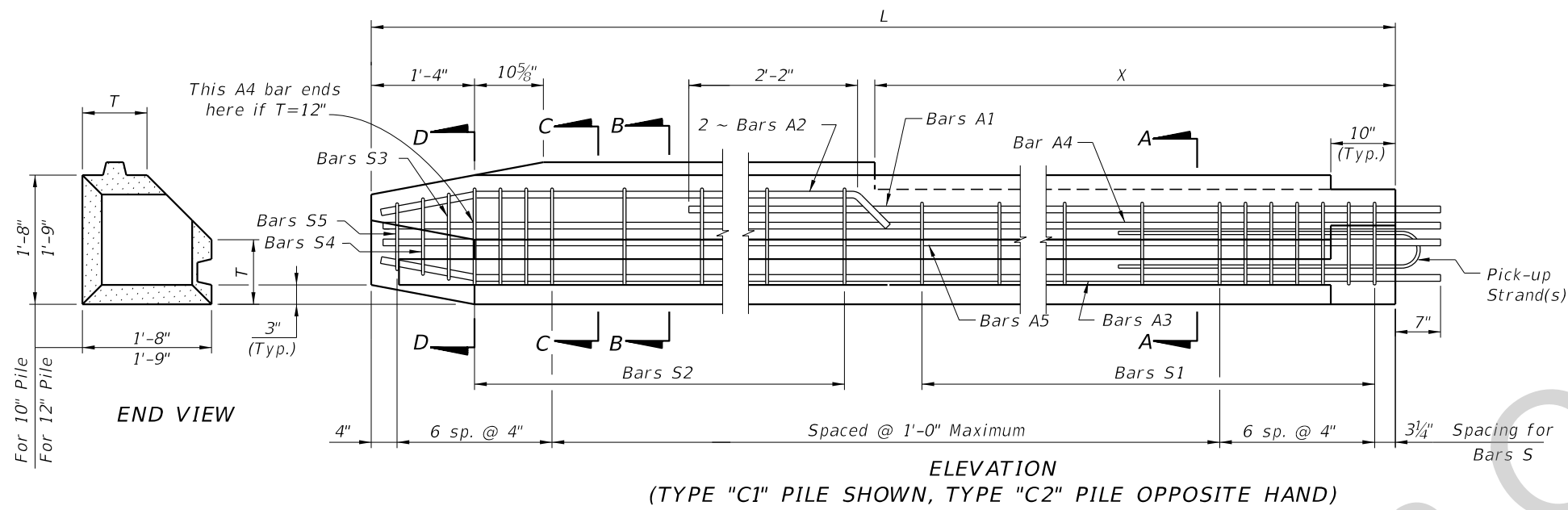
SDATES

LAST REVISION 09/01/16	REVISION	DESCRIPTION:
---------------------------	----------	--------------



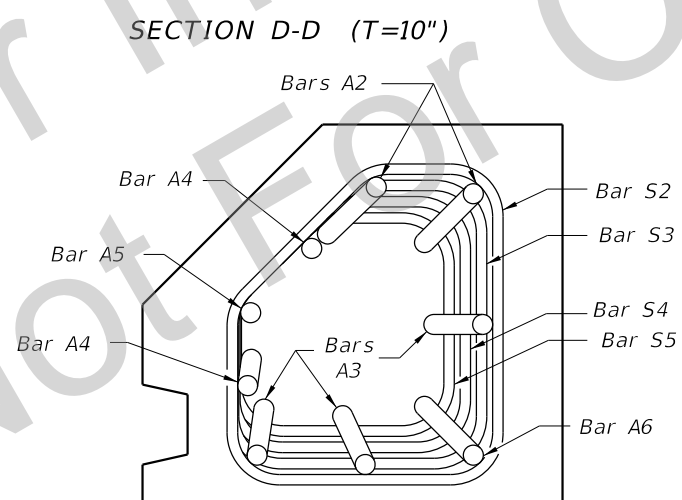
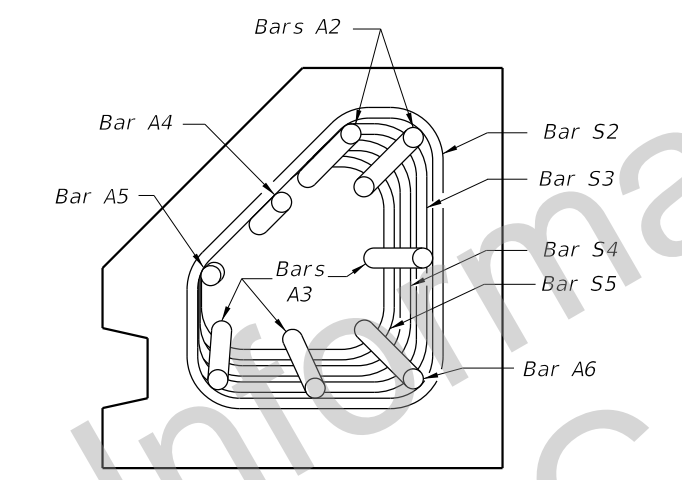
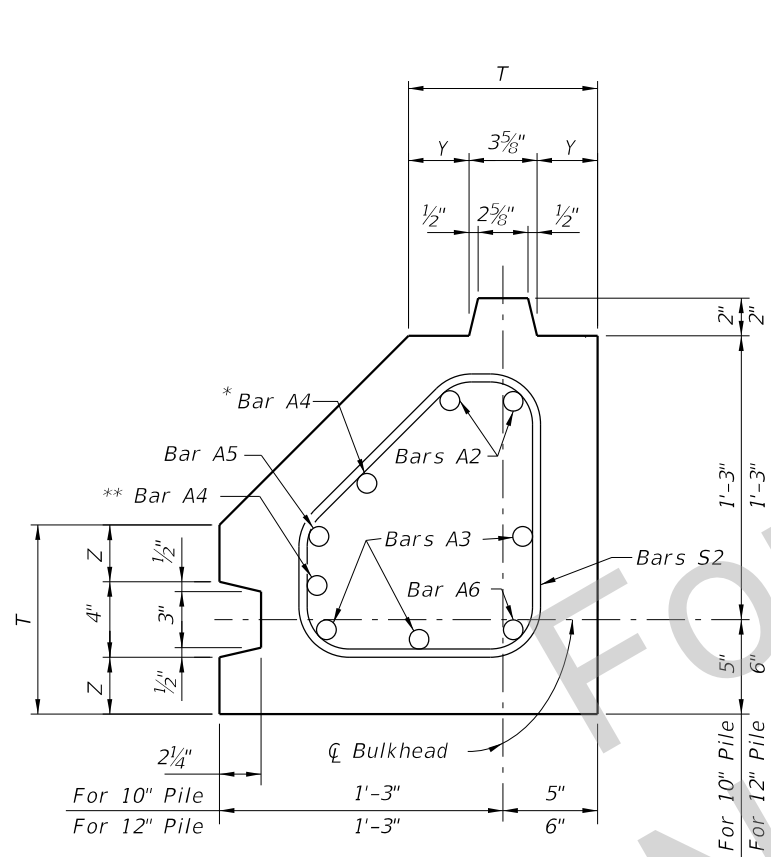
PRECAST CONCRETE CFRP/GFRP SHEET PILE WALL

INDEX NO. D22440	SHEET NO. 4 of 5
---------------------	---------------------



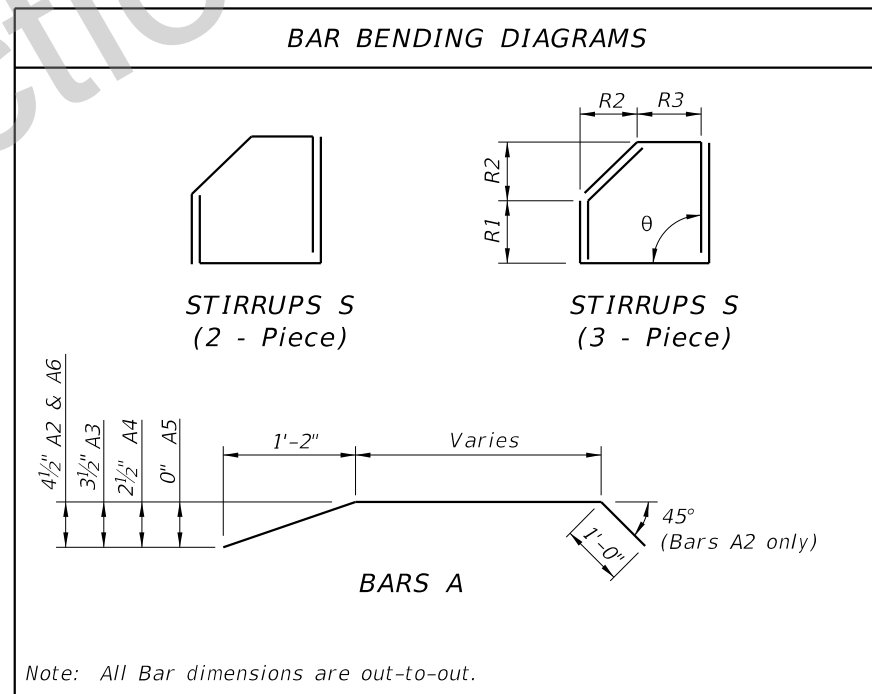
**ELEVATION**  
(TYPE "C1" PILE SHOWN, TYPE "C2" PILE OPPOSITE HAND)

\* This Bar A4 shall be 1'-2" shorter than other A4 bars for T = 12".  
 \*\* This Bar A4 (not shown in elevation) is included only if T = 12".



$\theta$	T (in.)	BAR MARK	R1	R2	R3
90°	10	S1	7"	5 3/4"	7"
		S2	7"	8"	4 3/4"
		S3	6 1/4"	7 1/4"	4 3/4"
		S4	5 1/2"	6 1/2"	4 3/4"
		S5	4 3/4"	5 3/4"	4 3/4"
90°	12	S1	9"	4 3/4"	9"
		S2	9"	7"	6 3/4"
		S3	8 1/4"	6 1/4"	6 3/4"
		S4	7 1/2"	5 1/2"	6 3/4"
		S5	6 3/4"	4 3/4"	6 3/4"

T (in.)	10	12
Y (in.)	3 3/16	4 3/16
Z (in.)	3	4



- Note: All Bar dimensions are out-to-out.
- NOTES:
- All bar dimensions are out-to-out.
  - Bars A are GFRP #8 and Bars S are GFRP #4.
  - This drawing includes information for precast Corner Piles for 10" and 12" thick Sheet Pile systems. The details apply to both thicknesses but the bar configurations change slightly according to the thickness values used.
  - If Type "C1" or "C2" pile is used as a Starter Pile show tongue on both sides of pile from Dim. X down. Show dimensions for Bars S2, S3, S4 & S5 in shop drawings.
  - At the Contractor's option Bars S may be fabricated as a 2 piece or 3 piece bar with a minimum lap length of 8", as shown in Bar Bending Diagrams, or as a single closed bar (hoop) when approved by the Engineer.
  - If tongue must be on opposite side (Groove Side) from that shown, all dimensions and reinforcement shall follow the corresponding Tongue or Groove side.
  - For Dimensions L and X see Sheet Pile Data Table in Structures Plans.

TYPE "C1" AND "C2" - RIGHT ANGLE CORNER PILE

8/24/2016 1:47:20 PM