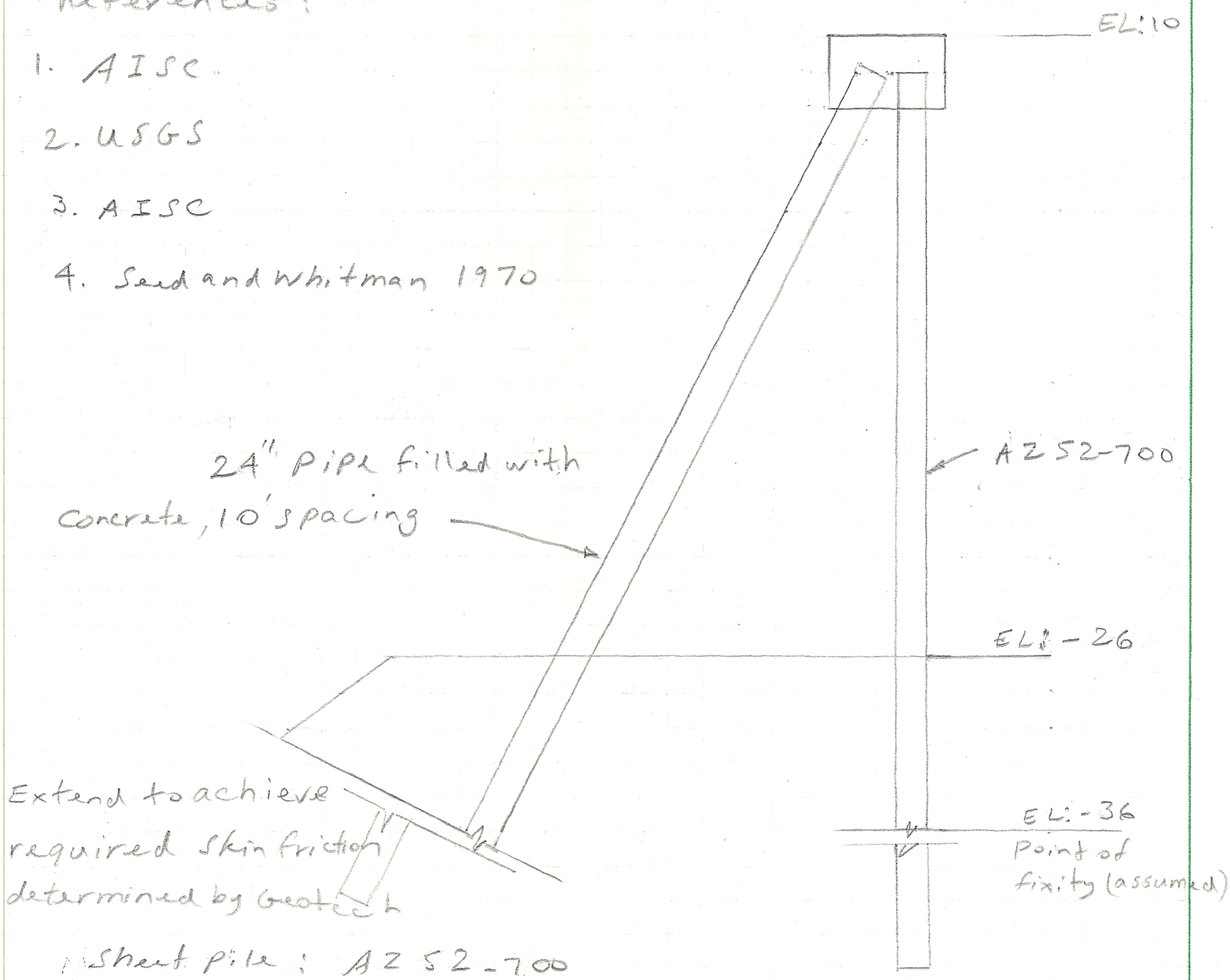
Design by: MR 10/12/2021
Checked by: MRC 10/12/2021

Sheet pile with batter pile Design

References:

1. AISC
2. USGS
3. AISC
4. Seed and Whitman 1970



Sheet pile: AZ52-700

weight: 50.93 lbs/ft^2

S = 95.9 in^3/ft Section Modulus

I = 953 in^4/ft Moment of Inertia

Depth: 19.88 in

Batter Pile: 24" ϕ with 10' spacing, filled with concrete

Assumptions: Water ballanced on both side of sheet pile
No water pressure

Ka = .35 active pressure coefficient

Kp = 3.0 passive Pressure Coefficient

γ_s = 120 lbs/ft^3 Soil Unit weight

γ_{sub} = 57.6 lbs/ft^3 submerged soil unit weight

Point of Pile fixity = EL: -36

Surcharge: 250 PSF.

Fa, Active Pressure: $w_a = K_a \gamma_{sub} H = .35 \times 57.6 \times 46 = 927.36$ lbs/ft^2

Fp, Passive Pressure: $w_p = K_p \gamma_{sub} H = 3 \times 57.6 \times 10' = 1728$ lbs/ft^2

Fs, Surcharge charge: $w_{surcharge} = Ka \times 250 = 87.50$ lbs/FL^2

Concrete cap weight: $5' \times 7' \times 10' \times 150 = 52,500$ lbs

Seismic:

Latitude: 37.791297, Longitude: -122.287034

USGS 2014:

Return period of 975 years: ER1110-2-1806

PGA = .6188g, S_s = 1.4419, S_1 = .4535

$w_s = \frac{3}{4} K_h \gamma H$ Seed and Whitman 1970

$K_h = \frac{S_{DS}}{2.5} = \frac{2/3 \times S_1}{2.5} = \frac{2/3 \times 1.441}{2.5} = .384$

E, $w_s = \frac{3}{4} \times .384 \times 120 \times 46 = 1590$ lbs/ft^2

STAAD output:

Load combination: 1.0D + 1.0Fa + 1.0Fp + 1.0Fs + 0.7E
A

Max. Moment @ point of fixity = 2,855 Kip-ft

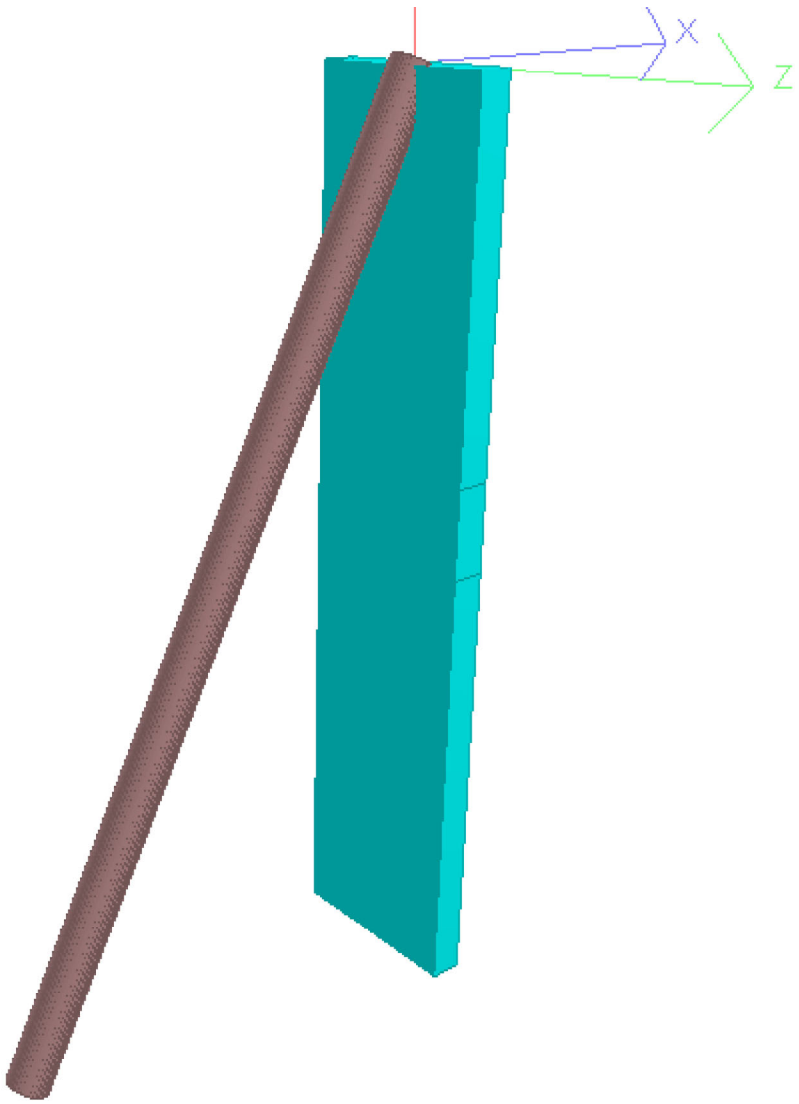
Sheet pile Moment Capacity:

Fy = 60,000 psi S = 95.9 in^3/ft

$M_n = Fy \times S = 60,000 \times 95.9 \times 10' = 57,540$ K-in

$= 4,795$ K-ft

$\frac{M_n}{\Omega_b} = \frac{4,795}{1.67} = 2,871$ K-ft > 2,855 K-ft : okay


X
Z

```
*************************************************
*                                               *
*           STAAD.Pro CONNECT Edition           *
*           Version  21.00.02.30                *
*           Proprietary Program of              *
*           Bentley Systems, Inc.               *
*           Date=    OCT 12, 2021               *
*           Time=    14:44:19                   *
*                                               *
*  Licensed to: USACE HQ                        *
*************************************************
```

```
     1. STAAD SPACE
INPUT FILE: C:\Users\g2ecdmr9\Desktop\Oakland Basin Bulkhead\STAAD\Oakland Basin Sheet Pile 10-12-21-3.STD
     2. START JOB INFORMATION
     3. ENGINEER DATE 05-OCT-21
     4. END JOB INFORMATION
     5. INPUT WIDTH 79
     6. UNIT FEET KIP
     7. JOINT COORDINATES
     8. 1 0 0 0; 2 0 -46 0; 3 -23 -45 0; 4 0 -36 0
     9. MEMBER INCIDENCES
    10. 2 1 3; 3 1 4; 4 4 2
    11. START USER TABLE
    12. TABLE 1
    13. UNIT FEET KIP
    14. PRISMATIC
    15. SHEETPILE
    16. 1.04 0.422 4 4 1.04 1.04 1.65 10
    17. TABLE 2
    18. UNIT FEET KIP
    19. PRISMATIC
    20. SHEETPILE2
    21. 1.04 0.46 4 4 1.04 1.04 1.66 10
    22. TABLE 3
    23. UNIT FEET KIP
    24. PRISMATIC
    25. SHEETPILE2
    26. 1.04 0.46 4 4 1.04 1.04 1.66 10
    27. END
    28. DEFINE MATERIAL START
    29. ISOTROPIC STEEL
    30. E 4.176E+06
    31. POISSON 0.3
    32. DENSITY 0.489024
    33. ALPHA 6.5E-06
    34. DAMP 0.03
    35. TYPE STEEL
    36. STRENGTH FY 5184 FU 8352 RY 1.5 RT 1.2
    37. END DEFINE MATERIAL
    38. MEMBER PROPERTY AMERICAN
```

```
 39. 2 TABLE ST PIPS240
 40. MEMBER PROPERTY
 41. 3 4 UPTABLE 2 SHEETPILE2
 42. CONSTANTS
 43. MATERIAL STEEL ALL
 44. SUPPORTS
 45. 2 3 FIXED
 46. MEMBER RELEASE
 47. 2 START MZ
 48. LOAD 1 LOADTYPE NONE  TITLE SELF WEIGHT
 49. SELFWEIGHT Y -1 LIST 2 3
 50. LOAD 2 LOADTYPE NONE  TITLE ACTIVE SOIL PRESSURE
 51. MEMBER LOAD
 52. 4 TRAP GX -7.25478 -9.27 0 10
 53. 3 TRAP GX 0 -7.25478 0 36
 54. LOAD 3 LOADTYPE NONE  TITLE SESIMIC PRESSURE
 55. MEMBER LOAD
 56. 4 TRAP GX -3.45652 0 0 10
 57. 3 TRAP GX -15.9 -3.45652 0 36
 58. LOAD 4 LOADTYPE NONE  TITLE CONCRETE CAP
 59. JOINT LOAD
 60. 1 FY -52.5
 61. LOAD 5 LOADTYPE NONE  TITLE PASSIVE PRESSURE
 62. MEMBER LOAD
 63. 4 TRAP GX 0 17.28 0 10
 64. LOAD 6 LOADTYPE NONE  TITLE SURCHARGE
 65. MEMBER LOAD
 66. 4 UNI GX -0.88 0 10
 67. 3 UNI GX -0.88 0 36
 68. LOAD COMB 7 DEAD + SOIL + SURCHARGE
 69. 1 1.0 2 1.0 4 1.0 5 1.0 6 1.0
 70. LOAD COMB 8 DEAD  + SOIL + SURCHARGE + .7 SEISMIC
 71. 1 1.0 2 1.0 3 0.7 4 1.0 5 1.0 6 1.0
 72. PERFORM ANALYSIS


        P R O B L E M   S T A T I S T I C S
        -----------------------------------

  NUMBER OF JOINTS          4  NUMBER OF MEMBERS       3
  NUMBER OF PLATES          0  NUMBER OF SOLIDS        0
  NUMBER OF SURFACES        0  NUMBER OF SUPPORTS      2

       Using 64-bit analysis engine.

       SOLVER USED IS THE OUT-OF-CORE BASIC SOLVER

  ORIGINAL/FINAL BAND-WIDTH=     3/     3/     12 DOF
TOTAL      PRIMARY LOAD CASES =     6, TOTAL DEGREES OF FREEDOM =      12
TOTAL LOAD COMBINATION  CASES =     2  SO FAR.
  SIZE OF STIFFNESS MATRIX =        1 DOUBLE  KILO-WORDS
  REQRD/AVAIL. DISK SPACE  =     12.0/ 769126.4 MB
```

*WARNING- APPLIED SELFWEIGHT IS LESS THAN TOTAL WEIGHT OF ALL
STRUCTURAL ELEMENTS IN LOAD CASE 1 ALONG Y.
THIS COULD BE DUE TO SELFWEIGHT APPLIED TO SPECIFIC
LIST OF MEMBERS/PLATES/SOLIDS/SURFACES.
TOTAL UNFACTORED WEIGHT OF THE STRUCTURE = 27.857 KIP
TOTAL UNFACTORED WEIGHT OF THE STRUCTURE APPLIED = 22.771 KIP

73. PARAMETER 1
74. CODE LRFD
75. LOAD LIST 7 8
76. CHECK CODE ALL
STEEL DESIGN

STAAD SPACE -- PAGE NO. 4

STAAD.Pro CODE CHECKING - (LRFD 3RD EDITION) v1.0
****

ALL UNITS ARE - KIP FEET (UNLESS OTHERWISE Noted)

MEMBER	TABLE	RESULT/ FX	CRITICAL COND/ MY	RATIO/ MZ	LOADING/ LOCATION
2	ST PIPS240	(AISC SECTIONS)			
		PASS	LRFD-H1-1A-C	0.741	8
		425.62 C	0.00	-20.90	33.69

**WARNING-THIS VERSION DOES NOT DESIGN PRISMATIC SECTIONS (MEMBER 3).
PLEASE DEFINE THE PROPERTIES THROUGH A USER TABLE GENERAL SECTION.

**WARNING-THIS VERSION DOES NOT DESIGN PRISMATIC SECTIONS (MEMBER 4).
PLEASE DEFINE THE PROPERTIES THROUGH A USER TABLE GENERAL SECTION.

********** END OF TABULATED RESULT OF DESIGN **********

77. PRINT MEMBER FORCES
MEMBER FORCES

MEMBER END FORCES STRUCTURE TYPE = SPACE

ALL UNITS ARE -- KIP FEET (LOCAL)

MEMBER	LOAD	JT	AXIAL	SHEAR-Y	SHEAR-Z	TORSION	MOM-Y	MOM-Z
2	7	1	120.75	0.91	0.00	0.00	0.00	0.00
		3	-124.73	1.12	0.00	0.00	0.00	-5.45
	8	1	422.97	1.30	0.00	0.00	0.00	0.00
		3	-426.95	0.73	0.00	0.00	0.00	14.25
3	7	1	-54.61	55.77	0.00	0.00	0.00	0.00
		4	36.30	106.50	0.00	0.00	0.00	-129.73
	8	1	-323.54	193.65	0.00	0.00	0.00	0.00
		4	305.23	212.50	0.00	0.00	0.00	-496.49
4	7	4	-36.30	-106.50	0.00	0.00	0.00	129.73
		2	36.30	111.52	0.00	0.00	0.00	-1347.06
	8	4	-305.23	-212.50	0.00	0.00	0.00	496.49
		2	305.23	229.63	0.00	0.00	0.00	-2854.50

********** END OF LATEST ANALYSIS RESULT **********

78. PRINT SUPPORT REACTION

SUPPORT REACTION

SUPPORT REACTIONS -UNIT KIP FEET STRUCTURE TYPE = SPACE

JOINT	LOAD	FORCE-X	FORCE-Y	FORCE-Z	MOM-X	MOM-Y	MOM Z
2	7	111.52	-36.30	0.00	0.00	0.00	-1347.06
	8	229.63	-305.23	0.00	0.00	0.00	-2854.50
3	7	55.77	111.57	0.00	0.00	0.00	5.45
	8	193.65	380.50	0.00	0.00	0.00	-14.25

********** END OF LATEST ANALYSIS RESULT **********

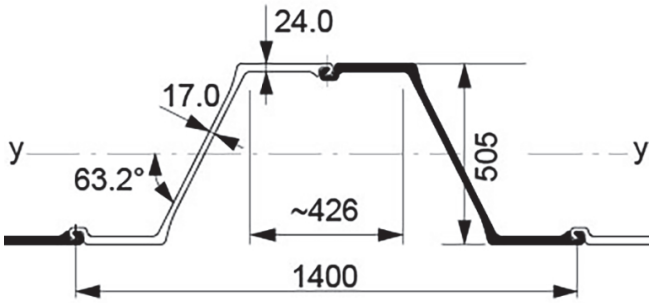
79. FINISH

********** END OF THE STAAD.Pro RUN **********

**** DATE= OCT 12,2021 TIME= 14:44:19 ****

```
     ************************************************************
     *   For technical assistance on STAAD.Pro, please visit    *
     *   http://www.bentley.com/en/support/                     *
     *                                                          *
     *   Details about additional assistance from               *
     *   Bentley and Partners can be found at program menu      *
     *   Help->Technical Support                                *
     *                                                          *
     *      Copyright (c) 1997-2017 Bentley Systems, Inc.       *
     *                http://www.bentley.com                    *
     ************************************************************
```

AZ 52-700 (Hot rolled sheet piles)



Section description	Product group	Shape	Section Modulus	Moment of Inertia	Width	Height	Thickness flange	Thickness web	Weight single	Weight	Coating 2 sides	Coating area
			in^3/ft cm^3/m	in^4/ft cm^4/m	inch mm	inch mm	inch mm	inch mm	lbs/ft kg/m	lbs/ft^2 kg/m^2	ft^2/ft m^2/m	ft^2/ft m^2/m
AZ 52-700	Hot rolled sheet piles	Z	95.9 5,156	953.0 130,140	27.56 700	19.88 505	0.945 24.0	0.669 17.0	117.0 174.05	50.93 248.66	6.70 2.05	1.46 1.46

Production acc. EN10248 1&2 in various steel grades
Origin: Luxembourg
Datasheet for estimation and comparison purposes