OBJECTIVE: To calculate the table parameters for the Tollway overhead cantilever truss sign structures for Contract I-21-4836

METHODOLOGY: Use roadway plan cross section and the Tollway Sign Structures Standard F4 to determine required truss type based on sign square footage, span and heights

REFERENCES:

1. Tollway Sign Structures Manual, March 2023

STA 11686+50
STA 11648+60

General Parameters:

$Min\_clearance := 17\ ft + 5\ in$ — Minimum required clearance from highest elevation of roadway to bottom of 18 ft high sign. (See F4 Sheet 1 of 12)

$level\_gap := 2.75\ in$ — Nominal gap for levelling between top of concrete and bottom of steel base plate. (See F4 Sheet 4 of 12)

$A_{fnd\_min} := 1\ ft$ — Minimum allowed exposure of grade beam above proposed grade.

$A_{fnd\_max} := 3.5\ ft$ — Maximum allowed exposure of grade beam above proposed grade.

$H_{max} := 12\ ft$ — Maximum allowed dimension from bottom of base plate to center line of upper chord. (See F4 Sheet 5 of 12)

$H1_{max} := 20\ ft$ — Maximum allowed dimension from top of grade beam to bottom of steel base plate. (See F4, Sheet 5 of 12)

$Excel\_file :=$ "Cant_Truss_Tollway_20220581.xlsm"

Excel spreadsheet for input and output of Tollway Cantilever structure parameters

Sign_Structure_No	*STA*	*Span* (*ft*)	*Elev_A* (*ft*)	*D* (*ft*)	*H_sign_max* (*ft*)	*TOC* (*ft*)	*Grade_ele* (*ft*)
"TS31.88C,SB"	"11686+50"	40	720.68	$27+\frac{5.125}{12}$	14.5	722.33	719.95
"TS31.17C,SB"	"11648+60"	50	723.59	$23+\frac{11.125}{12}$	14.5	723.03	720.03

$no\_structures := \text{length}(Sign\_Structure\_No) = 2$

F4-14 Tollway Standard for Cantilever sign truss structure

F4-14, Table C

$Sheet\_name :=$ "F4−14 Table C"

$Range\_text :=$ "!A4:X10"

$read := \text{concat}(Sheet\_name, Range\_text) =$ "F4−14 Table C!A4:X10"

$F14\_C := \text{READEXCEL}(Excel\_file, read)$

$$F14\_C = \begin{array}{c} \begin{matrix} 0 & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10 & \dots & 23 \end{matrix} \\ \begin{bmatrix} 20 & \text{"20−D"} & 2.5 & 5.5 & 20.083 & 15 & 18 & 104.67 & 0.562 & 12 & \text{"HSS 5x5x1/4"} & & \\ 25 & \text{"25−D"} & 3.5 & 5.6 & 24.917 & 18.75 & 18 & 104.67 & 0.562 & 12 & \text{"HSS 5x5x1/4"} & & \\ 30 & \text{"30−D"} & 3.5 & 7 & 30.167 & 22.5 & 18 & 104.67 & 0.562 & 12 & \text{"HSS 6x6x1/4"} & & \\ 35 & \text{"35−D"} & 4 & 7 & 35 & 24 & 24 & 171.29 & 0.687 & 12 & \text{"HSS 6x6x1/4"} & & \\ 40 & \text{"40−D"} & 4 & 7 & 40 & 24 & 24 & 171.29 & 0.687 & 12 & \text{"HSS 6x6x1/4"} & & \\ 45 & \text{"45−D"} & 4.5 & 7 & 45.042 & 24 & 24 & 171.29 & 0.687 & 12 & \text{"HSS 6x6x1/4"} & & \\ 50 & \text{"50−D"} & 4.5 & 7 & 50.083 & 24 & 24 & 171.29 & 0.687 & 12 & \text{"HSS 10x10x1/4"} & \dots & \end{bmatrix} \end{array}$$

Tollway F4-14, Table C break down for parameter check

$Range\_text := \text{“!A4:K10”}$

$read := \text{concat}(Sheet\_name, Range\_text) = \text{“F4−14 Table C!A4:K10”}$

$F14\_C\_0\_11 := \text{READEXCEL}(Excel\_file, read)$

$$F14\_C\_0\_11 = \begin{bmatrix} 20 & \text{“20−D”} & 2.5 & 5.5 & 20.083 & 15 & 18 & 104.67 & 0.562 & 12 & \text{“HSS 5x5x1/4”} \\ 25 & \text{“25−D”} & 3.5 & 5.6 & 24.917 & 18.75 & 18 & 104.67 & 0.562 & 12 & \text{“HSS 5x5x1/4”} \\ 30 & \text{“30−D”} & 3.5 & 7 & 30.167 & 22.5 & 18 & 104.67 & 0.562 & 12 & \text{“HSS 6x6x1/4”} \\ 35 & \text{“35−D”} & 4 & 7 & 35 & 24 & 24 & 171.29 & 0.687 & 12 & \text{“HSS 6x6x1/4”} \\ 40 & \text{“40−D”} & 4 & 7 & 40 & 24 & 24 & 171.29 & 0.687 & 12 & \text{“HSS 6x6x1/4”} \\ 45 & \text{“45−D”} & 4.5 & 7 & 45.042 & 24 & 24 & 171.29 & 0.687 & 12 & \text{“HSS 6x6x1/4”} \\ 50 & \text{“50−D”} & 4.5 & 7 & 50.083 & 24 & 24 & 171.29 & 0.687 & 12 & \text{“HSS 10x10x1/4”} \end{bmatrix}$$

$Range\_text := \text{“!L4:P10”}$

$read := \text{concat}(Sheet\_name, Range\_text) = \text{“F4−14 Table C!L4:P10”}$

$F14\_C\_12\_16 := \text{READEXCEL}(Excel\_file, read)$

$$F14\_C\_12\_16 = \begin{bmatrix} \text{“2 1/2″Ø X.S”} & 0.276 & \text{“3″Ø X.X.S”} & 0.6 & \text{“1 1/2″Ø X.S”} \\ \text{“2 1/2″Ø X.S”} & 0.276 & \text{“4″Ø X.X.S”} & 0.6 & \text{“2″Ø X.S”} \\ \text{“3″Ø X.S”} & 0.3 & \text{“4″Ø X.X.S”} & 0.674 & \text{“2″Ø X.S”} \\ \text{“3″Ø X.S”} & 0.3 & \text{“4″Ø X.X.S”} & 0.674 & \text{“2″Ø X.S”} \\ \text{“3″Ø X.S”} & 0.3 & \text{“4″Ø X.X.S”} & 0.674 & \text{“2″Ø X.S”} \\ \text{“3″Ø X.S”} & 0.3 & \text{“4″Ø X.X.S”} & 0.674 & \text{“2″Ø X.S”} \\ \text{“3″Ø X.S”} & 0.3 & \text{“HSS 8.625x0.5”} & 0.465 & \text{“2″Ø X.S”} \end{bmatrix}$$

$Range\_text := \text{“!Q4:X10”}$

$read := \text{concat}(Sheet\_name, Range\_text) = \text{“F4−14 Table C!Q4:X10”}$

$F14\_C\_17\_23 := \text{READEXCEL}(Excel\_file, read)$

$$F14\_C\_17\_23 = \begin{bmatrix} 0.2 & \text{“2 1/2”Ø X.S”} & 0.276 & \text{“1 1/2”Ø X.S”} & 0.2 & 4 & 4.583 & 1.5 \\ 0.218 & \text{“2 1/2”Ø X.S”} & 0.276 & \text{“2”Ø X.S”} & 0.218 & 5 & 4.583 & 1.75 \\ 0.218 & \text{“2 1/2”Ø X.S”} & 0.276 & \text{“2”Ø X.S”} & 0.218 & 5 & 5.583 & 2 \\ 0.218 & \text{“2 1/2”Ø X.S”} & 0.276 & \text{“2”Ø X.S”} & 0.218 & 5 & 6.5 & 2.25 \\ 0.218 & \text{“2 1/2”Ø X.S”} & 0.276 & \text{“2”Ø X.S”} & 0.218 & 6 & 5.25 & 2.25 \\ 0.218 & \text{“2 1/2”Ø X.S”} & 0.276 & \text{“2”Ø X.S”} & 0.218 & 7 & 6.042 & 2.5 \\ 0.218 & \text{“3”Ø X.S”} & 0.276 & \text{“2”Ø X.S”} & 0.218 & 8 & 5.917 & 2.5 \end{bmatrix}$$

F4-14, Table A.

$Sheet\_name := \text{“F4–14 Table A”}$

$Range\_text := \text{“!A2:D8”}$

$read := \text{concat}(Sheet\_name, Range\_text) = \text{“F4–14 Table A!A2:D8”}$

$F14\_A := \text{READEXCEL}(Excel\_file, read)$

$$F14\_A = \begin{bmatrix} 20 & \text{“20–D”} & 270 & 15 \\ 25 & \text{“25–D”} & 338 & 18.75 \\ 30 & \text{“30–D”} & 405 & 22.5 \\ 35 & \text{“35–D”} & 432 & 24 \\ 40 & \text{“40–D”} & 432 & 24 \\ 45 & \text{“45–D”} & 432 & 24 \\ 50 & \text{“50–D”} & 432 & 24 \end{bmatrix}$$

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$i := 0$ index counter

$First\_col := Span_i \cdot \frac{1}{ft} = 40$

$$\begin{bmatrix} cant\_type_i \\ max\_sign\_area_i \\ max\_sign\_length_i \end{bmatrix} := \begin{bmatrix} \text{hlookup}(First\_col, F14\_A^{\mathrm{T}}, 1)_0 \\ \text{hlookup}(First\_col, F14\_A^{\mathrm{T}}, 2)_0 \cdot ft^2 \\ \text{hlookup}(First\_col, F14\_A^{\mathrm{T}}, 3)_0 \cdot ft \end{bmatrix}$$

$cant\_type_i = \text{“40–D”}$

$max\_sign\_area_i = 432 \cdot ft^2$

$max\_sign\_length_i = 24\ ft$

$sign\_area_i := 17\ ft \cdot 14.5\ ft + 9.5\ ft \cdot 2.5\ ft$

$sign\_area_i = 270.25\ ft^2$

Table on sheet

$$\begin{bmatrix} \vdots \\ Truss\_v\_wall_i \\ Truss\_vd\_pipe_i \\ Truss\_vd\_wall_i \\ Truss\_h\_pipe_i \\ Truss\_h\_wall_i \\ Truss\_hd\_pipe_i \\ Truss\_hd\_wall_i \\ Truss\_int\_pipe_i \\ Truss\_int\_wall_i \\ Panel\_No_i \\ Panel\_P_i \\ Panel\_S_i \end{bmatrix} := \begin{bmatrix} \vdots \\ \text{hlookup}\left(First\_col, F14\_C^{\mathrm{T}}, 14\right)_0\ in \\ \text{hlookup}\left(First\_col, F14\_C^{\mathrm{T}}, 15\right)_0 \\ \text{hlookup}\left(First\_col, F14\_C^{\mathrm{T}}, 16\right)_0\ in \\ \text{hlookup}\left(First\_col, F14\_C^{\mathrm{T}}, 17\right)_0 \\ \text{hlookup}\left(First\_col, F14\_C^{\mathrm{T}}, 18\right)_0\ in \\ \text{hlookup}\left(First\_col, F14\_C^{\mathrm{T}}, 19\right)_0 \\ \text{hlookup}\left(First\_col, F14\_C^{\mathrm{T}}, 20\right)_0\ in \\ \text{hlookup}\left(First\_col, F14\_C^{\mathrm{T}}, 21\right)_0 \\ \text{hlookup}\left(First\_col, F14\_C^{\mathrm{T}}, 22\right)_0\ ft \\ \text{hlookup}\left(First\_col, F14\_C^{\mathrm{T}}, 23\right)_0\ ft \end{bmatrix}$$

Print out parameter for Cantilever Type and Size from Tollway Table C

Truss size

$e\_dim_i = 4\ ft$ $d\_dim_i = 7\ ft$

Steel Support Post Column

$Col\_dia_i = 24\ in$ $Col\_wall\_thick_i = 0.687\ in$ $H\_max_i = 12\ ft$

Truss Members and Details

$Truss\_top\_bot\_chord_i = \text{“HSS 6x6x1/4”}$

$Truss\_v\_pipe_i = \text{“3″Ø X.S”}$ $Truss\_v\_wall_i = 0.3\ in$

$Truss\_vd\_pipe_i = \text{“4″Ø X.X.S”}$ $Truss\_vd\_wall_i = 0.674\ in$

$Truss\_h\_pipe_i = \text{“2″Ø X.S”}$ $Truss\_h\_wall_i = 0.218\ in$

$Truss\_hd\_pipe_i = \text{“2 1/2″Ø X.S”}$ $Truss\_hd\_wall_i = 0.276\ in$

$Truss\_int\_pipe_i = \text{“2″Ø X.S”}$ $Truss\_int\_wall_i = 0.218\ in$

Panels

$Panel\_No_i = 6$ $Panel\_P_i = 5.25\ ft$ $Panel\_S_i = 2.25\ ft$

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$i := i + 1$

$Second\_col := Span_i \dfrac{1}{ft}$

$$\begin{bmatrix} cant\_type_i \\ max\_sign\_area_i \\ max\_sign\_length_i \end{bmatrix} := \begin{bmatrix} \text{hlookup}\left(Second\_col, F14\_A^{\mathrm{T}}, 1\right)_0 \\ \text{hlookup}\left(Second\_col, F14\_A^{\mathrm{T}}, 2\right)_0\ ft^2 \\ \text{hlookup}\left(Second\_col, F14\_A^{\mathrm{T}}, 3\right)_0\ ft \end{bmatrix}$$

$cant\_type_i = \text{“50–D”}$

$max\_sign\_area_i = 432\ ft^2$

$max\_sign\_length_i = 24\ ft$

$sign\_area_i := 17\ ft \cdot 14.5\ ft + 9.5\ ft \cdot 2.5\ ft$ Total sign area

$sign\_area_i = 270.25\ ft^2$

Table on sheet

$$\begin{bmatrix} e\_dim_i \\ d\_dim_i \\ Col\_dia_i \\ Col\_weigh_i \\ Col\_wall\_thick_i \\ H\_max_i \\ Truss\_top\_bot\_chord_i \\ Truss\_v\_pipe_i \\ Truss\_v\_wall_i \\ Truss\_vd\_pipe_i \\ Truss\_vd\_wall_i \\ Truss\_h\_pipe_i \\ \vdots \end{bmatrix} := \begin{bmatrix} \text{hlookup}\left(Second\_col, F14\_C^{\mathrm{T}}, 2\right)_0\ ft \\ \text{hlookup}\left(Second\_col, F14\_C^{\mathrm{T}}, 3\right)_0\ ft \\ \text{hlookup}\left(Second\_col, F14\_C^{\mathrm{T}}, 6\right)_0\ in \\ \text{hlookup}\left(Second\_col, F14\_C^{\mathrm{T}}, 7\right)_0 \\ \text{hlookup}\left(Second\_col, F14\_C^{\mathrm{T}}, 8\right)_0\ in \\ \text{hlookup}\left(Second\_col, F14\_C^{\mathrm{T}}, 9\right)_0\ ft \\ \text{hlookup}\left(Second\_col, F14\_C^{\mathrm{T}}, 10\right)_0 \\ \text{hlookup}\left(Second\_col, F14\_C^{\mathrm{T}}, 11\right)_0 \\ \text{hlookup}\left(Second\_col, F14\_C^{\mathrm{T}}, 12\right)_0\ in \\ \text{hlookup}\left(Second\_col, F14\_C^{\mathrm{T}}, 13\right)_0 \\ \text{hlookup}\left(Second\_col, F14\_C^{\mathrm{T}}, 14\right)_0\ in \\ \vdots \end{bmatrix}$$

Print out parameter for Cantilever Type and Size from Tollway Table C

Truss size

$e\_dim_i = 4.5\ ft$ $d\_dim_i = 7\ ft$

Steel Support Post Column

$Col\_dia_i = 2\ ft$ $Col\_wall\_thick_i = 0.057\ ft$ $H\_max_i = 12\ ft$

$Col\_weigh_i = 171.29$

Truss Member and Details

$Truss\_top\_bot\_chord_i = \text{“HSS 10x10x1/4”}$

$Truss\_v\_pipe_i = \text{“3″Ø X.S”}$ $Truss\_v\_wall_i = 0.3\ in$

$Truss\_vd\_pipe_i = \text{“HSS 8.625x0.5”}$ $Truss\_vd\_wall_i = 0.465\ in$

$Truss\_h\_pipe_i = \text{“2″Ø X.S”}$ $Truss\_h\_wall_i = 0.218\ in$

$Truss\_hd\_pipe_i = \text{“3″Ø X.S”}$ $Truss\_hd\_wall_i = 0.276\ in$

$Truss\_int\_pipe_i = \text{“2″Ø X.S”}$ $Truss\_int\_wall_i = 0.218\ in$

Panels

$Panel\_No_i = 8$ $Panel\_P_i = 5.917\ ft$ $Panel\_S_i = 2.5\ ft$

Calculate Sign Structure Parameters

$k := 0\,..\,no\_structures - 1$ Index variable for looping thru cases

$$Elev\_Cl\_truss_k := Elev\_A_k + Min\_clearance + \frac{1}{2}\cdot\left(\max\left(H\_sign\_max_k, 18\ ft\right)\right)$$

$$Elev\_Cl\_truss = \begin{bmatrix} 747.097 \\ 750.007 \end{bmatrix} ft$$ Elevation at truss centerline

$$Elev\_top_k := Elev\_Cl\_truss_k + \frac{d\_dim_k}{2}$$

$$Elev\_top = \begin{bmatrix} 750.597 \\ 753.507 \end{bmatrix} ft$$ Elevation at truss top chord

$H1 := Elev\_top - TOC - H\_max$

$H1 = \begin{bmatrix} 16.267 \\ 18.477 \end{bmatrix} ft$ Length of concrete column

$Hmax := Elev\_top - TOC - H1$

$Hmax = \begin{bmatrix} 12 \\ 12 \end{bmatrix} ft$ Elevation from bottom base plate to the centerline of truss

$Elev\_C := TOC - 4\ ft$ 4 feets is the height of the grade beam foundation (See Sheet 6 of 12, Tollway F4-13 Standard)

$Elev\_C = \begin{bmatrix} 718.33 \\ 719.03 \end{bmatrix} ft$ Elevation of bottom of grade beam

$road\_clearance := Elev\_Cl\_truss - \frac{1}{2} \cdot (H\_sign\_max) - Elev\_A$

$road\_clearance = \begin{bmatrix} 19.167 \\ 19.167 \end{bmatrix} ft$

Calculate foundation parameters

$A_{fnd_k} := TOC_k - Grade\_ele_k$

$A_{fnd} = \begin{bmatrix} 2.38 \\ 3 \end{bmatrix} ft$

Check max heights of posts, max sign area, and required road clearances.

$check\_max\_H_k := \text{if}\left(H\_max_k \geq Hmax_k, \text{“OK”}, \text{“NG”}\right)$

$check\_max\_H = \begin{bmatrix} \text{“OK”} \\ \text{“OK”} \end{bmatrix}$ Check max H

$check\_max\_H1_k := \text{if}\left(H1_{max} \geq H1_k, \text{“OK”}, \text{“NG”}\right)$

$check\_max\_H1_k = \begin{bmatrix} \text{“OK”} \\ \text{“OK”} \end{bmatrix}$ Check max H1

$sign\_area\_check_k := \text{if}\left(max\_sign\_area_k \geq sign\_area_k, \text{“OK”}, \text{“NG”}\right)$

$sign\_area\_check_k = \begin{bmatrix} \text{“OK”} \\ \text{“OK”} \end{bmatrix}$ Check max sign area

$road\_clearance\_check_k := \text{if}\left(Min\_clearance \leq road\_clearance_k, \text{“OK”}, \text{“NG”}\right)$

$road\_clearance\_check = \begin{bmatrix} \text{“OK”} \\ \text{“OK”} \end{bmatrix}$ Check max road clearance

$check\_grade\_beam\_exposure_k := \text{if}\left(A_{fnd_k} \leq A_{fnd\_max} \wedge A_{fnd_k} \geq A_{fnd\_min}, \text{“OK”}, \text{“NG”}\right)$

$check\_grade\_beam\_exposure_k = \begin{bmatrix} \text{“OK”} \\ \text{“OK”} \end{bmatrix}$ Check allowed grade beam exposure

CONCRETE DESIGN

F4-14 Table F

$Sheet\_name := \text{“F4–14 Table F”}$

$Range := \text{“!A3:G6”}$

$read := \text{concat}\left(Sheet\_name, Range\right) = \text{“F4–14 Table F!A3:G6”}$

$F4\_F := \text{READEXCEL}\left(Excel\_file, read\right)$

$$F4\_F = \begin{bmatrix} \text{“<= 20′”} & 18 & 3.5 & 16 & 9 & 7.1 & 1910 \\ \text{“21′ – 30′”} & 18 & 3.5 & 16 & 9 & 7.1 & 1910 \\ \text{“31′ – 40′”} & 24 & 4 & 20 & 9 & 9.2 & 2330 \\ \text{“41′ – 50′”} & 24 & 4 & 20 & 9 & 9.2 & 2330 \end{bmatrix}$$

F4-14 Table G

$Sheet\_name := \text{“F4–14 Table G”}$

$Range := \text{“!A3:K6”}$

$read := \text{concat}(Sheet\_name, Range) = \text{“F4–14 Table G!A3:K6”}$

$F4\_G := \text{READEXCEL}(Excel\_file, read)$

$$F4\_G = \begin{bmatrix} \text{“<= 20′”} & 5 & 3 & 40 & 44 & \text{“12– #9”} & \text{“12– #9”} & \text{“16– #9”} & 13.4 & 21 & 7700 \\ \text{“21′ – 30′”} & 5 & 3 & 40 & 44 & \text{“12– #9”} & \text{“12– #9”} & \text{“16– #9”} & 13.4 & 21 & 7700 \\ \text{“31′ – 40′”} & 6 & 4 & 40 & 44 & \text{“20– #9”} & \text{“20– #9”} & \text{“20– #9”} & 16 & 37.3 & 10800 \\ \text{“41′ – 50′”} & 6 & 4 & 40 & 44 & \text{“20– #9”} & \text{“20– #9”} & \text{“20– #9”} & 16 & 37.3 & 10800 \end{bmatrix}$$

SB I-294 STA 11686+50

$i := 0$ index counter

$Sign\_span_i :=$
- if $Span_i \le 20\ ft$
  - return “<= 20′”
- if $Span_i \ge 21\ ft \wedge Span_i \le 30\ ft$
  - return “21′ – 30′”
- if $Span_i \ge 31\ ft \wedge Span_i \le 40\ ft$
  - return “31′ – 40′”
- if $Span_i \ge 41\ ft \wedge Span_i \le 50\ ft$
  - return “41′ – 50′”

$Sign\_span_i = \text{“}31' - 40\text{”}$

$$\begin{bmatrix} \vdots \\ Size\_rebar_{vert_i} \\ Class\_SI\_concr_i \\ Weigh_{SI\_Col\_Rebar_i} \\ W\_dim_i \\ D\_dim_i \\ B\_dim_i \\ F\_dim_i \\ V_e\_Shaft1_i \\ V_e\_Shaft2_i \\ V_e\_Shaft3_i \\ Class\_DS\_concr_i \\ rebar\_weight\_shaft_i \end{bmatrix} := \begin{bmatrix} \text{hlookup}\left(Sign\_span_i, F4\_F^{\mathrm{T}}, 1\right)_0 \ \textbf{in} \\ \text{hlookup}\left(Sign\_span_i, F4\_F^{\mathrm{T}}, 2\right)_0 \ \textbf{ft} \\ \text{hlookup}\left(Sign\_span_i, F4\_F^{\mathrm{T}}, 3\right)_0 \\ \text{hlookup}\left(Sign\_span_i, F4\_F^{\mathrm{T}}, 4\right)_0 \\ \frac{H1_i}{20\ \textbf{ft}} \cdot \text{hlookup}\left(Sign\_span_i, F4\_F^{\mathrm{T}}, 5\right)_0 \ \textbf{yd}^3 \\ \text{hlookup}\left(Sign\_span_i, F4\_F^{\mathrm{T}}, 6\right)_0 \ \textbf{lb} \\ \vdots \end{bmatrix}$$

CONCRETE COLUMN DESIGN

$Steel\_post\_dia_i = 2\ \textbf{ft}$ $Col\_concr\_dia_i = 4\ \textbf{ft}$

$No\_rebar_{vert_i} = 20$ $Size\_rebar_{vert_i} = 9$

$Class\_SI\_concr_i = 7.483\ \textbf{yd}^3$ $Weigh_{SI\_Col\_Rebar_i} = 2330\ \textbf{lb}$

CONCRETE DRILLED SHAFTS

$W\_dim_i = 6\ \textbf{ft}$ $D\_dim_i = 4\ \textbf{ft}$ $B\_dim_i = 40\ \textbf{ft}$ $F\_dim_i = 44\ \textbf{ft}$

$V_e\_Shaft1_i = \text{“}20 - \#9\text{”}$ $V_e\_Shaft2_i = \text{“}20 - \#9\text{”}$ $V_e\_Shaft3_i = \text{“}20 - \#9\text{”}$

$Class\_DS\_concr_i = 37.3\ \textbf{yd}^3$ $rebar\_weight\_shaft_i = 10800\ \textbf{lb}$

SB I-294 STA 11648+60

$i := i + 1$

$$Sign\_span_i := \left\| \begin{array}{l} \text{if } Span_i \le 20\ ft \\ \quad \left\| \text{return } \text{“<= 20”} \right. \\ \text{if } Span_i \ge 21\ ft \wedge Span_i \le 30\ ft \\ \quad \left\| \text{return } \text{“21′ – 30”} \right. \\ \text{if } Span_i \ge 31\ ft \wedge Span_i \le 40\ ft \\ \quad \left\| \text{return } \text{“31′ – 40”} \right. \\ \text{if } Span_i \ge 41\ ft \wedge Span_i \le 50\ ft \\ \quad \left\| \text{return } \text{“41′ – 50”} \right. \end{array} \right.$$

$$Sign\_span_i = \text{“41′ – 50”}$$

$$\begin{bmatrix} Steel\_post\_dia_i \\ Col\_concr\_dia_i \\ No\_rebar_{vert_i} \\ Size\_rebar_{vert_i} \\ Class\_SI\_concr_i \\ Weigh_{SI\_Col\_Rebar_i} \\ W\_dim_i \\ D\_dim_i \\ B\_dim_i \\ F\_dim_i \\ V_e\_Shaft1_i \\ V_e\_Shaft2_i \\ \vdots \end{bmatrix} := \begin{bmatrix} \text{hlookup}\left(Sign\_span_i, F4\_F^{\mathrm{T}}, 1\right)_0\ in \\ \text{hlookup}\left(Sign\_span_i, F4\_F^{\mathrm{T}}, 2\right)_0\ ft \\ \text{hlookup}\left(Sign\_span_i, F4\_F^{\mathrm{T}}, 3\right)_0 \\ \text{hlookup}\left(Sign\_span_i, F4\_F^{\mathrm{T}}, 4\right)_0 \\ \frac{H1_i}{20\ ft} \cdot \text{hlookup}\left(Sign\_span_i, F4\_F^{\mathrm{T}}, 5\right)_0\ yd^3 \\ \text{hlookup}\left(Sign\_span_i, F4\_F^{\mathrm{T}}, 6\right)_0\ lb \\ \text{hlookup}\left(Sign\_span_i, F4\_G^{\mathrm{T}}, 1\right)_0\ ft \\ \text{hlookup}\left(Sign\_span_i, F4\_G^{\mathrm{T}}, 2\right)_0\ ft \\ \text{hlookup}\left(Sign\_span_i, F4\_G^{\mathrm{T}}, 3\right)_0\ ft \\ \text{hlookup}\left(Sign\_span_i, F4\_G^{\mathrm{T}}, 4\right)_0\ ft \\ \text{hlookup}\left(Sign\_span_i, F4\_G^{\mathrm{T}}, 5\right)_0 \\ \text{hlookup}\left(Sign\_span_i, F4\_G^{\mathrm{T}}, 6\right)_0 \\ \text{hlookup}\left(Sign\_span_i, F4\_G^{\mathrm{T}}, 7\right)_0 \\ \text{hlookup}\left(Sign\_span_i, F4\_G^{\mathrm{T}}, 9\right)_0\ yd^3 \\ \text{hlookup}\left(Sign\_span_i, F4\_G^{\mathrm{T}}, 10\right)_0\ lb \end{bmatrix}$$

CONCRETE COLUMN DESIGN

$Steel\_post\_dia_i = 2\ \boldsymbol{ft}$ $Col\_concr\_dia_i = 4\ \boldsymbol{ft}$

$No\_rebar_{vert_i} = 20$ $Size\_rebar_{vert_i} = 9$

$Class\_SI\_concr_i = 8.499\ \boldsymbol{yd^3}$ $Weigh_{SI\_Col\_Rebar_i} = 2330\ \boldsymbol{lb}$

CONCRETE DRILLED SHAFTS

$W\_dim_i = 6\ \boldsymbol{ft}$ $D\_dim_i = 4\ \boldsymbol{ft}$ $B\_dim_i = 40\ \boldsymbol{ft}$ $F\_dim_i = 44\ \boldsymbol{ft}$

$V_e\_Shaft1_i = \text{“20– \#9”}$ $V_e\_Shaft2_i = \text{“20– \#9”}$ $V_e\_Shaft3_i = \text{“20– \#9”}$

$Class\_DS\_concr_i = 37.3\ \boldsymbol{yd^3}$ $rebar\_weight\_shaft_i = 10800\ \boldsymbol{lb}$

REINFORCEMENT BAR WEIGHT / PROTECTIVE COAT CALCULATION

$Sheet\_name := \text{“Rebar Info”}$

$Range := \text{“!A2:D14”}$

$read := \text{concat}(Sheet\_name, Range)$

$Rebar\_parameter := \text{READEXCEL}(Excel\_file, read)$

$Rebar\_parameter =$

0	2	0.25	0.49	0.167
1	3	0.375	0.11	0.376
2	4	0.5	0.196	0.668
3	5	0.625	0.307	1.043
4	6	0.75	0.442	1.502
5	7	0.875	0.601	2.044
6	8	1	0.785	2.67
7	9	1.128	1	3.4
8	10	1.27	1.267	4.303
9	11	1.41	1.562	5.313
10	14	1.693	2.251	7.65
11	18	2.257	4.001	13.6
⋮				⋮
12				

Rebar parameter table : rebar number, diamter, area and weight

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$i := 0$

$W\_rebar\_table := \text{hlookup}\left(Sign\_span_i, F4\_F^{\mathrm{T}}, 6\right)_0 \ lb$

$W\_rebar\_table = 2330 \ lb$

$cover_i := 3.5 \ in$ Concrete column cover thickness (See Sheet 5 of 12, F4-13 Tollway Standard)

$d\_steel\_spiral_i := \text{hlookup}\left(5, Rebar\_parameter^{\mathrm{T}}, 1\right)_0 \ in$

$d\_steel\_spiral_i = 0.052 \ ft$ Diameter of number 5 steel rebar spiral (from ACI 318-16 Table)

$\gamma_{spiral_i} := \text{hlookup}\left(5, Rebar\_parameter^{\mathrm{T}}, 3\right)_0 \ \frac{lb}{ft}$ Weight of spiral rebar with unit pound per unit foot

$\gamma_{spiral_i} = 1.043 \ \frac{lb}{ft}$

$\gamma_{vert_i} := \text{hlookup}\left(Size\_rebar_{vert_i}, Rebar\_parameter^{T}, 3\right)_0 \ \frac{lb}{ft}$

$\gamma_{vert_i} = 3.4 \ \frac{lb}{ft}$ Weight of vertical steel bar with unit pound per unit foot

$pitch_i := 3 \ in$ Pitch dimension (See Sheet 6 of 12, F4-13 Tollway Standard

Calculate total rebar weight

$d_{o_i} := Col\_concr\_dia_i - 2 \cdot cover_i - d\_steel\_spiral_i$

$d_{o_i} = 3.365 \ ft$

$no\_turns\_reduced_i := \frac{20 \ ft - H1_i}{pitch_i} = 14.933$ number of turns reduced for spiral rebar

$L_{spiral_i} := no\_turns\_reduced_i \cdot \sqrt{\left(d_{o_i} \cdot \pi\right)^2 + pitch_i^{\ 2}} = 157.892 \ ft$

$rebar\_weight\_col_i := Weigh_{SI\_Col\_Rebar_i} - \left(20 \ ft - H1_i\right) \cdot \gamma_{vert_i} \cdot No\_rebar_{vert_i} - L_{spiral_i} \cdot \gamma_{spiral_i}$

$rebar\_weight\_col_i = 1911.452 \ lb$ This is the rebar for the concrete column. The total rebar weight in final table will include rebar from foundation

$total\_rebar\_weight_i := rebar\_weight\_col_i + rebar\_weight\_shaft_i$

$total\_rebar\_weight_i = 12711.452 \ lb$ Total rebar weight

Calculate protective coat

$Surface\_Area\_column_i := \pi \cdot Col\_concr\_dia_i \cdot H1_i = 204.413\ ft^2$

Note: Circumference of a circle is given by "2*PI*radius" or "Pi*Diameter"

$Surface\_Area\_base_i := 4\ ft \cdot W\_dim_i \cdot 2 + 4\ ft \cdot 18\ ft \cdot 2 + W\_dim_i \cdot 18\ ft = 300\ ft^2$

$Protective\_Coat_i := \left(Surface\_Area\_column_i + Surface\_Area\_base_i\right)$

$Protective\_Coat_i = 56.046\ yd^2$ Protective coat in square yard

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$i := i + 1$

$Sign\_span_i = \text{“}41' - 50''\text{”}$

$W\_rebar\_table := \text{hlookup}\left(Sign\_span_i, F4\_F^{\mathrm{T}}, 6\right)_0\ lb$

$W\_rebar\_table = 2330\ lb$

$cover_i := 3.5\ in$ Concrete column cover thickness (See Sheet 5 of 12, F4-13 Tollway Standard)

$d\_steel\_spiral_i := \text{hlookup}\left(5, Rebar\_parameter^{\mathrm{T}}, 1\right)_0\ in$

$d\_steel\_spiral_i = 0.052\ ft$ Diameter of number 5 steel rebar spiral (from ACI 318-16 Table)

$\gamma_{spiral_i} := \text{hlookup}\left(5, Rebar\_parameter^{\mathrm{T}}, 3\right)_0\ \frac{lb}{ft}$

$\gamma_{spiral_i} = 1.043\ \frac{lb}{ft}$

$\gamma_{vert_i} := \text{hlookup}\left(Size\_rebar_{vert_i}, Rebar\_parameter^{\mathrm{T}}, 3\right)_0 \ \frac{lb}{ft}$

$\gamma_{vert_i} = 3.4 \ \frac{lb}{ft}$

$pitch_i := 3 \ in$ Pitch dimension (See Sheet 6 of 12, F4-13 Tollway Standard

Calculate total rebar weight

$d_{o_i} := Col\_concr\_dia_i - 2 \cdot cover_i - d\_steel\_spiral_i$

$d_{o_i} = 3.365 \ ft$

$no\_turns\_reduced_i := \frac{20 \ ft - H1_i}{pitch_i} = 6.093$ number of turns reduced for spiral rebar

$L_{spiral_i} := no\_turns\_reduced_i \cdot \sqrt{\left(d_{o_i} \cdot \pi\right)^2 + pitch_i^{\ 2}} = 64.425 \ ft$

$rebar\_weight\_col_i := Weigh_{SI\_Col\_Rebar_i} - \left(20 \ ft - H1_i\right) \cdot \gamma_{vert_i} \cdot No\_rebar_{vert_i} - L_{spiral_i} \cdot \gamma_{spiral_i}$

$rebar\_weight\_col_i = 2159.218 \ lb$ This is the rebar for the concrete column. The total rebar weight in final table will include rebar from foundation

$total\_rebar\_weight_i := rebar\_weight\_col_i + rebar\_weight\_shaft_i$

$total\_rebar\_weight_i = 12959.218\ lb$ Total rebar weight

Calculate protective coat:

$Surface\_Area\_column_i := \pi \cdot Col\_concr\_dia_i \cdot H1_i = 232.185\ ft^2$

Note: Circumference of a circle is given by "2*PI*radius" or "Pi*Diameter"

$Surface\_Area\_base_i := 4\ ft \cdot W\_dim_i \cdot 2 + 4\ ft \cdot 18\ ft \cdot 2 + W\_dim_i \cdot 18\ ft = 300\ ft^2$

$Protective\_Coat_i := \left(Surface\_Area\_column_i + Surface\_Area\_base_i\right)$

$Protective\_Coat_i = 59.132\ yd^2$ Protective coat in square yard

Output table data to Excel spreadsheet "Cant_Truss_Tollway_20220581.xlsxm" for further processing

$file\_name := Excel\_file$

$file\_out := \mathrm{WRITEEXCEL}(file\_name, Sign\_Structure\_No, \text{“[1]A3”})$

$file\_out := \mathrm{WRITEEXCEL}(file\_name, STA, \text{“[1]B3”})$

$file\_out := \mathrm{WRITEEXCEL}(file\_name, cant\_type, \text{“[1]C3”})$

$file\_out := \mathrm{WRITEEXCEL}\left(file\_name, \frac{Span}{ft}, \text{“[1]D3”}\right)$

$file\_out := \mathrm{WRITEEXCEL}\left(file\_name, \frac{Elev\_A}{ft}, \text{“[1]E3”}\right)$

$file\_out := \mathrm{WRITEEXCEL}\left(file\_name, \frac{TOC}{ft}, \text{“[1]F3”}\right)$

$file\_out := \mathrm{WRITEEXCEL}\left(file\_name, \frac{Elev\_C}{ft}, \text{“[1]G3”}\right)$

$file\_out := \mathrm{WRITEEXCEL}\left(file\_name, \frac{road\_clearance}{ft}, \text{“[1]H3”}\right)$

$file\_out := \mathrm{WRITEEXCEL}\left(file\_name, \frac{D}{ft}, \text{“[1]I3”}\right)$

$file\_out := \mathrm{WRITEEXCEL}\left(file\_name, \frac{Hmax}{ft}, \text{“[1]J3”}\right)$

$file\_out := \mathrm{WRITEEXCEL}\left(file\_name, \frac{H1}{ft}, \text{“[1]K3”}\right)$

$file\_out := \mathrm{WRITEEXCEL}\left(file\_name, \frac{H\_sign\_max}{ft}, \text{“[1]L3”}\right)$

$file\_out := \mathrm{WRITEEXCEL}\left(file\_name, \frac{sign\_area}{ft^2}, \text{“[1]M3”}\right)$

$file\_out := \mathrm{WRITEEXCEL}\left(file\_name, \frac{Class\_SI\_concr}{yd^3}, \text{“[1]N3”}\right)$

$file\_out := \mathrm{WRITEEXCEL}\left(file\_name, \frac{Class\_DS\_concr}{yd^3}, \text{“[1]O3”}\right)$

$file\_out := \mathrm{WRITEEXCEL}\left(file\_name, \frac{total\_rebar\_weight}{lb}, \text{“[1]P3”}\right)$

$file\_out := \mathrm{WRITEEXCEL}\left(file\_name, \frac{Protective\_Coat}{yd^2}, \text{“[1]Q3”}\right)$