

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:

$Min_clearance := 17\text{ ft} + 5\text{ in}$	Minimum required clearance from highest elevation of roadway to bottom of 18 ft high sign. (See F4 Sheet 1 of 12)
$level_gap := 2.75\text{ in}$	Nominal gap for levelling between top of concrete and bottom of steel base plate. (See F4 Sheet 4 of 12)
$A_{fnd_min} := 1\text{ ft}$	Minimum allowed exposure of grade beam above proposed grade.
$A_{fnd_max} := 3.5\text{ ft}$	Maximum allowed exposure of grade beam above proposed grade.
$H_{max} := 12\text{ ft}$	Maximum allowed dimension from bottom of base plate to center line of upper chord. (See F4 Sheet 5 of 12)
$H1_{max} := 20\text{ ft}$	Maximum allowed dimension from top of grade beam to bottom of steel base plate. (See F4, Sheet 5 of 12)
$path := "C:\Users\Terry\Downloads\"$	
$Excel_file := "C:\Users\Terry\Downloads\Cant_Truss_Tollway_20220581.xlsx"$	
	Excel spreadsheet for input and output of Tollway Cantilever structure parameters

<i>Sign_Structure_No</i>	<i>STA</i>	<i>Span</i> (ft)	<i>Elev_A</i> (ft)	<i>D</i> (ft)	<i>H_sign_max</i> (ft)	<i>TOC</i> (ft)	<i>Grade_ele</i> (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 := 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 := concat(*Sheet_name*, *Range_text*) = "F4-14 Table C!A4:X10"

F14_C := READEXCEL(*Excel_file*, *read*)

<i>F14_C</i> =	0	1	2	3	4	5	6	7	8	9	10	...	23
	20	"20-D"	2.5	5.5	20.083	15	18	104.67	0.562	12	"HSS 5x5x1/4"		
	25	"25-D"	3.5	5.6	24.917	18.75	18	104.67	0.562	12	"HSS 5x5x1/4"		
	30	"30-D"	3.5	7	30.167	22.5	18	104.67	0.562	12	"HSS 6x6x1/4"		
	35	"35-D"	4	7	35	24	24	171.29	0.687	12	"HSS 6x6x1/4"		
	40	"40-D"	4	7	40	24	24	171.29	0.687	12	"HSS 6x6x1/4"		
	45	"45-D"	4.5	7	45.042	24	24	171.29	0.687	12	"HSS 6x6x1/4"		
50	"50-D"	4.5	7	50.083	24	24	171.29	0.687	12	"HSS 10x10x1/4"	...		

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

Range_text := “!A4:K10”

read := concat(*Sheet_name*, *Range_text*) = “F4-14 Table C!A4:K10”

F14_C_0_11 := READEXCEL(*Excel_file*, *read*)

<i>F14_C_0_11</i> =	20	“20-D”	2.5	5.5	20.083	15	18	104.67	0.562	12	“HSS 5x5x1/4”
	25	“25-D”	3.5	5.6	24.917	18.75	18	104.67	0.562	12	“HSS 5x5x1/4”
	30	“30-D”	3.5	7	30.167	22.5	18	104.67	0.562	12	“HSS 6x6x1/4”
	35	“35-D”	4	7	35	24	24	171.29	0.687	12	“HSS 6x6x1/4”
	40	“40-D”	4	7	40	24	24	171.29	0.687	12	“HSS 6x6x1/4”
	45	“45-D”	4.5	7	45.042	24	24	171.29	0.687	12	“HSS 6x6x1/4”
	50	“50-D”	4.5	7	50.083	24	24	171.29	0.687	12	“HSS 10x10x1/4”

Range_text := “!L4:P10”

read := concat(*Sheet_name*, *Range_text*) = “F4-14 Table C!L4:P10”

F14_C_12_16 := READEXCEL(*Excel_file*, *read*)

<i>F14_C_12_16</i> =	“2 1/2”Ø X.S”	0.276	“3”Ø X.X.S”	0.6	“1 1/2”Ø X.S”
	“2 1/2”Ø X.S”	0.276	“4”Ø X.X.S”	0.6	“2”Ø X.S”
	“3”Ø X.S”	0.3	“4”Ø X.X.S”	0.674	“2”Ø X.S”
	“3”Ø X.S”	0.3	“4”Ø X.X.S”	0.674	“2”Ø X.S”
	“3”Ø X.S”	0.3	“4”Ø X.X.S”	0.674	“2”Ø X.S”
	“3”Ø X.S”	0.3	“4”Ø X.X.S”	0.674	“2”Ø X.S”
	“3”Ø X.S”	0.3	“HSS 8.625x0.5”	0.465	“2”Ø X.S”

Range_text := “!Q4:X10”

read := concat(*Sheet_name*, *Range_text*) = “F4-14 Table C!Q4:X10”

F14_C_17_23 := 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 := "F4-14 Table A"

Range_text := "!A2:D8"

read := concat(*Sheet_name*, *Range_text*) = "F4-14 Table A!A2:D8"

F14_A := READEXCEL(*Excel_file*, *read*)

$$F14_A = \begin{bmatrix} 20 & \text{"20-D"} & 270 & 15 \\ 25 & \text{"25-D"} & 338 & 18.75 \\ 30 & \text{"30-D"} & 405 & 22.5 \\ 35 & \text{"35-D"} & 432 & 24 \\ 40 & \text{"40-D"} & 432 & 24 \\ 45 & \text{"45-D"} & 432 & 24 \\ 50 & \text{"50-D"} & 432 & 24 \end{bmatrix}$$

SB I-294 STA 11686+50

i := 0

index counter

$$First_col := Span_i \frac{1}{ft} = 40$$

$$\begin{bmatrix} cant_type_i \\ max_sign_area_i \\ max_sign_length_i \end{bmatrix} := \begin{bmatrix} hlookup(First_col, F14_A^T, 1)_0 \\ hlookup(First_col, F14_A^T, 2)_0 \text{ ft}^2 \\ hlookup(First_col, F14_A^T, 3)_0 \text{ ft} \end{bmatrix}$$

*cant_type*_{*i*} = "40-D"

*max_sign_area*_{*i*} = 432 ft²

$$max_sign_length_i = 24 \text{ ft}$$

$$sign_area_i := 17 \text{ ft} \cdot 14.5 \text{ ft} + 9.5 \text{ ft} \cdot 2.5 \text{ ft}$$

$$sign_area_i = 270.25 \text{ ft}^2$$

Table on sheet

\vdots		\vdots	
$Truss_v_wall_i$		hlookup($First_col, F14_C^T, 14$) ₀	in
$Truss_vd_pipe_i$		hlookup($First_col, F14_C^T, 15$) ₀	
$Truss_vd_wall_i$		hlookup($First_col, F14_C^T, 16$) ₀	in
$Truss_h_pipe_i$		hlookup($First_col, F14_C^T, 17$) ₀	
$Truss_h_wall_i$		hlookup($First_col, F14_C^T, 18$) ₀	in
$Truss_hd_pipe_i$:=	hlookup($First_col, F14_C^T, 19$) ₀	
$Truss_hd_wall_i$		hlookup($First_col, F14_C^T, 20$) ₀	in
$Truss_int_pipe_i$		hlookup($First_col, F14_C^T, 21$) ₀	
$Truss_int_wall_i$		hlookup($First_col, F14_C^T, 22$) ₀	ft
$Panel_No_i$		hlookup($First_col, F14_C^T, 23$) ₀	ft
$Panel_P_i$			
$Panel_S_i$			

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

Truss size

$$e_dim_i = 4 \text{ ft}$$

$$d_dim_i = 7 \text{ ft}$$

Steel Support Post Column

$$Col_dia_i = 24 \text{ in}$$

$$Col_wall_thick_i = 0.687 \text{ in}$$

$$H_max_i = 12 \text{ ft}$$

Truss Members and Details

$$Truss_top_bot_chord_i = \text{"HSS 6x6x1/4"}$$

$$Truss_v_pipe_i = \text{"3"Ø X.S"}$$

$$Truss_v_wall_i = 0.3 \text{ in}$$

$$Truss_vd_pipe_i = "4" \varnothing X.X.S" \quad Truss_vd_wall_i = 0.674 \text{ in}$$

$$Truss_h_pipe_i = "2" \varnothing X.S" \quad Truss_h_wall_i = 0.218 \text{ in}$$

$$Truss_hd_pipe_i = "2 \frac{1}{2} \varnothing X.S" \quad Truss_hd_wall_i = 0.276 \text{ in}$$

$$Truss_int_pipe_i = "2" \varnothing X.S" \quad Truss_int_wall_i = 0.218 \text{ in}$$

Panels

$$Panel_No_i = 6 \quad Panel_P_i = 5.25 \text{ ft} \quad Panel_S_i = 2.25 \text{ ft}$$

SB I-294 STA 11648+60

$$i := i + 1$$

$$Second_col := Span_i \frac{1}{ft}$$

$$\begin{bmatrix} cant_type_i \\ max_sign_area_i \\ max_sign_length_i \end{bmatrix} := \begin{bmatrix} \text{hlookup}(Second_col, F14_A^T, 1)_0 \\ \text{hlookup}(Second_col, F14_A^T, 2)_0 \text{ ft}^2 \\ \text{hlookup}(Second_col, F14_A^T, 3)_0 \text{ ft} \end{bmatrix}$$

$$cant_type_i = "50-D"$$

$$max_sign_area_i = 432 \text{ ft}^2$$

$$max_sign_length_i = 24 \text{ ft}$$

$$sign_area_i := 17 \text{ ft} \cdot 14.5 \text{ ft} + 9.5 \text{ ft} \cdot 2.5 \text{ ft} \quad \text{Total sign area}$$

$$sign_area_i = 270.25 \text{ ft}^2$$

Table on sheet

$$\begin{bmatrix}
 e_{dim}_i \\
 d_{dim}_i \\
 Col_{dia}_i \\
 Col_{weigh}_i \\
 Col_{wall_thick}_i \\
 H_{max}_i \\
 Truss_{top_bot_chord}_i \\
 Truss_{v_pipe}_i \\
 Truss_{v_wall}_i \\
 Truss_{vd_pipe}_i \\
 Truss_{vd_wall}_i \\
 Truss_{h_pipe}_i \\
 \vdots
 \end{bmatrix}
 :=
 \begin{bmatrix}
 hlookup(Second_col, F14_C^T, 2)_0 \text{ ft} \\
 hlookup(Second_col, F14_C^T, 3)_0 \text{ ft} \\
 hlookup(Second_col, F14_C^T, 6)_0 \text{ in} \\
 hlookup(Second_col, F14_C^T, 7)_0 \\
 hlookup(Second_col, F14_C^T, 8)_0 \text{ in} \\
 hlookup(Second_col, F14_C^T, 9)_0 \text{ ft} \\
 hlookup(Second_col, F14_C^T, 10)_0 \\
 hlookup(Second_col, F14_C^T, 11)_0 \\
 hlookup(Second_col, F14_C^T, 12)_0 \text{ in} \\
 hlookup(Second_col, F14_C^T, 13)_0 \\
 hlookup(Second_col, F14_C^T, 14)_0 \text{ in} \\
 \vdots
 \end{bmatrix}$$

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

Truss size

$$e_{dim}_i = 4.5 \text{ ft}$$

$$d_{dim}_i = 7 \text{ ft}$$

Steel Support Post Column

$$Col_dia_i = 2 \text{ ft} \quad Col_wall_thick_i = 0.057 \text{ ft} \quad H_max_i = 12 \text{ ft}$$

$$Col_weigh_i = 171.29$$

Truss Member and Details

$$Truss_top_bot_chord_i = \text{"HSS 10x10x1/4"}$$

$$Truss_v_pipe_i = \text{"3"Ø X.S"} \quad Truss_v_wall_i = 0.3 \text{ in}$$

$$Truss_vd_pipe_i = \text{"HSS 8.625x0.5"} \quad Truss_vd_wall_i = 0.465 \text{ in}$$

$$Truss_h_pipe_i = \text{"2"Ø X.S"} \quad Truss_h_wall_i = 0.218 \text{ in}$$

$$Truss_hd_pipe_i = \text{"3"Ø X.S"} \quad Truss_hd_wall_i = 0.276 \text{ in}$$

$$Truss_int_pipe_i = \text{"2"Ø X.S"} \quad Truss_int_wall_i = 0.218 \text{ in}$$

Panels

$$Panel_No_i = 8 \quad Panel_P_i = 5.917 \text{ ft} \quad Panel_S_i = 2.5 \text{ ft}$$

Calculate Sign Structure Parameters

$$k := 0 .. no_structures - 1$$

Index variable for looping thru cases

$$Elev_Cl_truss_k := Elev_A_k + Min_clearance + \frac{1}{2} \cdot \left(\max \left(H_sign_max_k, 18 \text{ ft} \right) \right)$$

$$Elev_Cl_truss = \begin{bmatrix} 747.097 \\ 750.007 \end{bmatrix} \text{ ft} \quad \text{Elevation at truss centerline}$$

$$Elev_top_k := Elev_Cl_truss_k + \frac{d_dim_k}{2}$$

$$Elev_top = \begin{bmatrix} 750.597 \\ 753.507 \end{bmatrix} \text{ ft} \quad \text{Elevation at truss top chord}$$

$$H1 := Elev_top - TOC - H_max$$

$$H1 = \begin{bmatrix} 16.267 \\ 18.477 \end{bmatrix} \text{ ft}$$

Length of concrete column

$$Hmax := Elev_{top} - TOC - H1$$

$$Hmax = \begin{bmatrix} 12 \\ 12 \end{bmatrix} \text{ ft}$$

Elevation from bottom base plate to the centerline of truss

$$Elev_C := TOC - 4 \text{ ft}$$

4 feet is the height of the grade beam foundation (See Sheet 6 of 12, Tollway F4-13 Standard)

$$Elev_C = \begin{bmatrix} 718.33 \\ 719.03 \end{bmatrix} \text{ ft}$$

Elevation of bottom of grade beam

$$road_clearance := Elev_{Cl_truss} - \frac{1}{2} \cdot (H_{sign_max}) - Elev_A$$

$$road_clearance = \begin{bmatrix} 19.167 \\ 19.167 \end{bmatrix} \text{ ft}$$

Calculate foundation parameters

$$A_{fnd_k} := TOC_k - Grade_{ele}_k$$

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

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

$$check_max_H_k := \text{if}(H_{max_k} \geq Hmax_k, \text{"OK"}, \text{"NG"})$$

$$check_max_H = \begin{bmatrix} \text{"OK"} \\ \text{"OK"} \end{bmatrix}$$

Check max H

$$check_max_H1_k := \text{if}(H1_{max_k} \geq H1_k, \text{"OK"}, \text{"NG"})$$

$check_max_H1_k = \begin{bmatrix} \text{"OK"} \\ \text{"OK"} \end{bmatrix}$ Check max H1

$sign_area_check_k := \text{if}(max_sign_area_k \geq sign_area_k, \text{"OK"}, \text{"NG"})$

$sign_area_check_k = \begin{bmatrix} \text{"OK"} \\ \text{"OK"} \end{bmatrix}$ Check max sign area

$road_clearance_check_k := \text{if}(Min_clearance \leq road_clearance_k, \text{"OK"}, \text{"NG"})$

$road_clearance_check_k = \begin{bmatrix} \text{"OK"} \\ \text{"OK"} \end{bmatrix}$ Check max road clearance

$check_grade_beam_exposure_k := \text{if}(A_{fnd_k} \leq A_{fnd_max} \wedge A_{fnd_k} \geq A_{fnd_min}, \text{"OK"}, \text{"NG"})$

$check_grade_beam_exposure_k = \begin{bmatrix} \text{"OK"} \\ \text{"OK"} \end{bmatrix}$ Check allowed grade beam exposure

CONCRETE DESIGN

F4-14 Table F

$Sheet_name := \text{"F4-14 Table F"}$

$Range := \text{"!A3:G6"}$

$read := \text{concat}(Sheet_name, Range) = \text{"F4-14 Table F!A3:G6"}$

$F4_F := \text{READEXCEL}(Excel_file, read)$

$$F4_F = \begin{bmatrix} "<= 20'" & 18 & 3.5 & 16 & 9 & 7.1 & 1910 \\ "<= 20'" & 18 & 3.5 & 16 & 9 & 7.1 & 1910 \\ "21' - 30'" & 18 & 3.5 & 16 & 9 & 7.1 & 1910 \\ "21' - 30'" & 18 & 3.5 & 16 & 9 & 7.1 & 1910 \\ "31' - 40'" & 24 & 4 & 20 & 9 & 9.2 & 2330 \\ "31' - 40'" & 24 & 4 & 20 & 9 & 9.2 & 2330 \\ "41' - 50'" & 24 & 4 & 20 & 9 & 9.2 & 2330 \\ "41' - 50'" & 24 & 4 & 20 & 9 & 9.2 & 2330 \end{bmatrix}$$

F4-14 Table G

Sheet_name := "F4-14 Table G"

Range := "!A3:K6"

read := concat(*Sheet_name*, *Range*) = "F4-14 Table G!A3:K6"

F4_G := READEXCEL(*Excel_file*, *read*)

$$F4_G = \begin{bmatrix} "<= 20'" & 5 & 3 & 40 & 44 & "12-#9" & "12-#9" & "16-#9" & 13.4 & 21 & 7700 \\ "<= 20'" & 5 & 3 & 40 & 44 & "12-#9" & "12-#9" & "16-#9" & 13.4 & 21 & 7700 \\ "21' - 30'" & 5 & 3 & 40 & 44 & "12-#9" & "12-#9" & "16-#9" & 13.4 & 21 & 7700 \\ "21' - 30'" & 5 & 3 & 40 & 44 & "12-#9" & "12-#9" & "16-#9" & 13.4 & 21 & 7700 \\ "31' - 40'" & 6 & 4 & 40 & 44 & "20-#9" & "20-#9" & "20-#9" & 16 & 37.3 & 10800 \\ "31' - 40'" & 6 & 4 & 40 & 44 & "20-#9" & "20-#9" & "20-#9" & 16 & 37.3 & 10800 \\ "41' - 50'" & 6 & 4 & 40 & 44 & "20-#9" & "20-#9" & "20-#9" & 16 & 37.3 & 10800 \\ "41' - 50'" & 6 & 4 & 40 & 44 & "20-#9" & "20-#9" & "20-#9" & 16 & 37.3 & 10800 \end{bmatrix}$$

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i := 0

index counter

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Sign_spani := || if Spani ≤ 20 ft
                || return "<= 20'"
                || if Spani ≥ 21 ft ∧ Spani ≤ 30 ft
                || return "21' - 30'"
                || if Spani ≥ 31 ft ∧ Spani ≤ 40 ft
                || return "31' - 40'"
                || if Spani ≥ 41 ft ∧ Spani ≤ 50 ft
                || return "41' - 50'"
    
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$$Sign_span_i = "31' - 40"$$

$$\begin{bmatrix} \vdots \\ Size_rebar_{vert_i} \\ Class_SI_concr_i \\ Weigh_{SI_Col_Rebar_i} \\ W_dim_i \\ D_dim_i \\ B_dim_i \\ F_dim_i \\ V_e_Shaft1_i \\ V_e_Shaft2_i \\ V_e_Shaft3_i \\ Class_DS_concr_i \\ rebar_weight_shaft_i \end{bmatrix} := \begin{bmatrix} hlookup(Sign_span_i, F4_F^T, 1)_0 \text{ in} \\ hlookup(Sign_span_i, F4_F^T, 2)_0 \text{ ft} \\ hlookup(Sign_span_i, F4_F^T, 3)_0 \\ hlookup(Sign_span_i, F4_F^T, 4)_0 \\ \frac{H1_i}{20 \text{ ft}} \cdot hlookup(Sign_span_i, F4_F^T, 5)_0 \text{ yd}^3 \\ hlookup(Sign_span_i, F4_F^T, 6)_0 \text{ lb} \\ \vdots \end{bmatrix}$$

CONCRETE COLUMN DESIGN

$$Steel_post_dia_i = 2 \text{ ft}$$

$$Col_concr_dia_i = 4 \text{ ft}$$

$$No_rebar_{vert_i} = 20$$

$$Size_rebar_{vert_i} = 9$$

$$Class_SI_concr_i = 7.483 \text{ yd}^3$$

$$Weigh_{SI_Col_Rebar_i} = 2330 \text{ lb}$$

CONCRETE DRILLED SHAFTS

$$W_dim_i = 6 \text{ ft}$$

$$D_dim_i = 4 \text{ ft}$$

$$B_dim_i = 40 \text{ ft}$$

$$F_dim_i = 44 \text{ ft}$$

$$V_e_Shaft1_i = "20- \#9"$$

$$V_e_Shaft2_i = "20- \#9"$$

$$V_e_Shaft3_i = "20- \#9"$$

$$Class_DS_concr_i = 37.3 \text{ yd}^3$$

$$rebar_weight_shaft_i = 10800 \text{ lb}$$

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$i := i + 1$

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Sign_span_i :=
    if Span_i ≤ 20 ft
    || return "<= 20'"
    if Span_i ≥ 21 ft ∧ Span_i ≤ 30 ft
    || return "21' - 30'"
    if Span_i ≥ 31 ft ∧ Span_i ≤ 40 ft
    || return "31' - 40'"
    if Span_i ≥ 41 ft ∧ Span_i ≤ 50 ft
    || return "41' - 50'"
    
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$Sign_span_i = "41' - 50'"$

	$hlookup(Sign_span_i, F4_F^T, 1)_0$	in
	$hlookup(Sign_span_i, F4_F^T, 2)_0$	ft
	$hlookup(Sign_span_i, F4_F^T, 3)_0$	
	$hlookup(Sign_span_i, F4_F^T, 4)_0$	
$Steel_post_dia_i$	$H1_i$	
$Col_concr_dia_i$	$\frac{H1_i}{20 \text{ ft}} \cdot hlookup(Sign_span_i, F4_F^T, 5)_0$	yd³
$No_rebar_{vert_i}$	$hlookup(Sign_span_i, F4_F^T, 6)_0$	lb
$Size_rebar_{vert_i}$	$hlookup(Sign_span_i, F4_G^T, 1)_0$	ft
$Class_SI_concr_i$	$hlookup(Sign_span_i, F4_G^T, 2)_0$	ft
$Weigh_{SI_Col_Rebar_i}$	$hlookup(Sign_span_i, F4_G^T, 3)_0$	ft
W_dim_i	$hlookup(Sign_span_i, F4_G^T, 4)_0$	ft
D_dim_i	$hlookup(Sign_span_i, F4_G^T, 5)_0$	ft
B_dim_i	$hlookup(Sign_span_i, F4_G^T, 6)_0$	ft
F_dim_i	$hlookup(Sign_span_i, F4_G^T, 7)_0$	ft
$V_{e_Shaft1_i}$	$hlookup(Sign_span_i, F4_G^T, 8)_0$	
$V_{e_Shaft2_i}$	$hlookup(Sign_span_i, F4_G^T, 9)_0$	yd³
\vdots	$hlookup(Sign_span_i, F4_G^T, 10)_0$	lb

CONCRETE COLUMN DESIGN

$$Steel_post_dia_i = 2 \text{ ft}$$

$$Col_concr_dia_i = 4 \text{ ft}$$

$$No_rebar_{vert_i} = 20$$

$$Size_rebar_{vert_i} = 9$$

$$Class_SI_concr_i = 8.499 \text{ yd}^3$$

$$Weigh_{SI_Col_Rebar_i} = 2330 \text{ lb}$$

CONCRETE DRILLED SHAFTS

$$W_dim_i = 6 \text{ ft}$$

$$D_dim_i = 4 \text{ ft}$$

$$B_dim_i = 40 \text{ ft}$$

$$F_dim_i = 44 \text{ ft}$$

$$V_e_Shaft1_i = "20- \#9"$$

$$V_e_Shaft2_i = "20- \#9"$$

$$V_e_Shaft3_i = "20- \#9"$$

$$Class_DS_concr_i = 37.3 \text{ yd}^3$$

$$rebar_weight_shaft_i = 10800 \text{ lb}$$

REINFORCEMENT BAR WEIGHT / PROTECTIVE COAT CALCULATION

$Sheet_name :=$ "Rebar Info"

$Range :=$ "!A2:D14"

$read :=$ concat($Sheet_name$, $Range$)

$Rebar_parameter :=$ 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

$W_rebar_table :=$ hlookup($Sign_span_i$, $F4_F^T$, 6)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)

$d_steel_spiral_i :=$ hlookup(5, $Rebar_parameter^T$, 1)₀ **in**

$d_steel_spiral_i =$ 0.052 **ft**

Diameter of number 5 steel rebar spiral (from ACI
 318-16 Table)

$\gamma_{spiral_i} :=$ hlookup(5, $Rebar_parameter^T$, 3)₀ $\frac{lb}{ft}$

Weight of spiral rebar with
 unit pound per unit foot

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

$$\gamma_{vert_i} := \text{hlookup}\left(\text{Size_rebar}_{vert_i}, \text{Rebar_parameter}^T, 3\right)_0 \frac{lb}{ft}$$

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

Weight of vertical steel bar
with unit pound per unit foot

$$pitch_i := 3 \text{ in}$$

Pitch dimension (See Sheet 6 of 12, F4-13 Tollway
Standard)

Calculate total rebar weight

$$d_{o_i} := \text{Col_concr_dia}_i - 2 \cdot \text{cover}_i - d_{steel_spiral}_i$$

$$d_{o_i} = 3.365 \text{ ft}$$

$$no_turns_reduced_i := \frac{20 \text{ ft} - H1_i}{pitch_i} = 14.933$$

number of turns reduced for
spiral rebar

$$L_{spiral_i} := no_turns_reduced_i \cdot \sqrt{(d_{o_i} \cdot \pi)^2 + pitch_i^2} = 157.892 \text{ ft}$$

$$rebar_weight_col_i := \text{Weigh}_{SI_Col_Rebar_i} - (20 \text{ ft} - H1_i) \cdot \gamma_{vert_i} \cdot No_rebar_{vert_i} - L_{spiral_i} \cdot \gamma_{spiral_i}$$

$$rebar_weight_col_i = 1911.452 \text{ lb}$$

This is the rebar for the concrete column. The
total rebar weight in final table will include rebar
from foundation

$$total_rebar_weight_i := rebar_weight_col_i + rebar_weight_shaft_i$$

$$total_rebar_weight_i = 12711.452 \text{ lb}$$

Total rebar weight

Calculate protective coat

$$Surface_Area_column_i := \pi \cdot Col_concr_dia_i \cdot H1_i = 204.413 \text{ ft}^2$$

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

$$Surface_Area_base_i := 4 \text{ ft} \cdot W_dim_i \cdot 2 + 4 \text{ ft} \cdot 18 \text{ ft} \cdot 2 + W_dim_i \cdot 18 \text{ ft} = 300 \text{ ft}^2$$

$$Protective_Coat_i := (Surface_Area_column_i + Surface_Area_base_i)$$

$$Protective_Coat_i = 56.046 \text{ yd}^2 \quad \text{Protective coat in square yard}$$

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$$i := i + 1$$

$$Sign_span_i = "41' - 50"$$

$$W_rebar_table := \text{hlookup}(Sign_span_i, F4_F^T, 6)_0 \text{ lb}$$

$$W_rebar_table = 2330 \text{ lb}$$

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

$$d_steel_spiral_i := \text{hlookup}(5, Rebar_parameter^T, 1)_0 \text{ in}$$

$$d_steel_spiral_i = 0.052 \text{ ft} \quad \text{Diameter of number 5 steel rebar spiral (from ACI 318-16 Table)}$$

$$\gamma_{spiral_i} := \text{hlookup}(5, Rebar_parameter^T, 3)_0 \frac{\text{lb}}{\text{ft}}$$

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

$$\gamma_{vert_i} := \text{hlookup} \left(\text{Size_rebar}_{vert_i}, \text{Rebar_parameter}^T, 3 \right)_0 \frac{\text{lb}}{\text{ft}}$$

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

$$\text{pitch}_i := 3 \text{ in}$$

Pitch dimension (See Sheet 6 of 12, F4-13 Tollway Standard)

Calculate total rebar weight

$$d_{o_i} := \text{Col_concr_dia}_i - 2 \cdot \text{cover}_i - d_{\text{steel_spiral}_i}$$

$$d_{o_i} = 3.365 \text{ ft}$$

$$\text{no_turns_reduced}_i := \frac{20 \text{ ft} - H1_i}{\text{pitch}_i} = 6.093$$

number of turns reduced for spiral rebar

$$L_{\text{spiral}_i} := \text{no_turns_reduced}_i \cdot \sqrt{\left(d_{o_i} \cdot \pi \right)^2 + \text{pitch}_i^2} = 64.425 \text{ ft}$$

$$\text{rebar_weight_col}_i := \text{Weigh}_{SI_Col_Rebar_i} - \left(20 \text{ ft} - H1_i \right) \cdot \gamma_{vert_i} \cdot \text{No_rebar}_{vert_i} - L_{\text{spiral}_i} \cdot \gamma_{\text{spiral}_i}$$

$$\text{rebar_weight_col}_i = 2159.218 \text{ lb}$$

This is the rebar for the concrete column.
The total rebar weight in final table will include rebar from foundation

$$total_rebar_weight_i := rebar_weight_col_i + rebar_weight_shaft_i$$

$$total_rebar_weight_i = 12959.218 \text{ lb} \quad \text{Total rebar weight}$$

Calculate protective coat:

$$Surface_Area_column_i := \pi \cdot Col_concr_dia_i \cdot H1_i = 232.185 \text{ ft}^2$$

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

$$Surface_Area_base_i := 4 \text{ ft} \cdot W_dim_i \cdot 2 + 4 \text{ ft} \cdot 18 \text{ ft} \cdot 2 + W_dim_i \cdot 18 \text{ ft} = 300 \text{ ft}^2$$

$$Protective_Coat_i := (Surface_Area_column_i + Surface_Area_base_i)$$

$$Protective_Coat_i = 59.132 \text{ yd}^2 \quad \text{Protective coat in square yard}$$

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

$file_name := Excel_file$

$file_out := WRITEEXCEL(file_name, Sign_Structure_No, "[1]A3")$

$file_out := WRITEEXCEL(file_name, STA, "[1]B3")$

$file_out := WRITEEXCEL(file_name, cant_type, "[1]C3")$

$file_out := WRITEEXCEL\left(file_name, \frac{Span}{ft}, "[1]D3"\right)$

$file_out := WRITEEXCEL\left(file_name, \frac{Elev_A}{ft}, "[1]E3"\right)$

$file_out := WRITEEXCEL\left(file_name, \frac{TOC}{ft}, "[1]F3"\right)$

$file_out := WRITEEXCEL\left(file_name, \frac{Elev_C}{ft}, "[1]G3"\right)$

$file_out := WRITEEXCEL\left(file_name, \frac{road_clearance}{ft}, "[1]H3"\right)$

$file_out := WRITEEXCEL\left(file_name, \frac{D}{ft}, "[1]I3"\right)$

$file_out := WRITEEXCEL\left(file_name, \frac{Hmax}{ft}, "[1]J3"\right)$

$file_out := WRITEEXCEL\left(file_name, \frac{H1}{ft}, "[1]K3"\right)$

$file_out := WRITEEXCEL\left(file_name, \frac{H_sign_max}{ft}, "[1]L3"\right)$

$file_out := WRITEEXCEL\left(file_name, \frac{sign_area}{ft^2}, "[1]M3"\right)$

$file_out := WRITEEXCEL\left(file_name, \frac{Class_SI_concr}{yd^3}, "[1]N3"\right)$

$file_out := WRITEEXCEL\left(file_name, \frac{Class_DS_concr}{yd^3}, "[1]O3"\right)$

$file_out := WRITEEXCEL\left(file_name, \frac{total_rebar_weight}{lb}, "[1]P3"\right)$

$file_out := WRITEEXCEL\left(file_name, \frac{Protective_Coat}{yd^2}, "[1]Q3"\right)$