

WIN-SABRE

Tutorial for ASD & LRFD (Cantilever)

Windows-Based Computer Analysis of 3-D Sign Bridge



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(<http://www.best.umd.edu>)



Step 1: Open an existing file or Create a new file. (File name will be shown on the Caption)

Step 1A: Once done, click Down Icon or next Tab to the next screen

mp\sspc1.dat - [System]

File Edit Input Screen Go To Input Graphics Help

Mesh

Project Data General Program Options

DATA TYPE : 01012 , 01022

DESCRIPTION	Woerner Wire Works Test
DATE	
CONTRACT NUMBER	
STRUCTURE NO.	
STRUCTURE UNIT	
DESIGN BY	ICL
CHECK BY	CCF
SPECIFICATION	AASHTO 2001

Step 2: Input General Program Options (Detailed level is needed for Postprocessor)

e:\temp\sspc1.dat - [System]

File Edit Input Screen Go To Input Graphic Help

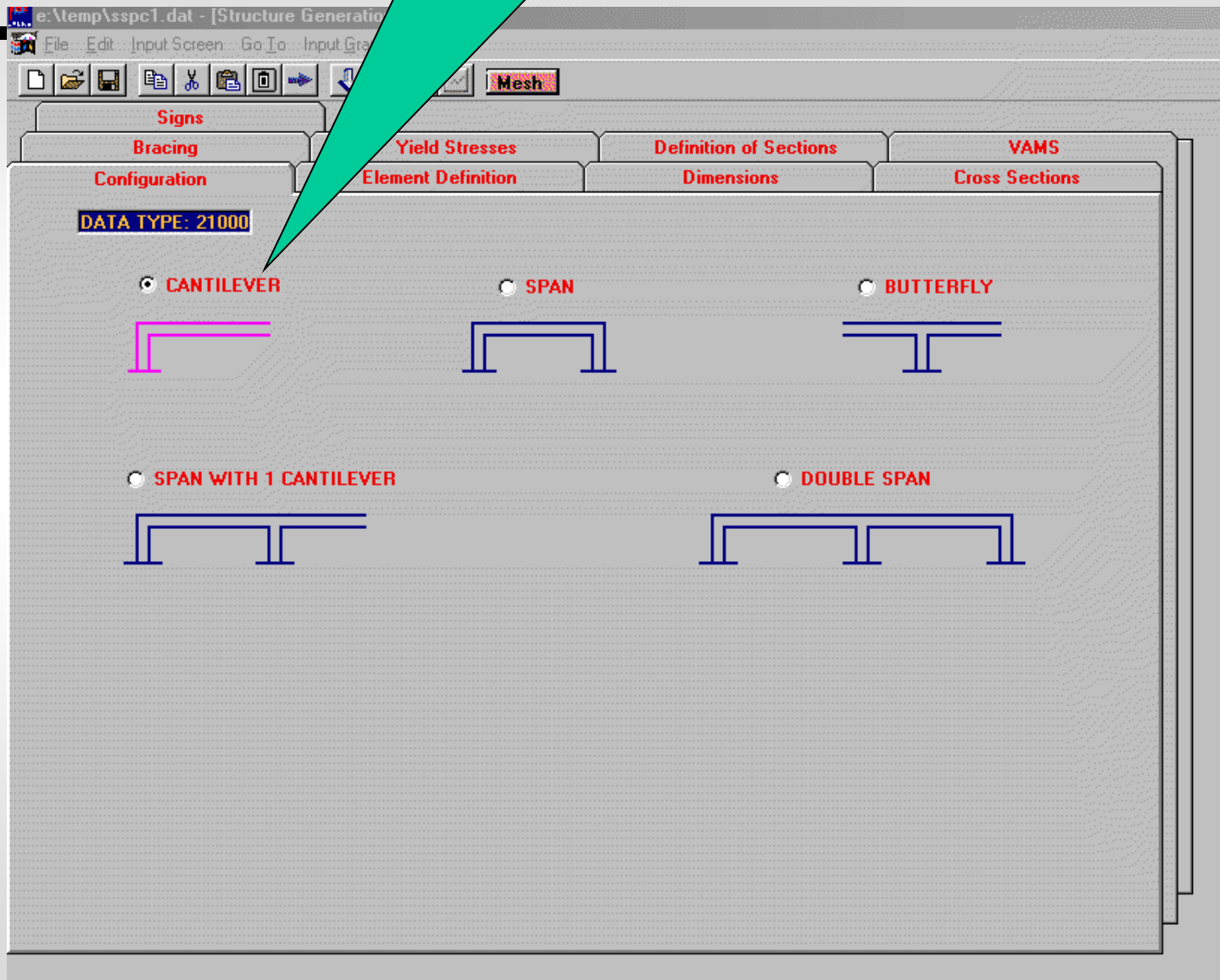
Mesh

Project Data **General Program Options**

DATA TYPE : 01032

ITEM	OPTION	DESCRIPTION
OUTPUT LEVEL	<input type="text" value="2"/>	<input type="text" value="2- Detail Level Output"/>
DESIGN CODE	AASHTO	AASHTO
TYPE OF UNIT	<input type="text" value="0"/>	<input type="text" value="0- English"/>
MATERIAL ID	<input type="text" value="0"/>	<input type="text" value="0- Steel"/>
MODULUS OF ELASTICITY	<input type="text"/>	Default 206,850 Mpa (30,000 ksi) for steel Default 68,950 Mpa (10,000 ksi) for aluminum
ALUMINUM TYPE ID (Aluminum only)	<input type="text"/>	<input type="text" value="1- 6061-T651"/>

Step 3: Select Configuration Type



Step 4: Select Post Type/Segments and Chord Types/Segments

e:\temp\sspc1.dat - [Structure Generation]

File Edit Input Screen Go To Input Graphic Help

Mesh

Signs

Bracing Yield Stresses Definitions Sections VAMS

Configuration Element Definition Connections Cross Sections

DATA TYPE: 31000

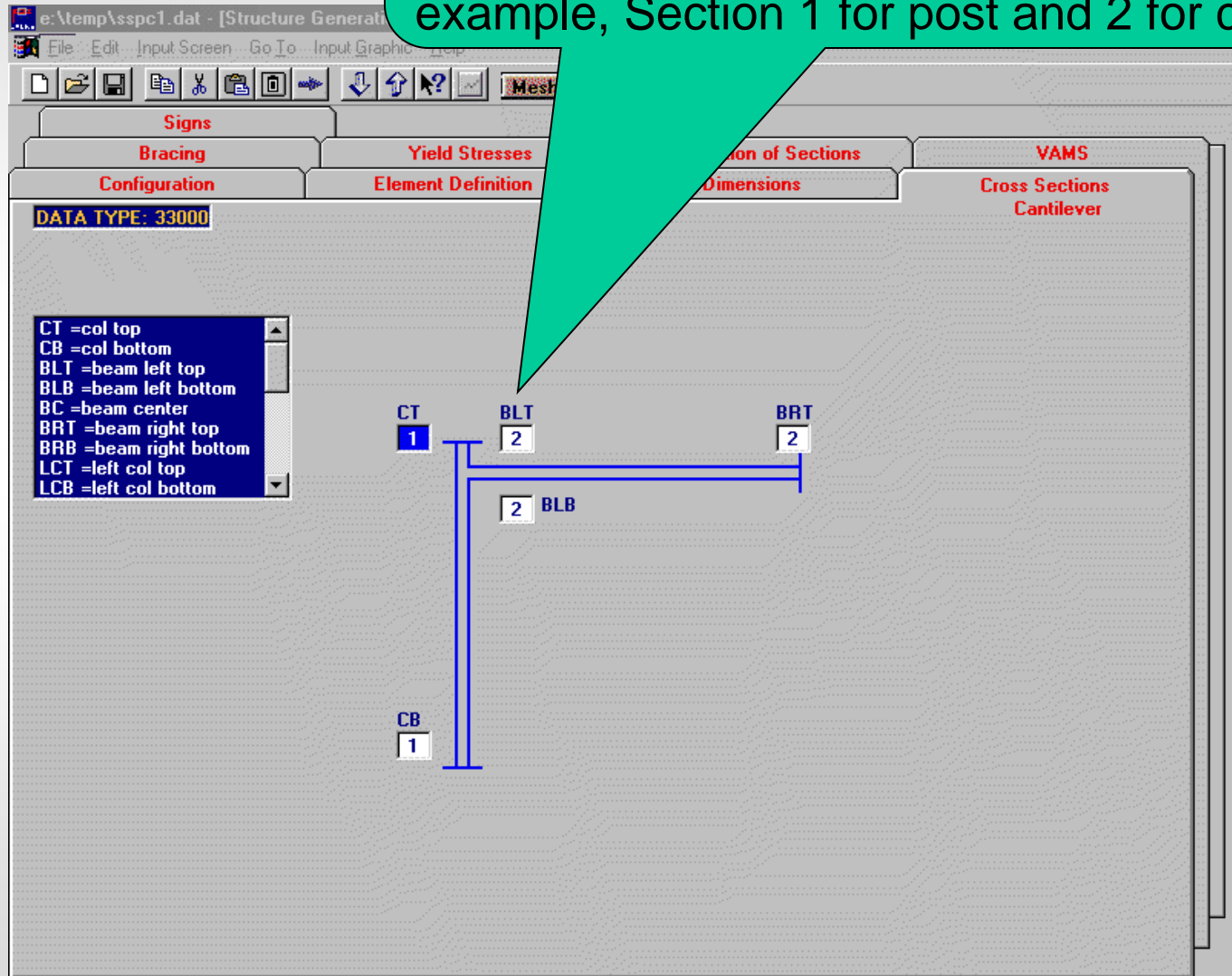
CHORDS : 4 4 - Box truss

SEGMENTS : 14

POSTS : 1 1 - Single post

SEGMENTS : 1

Step 5: Predefine Cross Section Numbers (see the screen for Definition of Sections) and assign them to Posts and Chords. (In this example, Section 1 for post and 2 for chords)



Step 6: Input Dimensions

e:\temp\sspc1.dat - [Structure Generation]

File Edit Input Screen Go To Input Graphic Help

Mesh

Signs

Bracing Yield Stresses Definition of Section VAMS

Configuration Element Definition Dimensions Cantilever Cross Sections

DATA TYPE: 34000

BEAM LENGTH : 52.166

LOW CHORD BEAM ELEV.: 20.729

BEAM DEPTH : 6.0

BEAM WIDTH : 6.0

2.0 : CONNECTION LENGTH

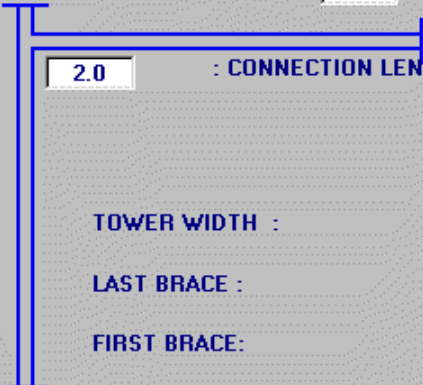
TOWER WIDTH :

LAST BRACE :

FIRST BRACE:

TOP ELEV. : 26.729

BOT. ELEV. : 0.0



The diagram shows a vertical cantilever beam fixed at the bottom. A horizontal beam is attached to the top of the vertical beam. The vertical beam has a height of 26.729 units. The horizontal beam has a length of 52.166 units. The vertical beam has a width of 6.0 units and a depth of 6.0 units. The horizontal beam has a depth of 6.0 units. The connection between the two beams has a length of 2.0 units. The bottom of the vertical beam is at elevation 0.0, and the top of the horizontal beam is at elevation 26.729. The low chord beam elevation is 20.729.

Step 7: Input Bracing Patterns and Section Numbers (In this example, no perpendicular, only diagonal bracing.)

e:\temp\sspc1.dat - [Structure Generation]

File Edit Input Screen Go To Input Graphic Help

Mesh

Configuration Element Definition Cross Sections

Signs Yield Stresses Definitions Sections VAMS

Bracing Cantilever

DATA TYPE: 38000

1. pratt truss
2. pratt truss, reversed
3. warren truss
4. warren truss, reversed

FRONT PATTERN : 3 3
TOP PATTERN : 3 3
REAR PATTERN : 3 3
BOTTOM PATTERN : 3 3
PERP. SECTION :
DIAG. SECTION : 4

PATTERN :
PERP. SECTION :
DIAG. SECTION :

Step 8: Input Yield Stresses for all Members

e:\temp\sspc1.dat - [Structure Generation]

File Edit Input Screen Go To Input Graphic Help

Mesh

Configuration Element Definition Dimension Cross Sections

Signs

Bracing Yield Stresses Definition of Sections VAMS

DATA TYPE: 39000

MEMBER TYPE	TOWERS	BEAMS
MAIN MEMBERS	46.0 ksi(MPa)	46.0 ksi(MPa)
PERPENDICULAR BRACING	36.0 ksi(MPa)	36.0 ksi(MPa)
DIAGONAL BRACING	36.0 ksi(MPa)	36.0 ksi(MPa)

Step 9: Define Sections used on the Cross Section screen (This example assigns 1 for the post, 2 for the chords, 4 for the bracing and 6 for the VAMs)

e:\temp\sspc1.dat - [Structure Generation]
 File Edit Input Screen Go To Input Graphic Help

Configuration Element Definition Dimensions Cross Sections
 Signs
 Bracing Yield Stress Definition of Sections VAMS

DATA TYPE: 04012 Section Lookup

Sec No	Std. Sect.			Tubular Shapes				General Sections						
	ID	DTH inch (mm)	WT/FT (Lb./ft)	ID	OUT D inch (mm)	Tw inch (mm)	Kt	ID	WT/FT Kip/ft (KN/m)	S1 inch (mm)	S2 inch (mm)	S3 inch (mm)	S4 inch (mm)	S5 inch (mm)
1				2	34.0	0.375	1.0							
2				2	6.625	0.280	1.0							
3				2	6.625	0.280	1.0							
4				2	2.375	0.154	1.0							
5				2	2.375	0.154	1.0							
6	W	6	9					9	.009	3.940	5.900	0.215		0.170
7				999										
8														
9														
10														
11														
12														
13														
14														
15														
16														
17														
18														
19														
20														

Click on SECTION LOOKUP to select a shape file first. Then use the scroll bar to view the selected file. Click on the desired data to import the section data.

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Step 10: Define Vertical Attachment Members and their relationship to the Sign and Walkway (This example has 11 VAMs where 7-11 support Sign #1 and Walkway #1. Section 6 for all the VAMs)

e:\temp\sspc1.dat - [S
File Edit Input Screen

Configuration Dimensions Cross Sections
Signs
Bracing Stresses Definition of Sections VAMS

DATA TYPE: 07012

VAM ID		Top VAM Coords.			Length feet (m)	Supporting Members			Attached Sign Units			Walkway Units		
No	Sect.	X feet (m)	Y feet (m)	Z feet (m)		No.	No.	No.	No.	No.	No.	No.	No.	No.
1	6	3.25	27.0	1.1	6.813	7	21							
2	6	7.417	27.0	1.1	6.813	8	22							
3	6	13.25	27.0	1.1	6.813	10	24							
4	6	17.417	27.0	1.1	6.813	11	25							
5	6	23.25	27.0	1.1	6.813	12	26							
6	6	29.25	27.0	1.1	6.813	14	28							
7	6	34.917	31.729	1.1	11.542	16	30		1			1		
8	6	38.917	31.729	1.1	11.542	17	31		1			1		
9	6	42.917	31.729	1.1	11.542	18	32		1			1		
10	6	46.917	31.729	1.1	11.542	19	33		1			1		
11	6	50.917	31.729	1.1	11.542	20	34		1			1		
12														
13														
14														
15														
16														
17														
18														
19														

Step 10A: Supporting Members are figured out by the Mesh. No input is needed

e:\temp\sspc1.dat - [Structure Generation]

File Edit Input Screen Go To Input Graphic Help

Mesh

Bracing Yield Stresses Definition of Sections VAMS
 Configuration Element Definition Dimensions Cross Sections

Signs

DATA TYPE: 09012

Sign No.	Dimensions			Slope in/ft (mm/m)	Density k/cf (Kg/m ³)	Lower Left Coord.		
	Width feet (m)	Height feet (m)	Thick. inch (mm)			X feet (m)	Y feet (m)	Z feet (m)
1	17.719	9.0	0.35		0.175	34.354	22.729	1.15
2								
3								
4								
5								
6								
7								
8								
9								
10								

Step 11: Signs' Dimensions and Positions are provided here

No Step: Parameters are generated by Mesh, unless override is needed

e:\winsabre\sspan1.dat - [Options]

File Edit Input Screen Go To Input Graph

Mesh

Connections Height Coeff. Hinges
Parameters Joint Loads Walkways

DATA TYPE: 01042

WIND VELOCITY	<input type="text" value="80.0"/>	(mph or m/s)
MEAN REGULAR INTERVAL	<input type="text" value="50"/>	(years)
GUST FACTOR	<input type="text" value="0.3"/>	
ICE LOADS	<input type="text" value="3.0"/>	(psf or KPa)
ICE LOAD OPTIONS	<input type="text" value="0"/> <input type="text" value="0- One side"/>	
D. L. DETAIL FACTOR	<input type="text" value="1.0"/>	

For Fatigue Design Only

YEARLY MEAN VELOCITY FOR NATURAL WIND GUST	<input type="text"/>	(default = 11.2 mph or 5 m/s)
VEHICLE SPEED FOR TRUCK-INDUCED GUST	<input type="text"/>	(default = 65 mph or 30 m/s)
IMPORTANCE FACTOR	<input type="text"/>	(default = 1.0)

No Step: Joint Loads are generated by Mesh, unless additional Joint Load is needed

e:\winsabre\sspan1.dat - [Options]

Edit Input Screen Go To Input Graphic Help

Mesh

Connections Height Coeff. Hinges
Parameters Joint Loads Walkways

DATA TYPE : 10012

No	Joint No.	Desc.	Forces			Moments		
			X kip(KN)	Y kip(KN)	Z kip(KN)	X-X k-ft (KN-m)	Y-Y k-ft (KN-m)	Z-Z k-ft (KN-m)
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								

No Step: Connections are generated by Mesh, unless override is needed

e:\temp\sspc1.dat - [Options]

Edit Input Screen Go To Input Graphic Help

Mesh

Parameters Joint Loads Walkways
Connections Height Coeff. Hinges

DATA TYPE : 01052

CONNECTION JOINTS

3	2																
---	---	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

* data is generated by Mesh

No Step: Height Coefficients are generated by Mesh, unless override is needed

e:\temp\sspc1.dat - [Options]

File Edit Input Screen Go Io Input Graphic Help

Mesh

Parameters Joint Loads Walkways
Connections Height Coeff. Hinges

DATA TYPE : 09112

<u>HEIGHT</u> (feet or m)	<u>COEFFICIENT (Ch)</u>
299	1.60
199	1.50
149	1.40
99	1.25
49	1.10
29	1.00
14	0.80
0	

No Step: Hinges, if exist, are generated by the program, unless overridden

e:\temp\sspc1.dat - [Options]

File Edit Input Screen Go Io Input Graphic Help

Mesh

Parameters Joint Loads Walkways
Connections Height Coeff. Hinges

DATA TYPE : 40000

	LEFT BEAM END		RIGHT BEAM END	
	Y-Y	Z-Z	Y-Y	Z-Z
	(0 or 1)		(0 or 1)	
MONOTUBE	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
PLANE TRUSS	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
TRICHORD TRUSS ON 1 POST	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
BOX TRUSS ON 1 POST	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
TRICHORD TRUSS ON 2 POSTS	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
BOX TRUSS ON 2 POSTS	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

No Step: Joints are generated by Mesh, unless override is needed

e:\winsabre\sspan1.dat - [Structure Lookup]

File Edit Input Screen Go To Input Graphic Help

Mesh

Definition of Joints

Definition of Members

DATA TYPE :03012

JNT No	Coordinates			Supp. Translation			Supp. Rotation		
	X ft(m)	Y ft(m)	Z ft(m)	X	Y	Z	XX	YY	ZZ
1	0.00	0.00	2.5	1	1	1	1	1	1
2	0.00	0.00	-2.5	1	1	1	1	1	1
3	0.00	15.	2.5						
4	0.00	15.	-2.5						
5	0.00	20.	2.5						
6	0.00	20.	-2.5						
7	1.	15.	2.5						
8	1.	20.	2.5						
9	1.	20.	-2.5						
10	1.	15.	-2.5						
11	10.	15.	2.5						
12	10.	20.	2.5						
13	10.	20.	-2.5						
14	10.	15.	-2.5						
15	19.	15.	-2.5						
16	19.	20.	-2.5						
17	19.	20.	2.5						
18	19.	15.	2.5						
19	20.	20.	-2.5						
20	20	20	2.5						

No Step: Members and section designations are generated by Mesh, unless override is needed

e:\temp\sspc1.dat - [Structure Lookup]

File Edit Input Screen Go To Input Graphic Help

Mesh

Definition of Joints

Definition of Members

DATA TYPE : 05012

	Mem. No.	Sect. From	Sect. To	Joints From	Joints To	Angle degree	Unit No.	Unit Type	Mat'l Yield ksi(MPa)	Mem. Type
	1	1		1	2		1	3	46.	
	2		1	2	3		1	3	46.	
	3	2	2	2	4				46.	
	4	2	2	3	5				46.	
	5	2	2	3	6				46.	
	6	2	2	2	7				46.	
	7	2		4	8		2	2	46.	
	8			8	12		2	2	46.	
	9			12	16		2	2	46.	
	10			16	20		2	2	46.	
	11			20	24		2	2	46.	
	12		2	24	28		2	2	46.	
	13	3		28	32		2	2	46.	
	14			32	36		2	2	46.	
	15			36	40		2	2	46.	
	16			40	44		2	2	46.	
	17			44	48		2	2	46.	
	18			48	52		2	2	46.	
	19			52	56		2	2	46.	
	20		3	56	60		2	2	46.	
	21	2		5	9		3	2	46.	

Step 12B: In this example, change of section occurs on the chords. After Mesh, modify Section 2 from joint 4 to 28 and Section 3 from joint 28 to 60

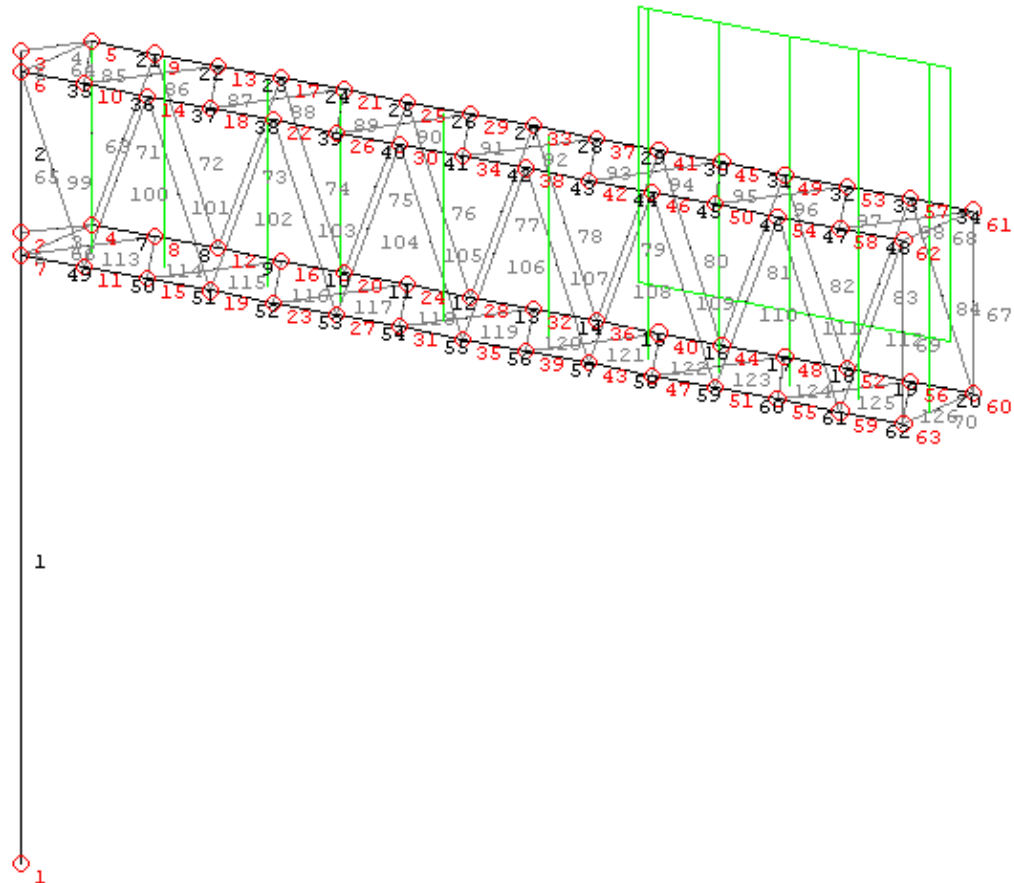
Step 13: Input Graphic is shown on the screen

Graphics for e:\temp\sspc1.dat

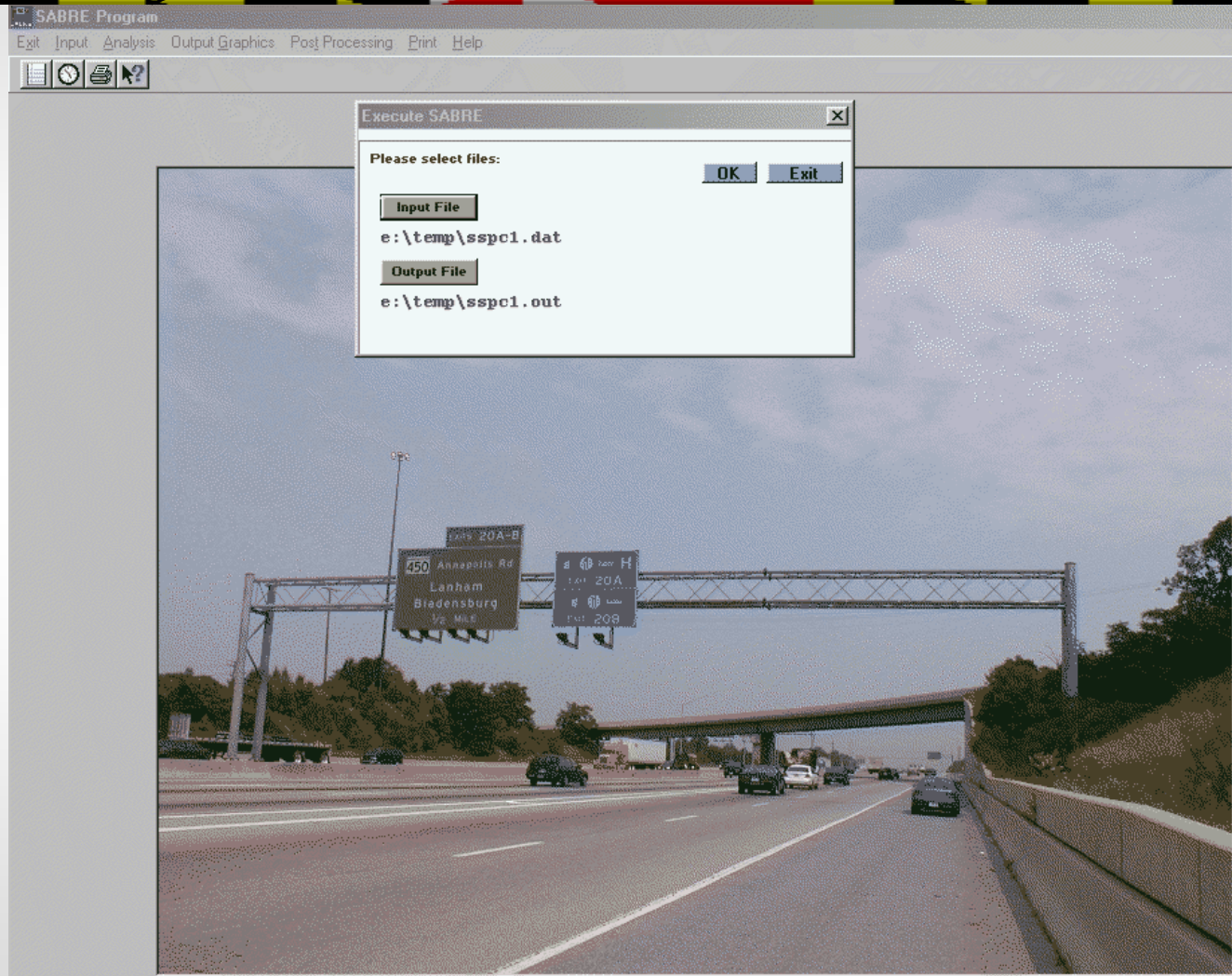
Exit Print Home Joints Member VAMs Zoom UnZoom

Right Left Up Down

Woerner Wire Works Test



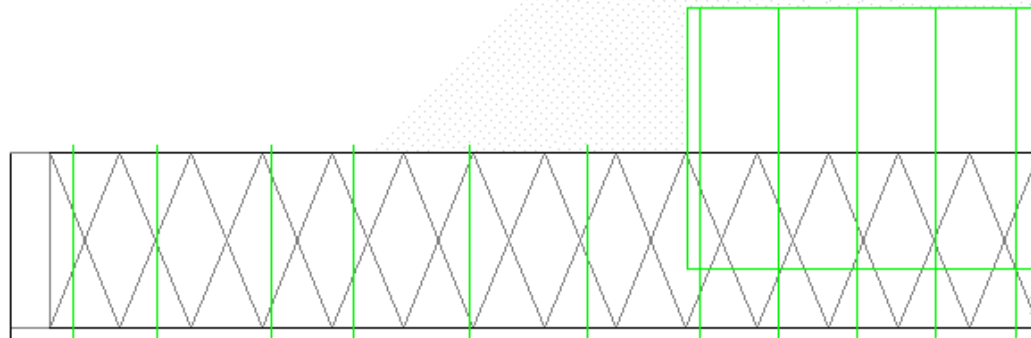
Step 14: Save the Input File,
Exit from Input Utility and click
Analysis



Step 15: Exit from Analysis, click Output Graphics and select one item under ActDef for analysis status



Woerner Wire Works Test



List of Deflections Tables in E:\temp\sspc1.out

- Group I Joint Deformations - DL
- Group II Joint Deformations - DL+W Combo. 1 in +Z
- Group II Joint Deformations - DL+W Combo. 2 in +Z
- Group II Joint Deformations - DL+W Combo. 1 in -Z
- Group II Joint Deformations - DL+W Combo. 2 in -Z
- Group III Joint Deformations - DL+1+1/2W Combo. 1 in +Z
- Group III Joint Deformations - DL+1+1/2W Combo. 2 in +Z
- Group III Joint Deformations - DL+1+1/2W Combo. 1 in -Z
- Group III Joint Deformations - DL+1+1/2W Combo. 2 in -Z
- Maximun Joint Deformations

Step 16: Exit from Output Graphics, select Post Process, Base Plate Design and then click Import for the analysis results

Post Processing - E:\temp\sspc1.out

Splice Plate Design Parameters **Base Plate Design Parameters** Base Plate Fatigue Check

ENG/SI UNIT 0 0 - English

YIELD STRESSES

BOLT 55.00 ksi(MPa)

BASE PLATE 36.00 ksi(MPa)

COLUMN 55.00 ksi(MPa)

BASE FORCES

X DIR. 1.961 kips(KN)

Y DIR. 10.94 kips(KN)

Z DIR. 9.591 kips(KN)

ALLOWABLE WELD STRESS 12.40 ksi(MPa)

GROUP LOAD NO. 2

COLUMN PARAMETERS

OUTSIDE DIAMETER 34. in(mm)

WALL THICKNESS .375 in(mm)

CROSS-SECTION SHAPE 2 2 - Round cross section

BASE MOMENTS

X-X AXIS 236.429 k-ft(KN-m)

Y-Y AXIS 277.508 k-ft(KN-m)

Z-Z AXIS 265.127 k-ft(KN-m)

BASE PLATE SHAPE 2 2 - Round cross section

DES. NO OF BOLTS 0

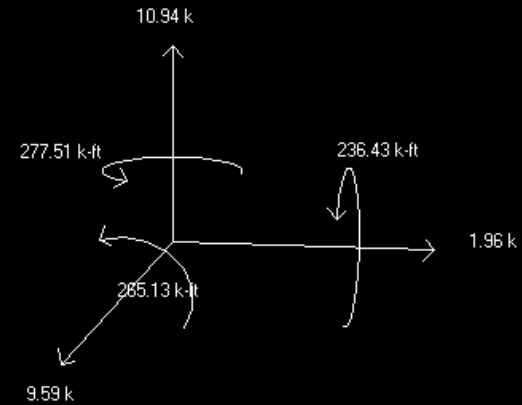
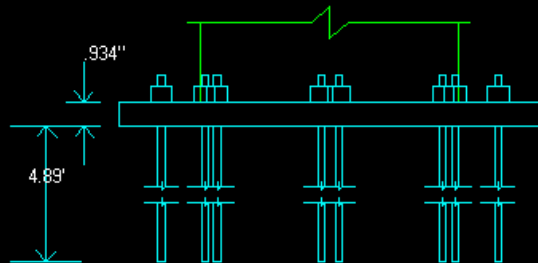
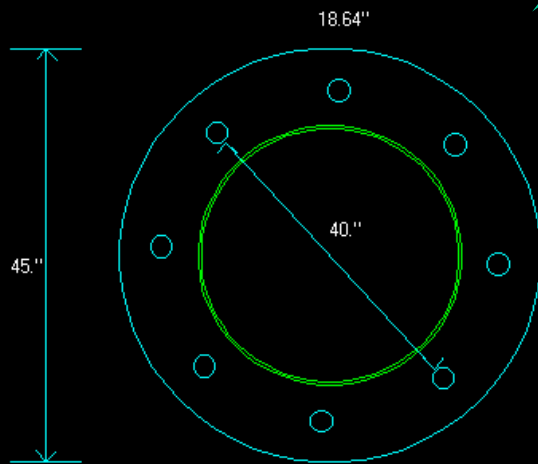
Base Plate Design Results

NO. OF BOLTS =8
BOLT DIAMETER =1.5 in.
BOLT AREA (EACH) =1.767 in.^2
EMBEDMENT LENGTH =4.9 ft.
WELD THROAT LENGTH =.221 in.
WELD LEG LENGTH =.313 in.
PLATE SHAPE = Round
PLATE O.D. =45. in.
PLATE SIDE LENGTH =18.6 in.
PLATE THICKNESS =.93 in.

Step 16A: Finish the input, click Calculation to show the design

Step 17: Click Graph on the Calculation popup screen to show the design

Base Plate Design Results - E:\temp\sspc1.out



Step 18: Exit from Base Plate Design and Click the Tab for Base Plate Fatigue Check

Post Processing - E:\temp\sspc1.ftg

Splice Plate Design Parameters Base Plate Design Parameters **Base Plate Fatigue Check**

ENG/SI UNIT 0 0 - English

BASE MOMENT RANGE

X-X AXIS 35.15 (k-ft or KN-m)

Z-Z AXIS 143.8 (k-ft or KN-m)

BASE PLATE PARAMETERS

SHAPE 2 - Round cross section

BOLT DIAMETER (in or mm)

BOLT THREAD PITCH (in or mm)

FARTHEST BOLT DISTANCE TO THE CENTER (in or mm)

NUMBER OF BOLT

COLUMN PARAMETERS

OUTSIDE DIAMETER 34. (in or mm)

WALL THICKNESS 0.38 (in or mm)

CROSS SECTION SHAPE 2 2 - Round cross section

STIFFENER PARAMETERS

HEIGHT (in or mm)

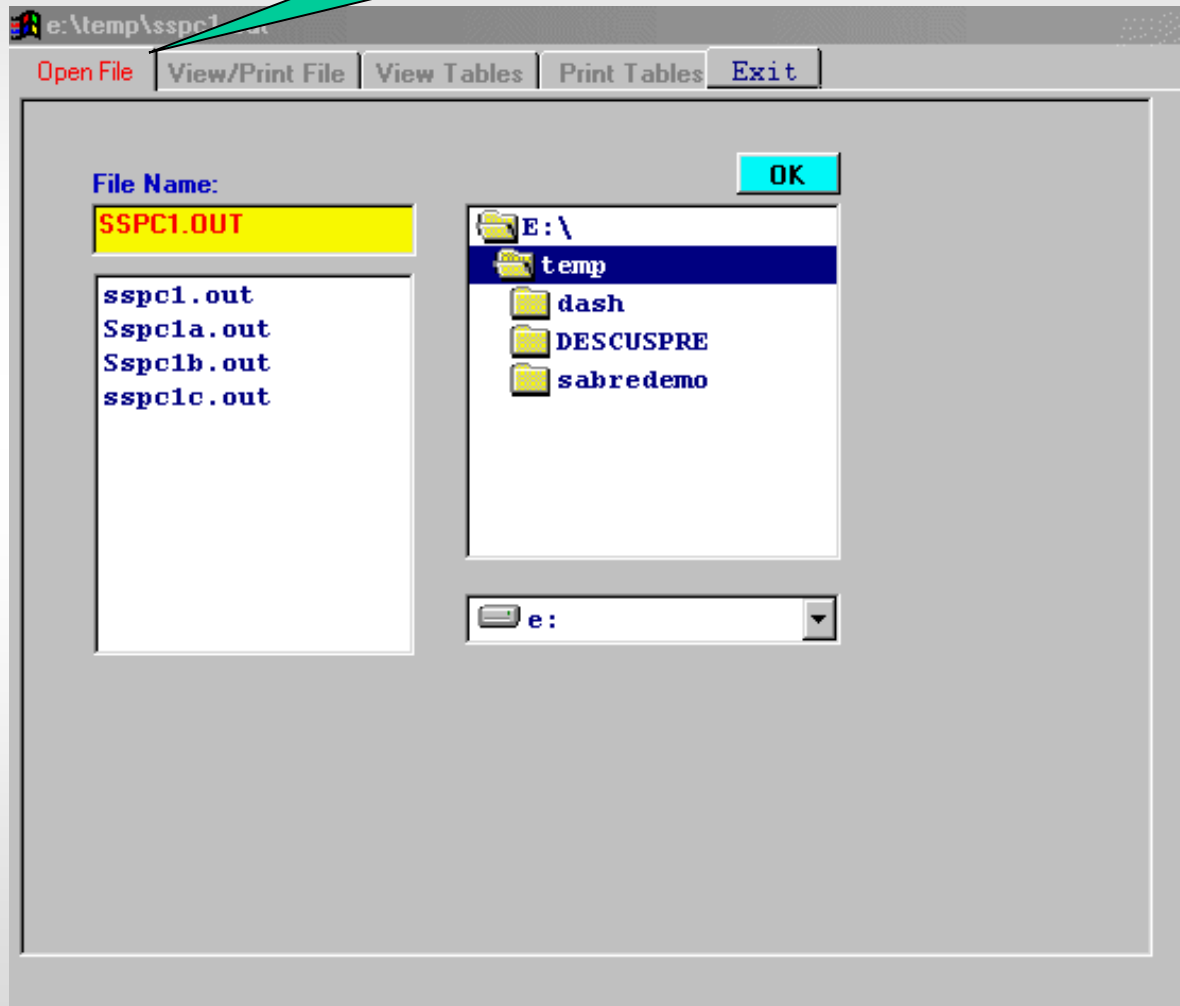
WIDTH (in or mm)

THICKNESS (in or mm)

TOTAL NUMBER

Step 18A: Click Import, finish all the input and then click Calculate

Step 19: Exit from Post Process. Click Print and then Open File



Step 20: View or Print the whole File or Table by Table

E:\temp\SSPC1.OUT

Open File View/Print File View Tables Print Tables Exit

1.0 : INPUT VERIFICATION
1.1 : DEFINITION OF JOINTS
1.2 : DEFINITION OF SECTIONS
1.3 : DEFINITION OF MEMBERS
1.4 : DEFINITION OF VERTICAL ATTACHMENT MEMBERS
1.5 : DEFINITION OF WALKWAYS AND CONDUITS
1.6 : DEFINITION OF SIGNS
1.7 : COEFFICIENT OF HEIGHT (Ch)

TABLE 1.0 : INPUT VERIFICATION

DEFINITION OF SYSTEM DATA

OUTPUT LEVEL	DESIGN CODE	DESIGN YEAR	DESIGN OPTION	STRU. TYPE	NO. OF POSTS	NO. OF CORDS	UNIT	TYPE	MATERIAL E	AL MODULUS	ID
2		0	0	1	1	4	0	0	30000.0		0

DESIGN PARAMETERS

WIND VEL. (MPH)	MEAN VEL. N.W. (MPH)	VEH. SPEED T.I. (MPH)	IMPOR- TANCE FACT.	MEAN REC INTERVAL (YEARS)	GUST FAC. (%)	ICE LOADS (PSF)	ICE LOAD OPTN	DEAD LOAD FAC.
80.00	.0	.0	.00	50	30.00	3.000	0	1.00

AASHTO LTS-6 & AASHTO LTS-LRFD



Updated SABRE includes following improvements:

1. AASHTO LST-6 & AASHTO LTS-LRFD Fatigue Design
 - a. Design parameters based on fatigue importance category
 - b. Cantilever and non-cantilever structures

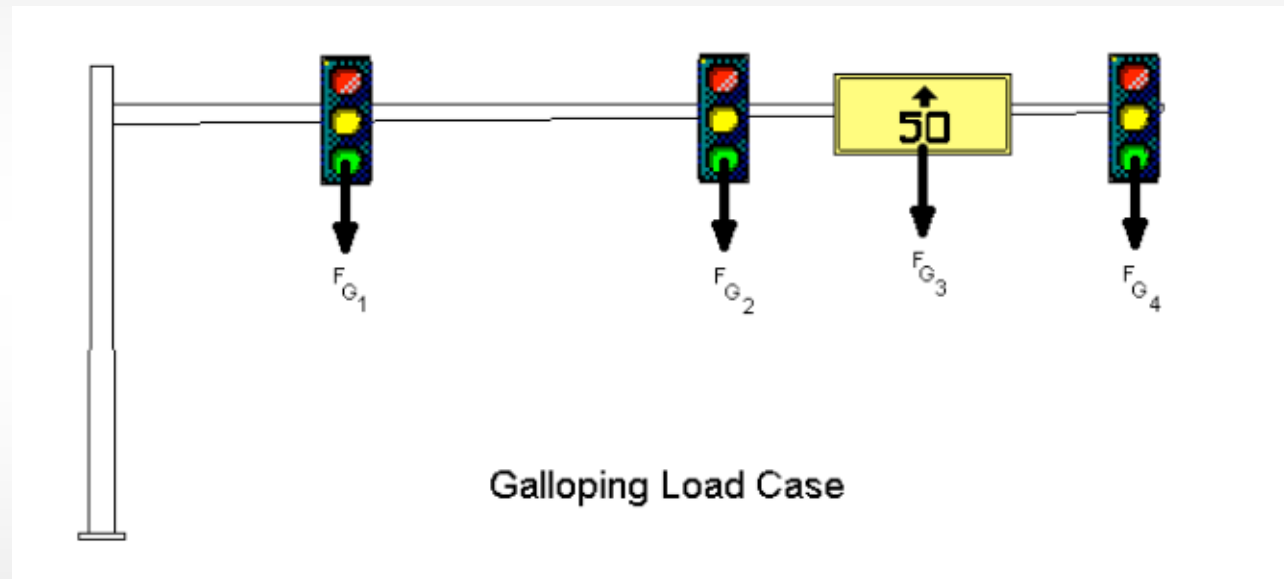
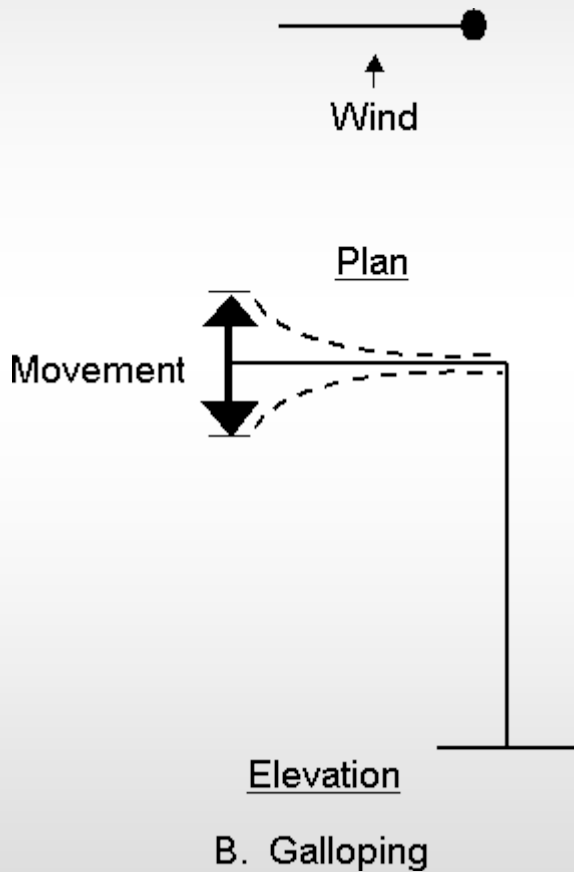
2. AASHTO LTS-LRFD Design
 - a. Determination of wind speed and wind pressure
 - b. Example of wind speed and wind pressure
 - c. Wind strength design consideration

Fatigue Design Parameters

Fatigue Importance Category			Galloping	Natural Wind Gusts	Truck-Induced Gusts
Cantilevered	I	Sign Traffic Signal	1.0 1.0	1.0 1.0	1.0 1.0
	II	Sign Traffic Signal	0.70 0.65	0.85 0.80	0.90 0.85
	III	Sign Traffic Signal	0.40 0.30	0.70 0.55	0.80 0.70
Non-Cantilevered	I	Sign Traffic Signal	x x	1.0 1.0	1.0 1.0
	II	Sign Traffic Signal	x x	0.85 0.80	0.90 0.85
	III	Sign Traffic Signal	x x	0.70 0.55	0.80 0.70

- Cat. I – without “mitigation devices”; roadways with a speed limit in excess of 60 km/h (35 mph) and average daily traffic (ADT) exceeding 10,000 or average daily truck traffic (ADTT) exceeding 1000
- Cat. III - speed limits 60km/h (35 mph) or less
- Cat. II – not “explicitly” meeting I or III; (NCHRP 469 Act. 3.2.1.4: include any structures with mitigation devices that would otherwise meet the Category I criteria.)

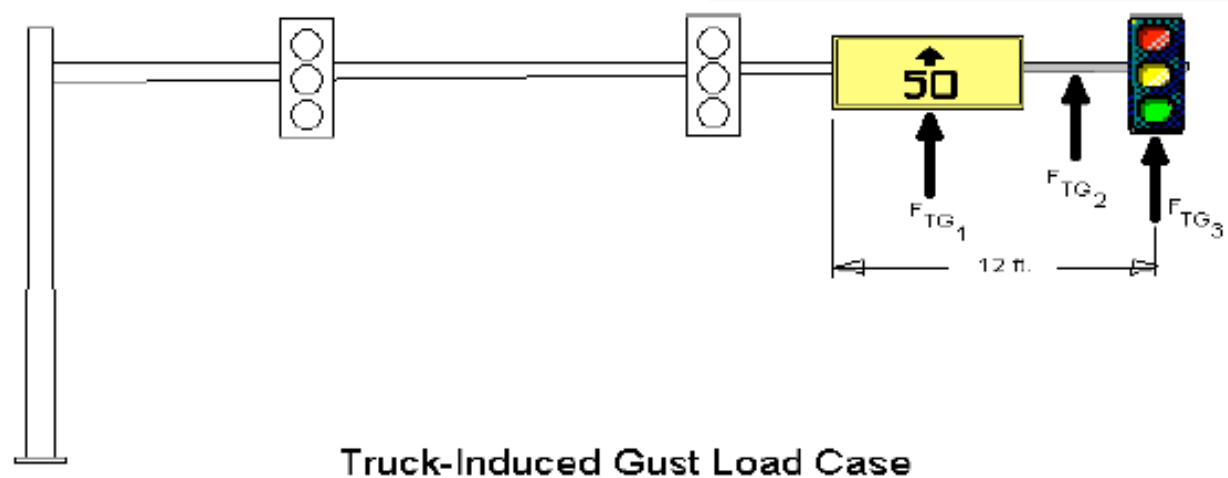
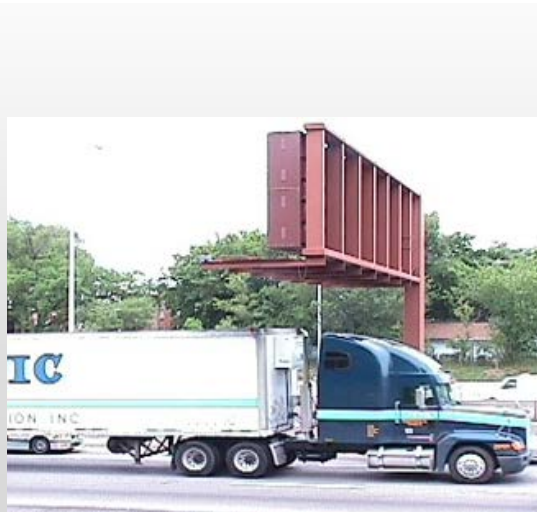
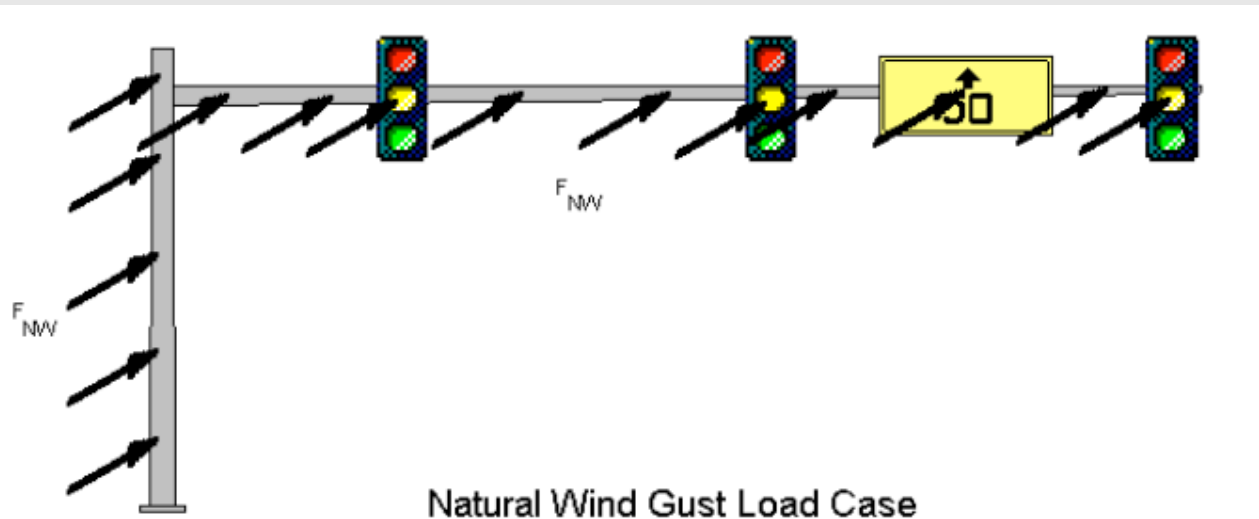
1. Introduction : Fatigue Design Loads - Galloping



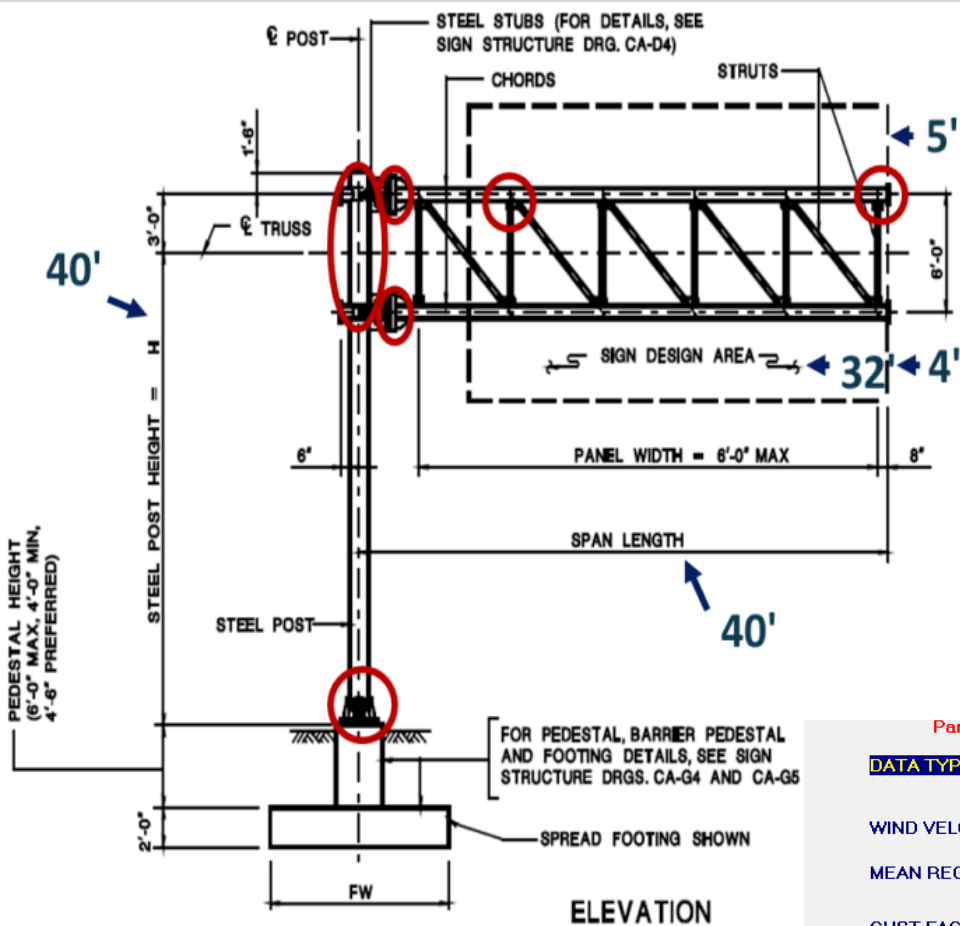
<https://www.youtube.com/watch?v=fRIUOXpfiyI>

1. Introduction : Fatigue Design Loads

– Natural Wind & Truck-Induced Gust



Fatigue Details



SABRE Fatigue Design Input

Source: NJDOT report "Fatigue Study on Structural Supports for Luminaries, Traffic Signals, Highway Signs", Chapter 8 example 1

Parameters	Additional Joint Loads	Walkways
DATA TYPE: 01042		
WIND VELOCITY	<input type="text" value="80.0"/> (mph or m/s)	
MEAN REGULAR INTERVAL	<input type="text" value="50"/> (years)	
GUST FACTOR	<input type="text" value="1.14"/> Regular Method - 1.14 (4th or 5th ed.)	
ICE LOADS	<input type="text" value="3.0"/> (psf or KPa) ICE LOAD OPTIONS <input type="text" value="0"/> 0- One Side	
TRUSS BRACING OPTIONS	<input type="text" value="0"/> 0- Moment Bracing (default)	
D. L. DETAIL FACTOR	<input type="text" value="1.0"/>	
WIND IMPORTANCE FACTOR	<input type="text" value="1.0"/> (default = 1.0; see AASHTO Table 3-2)	
For Fatigue Design Only		
YEARLY MEAN VELOCITY FOR NATURAL WIND GUST	<input type="text" value="11.2"/> (default = 11.2 mph or 5 m/s)	
VEHICLE SPEED FOR TRUCK-INDUCED GUST	<input type="text" value="65"/> (default = 65 mph or 30 m/s)	
FATIGUE IMPORTANCE FACTOR OPTIONS		
GALLOPING (default = 1.0)	NATURAL WIND (default = 1.0)	TRUCK - INDUCED GUST (default = 1.0)
<input type="text" value="0.7"/>	<input type="text" value="0.85"/>	<input type="text" value="0.9"/>

SABRE Fatigue Verification

Sabre calculation, NJDOT report and STAAD fatigue calculation comparison

Example I	(Fatigue II)	Sabre	Report	STAAD
Joint load (kips)	Gallop	7.056	7.056	7.056
	Natural wind total	3.761	3.2551*	3.237*
	sign	2.534	2.545	2.544
	chord	0.703	0.17	0.17
	column	0.525	0.5401	0.522
	Truck.W	0.408	0.271	0.271
	TW sign	0.134	0.134	0.134
	TW chord	0.274	0.137**	0.137**
	Moment (K-ft)	Gallop	169.9	169
Natural.W		63.6	57.65	61.1
Truck.W		13.92	8.87	9.21

Fatigue Check Example using Spreadsheet

Fatigue check using the spreadsheet example

- The sabre output file element #1 represent the base plate. The output list moments for both ends of element. Please select the higher moment from the table.
- The sabre file is in kip-ft unit, the spreadsheet is in kip-in. In this case, the moment should be, $6.2 \times 12 = 74.4$ kip-in.

Dia d_{ar} =	2.5 in	Red ink cells are for input
Thread series =	4 unc	
Circle dia d_{arc} =	32 in	
$M_{Z,TG,base}$ =	74.4 kip-in	moment from Sabre, k-in
Number of anchor rods =	6	(min. 4 bolts)
Thread pitch =	0.243575 in	
$A_T = \pi/4(d_{ar} - 0.9743/n)^2$		
A_T =	4.00 in ²	
$I_{ar} = \sum A_T z^2$		
I_{ar} =	3112.33 in ⁴	
Stress range		
$(f_r)_{rod} = M_{Z,TG,base} \times c / I_{ar}$		
$(f_r)_{rod}$ =	0.38 ksi	Category D, CAFL=7ksi
	0.38ksi	OK

Wind Speed/Pressure

Wind loads based on 2013 ASD (STD-LTS) and 2015 LRFD are shown below:

a) 2013 wind pressure

$$P_z = 0.00256 K_z * G * V^2 * I_r * C_d$$

b) 2015 LRFD wind pressure

$$P_z = 0.00256 K_z * K_d * G * V^2 * C_d$$

AASHTO LRFD-LTS Table 3.8-1 – Mean Recurrence Interval

Traffic Volume	Risk Category		
	Typical	High	Low
ADT ≤ 100	300	1700	300
100 < ADT ≤ 1000	700	1700	300
1000 < ADT ≤ 10000	700	1700	300
ADT > 10000	1700	1700	300

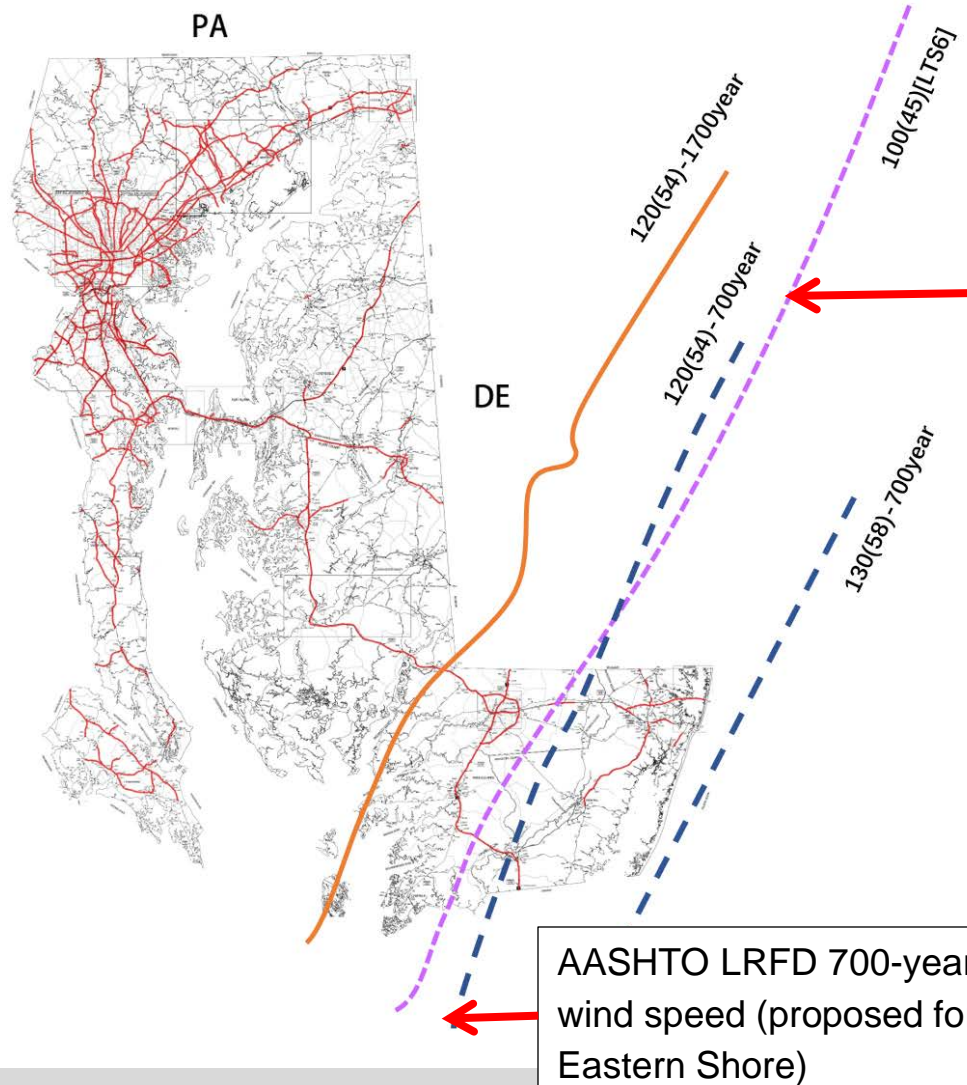
Typical: Failure could cross travelway

High: Support failure could stop a lifeline travelway

Low: Support failure could not cross travelway

Roadside sign supports: use 10-yr MRI, see Figure 3.8-4

Example of Maryland Wind Speed/Pressure



AASHTO LTS-6 wind speed
(current MD design 100 mph)

AASHTO LRFD 700-year
wind speed (proposed for
Eastern Shore)

Example of Wind Speed/Pressure

Assumption:

$K_z = 0.87$ for 2013 and 084 for the 2015 LRFD Specifications

$K_d = 0.85$ (signal and sign support structures) for the 2015 LRFD Specifications only

$G = 1.14$ for both

$C_d = 1.20$ for both

$I_r = 1.00$ for the 2013 Specifications only

Case 1	2013	2015 LRFD	2015 LRFD	2015 LRFD
Wind speed (V)	100mph	100mph	110mph	120mph
P_z	30.47	25.01	30.26	36.01

- For LTS-6 (2013) still use wind speed 100 mph statewide, which is equivalent for 110 mph for LTS-LRFD (2015)
- For LTS-LRFD (2015) may consider using wind speed 120 mph statewide (? To be determined)

Wind Strength Design Consideration

- LTS-6: Only basic load (BL) on one arm plane is considered

Load Case	Normal component	Transverse component
1	1.0 BL	0.2 BL
2	0.6 BL	0.3 BL

- LTS-LRFD: Two basic load are considered (BL_n) on one arm plane/(BL_t) on the arm plane spaced at 90 degree

Load Case	Normal component	Transverse component
1	1.0 BL _n	0
2	0	1.0 BL _t
3	0.75 BL _n	0.75BL _t

SABRE Input & Analysis Module for LRFD

Parameters Additional Joint Loads Walkways

DATA TYPE: 01042

WIND VELOCITY (mph or m/s) (mph or m/s) (SERVICE I, LRFD only)

MEAN REGULAR INTERVAL (years)

GUST FACTOR Regular Method - 1.14 (4th or 5th ed.)

ICE LOADS (psf or KPa) ICE LOAD OPTIONS 0- One Side

TRUSS BRACING OPTIONS 0- Moment Bracing (default)

D. L. DETAIL FACTOR

ASD: WIND IMPORTANCE FACTOR or (default = 1.0; see AASHTO Table 3-2)

LRFD: DIRECTIONALITY FACTOR, K_d (post) (others) (post) (others) (post default = 0.95, others = 0.85, see AASHTO LRFD Table 3.8.5-1)

For Fatigue Design Only

YEARLY MEAN VELOCITY FOR NATURAL WIND GUST (default = 11.2 mph or 5 m/s)

VEHICLE SPEED FOR TRUCK-INDUCED GUST (default = 65 mph or 30 m/s)

FATIGUE IMPORTANCE FACTOR OPTIONS

GALLOPING (default = 1.0) NATURAL WIND (default = 1.0) TRUCK - INDUCED GUST (default = 1.0)

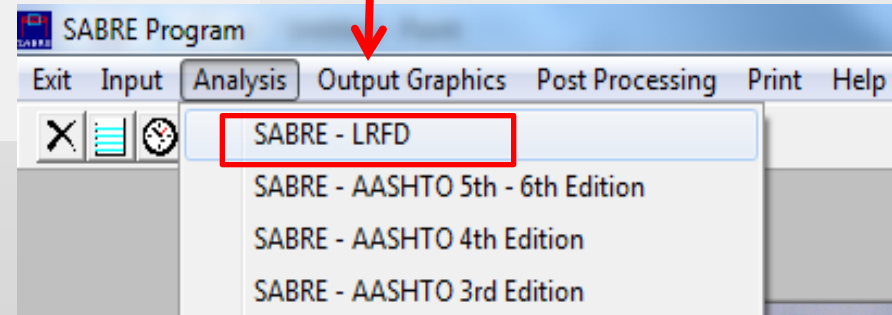
Overall Effective Length K (Table 7.4.1 of the User's Manual)

CASE 1: VERTICAL (POLE TYPE) (default = 2.0)

CASE 2: VERTICAL (TRUSS TYPE) (default = 1.2)

CASE 3: HORIZONTAL (POLE AND TRUSS) (default = 0.65)

See the red-ink block for the only input change of LRFD



SABRE Load Combinations for LRFD



A. Strength Limit State

- Group 1 – $1.25DL + 1.6LL$ (T8.1, check for T10.1 & T13.1)

B. Extreme Limit State

- Group 2 – $1.1DC+W$ (Comb 1 +Z) (T8.2, check for T10.2, T13.2)
- Group 2 – $1.1DC+W$ (Comb 2 +Z) (T8.3, check for T10.3, T13.3)
- Group 2 – $1.1DC+W$ (Comb 3 +Z) (T8.4, check for T10.4, T13.4)
- Group 2 – $1.1DC+W$ (Comb 1 -Z) (T8.5, check for T10.5, T13.5)
- Group 2 – $1.1DC+W$ (Comb 2 -Z) (T8.6, check for T10.6, T13.6)
- Group 2 – $1.1DC+W$ (Comb 3 -Z) (T8.7, check for T10.7, T13.7)
- Group 3 – $0.9DC+W$ (Comb 1 +Z) (T8.8, check for T10.8, T13.8)
- Group 3 – $0.9DC+W$ (Comb 2 +Z) (T8.9, check for T10.9, T13.9)
- Group 3 – $0.9DC+W$ (Comb 3 +Z) (T8.10, check for T10.10, T13.10)
- Group 3 – $0.9DC+W$ (Comb 1 -Z) (T8.11, check for T10.11, T13.11)
- Group 3 – $0.9DC+W$ (Comb 2 -Z) (T8.12, check for T10.12, T13.12)
- Group 3 – $0.9DC+W$ (Comb 3 -Z) (T8.13, check for T10.13, T13.13)

C. LRFD Strength/Extreme Limit State Combination Checks

- Tower and Truss Member Capacities (T11.2 & T12.2)
- Tower and Truss Member Maximum Combined Force Ratios (CSR) (T11.4 & T12.4)

SABRE Load Combinations for LRFD

D. Service I Limit State

- Group 4 – $1.0DC + W_{SE}$ (Comb 1 +Z) (T8.14, check for T9.14)
- Group 4 – $1.0DC + W_{SE}$ (Comb 2 +Z) (T8.15, check for T9.15)
- Group 4 – $1.0DC + W_{SE}$ (Comb 3 +Z) (T8.16, check for T9.16)
- Group 4 – $1.0DC + W_{SE}$ (Comb 1 -Z) (T8.17, check for T9.17)
- Group 4 – $1.0DC + W_{SE}$ (Comb 2 -Z) (T8.18, check for T9.18)
- Group 4 – $1.0DC + W_{SE}$ (Comb 3 -Z) (T8.19, check for T9.19)

E. LRFD Service Limit State Deflection Checks

- Maximum Joint Deflection tables (T9.10)

F. LRFD Fatigue Limit State Checks

- Group 5 – Galloping (T19.1, T9.11, T10.11, check for T20.1)
- Group 5 – Natural Wind Gust (T19.2, T9.12, T10.12, check for T20.2)
- Group 5 – Truck Gust (T19.3, T9.13, T10.13, check for T20.3)