HSE SOFTWARE
Highway Sign Structural Engineering

APPLICATION
Overhead Sign Structure Analysis and Design

FUNCTIONALITY
Efficiently setting fatigue parameters of the structure

FATIGUE LIMIT STATE

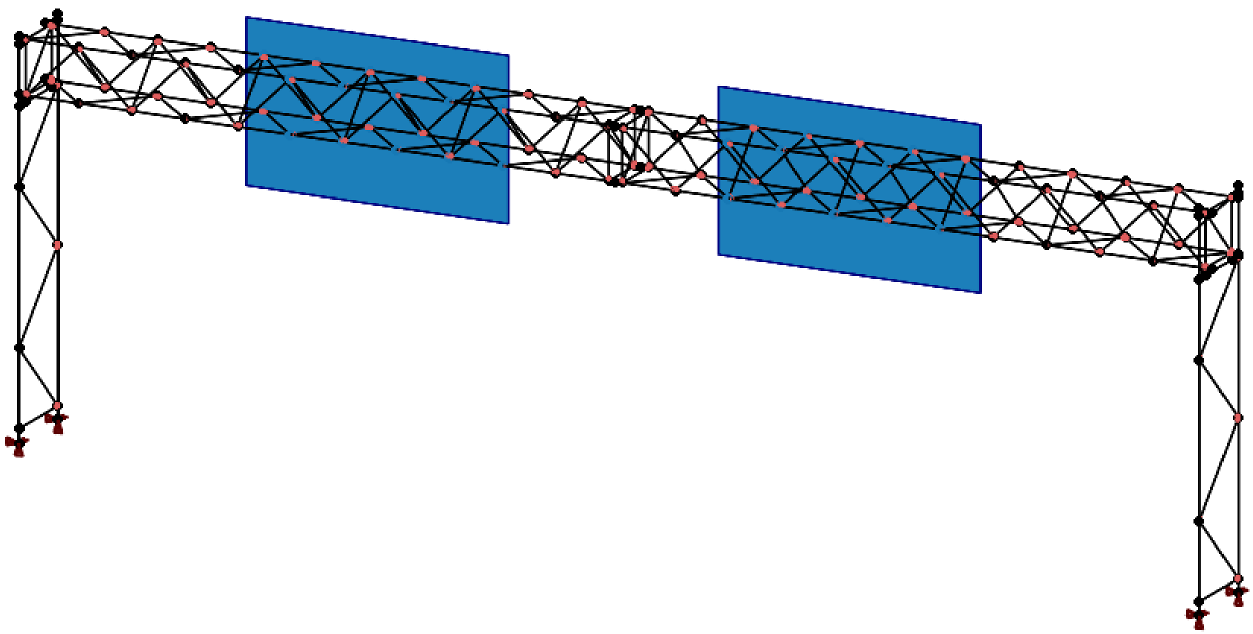
A step has been added into the highway sign wizard so all fatigue parameters for the structure can be set here.

The CAFT (Constant Amplitude Fatigue Threshold) or (ΔF)TH for infinite life for the different fatigue detail categories are found in AASHTO LTS-13 (ASD) Table 11.9.3.1-1 and AASHTO LTS-15 (LRFD) Table 11.9.3.1-1.

The SAFI HSE software includes the fatigue limit states.

Here are some highlights about fatigue in the HSE software.

FATIGUE LIMIT STATE IN SAFI HSE SOFTWARE



Highway Sign Wizard

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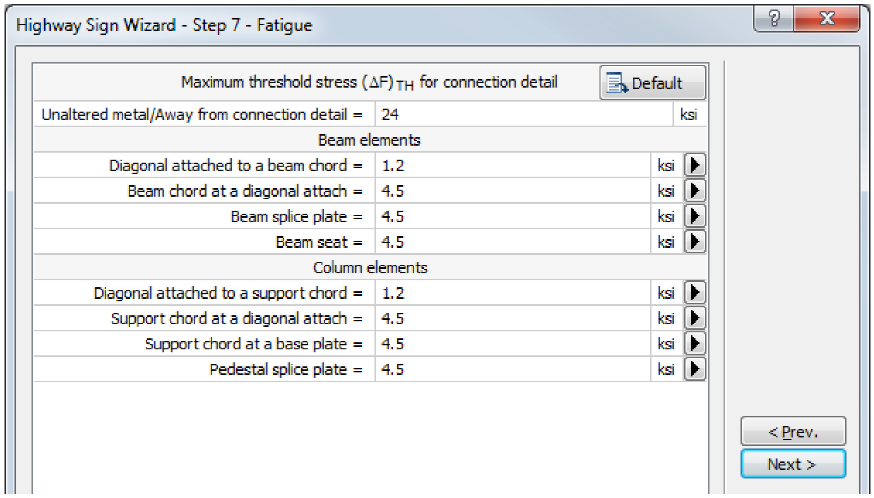
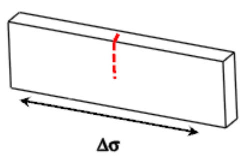
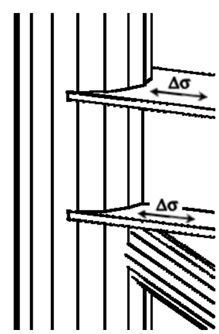
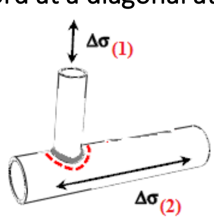
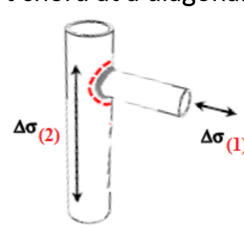
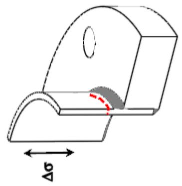
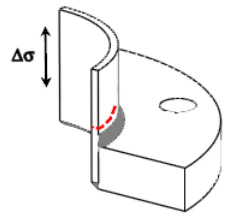


If you click on the **Default** button the (ΔF)TH values will be set to typical values for the different connection details based on the AASHTO. These value **must be validated** by the user since some of the (ΔF)TH depends on the connection details which are not known precisely by the program. The AASHTO LTS-13 (ASD) Cl. 11.9.3.1 and AASHTO LTS-15 (LRFD) Cl. 11.9.3.1 provide full information to compute (ΔF)TH.

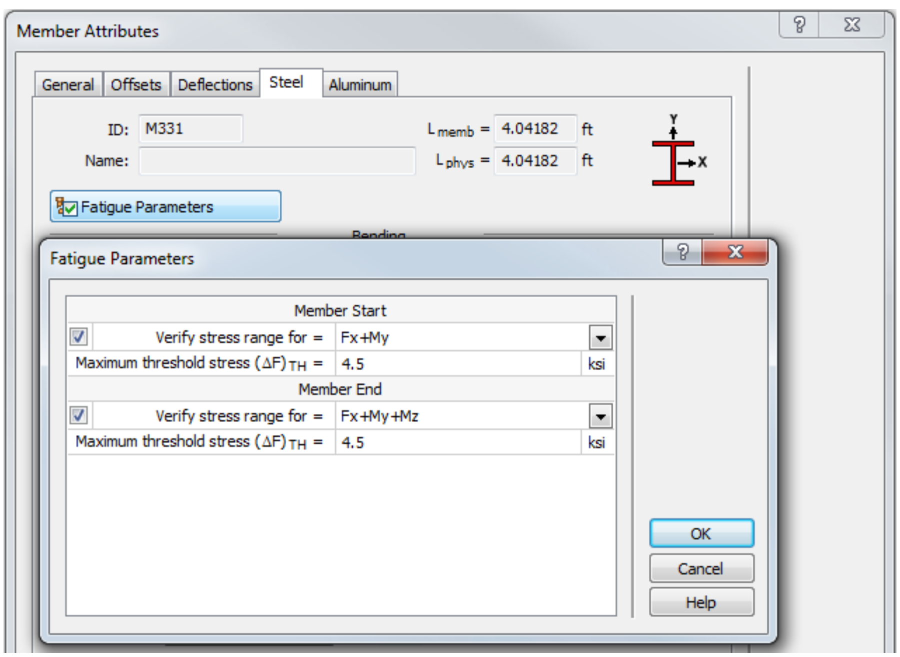
The typical connection details for this structure are shown below:

Unaltered metal/Away from connection detail  	Beam: Beam seat 
Beam: Diagonal attached to a beam chord Δσ(1) Beam: Beam chord at a diagonal attach Δσ(2)  	Column: Diagonal attached to a support chord Δσ(1) Column: Support chord at a diagonal attach Δσ(2) 

Beam: Beam splice plate	Column: Support chord at a base plate Column: Pedestal splice plate
	

Editing Fatigue Parameters

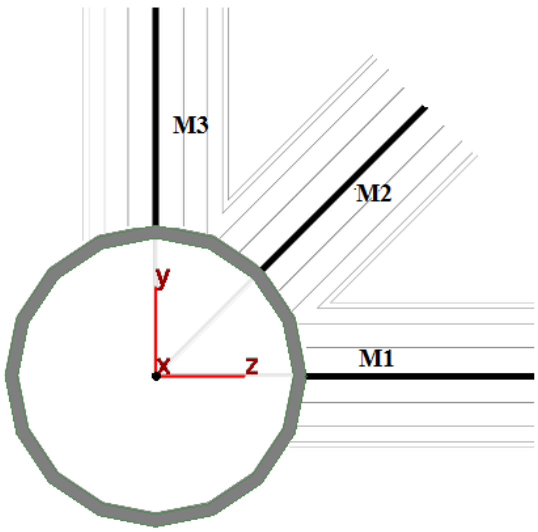
The **Highway Sign Wizard** auto assign these values when generating the model according to the input data. If the model has not been generated or after the model generation is done, the user can edit this table to change the fatigue parameters for the connection details for both ends of the member. This command is available only for AASHTO LTS et S6 code.



Stress range for (Joint I or J)

The axial fatigue stress range at end I or J of the member is based on a combination of the axial force (Fx), the bending moment around the strong axis (Mx) and/or the bending moment around the weak axis (My). Depending on which part of the connection is affected by the connection detail, the calculated stress range Δf may consider Mx and/or My.

In the example below, 3 members are attached to the main chord. A connection at the end of member M1 only affects the stress range for a moment around the internal **y** axis of the chord. A connection at the end of member 3 only affects the stress range for a moment around the internal **z** axis of the chord. A connection at the end of member 2 affects the stress range for moments around the internal **y** and **z** axes of the chord.

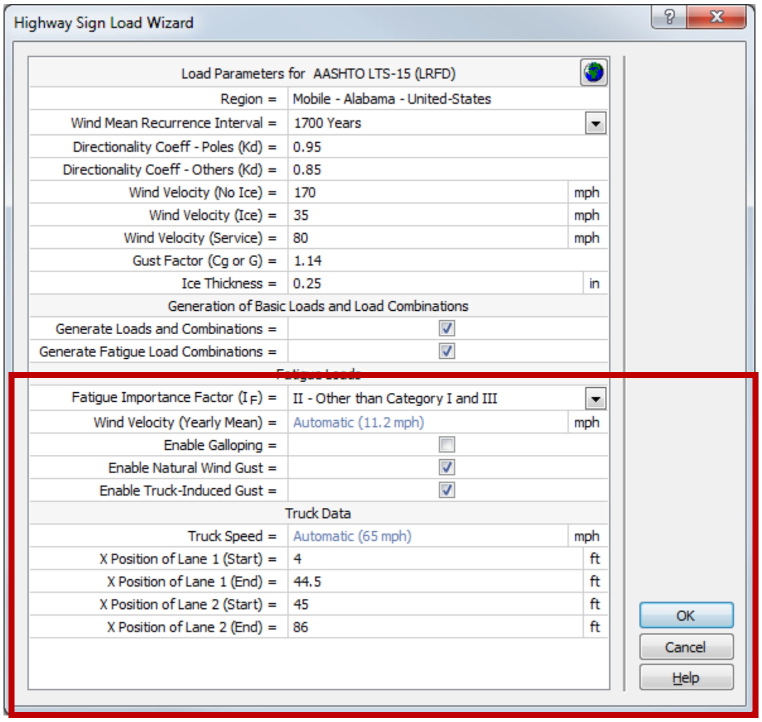


(ΔF)TH (Joint I or J)

The allowable stress range (ΔF)TH depends on the fatigue sensitivity of the connection at end I or J of the member. This value can be set according to the connection detail. If the value is zero, the fatigue verification at this end of the member will be ignored.

Generating Fatigue Loads

The **Fatigue** load combinations are required to compute the equivalent static forces and stresses range due to cyclic loading. The fatigue resistance is specified in AASHTO LTS-15 LRFD clause 11.9 and AASHTO LTS-13 ASD clause 11.9.



This main option activates the input required for fatigue verification. Depending on the type of structures, the fatigue verifications (Galloping, Natural Wind Gust, Truck-Induced Gust) may be activated or not. The user must check on the applicable fatigue loads according to its type of structure based on the requirements of the AASHTO LTS code.

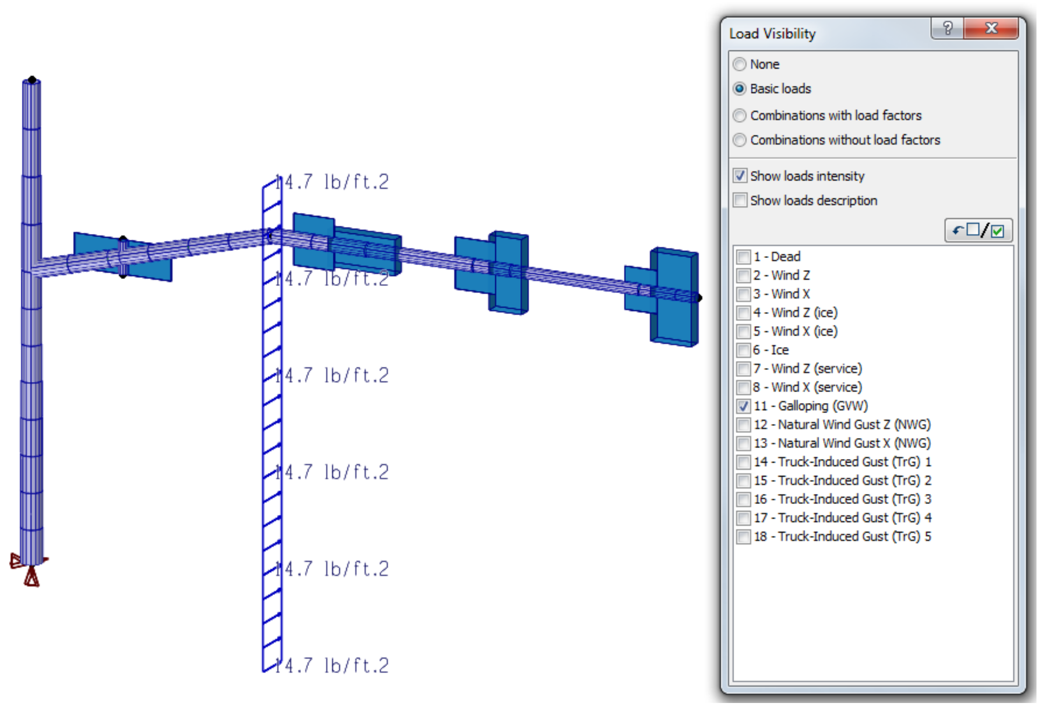
Enable Galloping

Galloping results in large amplitude, resonant oscillations in a plane perpendicular to the direction of the wind. It is generally limited to sign/signal mast arms with attachments to the arm. Galloping is typically not caused by the support members, but rather by the attachments to the horizontal mast arms. Therefore, structures without attachments are not susceptible to galloping induced wind load effects.

The galloping force is based on the frontal projected area of each sign panel, traffic signal head including back plate, and all other devices attached to the mast arm. The galloping force is not applied to the projected area of the arm or the pole members. The galloping force is applied in the vertical direction.

The software applies the galloping force for all sign panels at the same time. In case of cantilever arms both sides of an individual vertical support, this procedure is not adequate.

Please refer to AASHTO LTS-13 ASD clause 11.7.1.1 or AASHTO LTS-15 LRFD art 11.7.1.1 for more information.

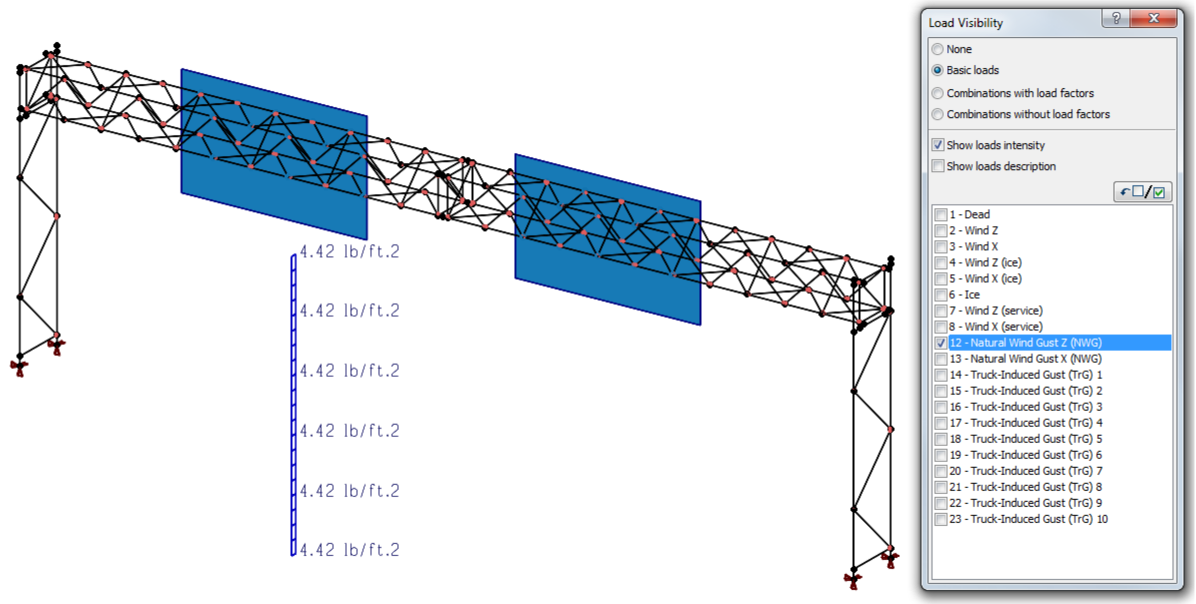


Enable Natural Wind Gust

Natural wind gust stresses result from the inherent variability in the direction and velocity of the wind induced airflow around the structure. Natural wind gusts are the most basic phenomena that may induce cyclic loads in lighting and traffic structures. It is generally applied to cantilevered and non-cantilevered overhead sign and overhead traffic signal supports.

The Natural Wind Gust is applied in the horizontal direction for all wind directions.

Please refer to AASHTO LTS-13 ASD clause 11.7.1.2 or AASHTO LTS-15 LRFD art 11.7.1.2 for more information.

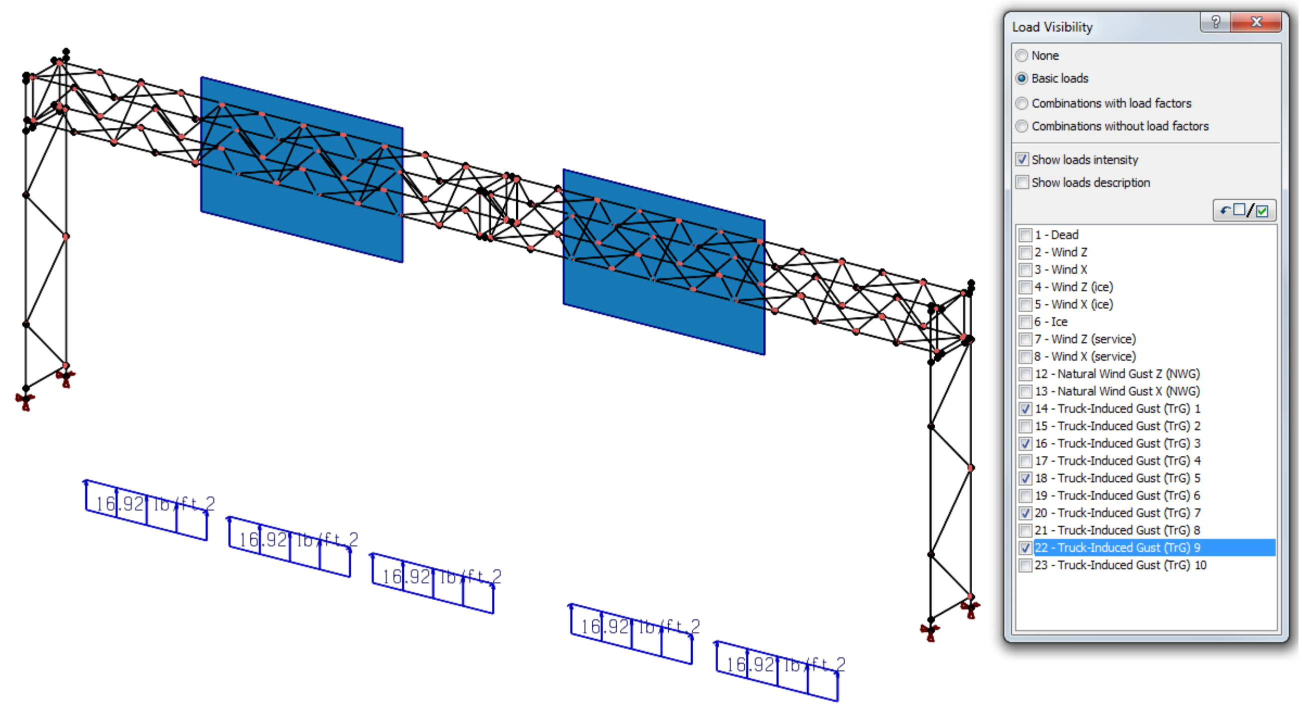


Enable Truck-Induced Gust

Truck-induced gust loads are caused by the passage of trucks under traffic structures. These gusts of wind are caused by moving trucks and create both horizontal and vertical pressure on the structure. The vertical mast arm vibration results in the most critical stresses and therefore only the vertical pressures are evaluated. It is generally applied to cantilevered and non-cantilevered overhead sign and overhead traffic signal supports.

The truck gust force should be applied in the vertical direction, to the horizontal plane (bottom projected area), along any 12' length of the mast arm. The pressure shall also be applied to the horizontal area of each traffic signal head, sign panel, and all other devices located within that 12’ length of the mast arm, to create the maximum stress range.

Please refer to AASHTO LTS-13 ASD clause 11.7.1.3 or AASHTO LTS-15 LRFD art 11.7.1.3 for more information.



Fatigue Load Combinations

The fatigue limit state is the ratio of the axial stress range (Δf) due to fatigue load divided by the allowable stress range (ΔF)TH. It is computed only for Fatigue load combinations.

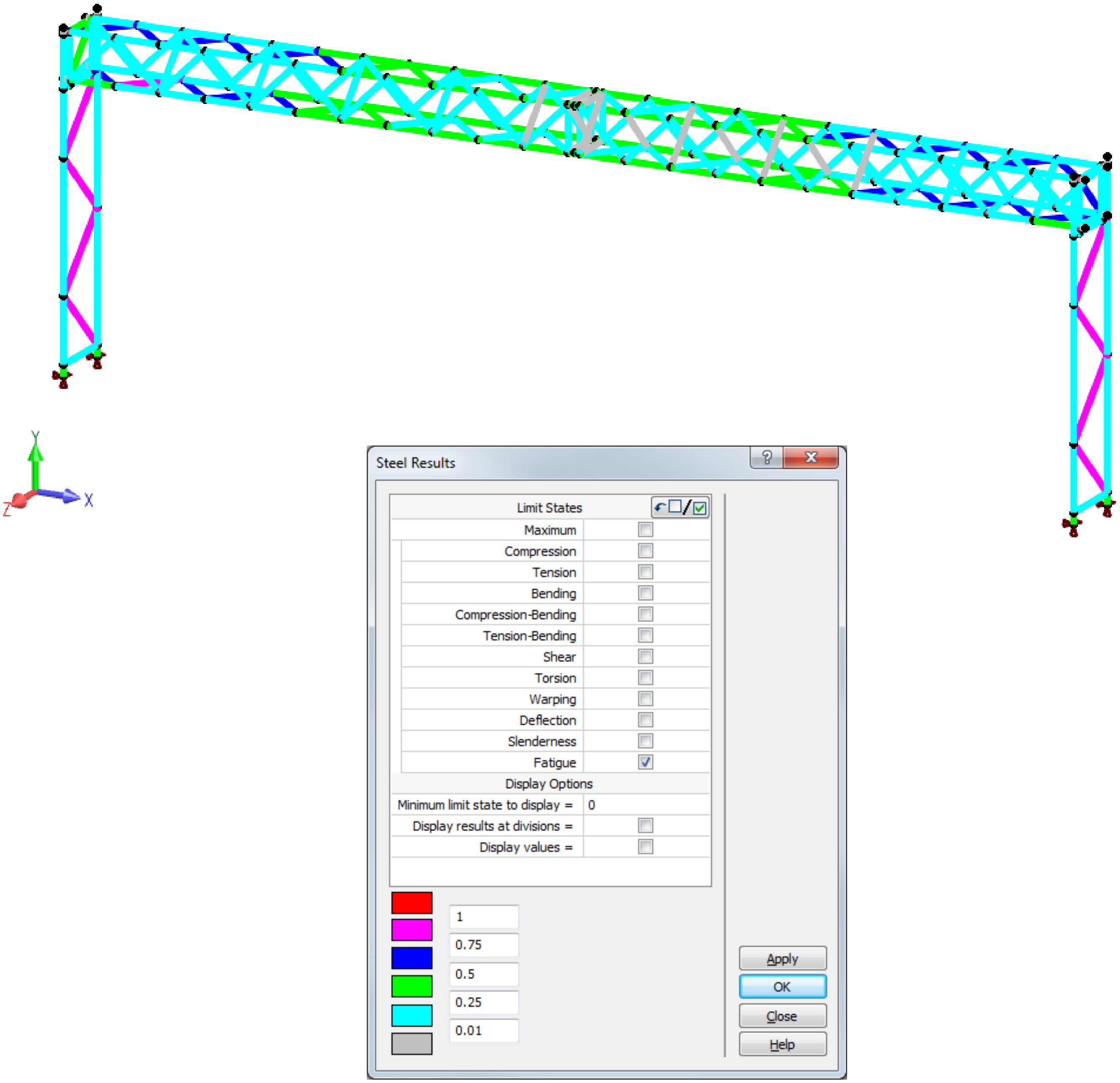
Load Combinations

Table Commands View

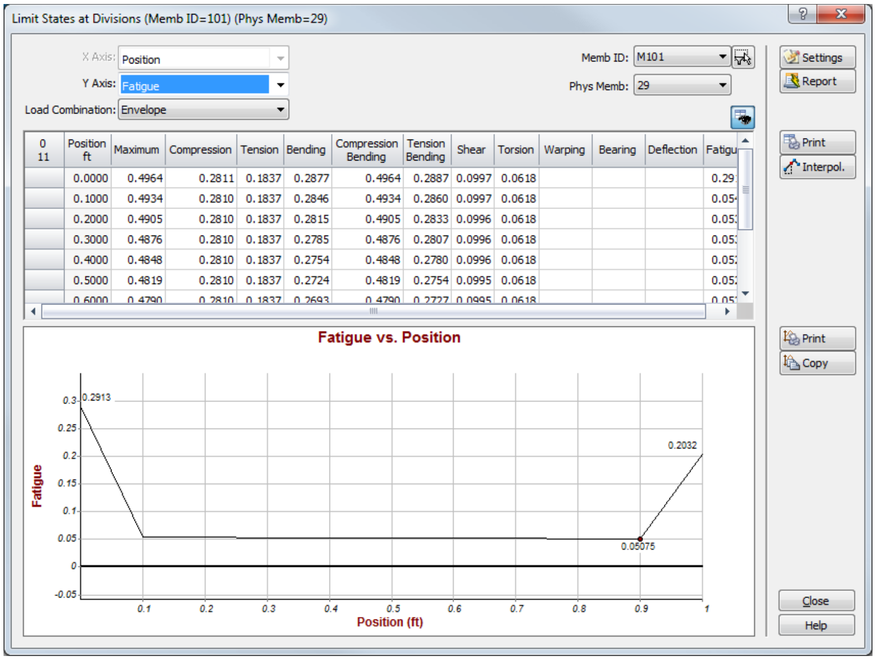
0 57	Combination ID	Combination Name	Enabled	Combination Type	Defl
	401	Fatigue I, GVW	☑	Fatigue	
	402	Fatigue I, NWG, Wz	☑	Fatigue	
	403	Fatigue I, NWG,-Wz	☑	Fatigue	
	404	Fatigue I, NWG, Wx	☑	Fatigue	
	405	Fatigue I, NWG,-Wx	☑	Fatigue	
	406	Fatigue I, NWG, 0.75(Wz+Wx)	☑	Fatigue	
	407	Fatigue I, NWG, 0.75(Wz-Wx)	☑	Fatigue	
	408	Fatigue I, NWG, 0.75(-Wz+Wx)	☑	Fatigue	
	409	Fatigue I, NWG, 0.75(-Wx-Wz)	☑	Fatigue	
	410	Fatigue I, TG 1	☑	Fatigue	
	411	Fatigue I, TG 2	☑	Fatigue	
	412	Fatigue I, TG 3	☑	Fatigue	
	413	Fatigue I, TG 4	☑	Fatigue	
	414	Fatigue I, TG 5	☑	Fatigue	

Fatigue Limit States Results

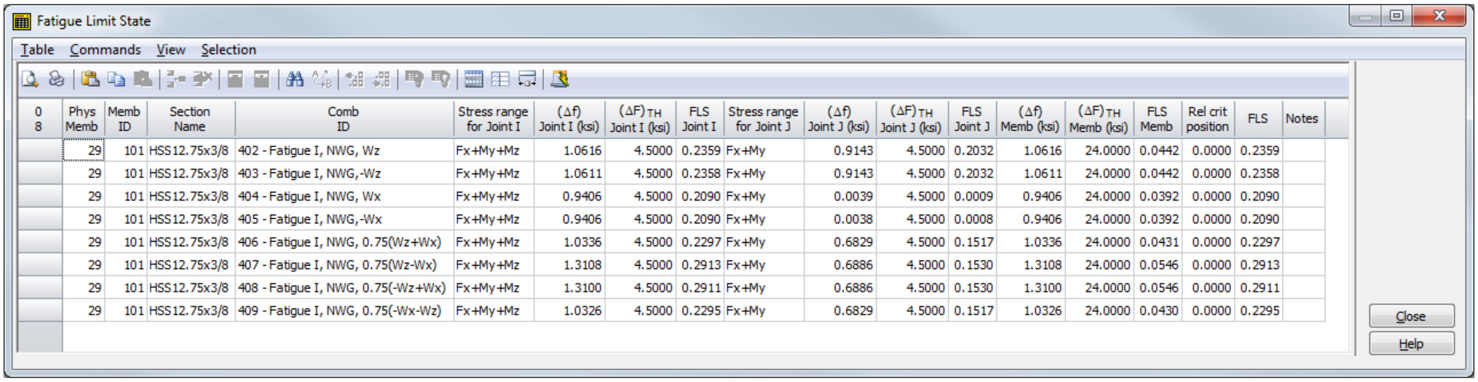
The following image corresponds to the fatigue limit state for the worse load combination.



Limit states at divisions allows to see the fatigue limit states at both ends and along the member, as shown below.



The fatigue limit state is the ratio of the axial stress range (Δf) due to fatigue load divided by the allowable stress range (ΔF)TH. These values can be verify at member Joint I and J, as well as along the member.

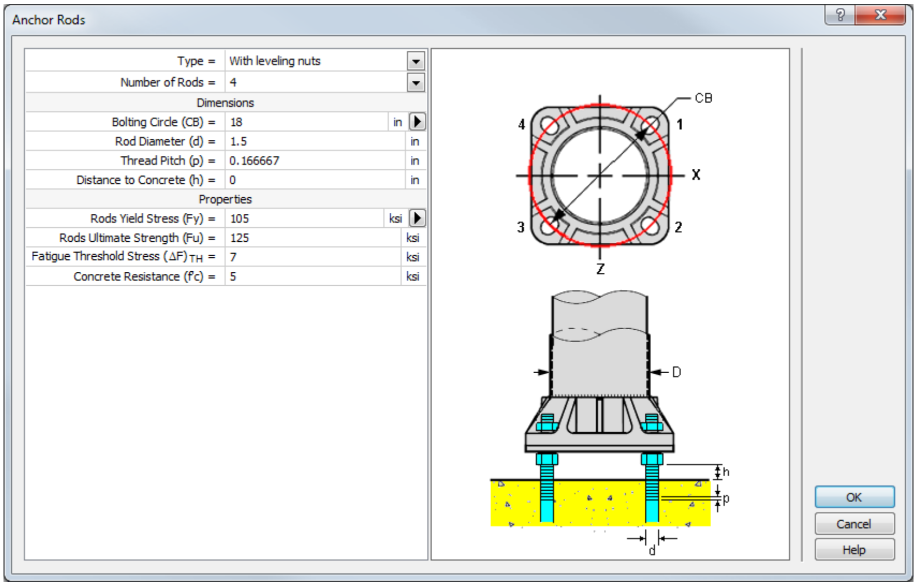


Fatigue Limit State

0 8	Phys Memb	Memb ID	Section Name	Comb ID	Stress range for Joint I	(Δf) Joint I (ksi)	$(\Delta F)_{TH}$ Joint I (ksi)	FLS Joint I	Stress range for Joint J	(Δf) Joint J (ksi)	$(\Delta F)_{TH}$ Joint J (ksi)	FLS Joint J	(Δf) Memb (ksi)	$(\Delta F)_{TH}$ Memb (ksi)	FLS Memb	Rel crit position	FLS	Notes
	29	101	HSS12.75x3/8	402 - Fatigue I, NWG, Wz	Fx+My+Mz	1.0616	4.5000	0.2359	Fx+My	0.9143	4.5000	0.2032	1.0616	24.0000	0.0442	0.0000	0.2359	
	29	101	HSS12.75x3/8	403 - Fatigue I, NWG,-Wz	Fx+My+Mz	1.0611	4.5000	0.2358	Fx+My	0.9143	4.5000	0.2032	1.0611	24.0000	0.0442	0.0000	0.2358	
	29	101	HSS12.75x3/8	404 - Fatigue I, NWG, Wx	Fx+My+Mz	0.9406	4.5000	0.2090	Fx+My	0.0039	4.5000	0.0009	0.9406	24.0000	0.0392	0.0000	0.2090	
	29	101	HSS12.75x3/8	405 - Fatigue I, NWG,-Wx	Fx+My+Mz	0.9406	4.5000	0.2090	Fx+My	0.0038	4.5000	0.0008	0.9406	24.0000	0.0392	0.0000	0.2090	
	29	101	HSS12.75x3/8	406 - Fatigue I, NWG, 0.75(Wz+Wx)	Fx+My+Mz	1.0336	4.5000	0.2297	Fx+My	0.6829	4.5000	0.1517	1.0336	24.0000	0.0431	0.0000	0.2297	
	29	101	HSS12.75x3/8	407 - Fatigue I, NWG, 0.75(Wz-Wx)	Fx+My+Mz	1.3108	4.5000	0.2913	Fx+My	0.6886	4.5000	0.1530	1.3108	24.0000	0.0546	0.0000	0.2913	
	29	101	HSS12.75x3/8	408 - Fatigue I, NWG, 0.75(-Wz+Wx)	Fx+My+Mz	1.3100	4.5000	0.2911	Fx+My	0.6886	4.5000	0.1530	1.3100	24.0000	0.0546	0.0000	0.2911	
	29	101	HSS12.75x3/8	409 - Fatigue I, NWG, 0.75(-Wx-Wz)	Fx+My+Mz	1.0326	4.5000	0.2295	Fx+My	0.6829	4.5000	0.1517	1.0326	24.0000	0.0430	0.0000	0.2295	

Anchor Rods

The command **Highway Sign Anchorages** allows to define the input data for the anchorages.



The anchorage resistances and limit states are computed according to the following clauses according to the selected standard.

- AASHTO LTS-15 (LRFD) clause 5.16.3
- AASHTO LTS-13 (ASD) clauses 5.17.4.1 to 5.17.4.3
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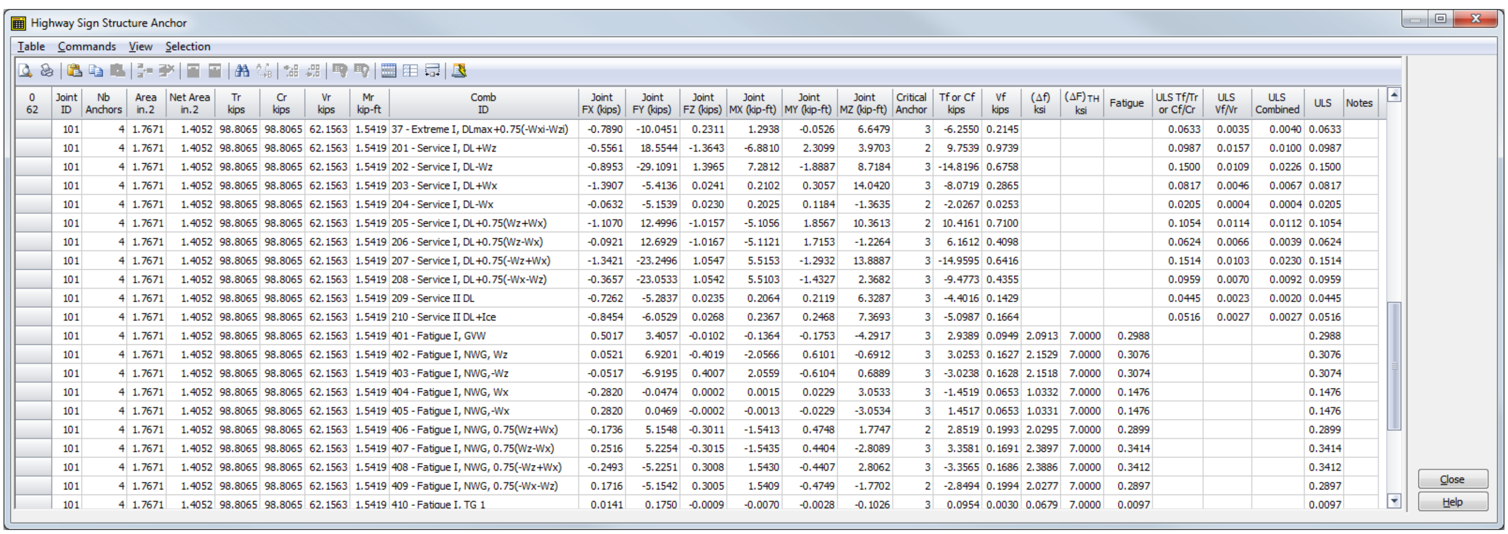
The fatigue verification for the anchorage rods is also computed according to the specified allowable stress range (ΔF)TH.



0 62	Joint ID	Nb Anchors	Area in.2	Net Area in.2	Tr kips	Cr kips	Vr kips	Mr kip-ft	Comb ID	Joint FX (kips)	Joint FY (kips)	Joint FZ (kips)	Joint MX (kip-ft)	Joint MY (kip-ft)	Joint MZ (kip-ft)	Critical Anchor	Tf or Cf kips	Vf kips	(Δf) ksi	$(\Delta F)_{TH}$ ksi	Fatigue	ULS Tf/Tr or Cf/Cr	ULS Vf/Vr	ULS Combined	ULS	Notes
	101	4	1.7671	1.4052	98.8065	98.8065	62.1563	1.5419	37 - Extreme I, DLmax+0.75(-Wxi-Wzi)	-0.7890	-10.0451	0.2311	1.2938	-0.0526	6.6479	3	-6.2550	0.2145				0.0633	0.0035	0.0040	0.0633	
	101	4	1.7671	1.4052	98.8065	98.8065	62.1563	1.5419	201 - Service I, DL+Wz	-0.5561	18.5544	-1.3643	-6.8810	2.3099	3.9703	2	9.7539	0.9739				0.0987	0.0157	0.0100	0.0987	
	101	4	1.7671	1.4052	98.8065	98.8065	62.1563	1.5419	202 - Service I, DL-Wz	-0.8953	-29.1091	1.3965	7.2812	-1.8887	8.7184	3	-14.8196	0.6758				0.1500	0.0109	0.0226	0.1500	
	101	4	1.7671	1.4052	98.8065	98.8065	62.1563	1.5419	203 - Service I, DL+Wx	-1.3907	-5.4136	0.0241	0.2102	0.3057	14.0420	3	-8.0719	0.2865				0.0817	0.0046	0.0067	0.0817	
	101	4	1.7671	1.4052	98.8065	98.8065	62.1563	1.5419	204 - Service I, DL-Wx	-0.0632	-5.1539	0.0230	0.2025	0.1184	-1.3635	2	-2.0267	0.0253				0.0205	0.0004	0.0004	0.0205	
	101	4	1.7671	1.4052	98.8065	98.8065	62.1563	1.5419	205 - Service I, DL+0.75(Wz+Wx)	-1.1070	12.4996	-1.0157	-5.1056	1.8567	10.3613	2	10.4161	0.7100				0.1054	0.0114	0.0112	0.1054	
	101	4	1.7671	1.4052	98.8065	98.8065	62.1563	1.5419	206 - Service I, DL+0.75(Wz-Wx)	-0.0921	12.6929	-1.0167	-5.1121	1.7153	-1.2264	3	6.1612	0.4098				0.0624	0.0066	0.0039	0.0624	
	101	4	1.7671	1.4052	98.8065	98.8065	62.1563	1.5419	207 - Service I, DL+0.75(-Wz+Wx)	-1.3421	-23.2496	1.0547	5.5153	-1.2932	13.8887	3	-14.9595	0.6416				0.1514	0.0103	0.0230	0.1514	
	101	4	1.7671	1.4052	98.8065	98.8065	62.1563	1.5419	208 - Service I, DL+0.75(-Wx-Wz)	-0.3657	-23.0533	1.0542	5.5103	-1.4327	2.3682	3	-9.4773	0.4355				0.0959	0.0070	0.0092	0.0959	
	101	4	1.7671	1.4052	98.8065	98.8065	62.1563	1.5419	209 - Service II DL	-0.7262	-5.2837	0.0235	0.2064	0.2119	6.3287	3	-4.4016	0.1429				0.0445	0.0023	0.0020	0.0445	
	101	4	1.7671	1.4052	98.8065	98.8065	62.1563	1.5419	210 - Service II DL+Ice	-0.8454	-6.0529	0.0268	0.2367	0.2468	7.3693	3	-5.0987	0.1664				0.0516	0.0027	0.0027	0.0516	
	101	4	1.7671	1.4052	98.8065	98.8065	62.1563	1.5419	401 - Fatigue I, GVW	0.5017	3.4057	-0.0102	-0.1364	-0.1753	-4.2917	3	2.9389	0.0949	2.0913	7.0000	0.2988				0.2988	
	101	4	1.7671	1.4052	98.8065	98.8065	62.1563	1.5419	402 - Fatigue I, NWG, Wz	0.0521	6.9201	-0.4019	-2.0566	0.6101	-0.6912	3	3.0253	0.1627	2.1529	7.0000	0.3076				0.3076	
	101	4	1.7671	1.4052	98.8065	98.8065	62.1563	1.5419	403 - Fatigue I, NWG,-Wz	-0.0517	-6.9195	0.4007	2.0559	-0.6104	0.6889	3	-3.0238	0.1628	2.1518	7.0000	0.3074				0.3074	
	101	4	1.7671	1.4052	98.8065	98.8065	62.1563	1.5419	404 - Fatigue I, NWG, Wx	-0.2820	-0.0474	0.0002	0.0015	0.0229	3.0533	3	-1.4519	0.0653	1.0332	7.0000	0.1476				0.1476	
	101	4	1.7671	1.4052	98.8065	98.8065	62.1563	1.5419	405 - Fatigue I, NWG,-Wx	0.2820	0.0469	-0.0002	-0.0013	-0.0229	-3.0534	3	1.4517	0.0653	1.0331	7.0000	0.1476				0.1476	
	101	4	1.7671	1.4052	98.8065	98.8065	62.1563	1.5419	406 - Fatigue I, NWG, 0.75(Wz+Wx)	-0.1736	5.1548	-0.3011	-1.5413	0.4748	1.7747	2	2.8519	0.1993	2.0295	7.0000	0.2899				0.2899	
	101	4	1.7671	1.4052	98.8065	98.8065	62.1563	1.5419	407 - Fatigue I, NWG, 0.75(Wz-Wx)	0.2516	5.2254	-0.3015	-1.5435	0.4404	-2.8089	3	3.3581	0.1691	2.3897	7.0000	0.3414				0.3414	
	101	4	1.7671	1.4052	98.8065	98.8065	62.1563	1.5419	408 - Fatigue I, NWG, 0.75(-Wz+Wx)	-0.2493	-5.2251	0.3008	1.5430	-0.4407	2.8062	3	-3.3565	0.1686	2.3886	7.0000	0.3412				0.3412	
	101	4	1.7671	1.4052	98.8065	98.8065	62.1563	1.5419	409 - Fatigue I, NWG, 0.75(-Wx-Wz)	0.1716	-5.1542	0.3005	1.5409	-0.4749	-1.7702	2	-2.8494	0.1994	2.0277	7.0000	0.2897				0.2897	
	101	4	1.7671	1.4052	98.8065	98.8065	62.1563	1.5419	410 - Fatigue I, TG 1	0.0141	0.1750	-0.0009	-0.0070	-0.0028	-0.1026	3	0.0954	0.0030	0.0679	7.0000	0.0097				0.0097	