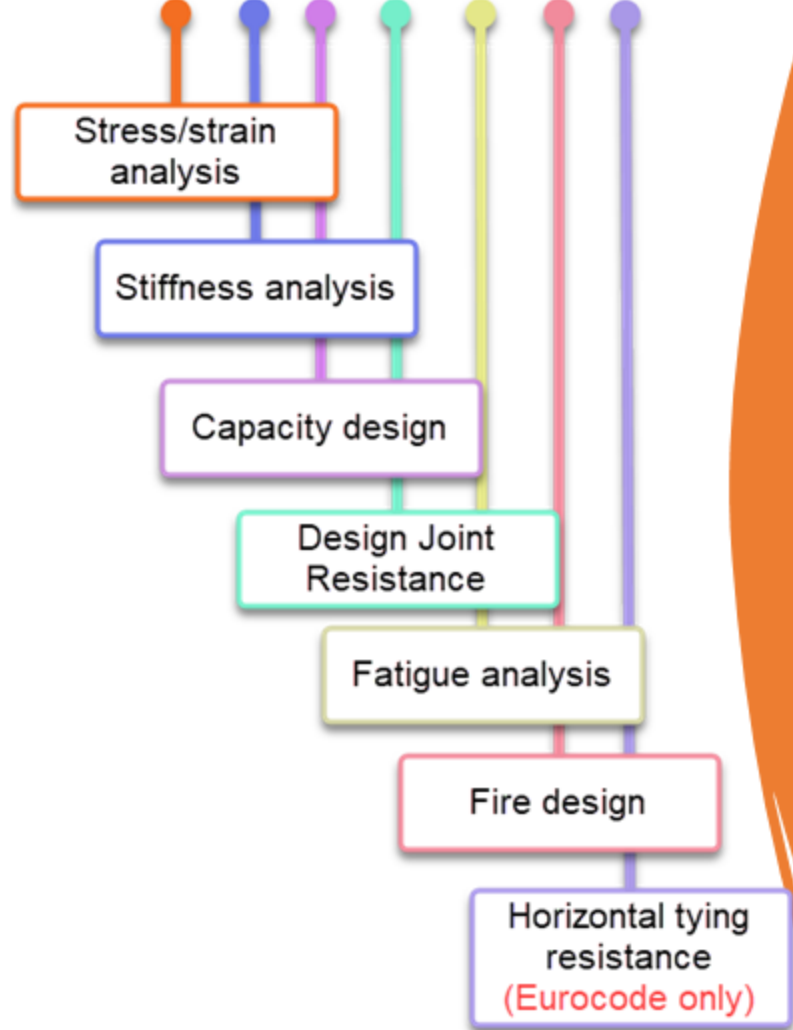




CON2

EPS ST CD DR FAT FIR HT



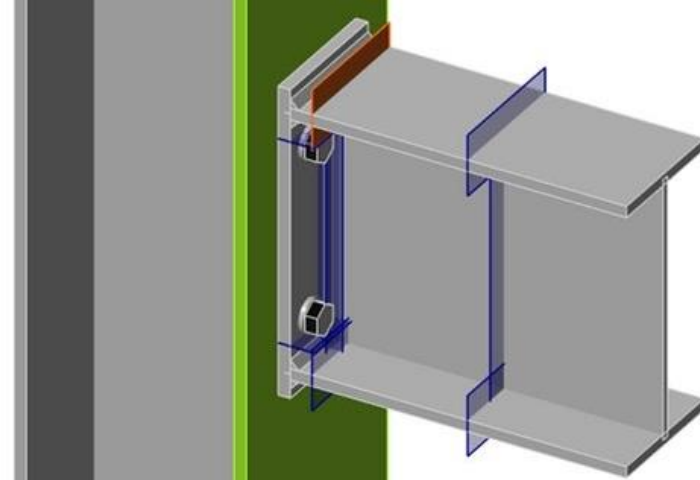
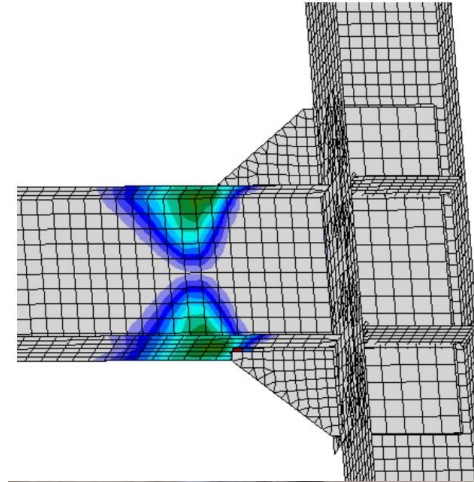
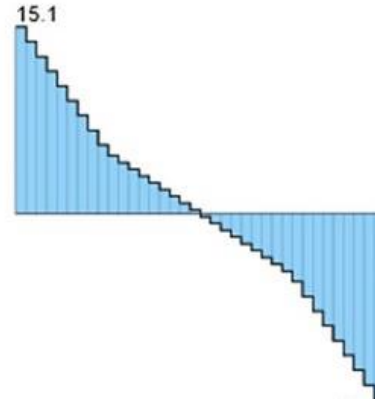
Analysis types for Steel Connection Design

November 30th

12:00 pm EST

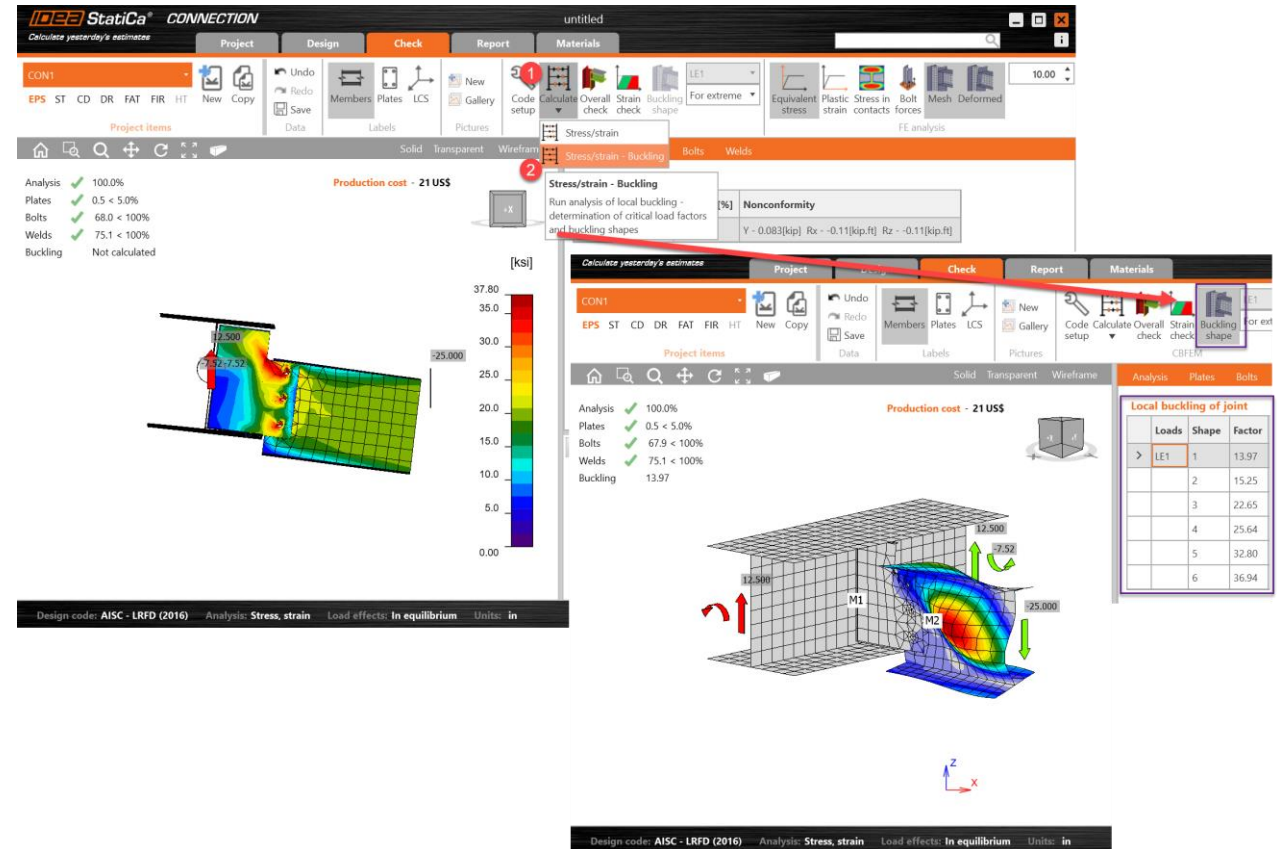
Agenda

- Buckling analysis
- Design resistance
- Stiffness analysis
- Capacity design
- Fatigue analysis
- Fire design
- [Horizontal Tying resistance](#)



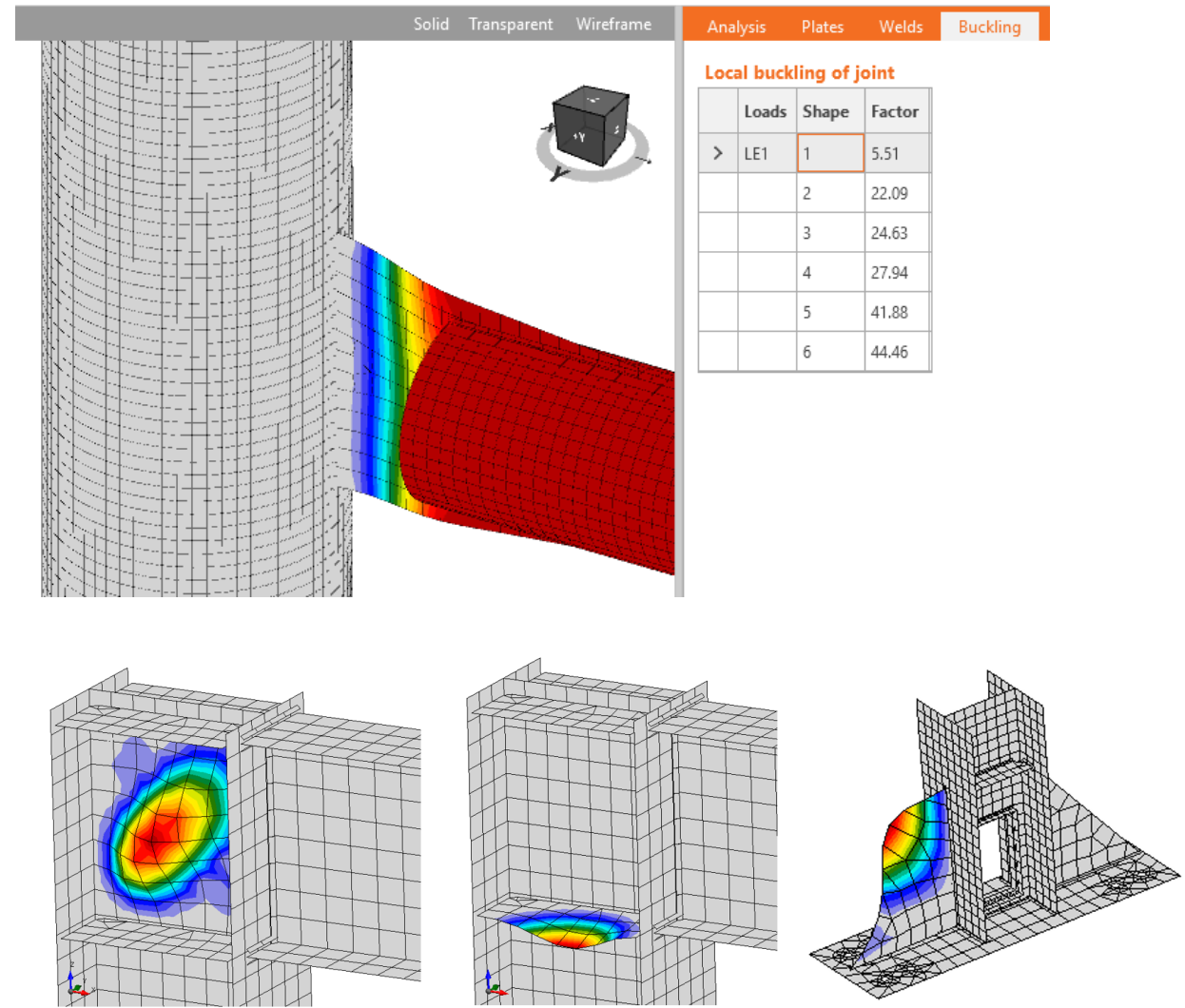
Buckling analysis

- Linear buckling analysis that provides buckling load factor
- Buckling mode shapes
- Deformation is unitless
- Critical mode shape is always the first



How to evaluate?

- Identify where the buckling is happening:
 - a. Plates connecting individual members
 - b. Stiffening plates in the joint – stiffeners, ribs, short haunches
 - c. Closed sections and thin-walled sections
- Compare buckling factor vs recommended limit factors



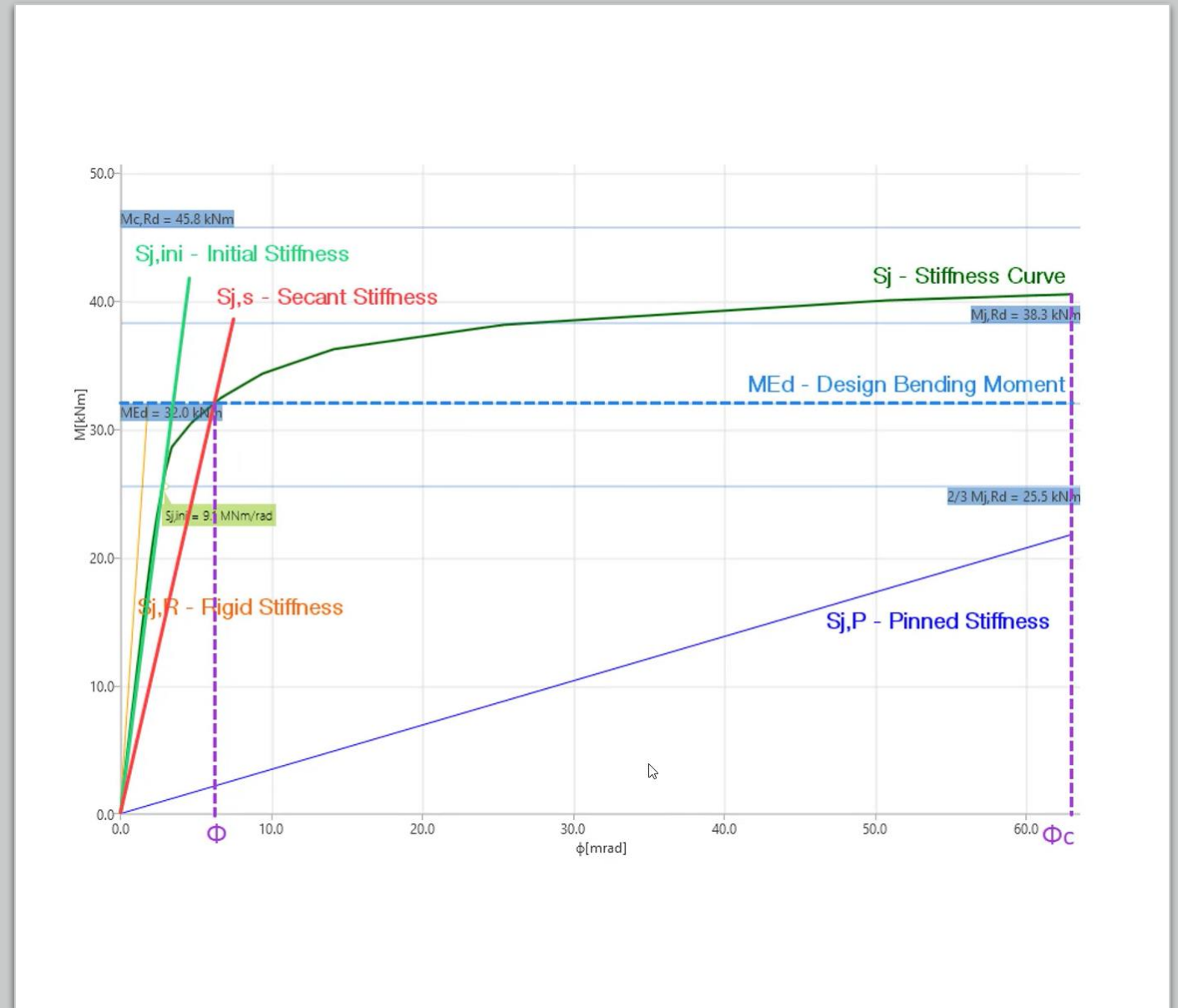
Recommended limit factors

- Global buckling: affecting the stability of the joint
- Local buckling: not affecting the stability of the joint, but influencing the plates in other parts of the connection
- [Buckling factor- AISC](#)
- [Research Stability of bracket plates](#)

Buckling type	Steel Fy	Recommended limit factor
Global	36 ksi	$\alpha_{cr} > 12.7$
Global	50 ksi	$\alpha_{cr} > 9.16$
Local		$\alpha_{cr} > 3$ – Member plates $\alpha_{cr} > 4$ – Bracket plates

Stiffness analysis

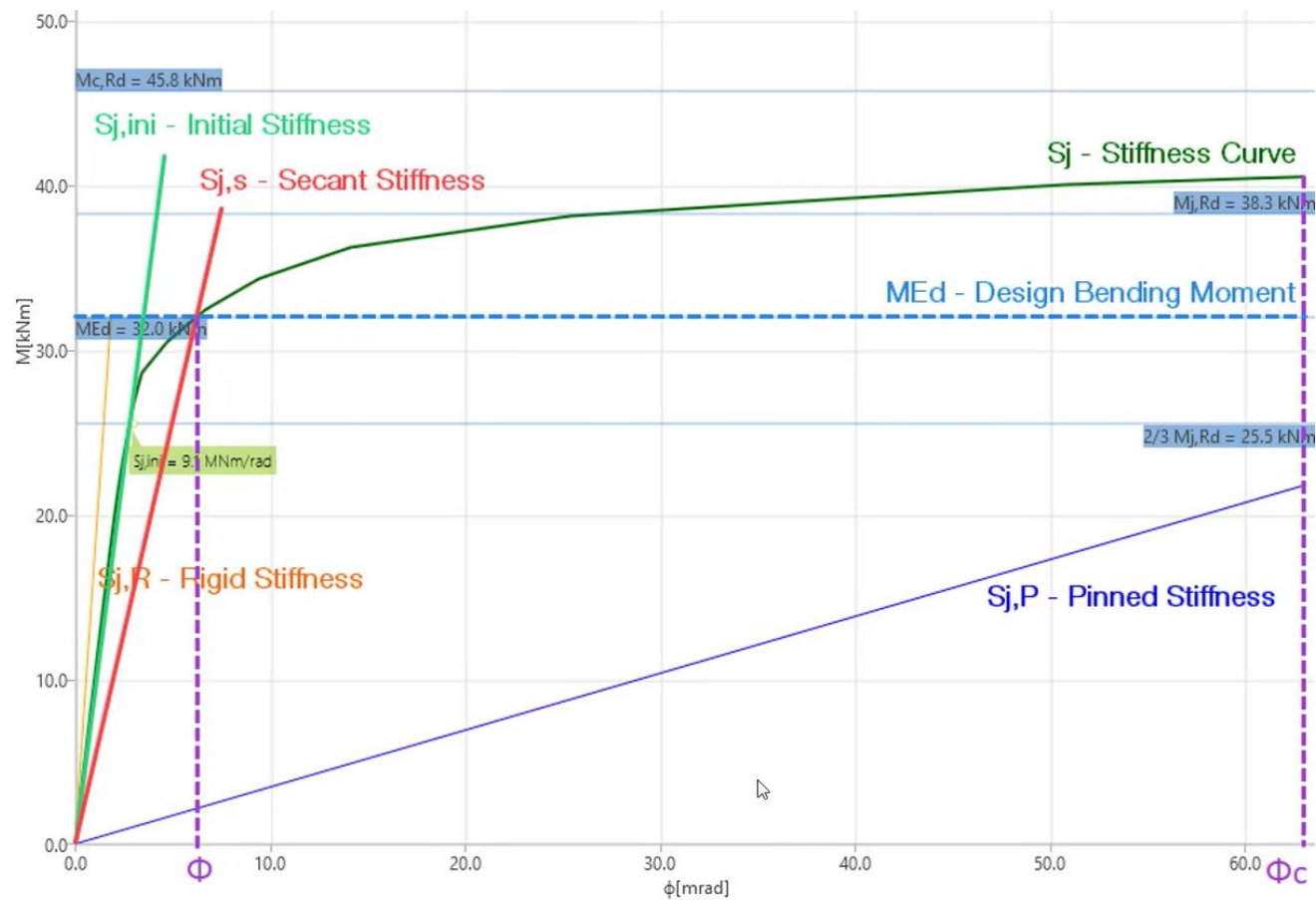
- Analyze the rotational/axial stiffness of the selected member
- Loads only applied to the analyzed member
- Only M_y , M_z or N forces
- Creates a moment vs rotation diagram
- Stiffness classification according AISC
- [Stiffness analysis blog](#)



Results

Rotational stiffness of joint component

Item	Comp.	Loads	MEd [kip.ft]	Mj,Rd [kip.ft]	Sj,ini [kip-in/deg]	Sjs [kip-in/deg]	ϕ [mrad]	ϕ_c [mrad]	L [in]	Sj,R [kip-in/deg]	Sj,P [kip-in/deg]	Class	
>	2-71	My	CO 3061 (1.200 D + 1.600 Lp)(2)	473.20	1027.55	120594.9	124183.2	0.8	2.4	19'-8"1/4	208303.7	20830.4	Semi-rigid



Stiffness input in your global FEM Model

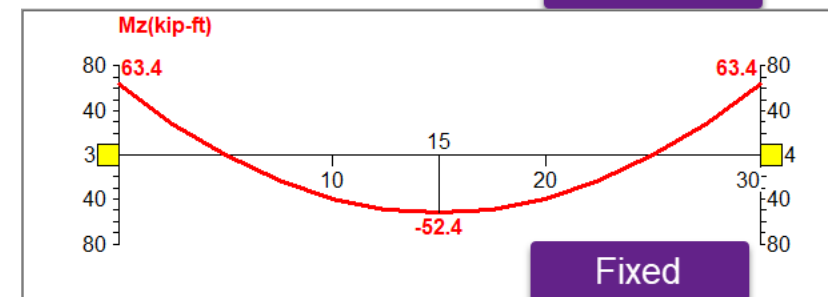
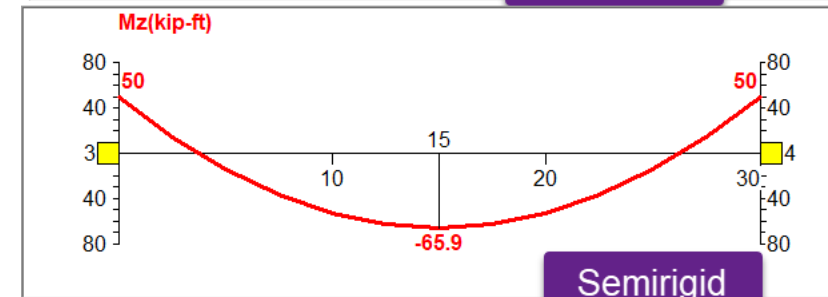
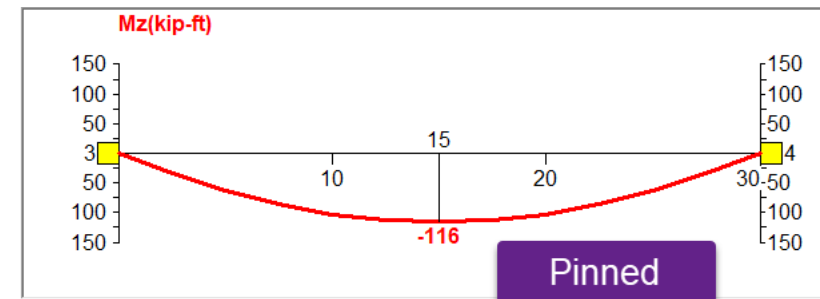
Release

<input type="checkbox"/> FX	<input type="checkbox"/> KFX	0	kip/ft	<input type="checkbox"/> MX	<input type="checkbox"/> KMX	0	kip-ft/deg.
<input type="checkbox"/> FY	<input type="checkbox"/> KFY	0	kip/ft	<input type="checkbox"/> MY	<input checked="" type="checkbox"/> KMY	0	kip-ft/deg.
<input type="checkbox"/> FZ	<input type="checkbox"/> KFZ	0	kip/ft	<input type="checkbox"/> MZ	<input type="checkbox"/> KMZ	0	kip-ft/deg.

Assignments

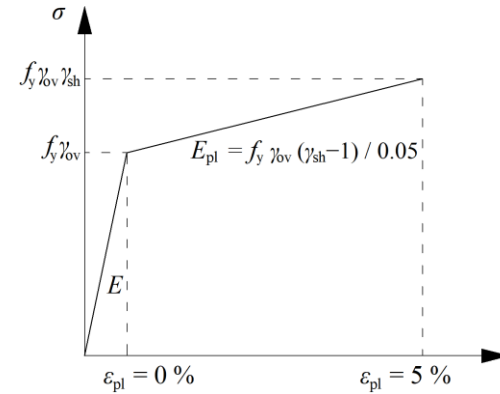
- Section Property W10X60
- > Moment Frame Beam Type Standard Moment Connection
- > Property Modifiers None
- > End Releases M33
 - > Axial None
 - > Shear 2 (Major) None
 - > Shear 3 (Minor) None
 - > Torsion None
 - > Moment 22 (Minor) None
 - > Moment 33 (Major) End I
 - Releases End I
 - Stiffness I (kip/in) 0
- > Slab Line Releases None
- > End Length Offsets Auto
- > Insertion Point CP at 8 - Top Center
- > Output Stations Max Station Spacing
- Local Axis 2 Angle (deg) Default
- Springs None
- Line Mass (lb-s²/ft²) 0
- > TC Limits None
- Spandrel None
- Material Overwrite None
- > Auto Mesh Yes - It Int

Stiffness I (kip/in)
Spring stiffness along major moment (33) direction, End I.



Capacity design

- A member (dissipative item) is selected to increase its strength and modify its material properties.
- Overstrength factor, R_y
- Hardening factor, C_{pr}



DISS1 [Dissipative item]

▼ **Properties**

Cpr calculated

Cpr user defined 1

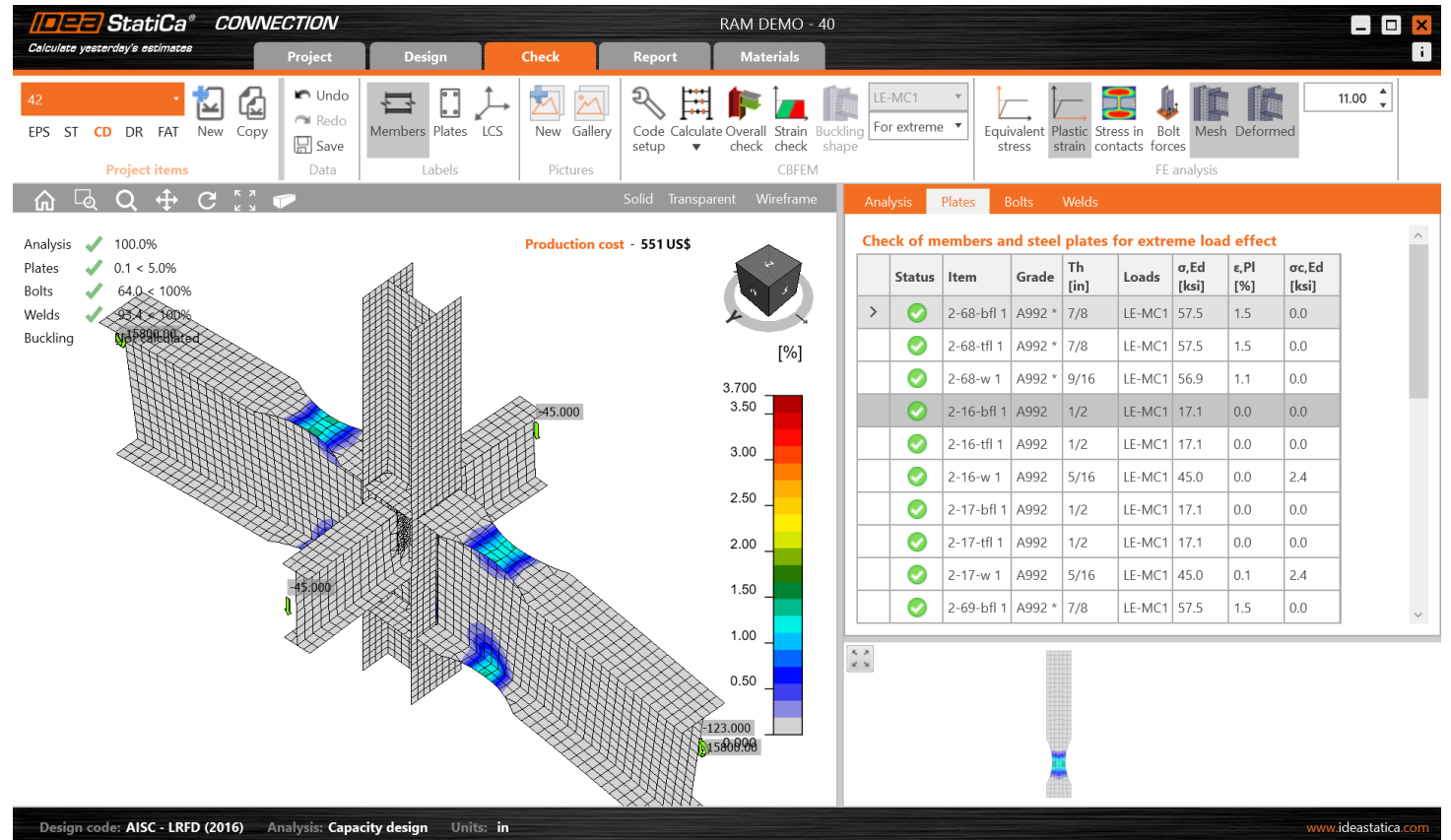
Items 1-68

Design data

	Grade	ϕ [-]	R_y [-]	F_y [ksi]	F_y, FEM [ksi]	C_{pr} [-]	ϵ, lim [%]
>	A992	0.90	-	50.0	45.0	-	5.0
	A992 *	-	1.10	50.0	55.0	1.15	5.0

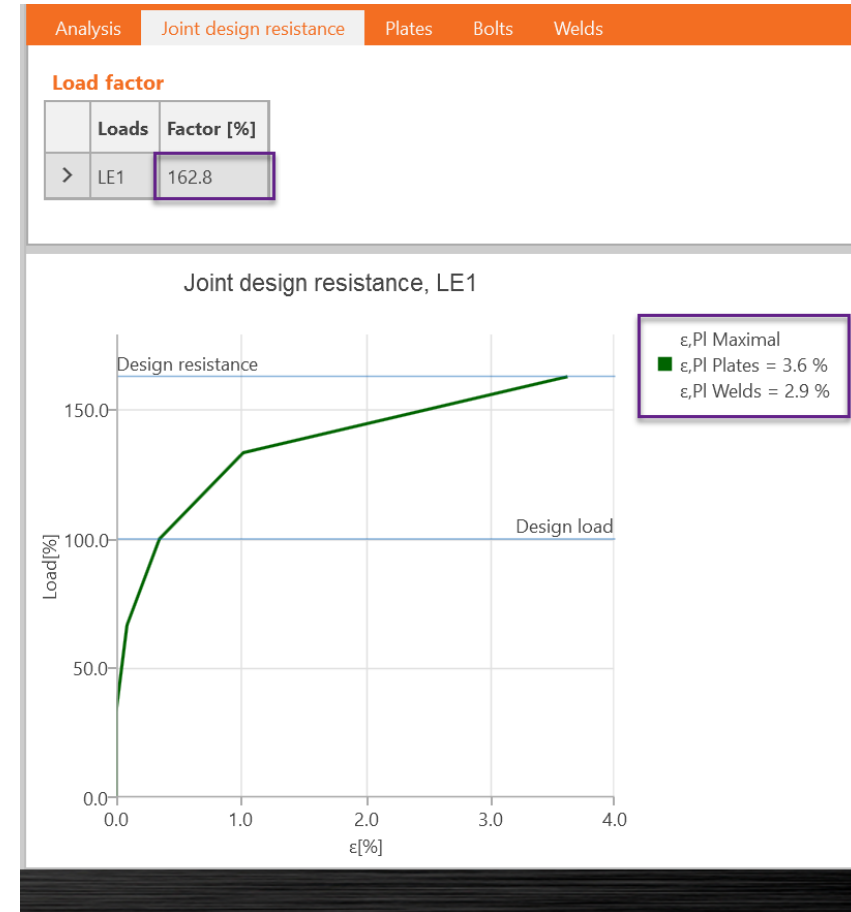
Capacity design fit

- Prequalified connections modeling and plastic hinge confirmation
- Interaction with other members and connections
- Panel zone shear check
- Continuity plates
- [Tutorial](#)



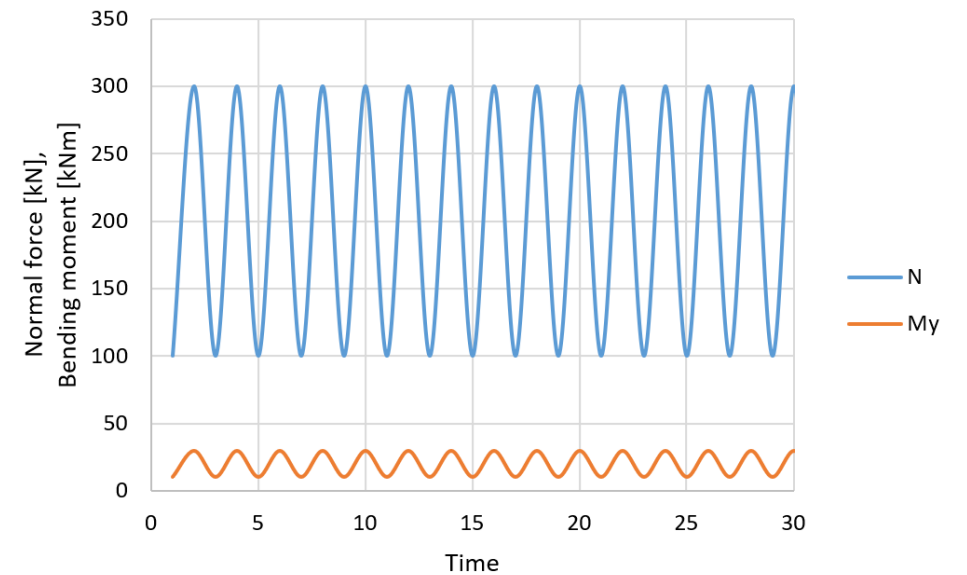
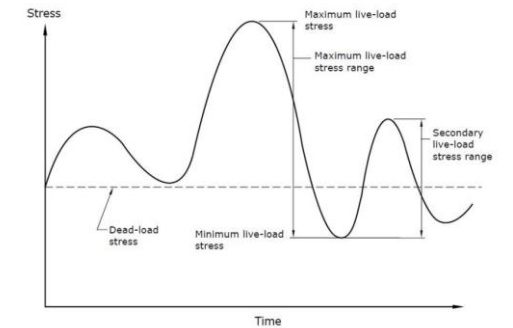
Design Resistance

- Provides a percentage of extra load that the joint can support until it fails
- Starting load input is needed
- DR checks for the following components:
 - Plastic strain in plates
 - Bolts – shear, tension, and a combination of tension and shear
 - Anchors – tension and shear steel resistance
 - Welds



Fatigue analysis

- Determine normal and shear stress range between two load cases
- It is assumed to be used for the design of high-cycle fatigue details, where no yielding is expected.
- Stresses are available for: bolts, welds and plates
- [Fatigue due to cyclic loading](#)



Fire design

- Set the temperature for each member or plate separately.
- Reduced material characteristics are used based on preset temperature and material degradation curve.
- Resistance of bolts and welds is reduced. Their stiffness remains the same as at ambient temperature.
- Thermal expansion is neglected and not assumed in any models.

The screenshot displays the IDEA StatiCa software interface for fire design. The main window is titled "untitled" and shows a "Materials" tab. The interface includes a toolbar with various tools like "Code setup", "Calculate", "Overall check", "Settings", "LRFD 2016", "XLS Import", "Connection Import", "XLS Export", "Member", "Temperature", "Load", and "Operation".

On the left side, there is a tree view showing the model's structure:

- Members
 - C
 - B
- Load effects
 - LE1
- Operations
 - CUT1
 - FP1
 - OPN1
 - STIFF1
 - Weld1
 - Weld2
- Temperature
 - TEMP1
 - TEMP2

Two temperature profiles are shown in the main area:

- TEMP1 [Temperature]**: Properties show Temperature [°F] set to 1000. Items listed are C, B.
- TEMP2 [Temperature]**: Properties show Temperature [°F] set to 1000. Items listed are Stiffener (STIFF1d), Stiffener (STIFF1b), Stiffener (STIFF1c), Fin plate (FP1), and Stiffener (STIFF1a).

Two purple dashed arrows point from the "TEMP1" and "TEMP2" entries in the tree view to their respective property panels.

The website www.ideastatica.com is visible in the bottom right corner.

AISC Material properties at elevated Temperatures

TABLE A-4.2.1
Properties of Steel at Elevated Temperatures

Steel Temperature, °F (°C)	$k_E = E(T)/E$ $= G(T)/G$	$k_p = F_p(T)/F_y$	$k_y = F_y(T)/F_y$	$k_u = F_u(T)/F_y$
68 (20)	1.00	1.00	*	*
200 (93)	1.00	1.00	*	*
400 (200)	0.90	0.80	*	*
600 (320)	0.78	0.58	*	*
750 (400)	0.70	0.42	1.00	1.00
800 (430)	0.67	0.40	0.94	0.94
1000 (540)	0.49	0.29	0.66	0.66
1200 (650)	0.22	0.13	0.35	0.35
1400 (760)	0.11	0.06	0.16	0.16
1600 (870)	0.07	0.04	0.07	0.07
1800 (980)	0.05	0.03	0.04	0.04
2000 (1100)	0.02	0.01	0.02	0.02
2200 (1200)	0.00	0.00	0.00	0.00
*Use ambient properties				

TABLE A-4.2.3
Properties of Group A and Group B High-Strength Bolts at Elevated Temperatures

Bolt Temperature, °F (°C)	$F_{nt}(T)/F_{nt}$ or $F_{nv}(T)/F_{nv}$
68 (20)	1.00
200 (93)	0.97
300 (150)	0.95
400 (200)	0.93
600 (320)	0.88
800 (430)	0.71
900 (480)	0.59
1000 (540)	0.42
1200 (650)	0.16
1400 (760)	0.08
1600 (870)	0.04
1800 (980)	0.01
2000 (1100)	0.00

Q&A



Thank you



David Eckrote

- Director
- David.Eckrote@ideastatica.com



Yann Gueguen

- Regional Engineer
- Yann.Gueguen@ideastatica.com



Andrea Castelo

- Product Engineer
- Andrea.Castelo@ideastatica.com