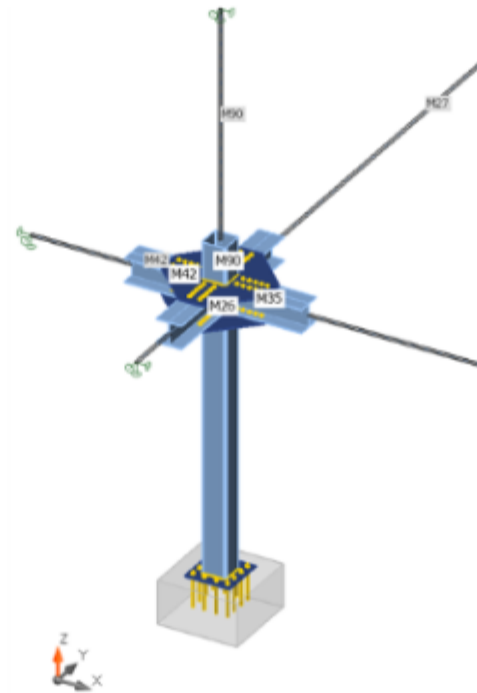


US Webinar

Critical Steel Member Design Workflow with IDEA StatiCa

August 2, 2023



MNA	✓	100.0 %
MNA Plates	✓✓	0.0 < 5.0 %
LBA		35.34
GMNIA	✓✓	100.0 %
GMNIA Plates	✓✓	0.0 < 5.0 %

IDEA StatiCa®

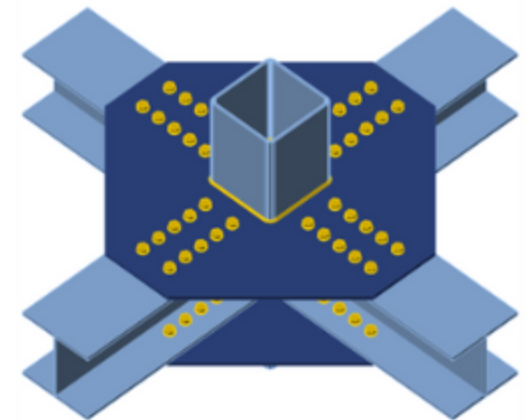
Calculate yesterday's estimates

22 [Connection]

Connection point [342.519; -342.519; 161.417]

▼ Loads

Result class All ULS Fund



Analysis	✓	100.0%
Plates	✓✓	0.0 < 5.0%
Bolts	✓✓	48.4 < 100%
Welds	✓✓	84.7 < 100%
Buckling	✓	Not calculated

Agenda

- Intro to IDEA Member
- Design workflow with other apps
- Results evaluation
- Q&A

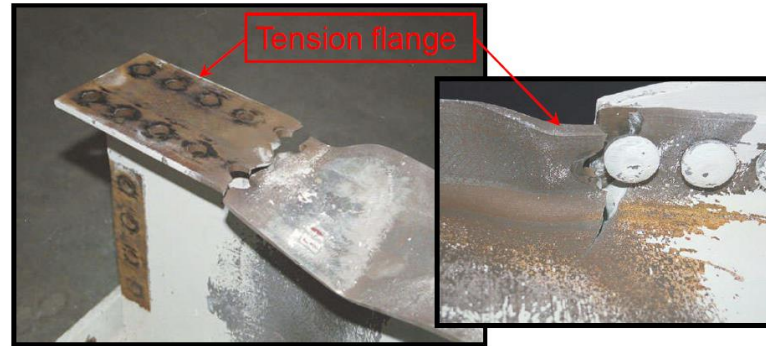


Beam limit states

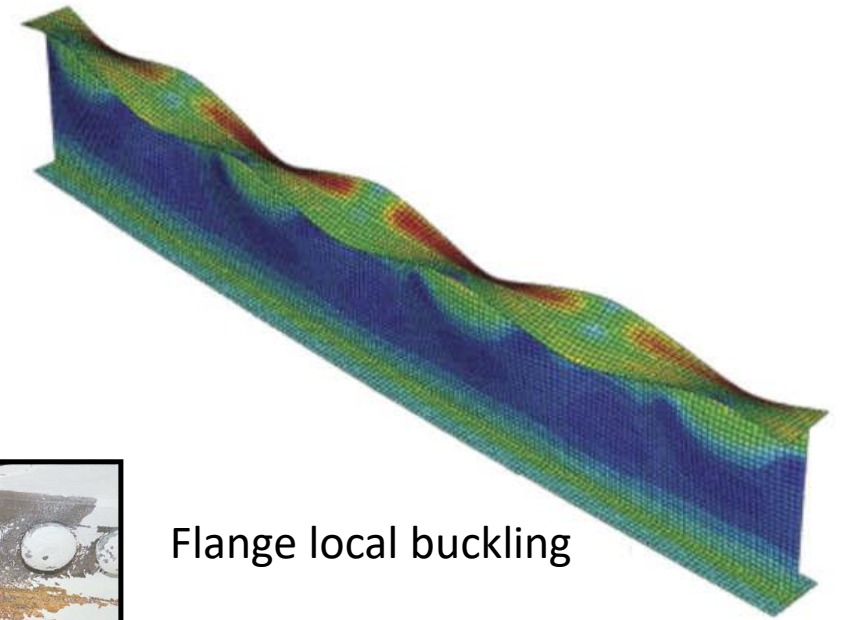
Flexural yielding



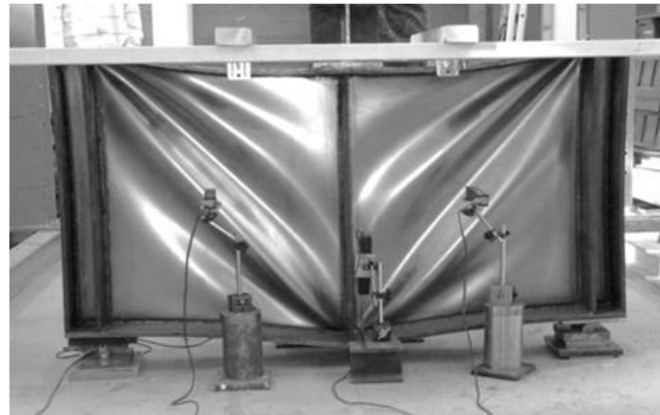
Tension flange rupture



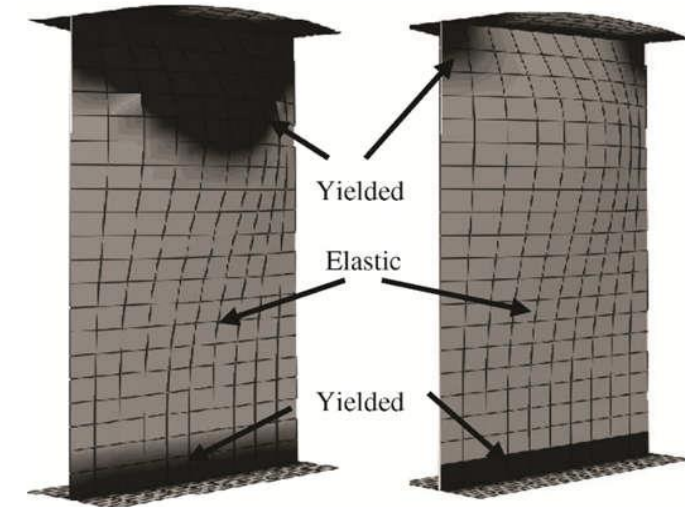
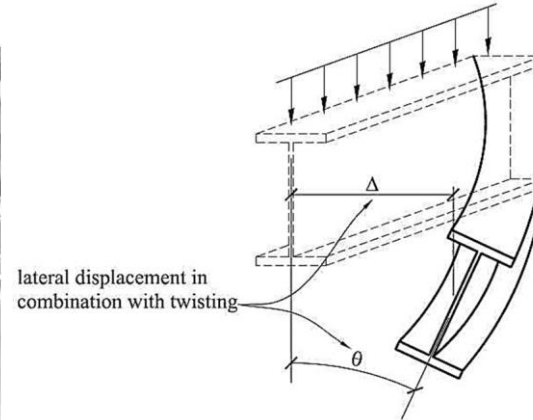
Flange local buckling



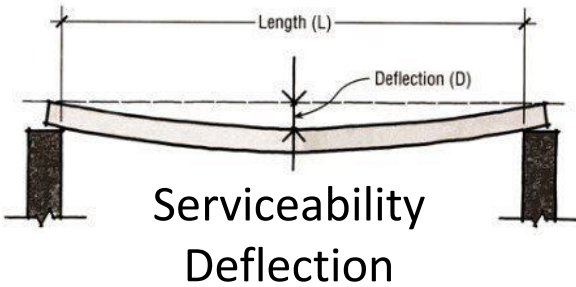
Shear buckling (deep girder beams)



Lateral-torsional buckling

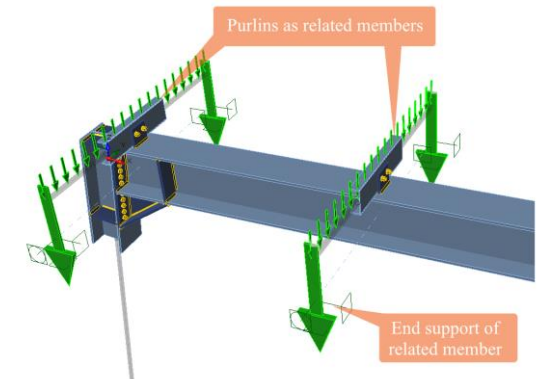
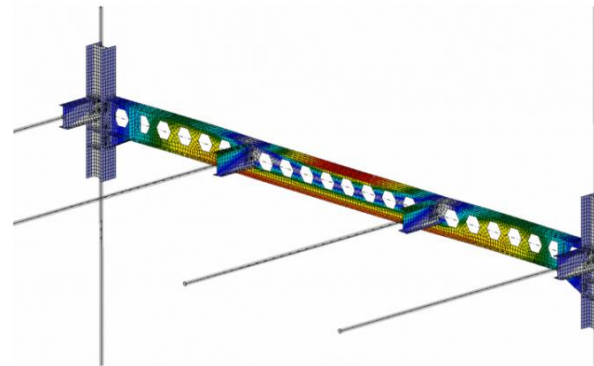
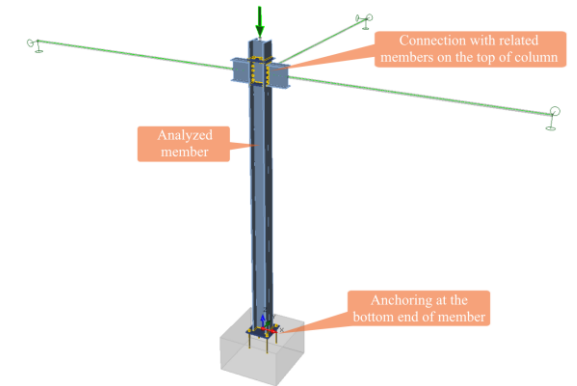
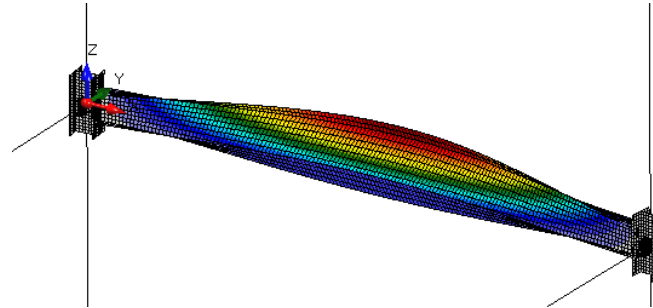
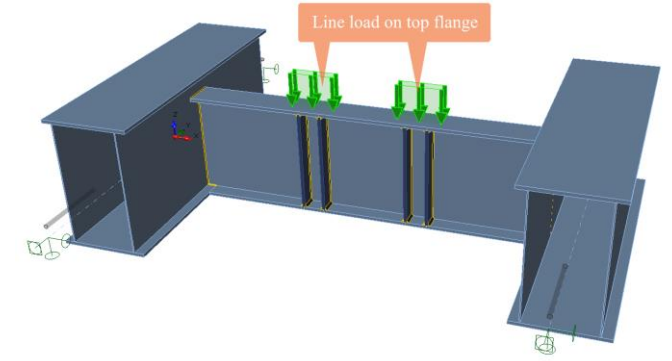
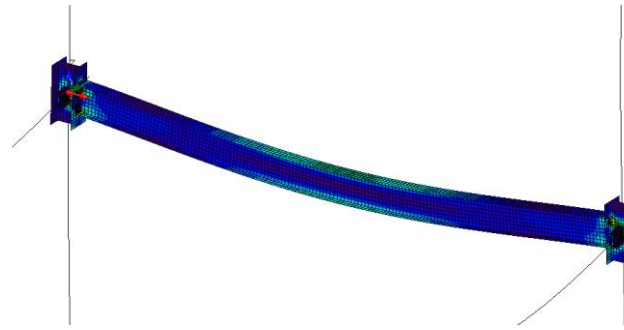


Web local buckling



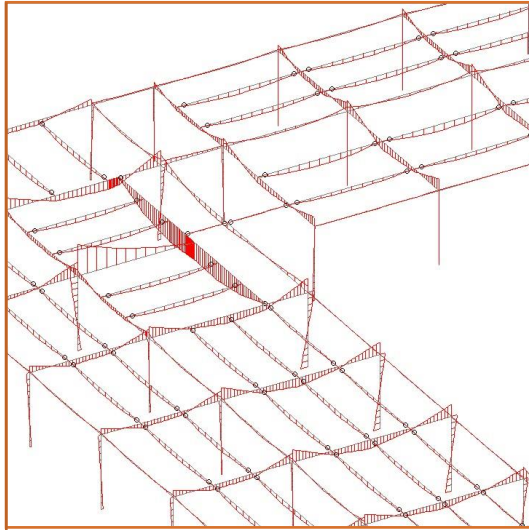
IDEA StatiCa Member

- MNA – Materially Non-linear Analysis.
- LBA – Linear Buckling Analysis (stability)
- GMNIA – Geometrically and Materially Non-linear Analysis with Imperfections
- [Theoretical background](#)

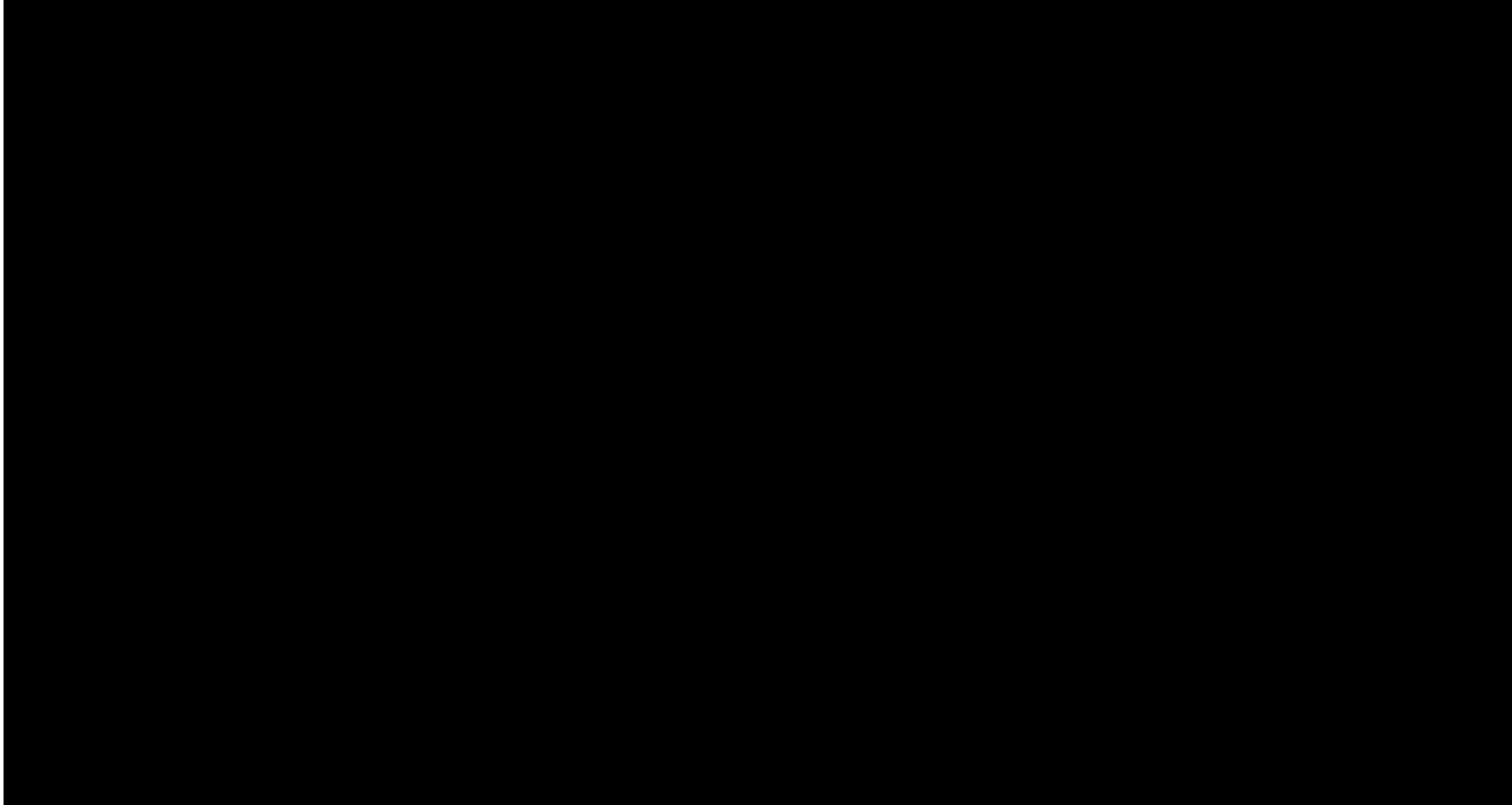


How can Member be used?

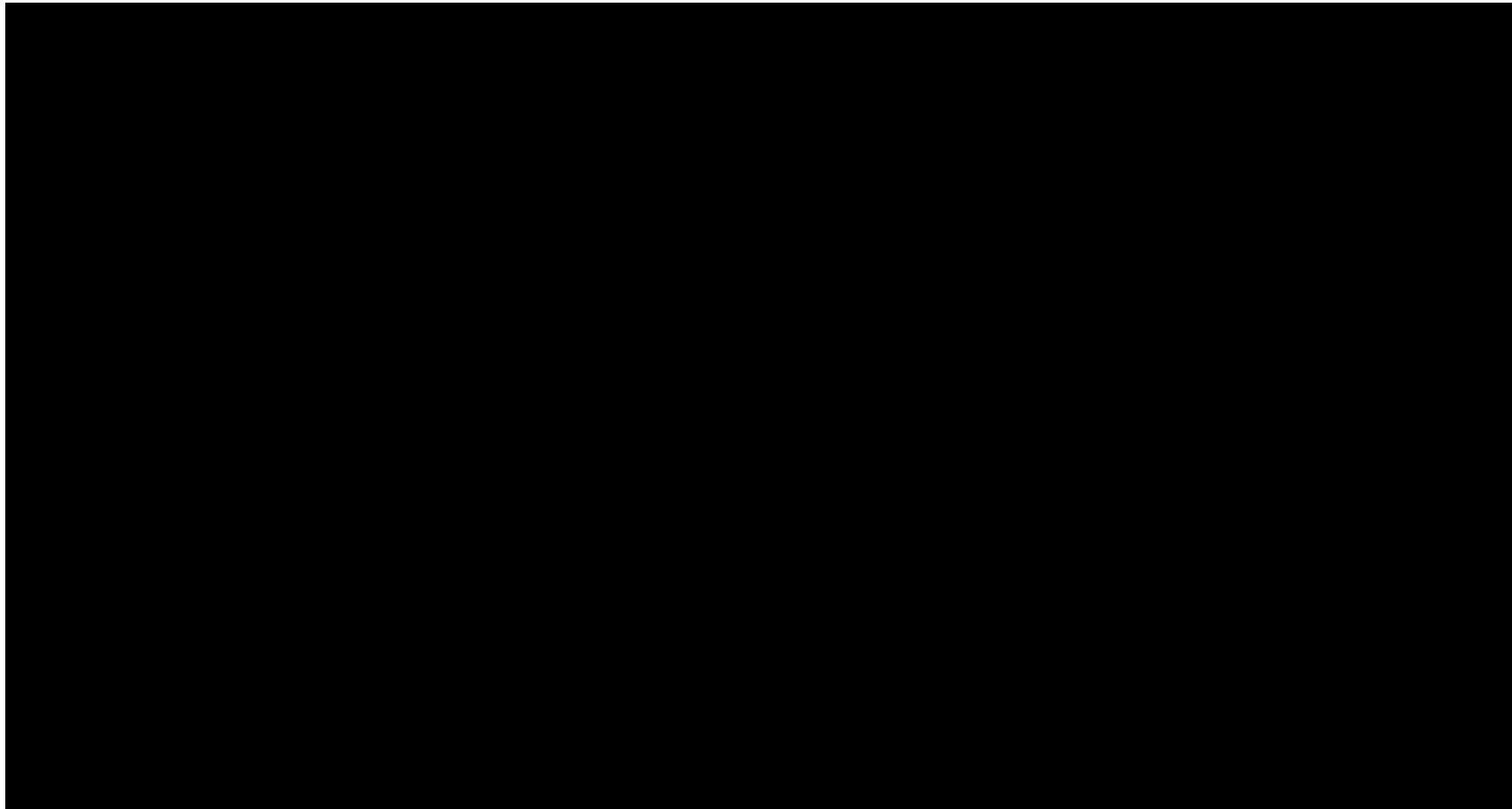
- Modeling a huge range of member types:
 - Non regular beams, i.e. openings, stiffeners,
 - Cold formed sections
 - Deep girder beams
 - Built up section
- Accurate FEA analysis results using shell elements:
 - Internal forces considering real stiffness of the model (connections and realistic assumptions)
 - Deformation on the member
 - Stresses and strain
- Geometrically and materially non-linear analysis to capture effects like torsion, warping and second order effects.
- Linear buckling factor to identify buckling issues on critical members



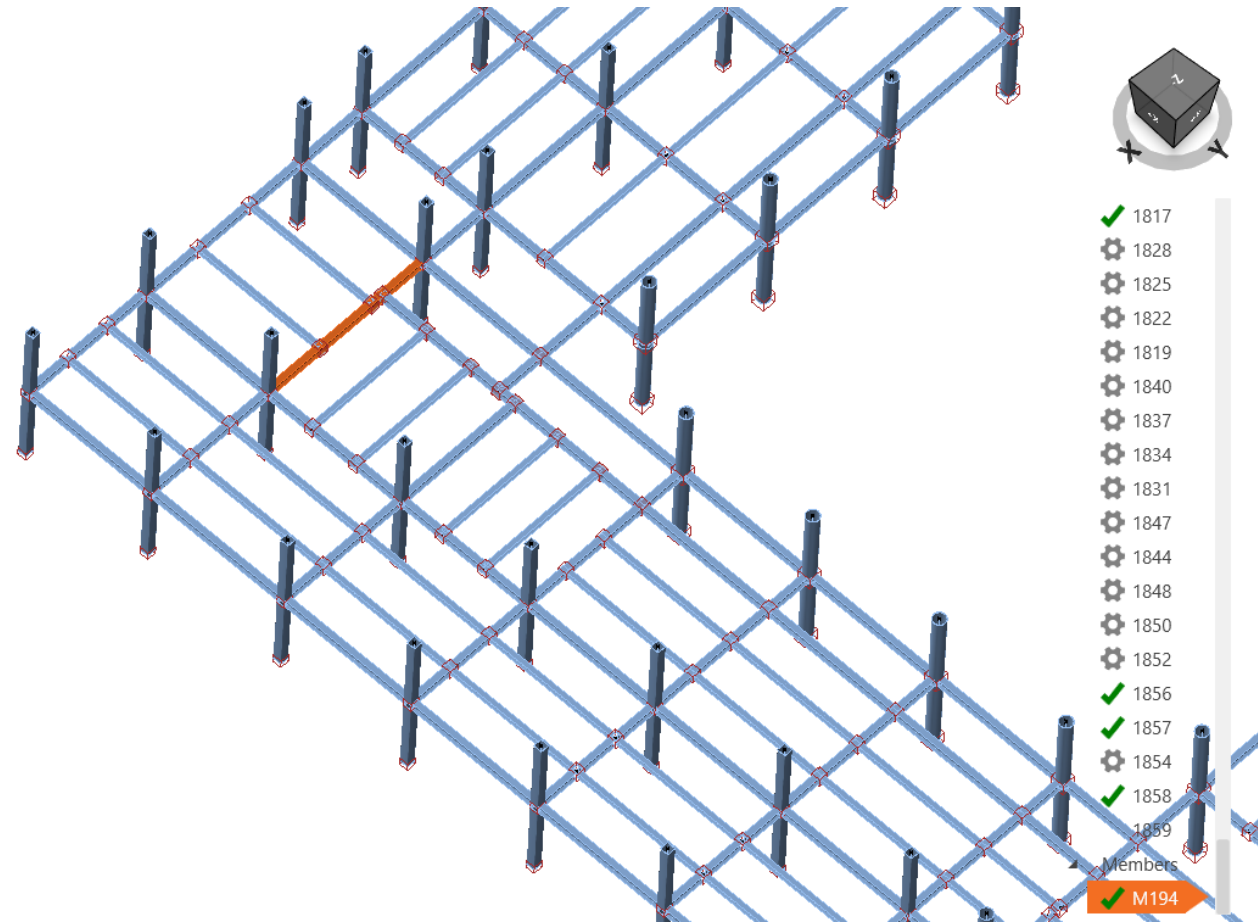
Proposed workflow



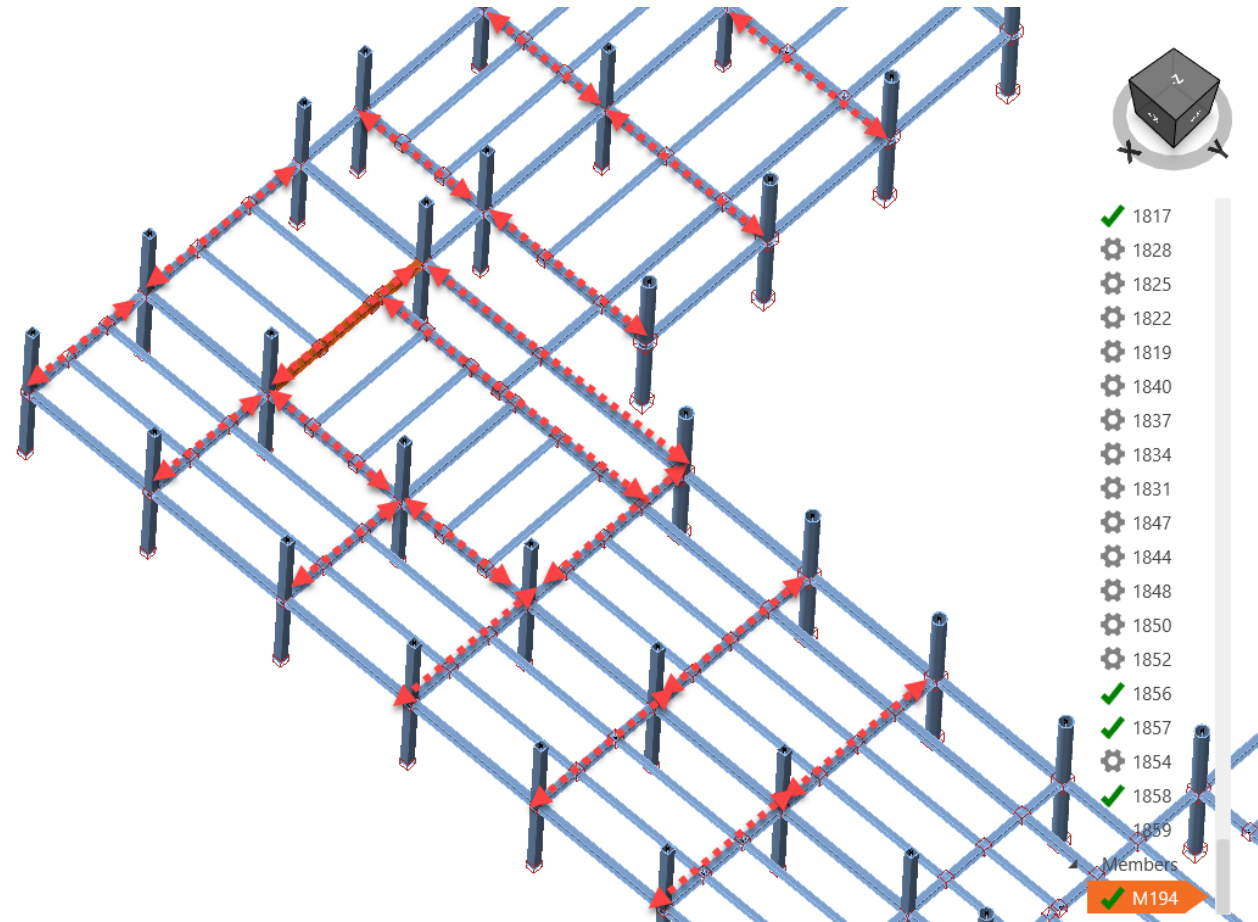
1. Import model to Checkbot



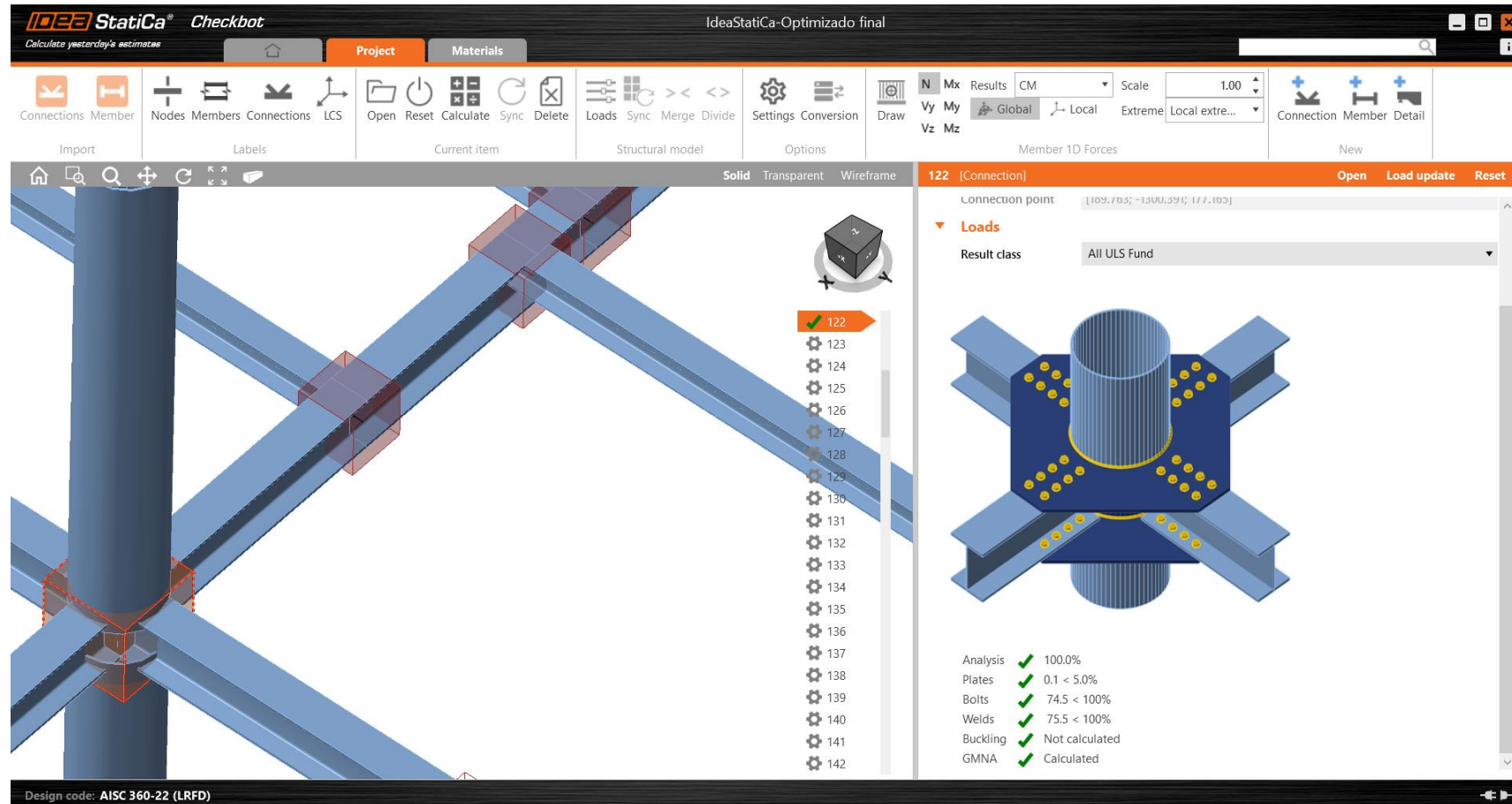
2. Merge continuous members



2. Merge continuous members



3. Model connections



4. Create Member item

IDEA StatiCa® Checkbot
IdeaStatiCa-Optimizado final

Project Materials

Connections Member Nodes Members Connections LCS Open Reset Calculate Sync Delete Loads Sync Merge Divide Settings Conversion Draw

Member 1D Forces

Member

M2612 [Design member]

Type	Prismatic
Name	M2612
Element	E1352
Begin node	163 [374.802; -1300.391; 177.165]
End node	1849 [374.802; -1539.761; 177.165]
Length [in]	239.370
Cross-section	1115. W8X24 (A36)
Material	A36
Rotation [°]	0.0
Eccentricity ey [in]	0.000
Eccentricity ez [in]	2.000
Substructures	
Related member in:	M264 M229

Design code: AISC 360-22 (LRFD)

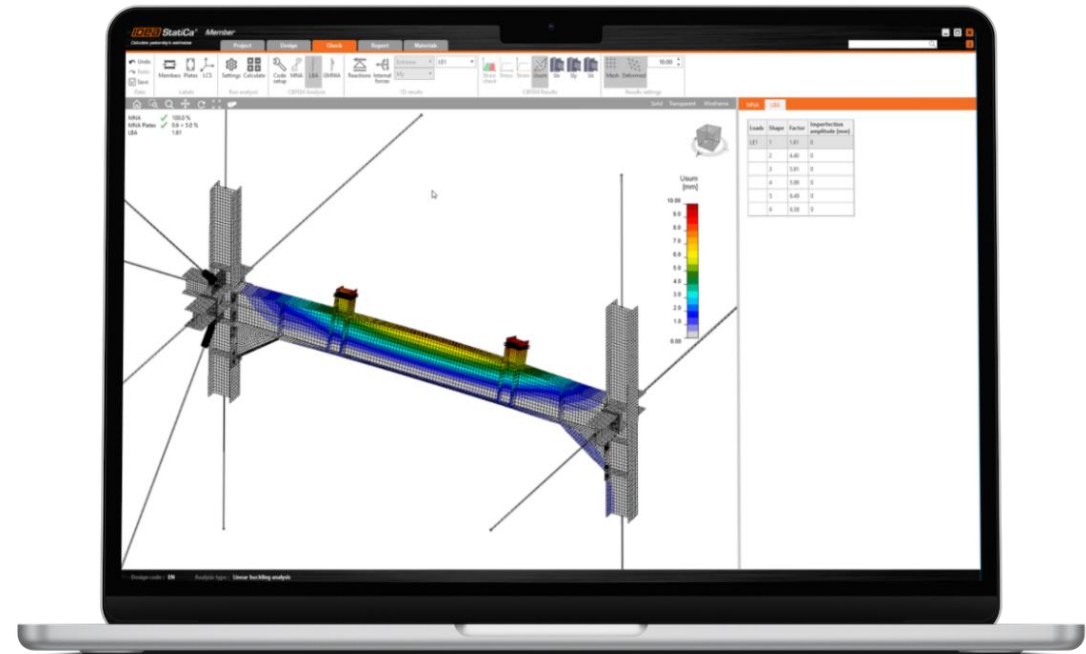
5. Open Member item in Member app

The screenshot displays the IDEA StatiCa Member software interface. The main window shows a 3D structural model of a truss-like structure with members labeled M229, M264, M272, and M2612. A specific member, 170:S8, is highlighted in orange. The software interface includes a top menu bar with options like Project, Design, Check, Report, and Materials. Below the menu is a toolbar with various analysis and design tools. On the right side, a panel titled '170:S8 [Load]' shows the 'Properties' section with a 'Check type' dropdown and a 'Line loads' table.

Member	Begin [in]	End [in]	Coordinate system	X [kip/in]	Y [kip/in]	Z [kip/in]	Location	ey [in]	ez [in]
M2612	0"	1'-7"15/16	Local	0.000	0.000	-0.083	Member axis	0"	0"
M2612	1'-7"15/16	3'-3"7/8	Local	0.000	0.000	-0.084	Member axis	0"	0"
M2612	3'-3"7/8	4'-11"13/16	Local	0.000	0.000	-0.084	Member axis	0"	0"
M2612	4'-11"13/16	6'-7"13/16	Local	0.000	0.000	-0.084	Member axis	0"	0"
M2612	6'-7"13/16	8'-3"3/4	Local	0.000	0.000	-0.084	Member axis	0"	0"
M2612	8'-3"3/4	9'-11"11/16	Local	0.000	0.000	-0.084	Member axis	0"	0"
M2612	9'-11"11/16	11'-7"5/8	Local	0.000	0.000	-0.084	Member axis	0"	0"
M2612	11'-7"5/8	13'-3"9/16	Local	0.000	0.000	-0.084	Member axis	0"	0"
M2612	13'-3"9/16	14'-11"1/2	Local	0.000	0.000	-0.084	Member axis	0"	0"
M2612	14'-11"1/2	16'-7"1/2	Local	0.000	0.000	-0.084	Member axis	0"	0"
M2612	16'-7"1/2	18'-3"7/16	Local	0.000	0.000	-0.084	Member axis	0"	0"
M2612	18'-3"7/16	19'-11"3/8	Local	0.000	0.000	-0.083	Member axis	0"	0"
M272	0"	1'-11"5/16	Local	0.000	0.000	-0.040	Member axis	0"	0"
M272	1'-11"5/16	3'-10"5/8	Local	0.000	0.000	-0.040	Member axis	0"	0"
M272	3'-10"5/8	5'-9"15/16	Local	0.000	0.000	-0.040	Member axis	0"	0"

Design code: AISC Analysis type: Materially non-linear analysis

Live demo

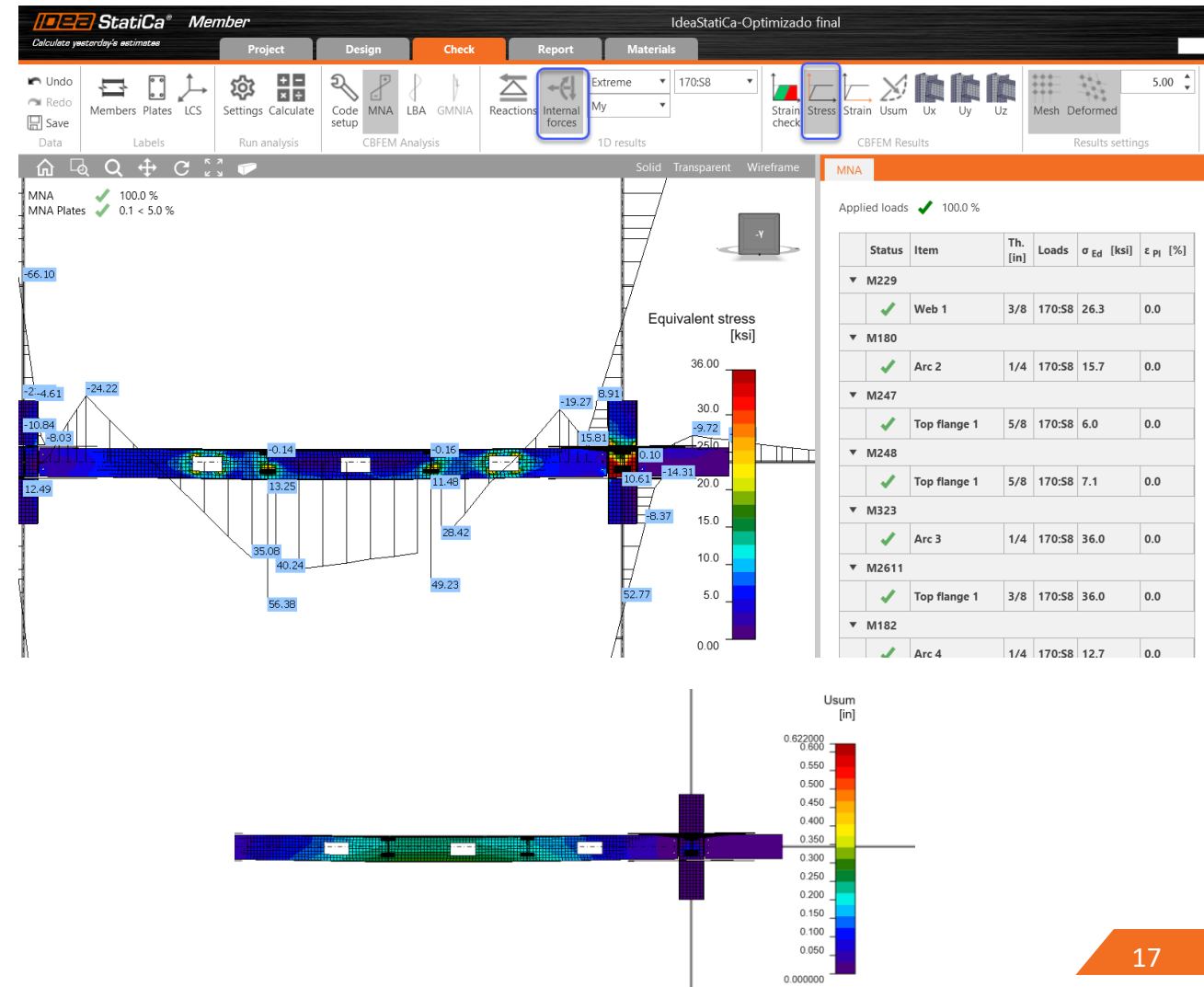


Understanding the results

1. MNA
2. LBA
3. GMNIA

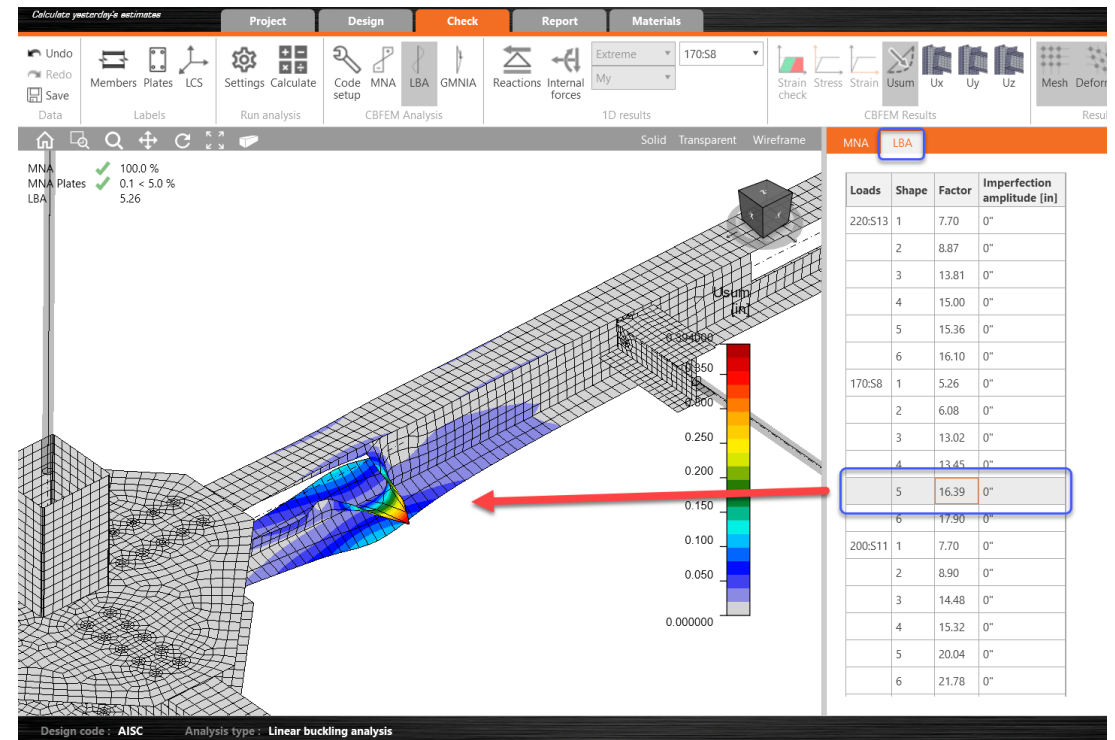
1. Materially nonlinear analysis

- **Stresses and strain**
 - Stresses and strain graphical plots
 - 5% limit plastic strain
- **Deflection**
 - Review deformation of serviceability load case
 - Check against deflection limits



2. Linear buckling analysis

- Six mode shapes and LB factors for each load combination
- Identify the critical factors by the limit recommended factors
- If the factor is below the recommended value, use GMNIA to get an accurate analysis including imperfections



Recommended limit factors (LRFD)

- Global buckling: affecting the stability of the member
- Local buckling: not affecting the stability of the member, but influencing the plates of connection or member plates
- [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

3. Geometrically and materially nonlinear analysis

- Geometrically and materially nonlinear analysis and checks with initial imperfection definitions
- Analysis considering imperfections set in previous step together with material and geometrical nonlinear behavior

- Plastic strain < 5%

MNA LBA GMNIA			
Loads	Shape	Factor	Imperfection amplitude [in]
190:S10	1	5.52	0"
	2	6.05	0"
	3	6.48	0"
	4	12.68	0"
	5	13.52	0"
	6	20.97	0"
170:S8	1	3.78	0"
	2	4.14	0"
	3	4.43	0"
	4	8.69	0"
	5	9.26	0"
	6	15.15	0"



Prev. Next
18.1-185
BACK

APPENDIX 1
DESIGN BY ADVANCED ANALYSIS

This Appendix permits the use of more advanced methods of structural analysis to directly model system and member imperfections and/or allow for the redistribution of member and connection forces and moments as a result of localized yielding.

The appendix is organized as follows:

- 1.1. General Requirements
- 1.2. Design by Elastic Analysis
- 1.3. Design by Inelastic Analysis

1.1. GENERAL REQUIREMENTS

The analysis methods permitted in this Appendix shall ensure that equilibrium and compatibility are satisfied for the structure in its deformed shape, including all flexural, shear, axial and torsional deformations, and all other component and connection deformations that contribute to the displacements of the structure.

Design by the methods of this Appendix shall be conducted in accordance with Section B3.1, using load and resistance factor design (LRFD).

1.2. DESIGN BY ELASTIC ANALYSIS

1. General Stability Requirements

Design by a second-order elastic analysis that includes the direct modeling of system and member imperfections is permitted for all structures subject to the limitations defined in this section. All requirements of Section C1 apply, with additional requirements and exceptions as noted below. All load-dependent effects shall be calculated at a level of loading corresponding to LRFD load combinations.

The influence of torsion shall be considered, including its impact on member deformations and second-order effects.

The provisions of this method apply only to doubly symmetric members, including I-shapes, HSS and box sections, unless evidence is provided that the method is applicable to other member types.

2. Calculation of Required Strengths

For design using a second-order elastic analysis that includes the direct modeling of system and member imperfections, the required strengths of components of the structure shall be determined from an analysis conforming to Section C2, with additional requirements and exceptions as noted in the following.

3. Calculation of Available Strengths

For design using a second-order elastic analysis that includes the direct modeling of system and member imperfections, the available strengths of members and connections shall be calculated in accordance with the provisions of Chapters D through K, as applicable, except as defined below, with no further consideration of overall structure stability.

The nominal compressive strength of members, P_n , may be taken as the cross-section compressive strength, $F_y A_g$, or as $F_y A_e$ for members with slender elements, where A_e is defined in Section E7.

1.3. DESIGN BY INELASTIC ANALYSIS

User Note: Design by the provisions of this section is independent of the requirements of Section 1.2.

1. General Requirements

The design strength of the structural system and its members and connections shall equal or exceed the required strength as determined by the inelastic analysis. The provisions of Section 1.3 do not apply to seismic design.

The inelastic analysis shall take into account: (a) flexural, shear, axial and torsional member deformations, and all other component and connection deformations that contribute to the displacements of the structure; (b) second-order effects (including $P-\Delta$, $P-\delta$ and twisting effects); (c) geometric imperfections; (d) stiffness reductions due to inelasticity, including partial yielding of the cross section that may be accentuated by the presence of residual stresses; and (e) uncertainty in system, member, and connection strength and stiffness.

Specification for Structural Steel Buildings, July 7, 2016
AMERICAN INSTITUTE OF STEEL CONSTRUCTION

Advanced analysis – AISC 360-16



a) flexural, shear, axial and torsional member deformations, and all other component and connection deformations that contribute to the displacements of the structure

b) Second-order effects (including P- Δ , P- δ and twisting effects)

c) Geometric imperfections

d) stiffness reductions due to inelasticity, including partial yielding of the cross section that may be accentuated by the presence of residual stresses

e) Uncertainty in system, member, and connection strength and stiffness.

IDEA StatiCa[®]

Calculate yesterday's estimates

Covered by use of GMNIA and member consisting of shell elements

GMNIA

Set by the user by using buckling mode shape from LBA analysis

It is not possible to set residual stress in the member. However, using Appendix 1.3.3c, residual stress modeling may be replaced by reduction of the elastic modulus, E, and modulus in shear, G, by 0.8.

Covered by use of geometrical imperfections and stiffness reduction

Initial Imperfections

3b. Geometric Imperfections

Because initial geometric imperfections may affect the nonlinear behavior of a structural system, it is imperative that they be included in the second-order analysis.

Discussion on how frame out-of-plumbness may be modeled is provided in Commentary Section C2.2. Additional information is provided in ECCS (1984), Bridge and Bizzanelli (1997), Bridge (1998), and Ziemian (2010).

Member out-of-straightness should be included in situations in which it can have a significant impact on the inelastic behavior of the structural system. The significance of such effects is a function of (1) the relative magnitude of the member's applied axial force and bending moments, (2) whether the member is subject to single or reverse curvature bending, and (3) the slenderness of the member.

In the development and calibration of the direct analysis method, initial geometric imperfections are conservatively assumed equal to the maximum material, fabrication and erection tolerances permitted in the AISC *Code of Standard Practice* (AISC, 2016a): a member out-of-straightness equal to $L/1,000$, where L is the member length between brace or framing points, and a frame out-of-plumbness equal to $H/500$, where H is the story height. The permitted out-of-plumbness may be smaller in some cases, as specified in the AISC *Code of Standard Practice*.

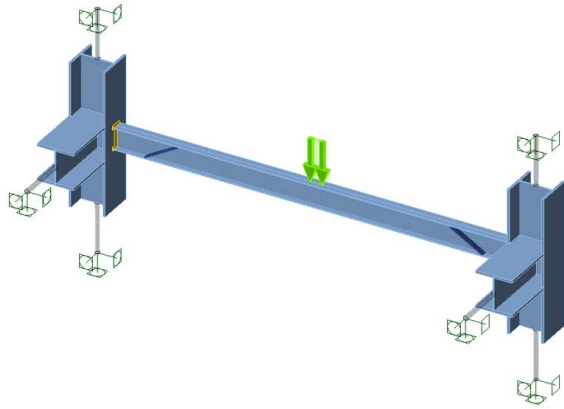
Specification for Structural Steel Buildings, July 7, 2016
AMERICAN INSTITUTE OF STEEL CONSTRUCTION

It is recommended to apply out-of-plumbness in the 3D FEA software and out-of-straightness in [IDEA StatiCa Member](#) application.

Apply out-of-plumbness $H / 500$ in 3D FEA software, out-of-straightness $L / 1000$ in Member and reduce the modulus of elasticity in tension/compression and shear by factor 0.8.

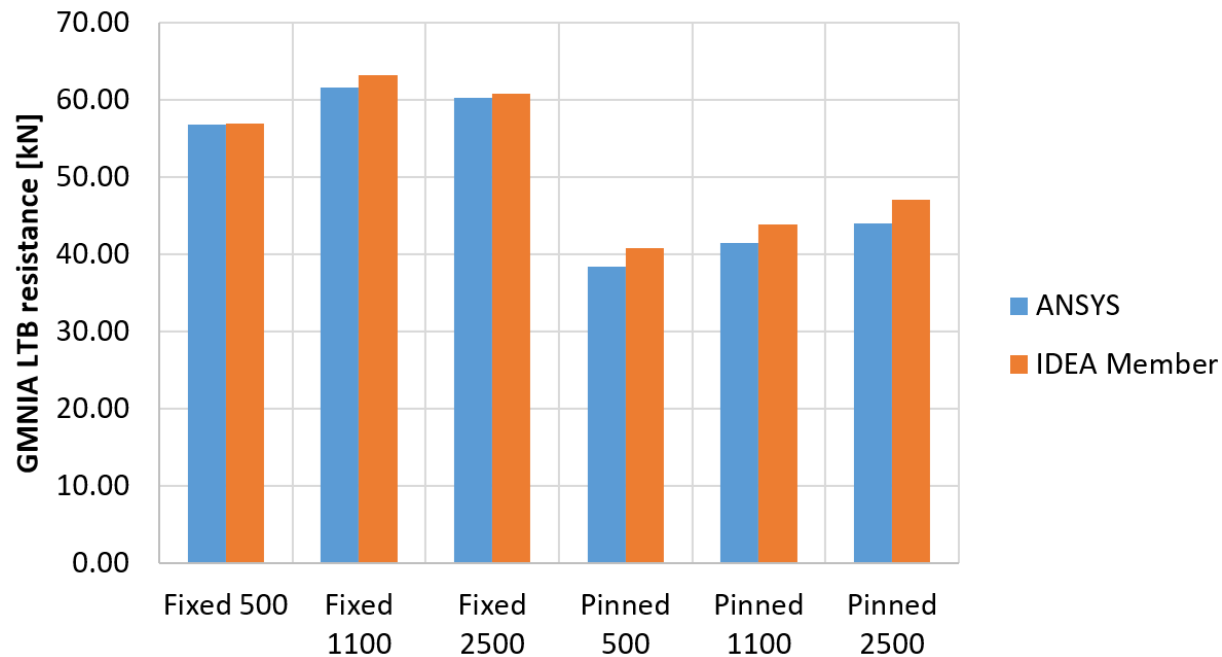
Global and local imperfections papers and studies

- [FEM-based design for global and local buckling interaction of welded box sections](#)
- [On the interaction between local and lateral-torsional buckling of I-shaped. Cuoto, Vilareal, 2019](#)
- [Simulation of geometric imperfections in cold formed steel members](#)



Member app verifications

- <https://www.ideastatica.com/support-center/lateral-torsional-buckling-of-a-beam-with-transverse-stiffeners>
- <https://www.ideastatica.com/support-center-verifications?product=steel&label=member>



Q&A



Thank you!

Visit <https://www.ideastatica.com/support-center-webinars> for previous webinars recording and presentations