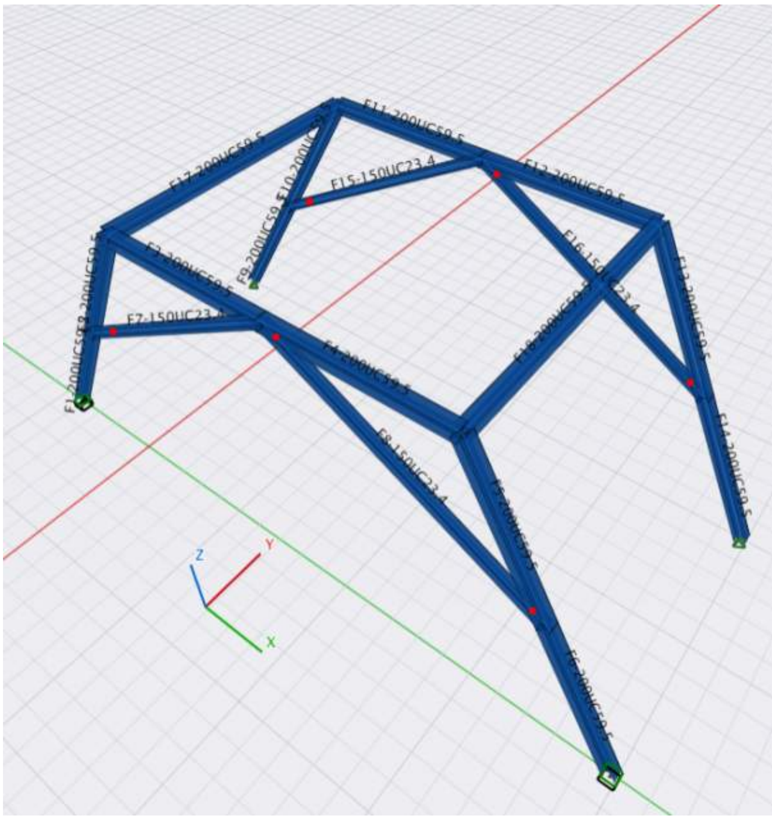
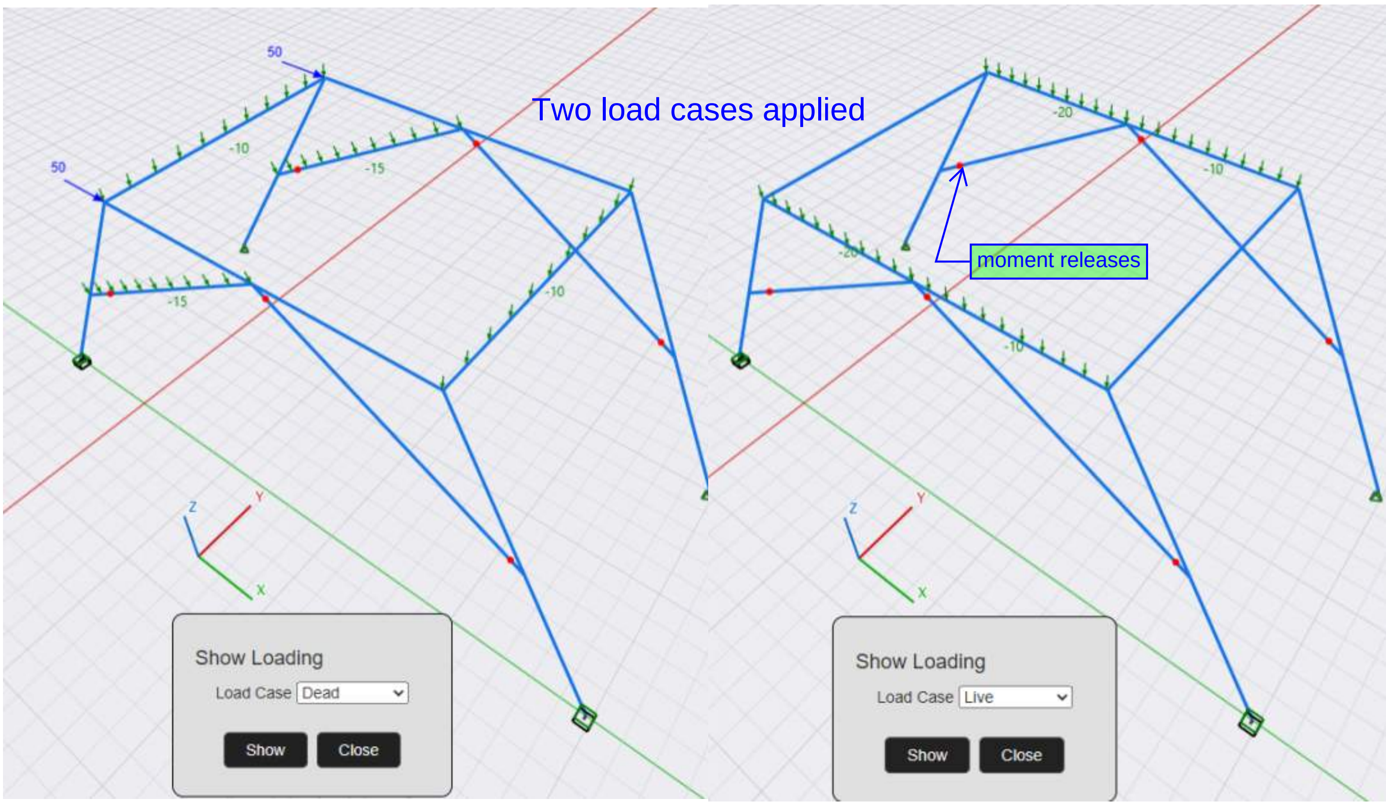
Verification example - FEAKalc 3D vs. ETABS

Verification Statement

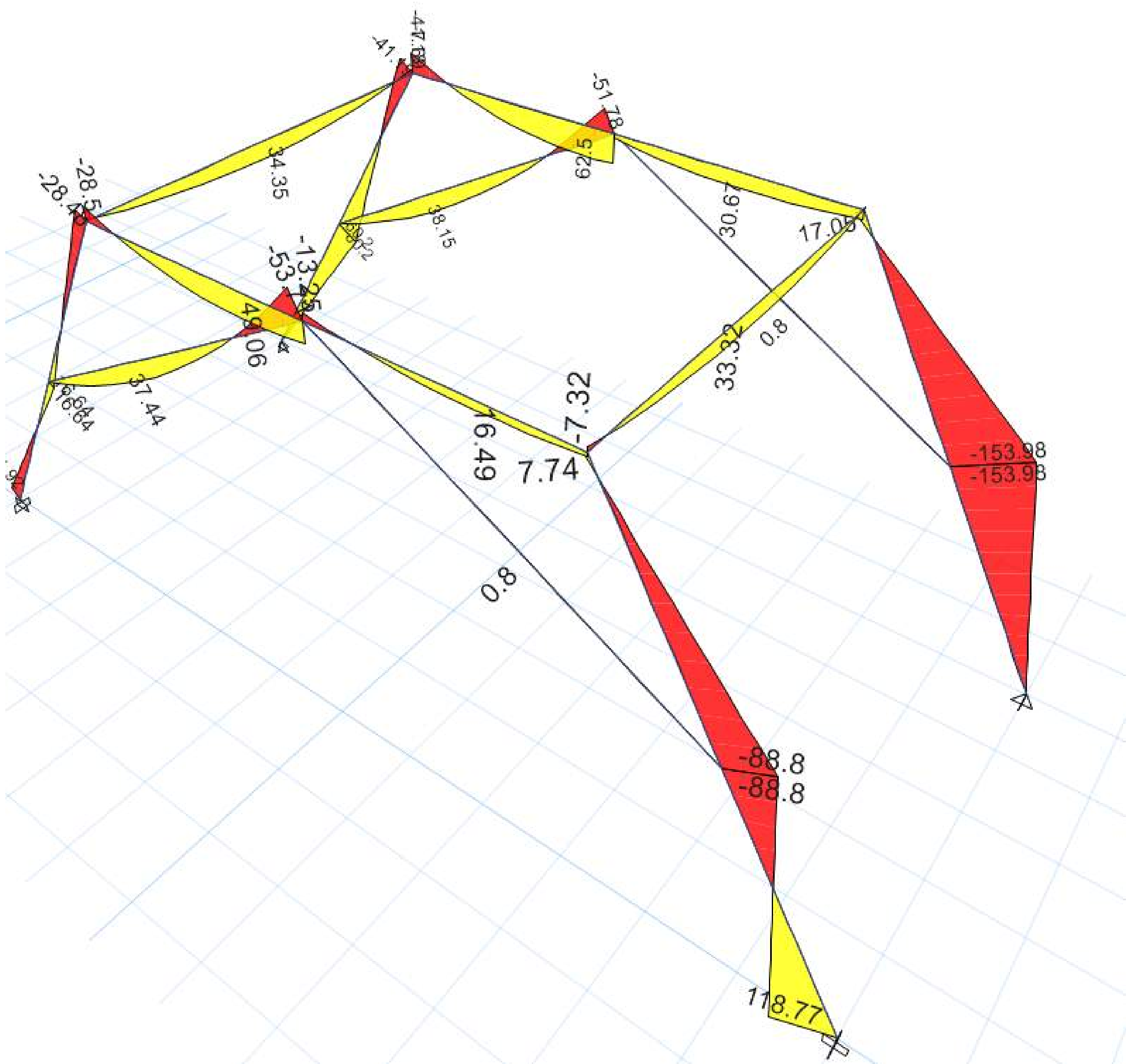
This example compares FEAKalc 3D directly with ETABS for a representative steel space frame. Independent agreement is demonstrated for structural displacements, internal force distributions and support reactions, providing confidence that FEAKalc accurately reproduces established finite element solutions for three-dimensional frame analysis. The comparison validates the underlying finite element implementation rather than a single numerical result, showing consistent behaviour across the entire structural model





LEARNING CENTRE	Analysis Verification	Concrete Frame	By	RK
		FEAKalc 3D Verifications	Sheet No. 2	Date 7/26

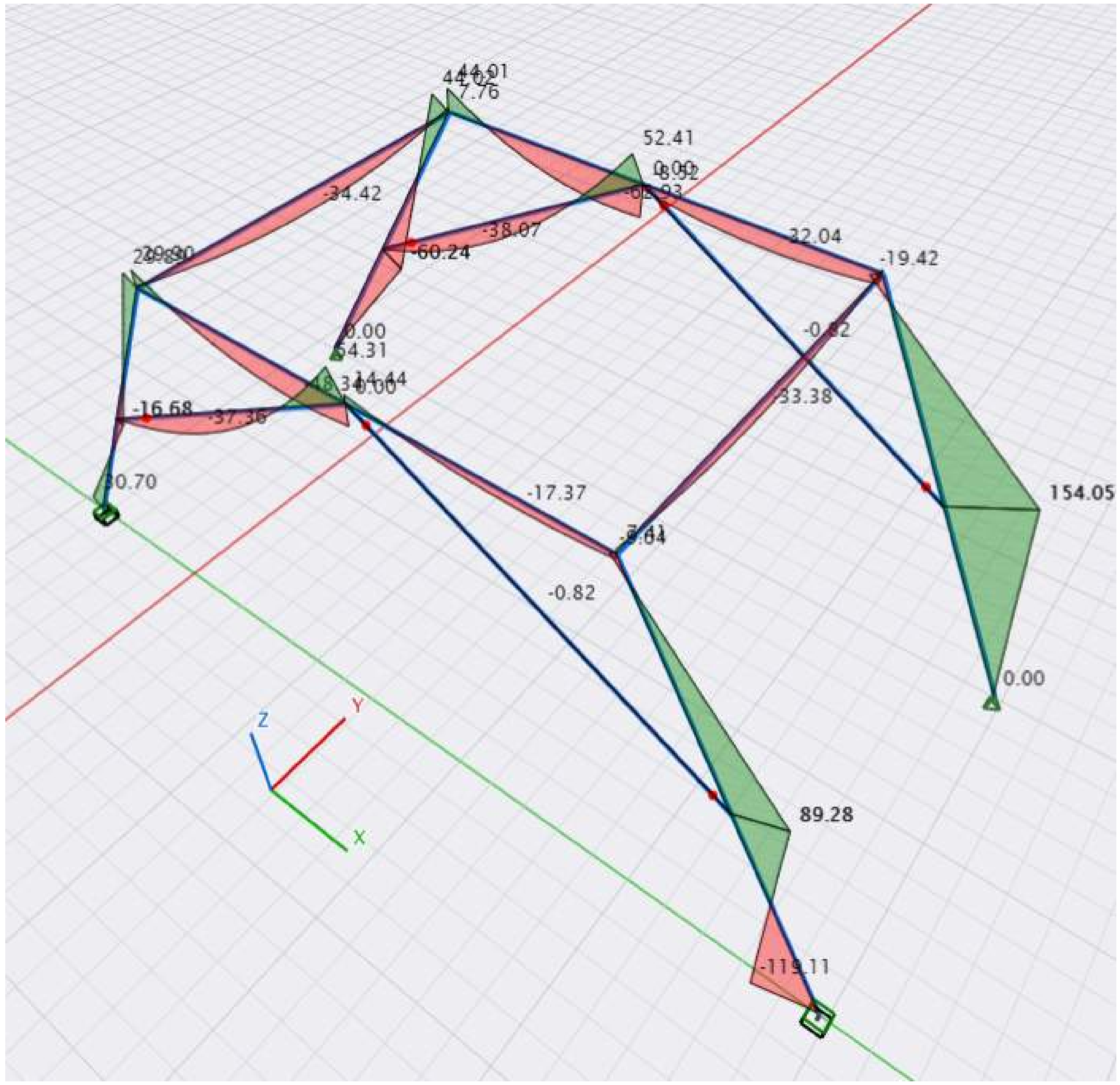
ETABS



Bending Moment Diagram M33

Load Combo : 1.2DL + 1.5LL

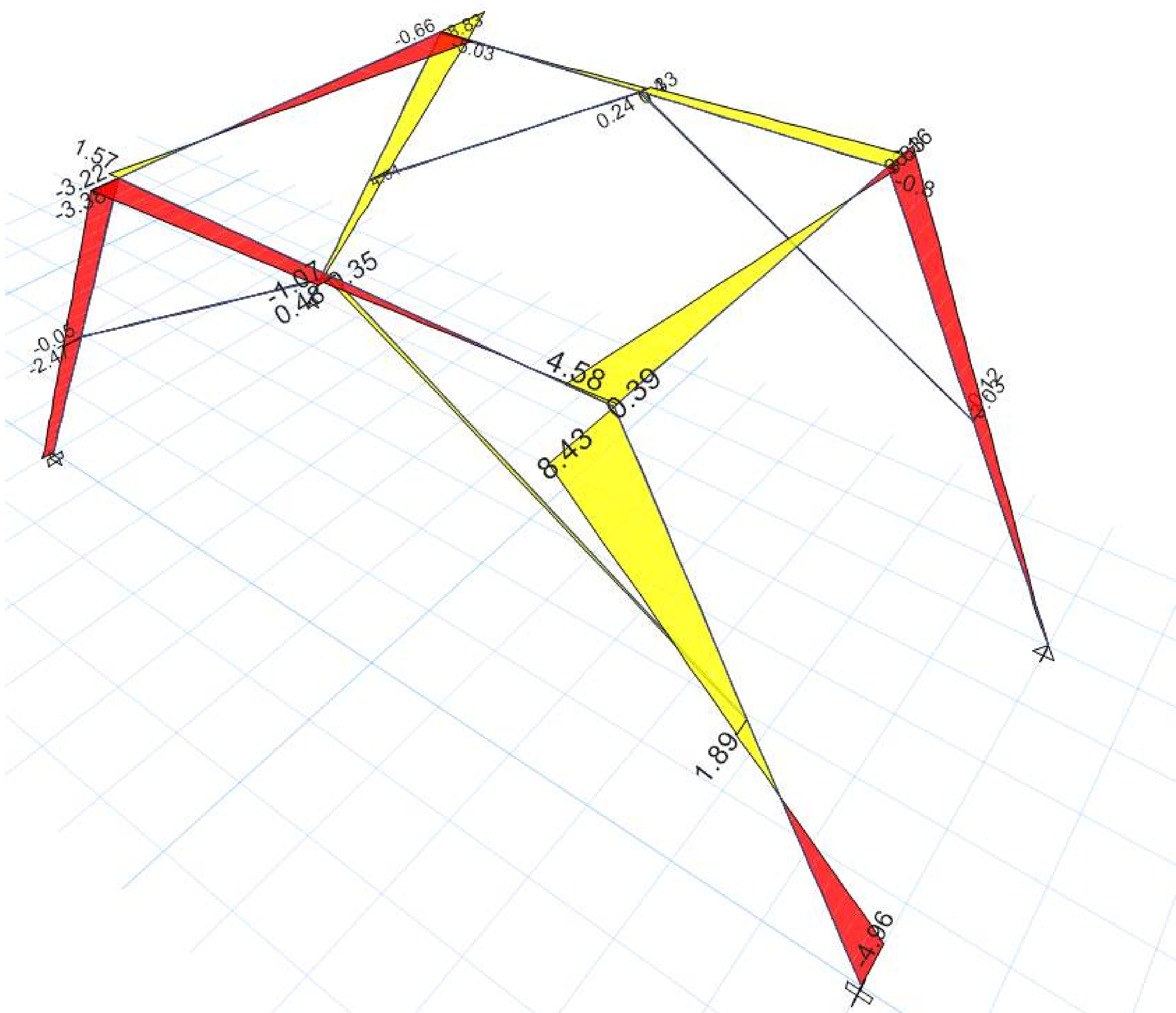
FEAKalc 3D



Bending Moment Diagram M33

Load Combo : 1.2DL + 1.5LL

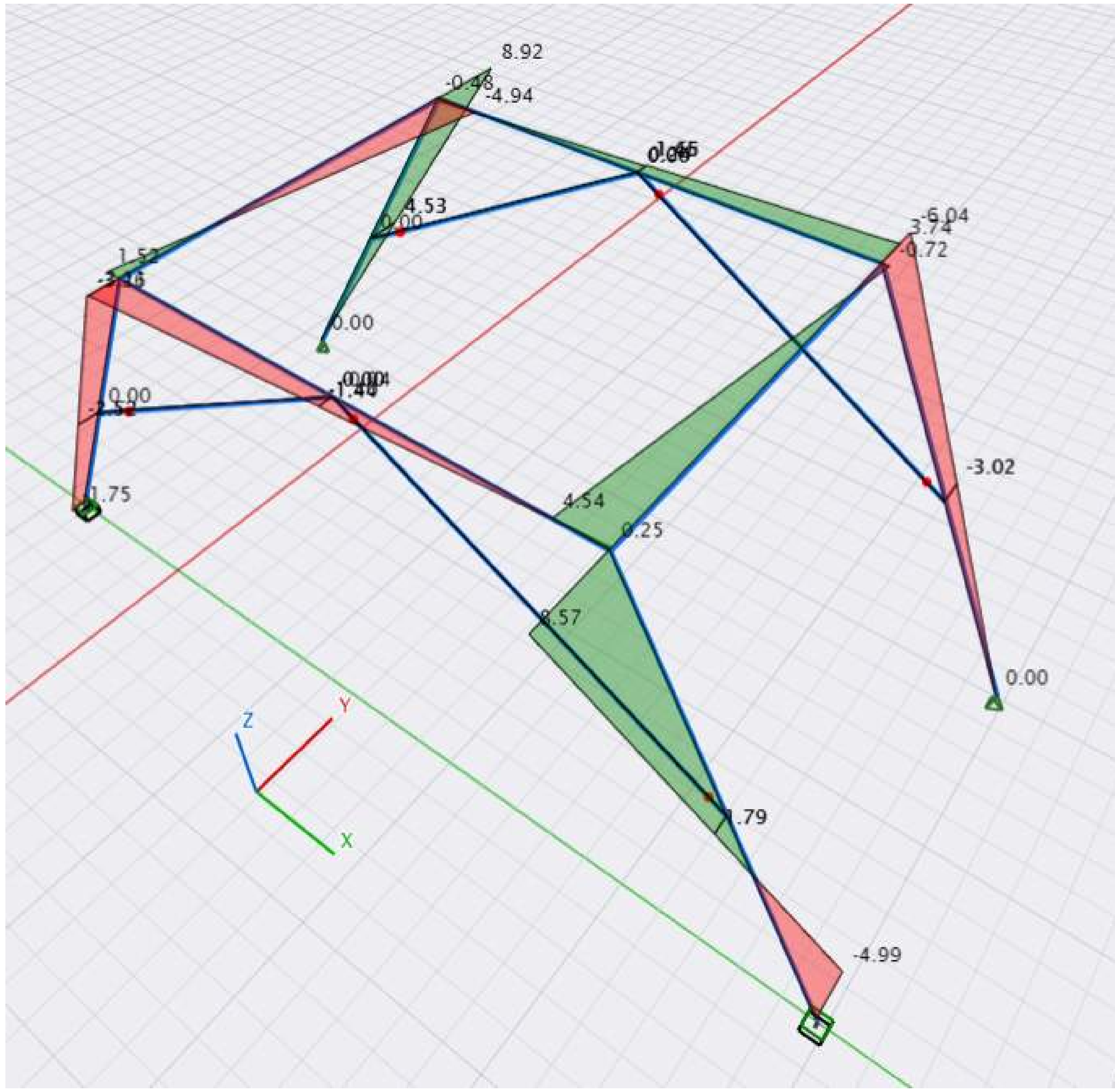
ETABS



Bending Moment Diagram M22

Load Combo : 1.2DL + 1.5LL

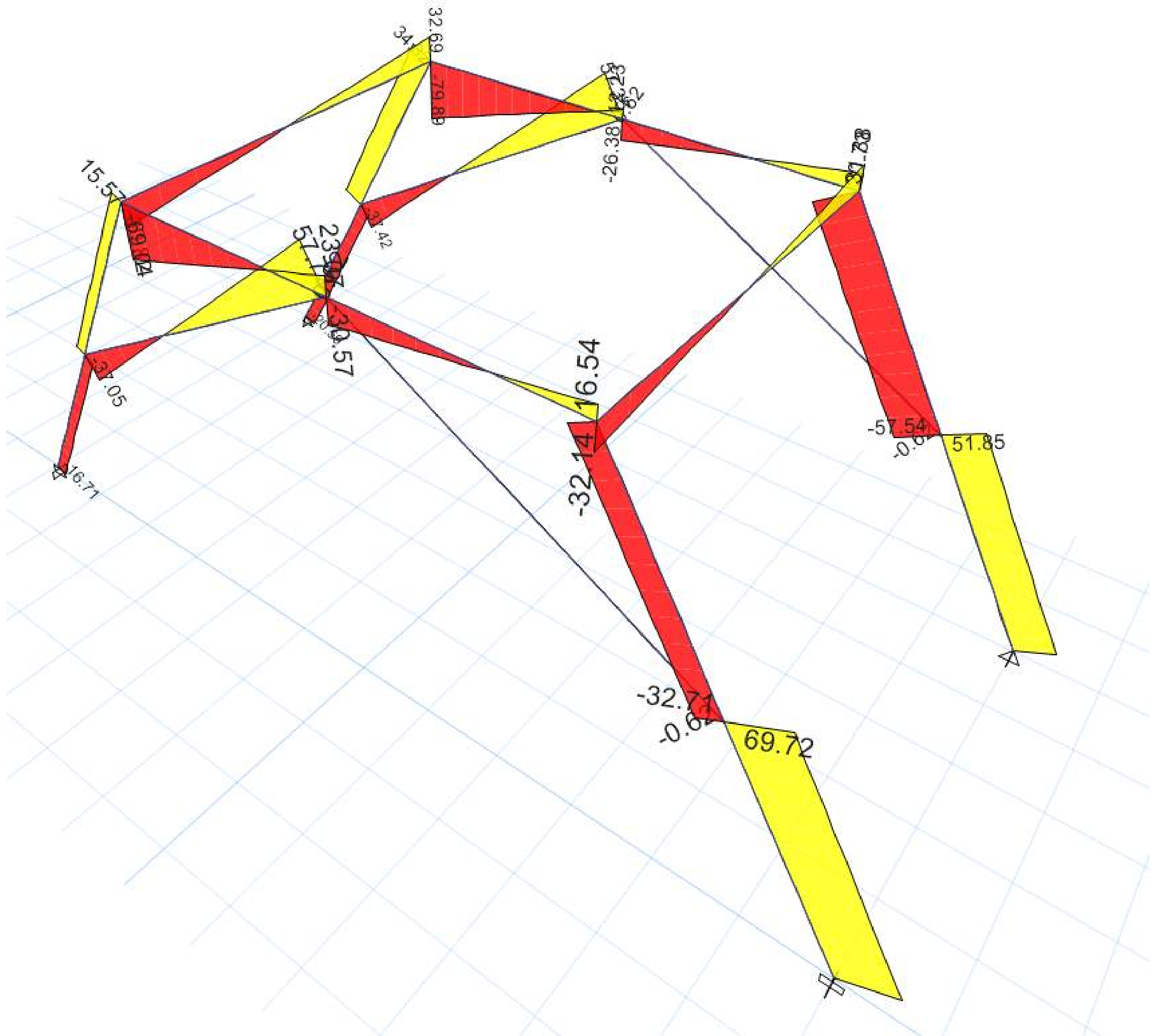
FEAKalc 3D



Bending Moment Diagram M22

Load Combo : 1.2DL + 1.5LL

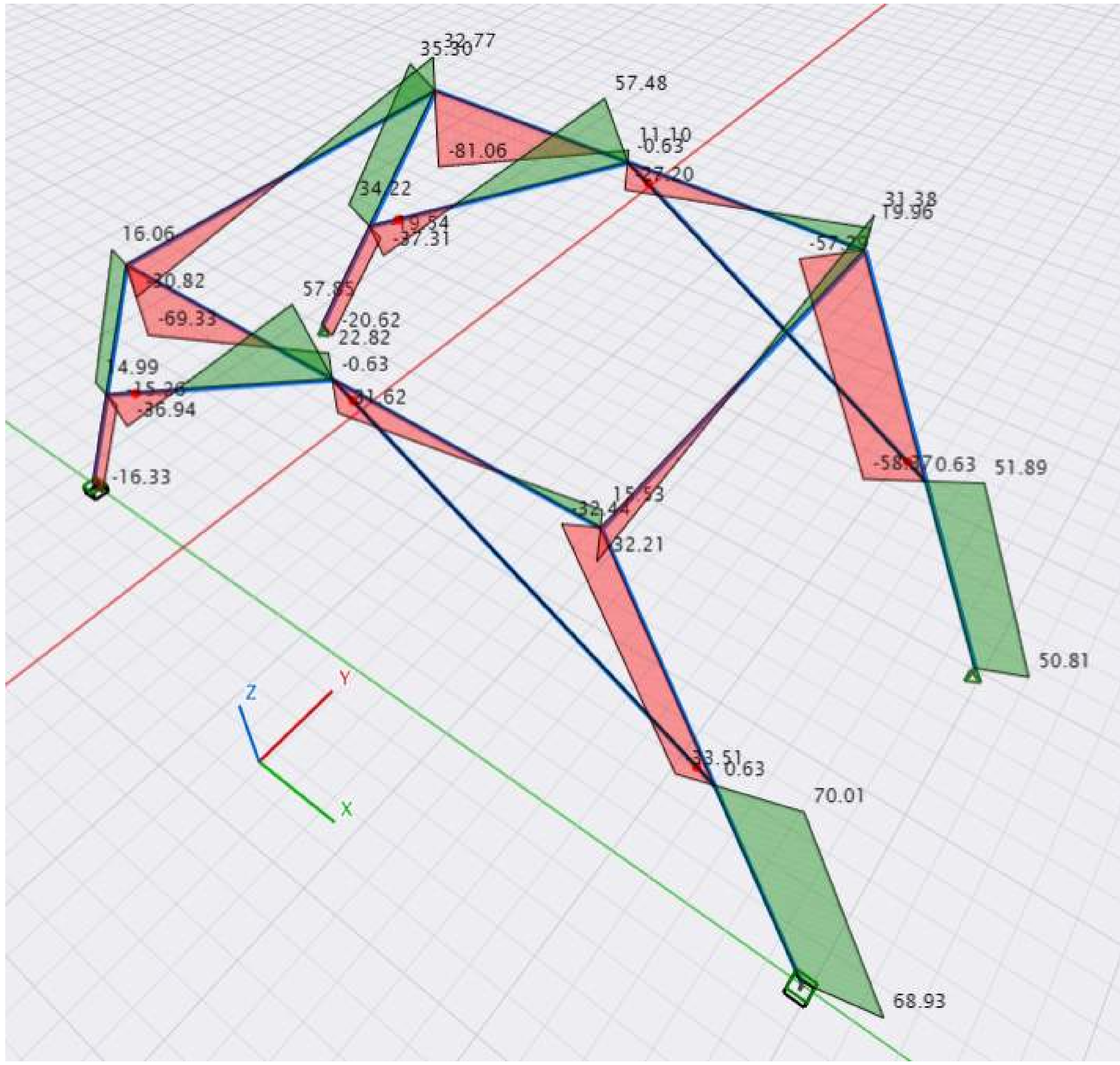
ETABS



Shear Diagram V22

Load Combo : 1.2DL + 1.5LL

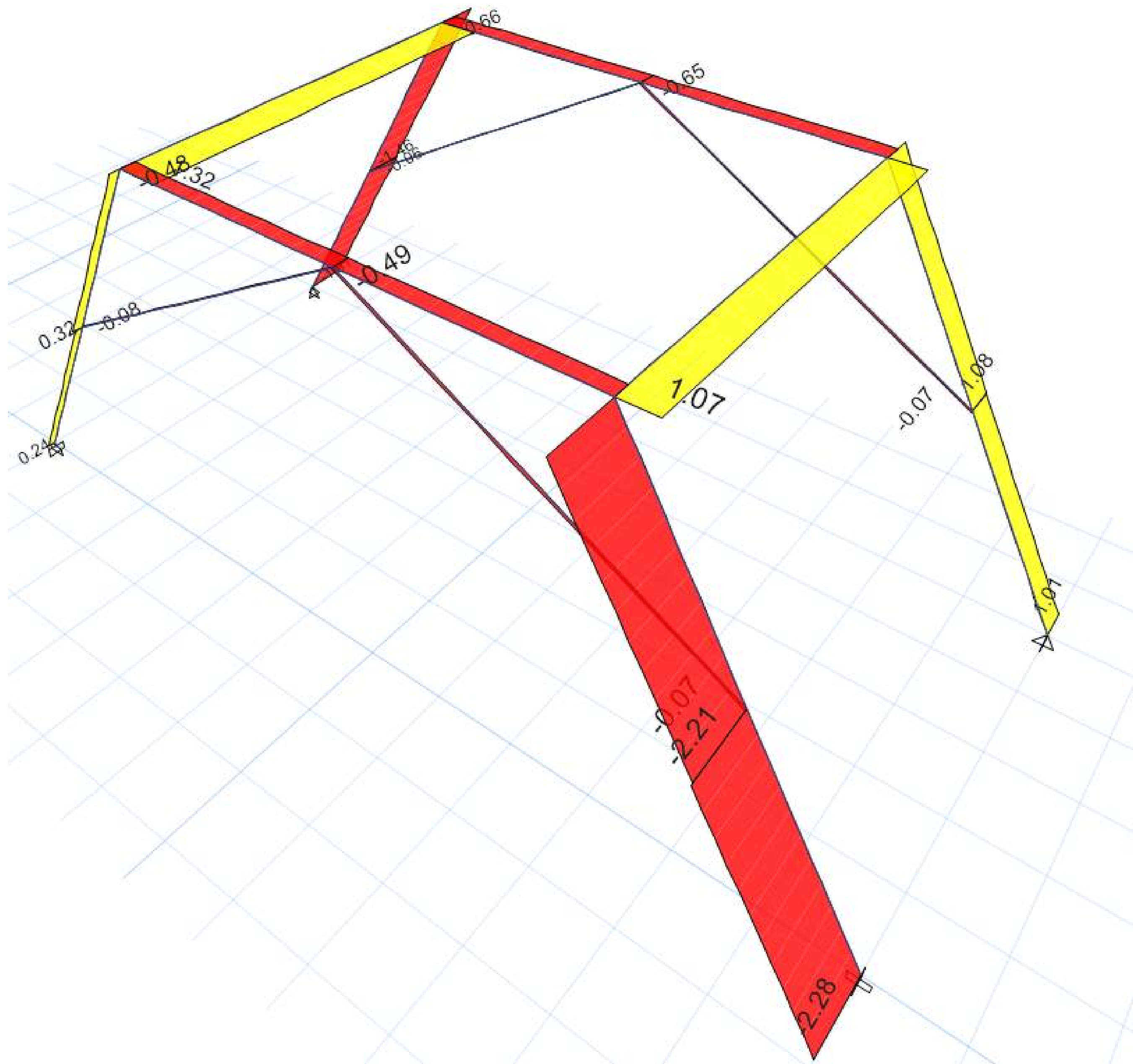
FEAKalc 3D



Shear Diagram V22

Load Combo : 1.2DL + 1.5LL

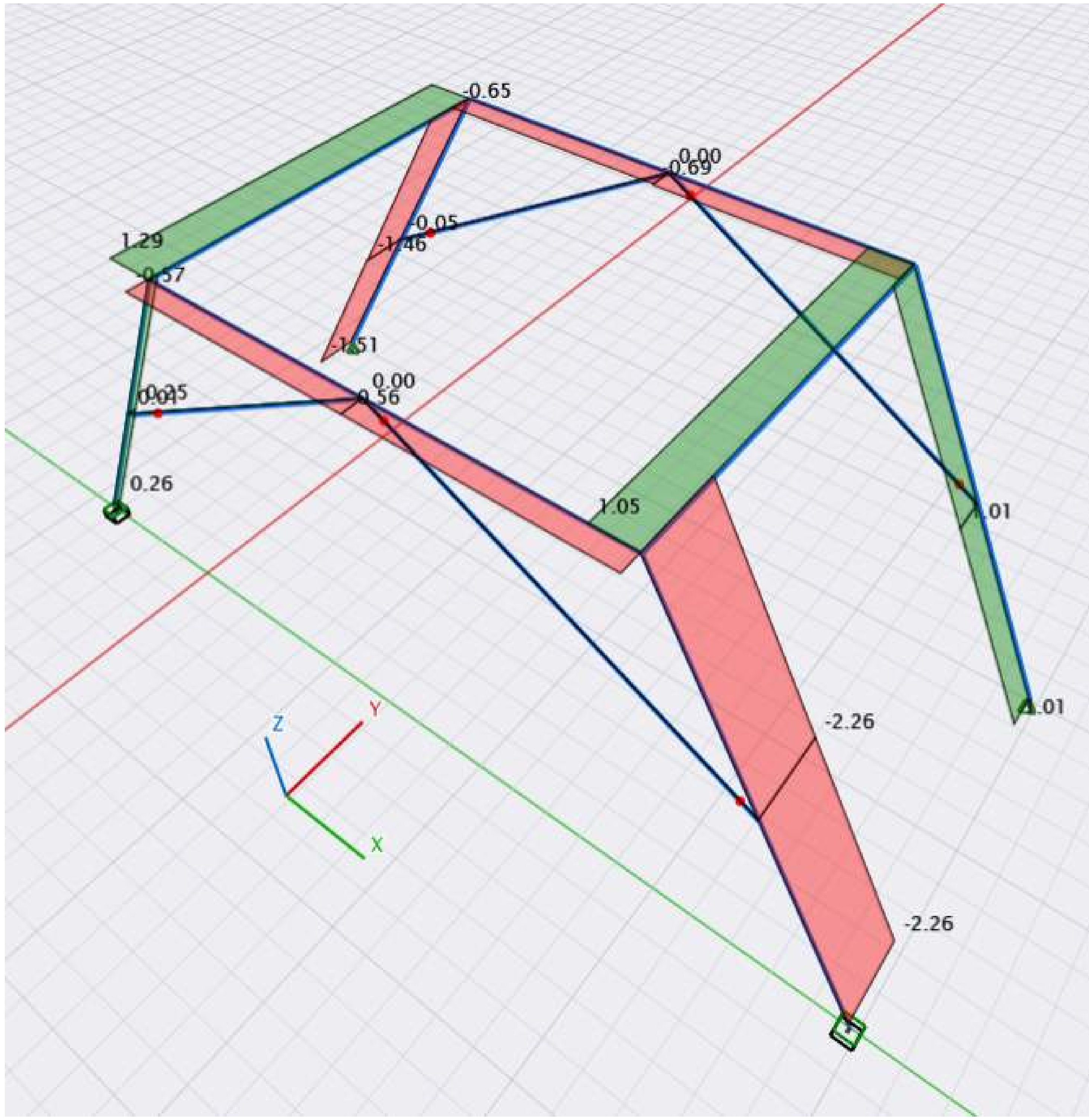
ETABS



Shear Diagram V33

Load Combo : 1.2DL + 1.5LL

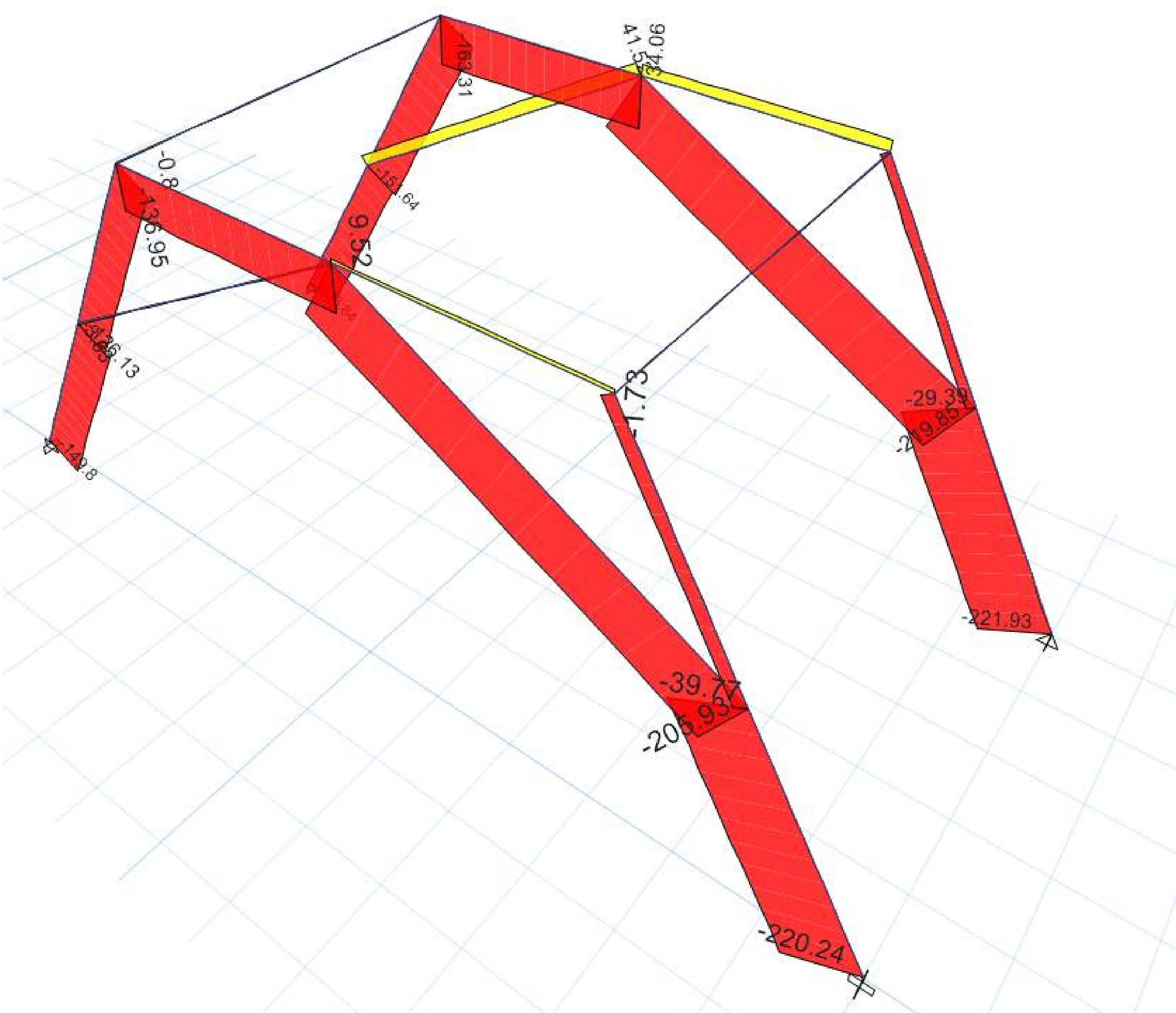
FEAKalc 3D



Shear Diagram V33

Load Combo : 1.2DL + 1.5LL

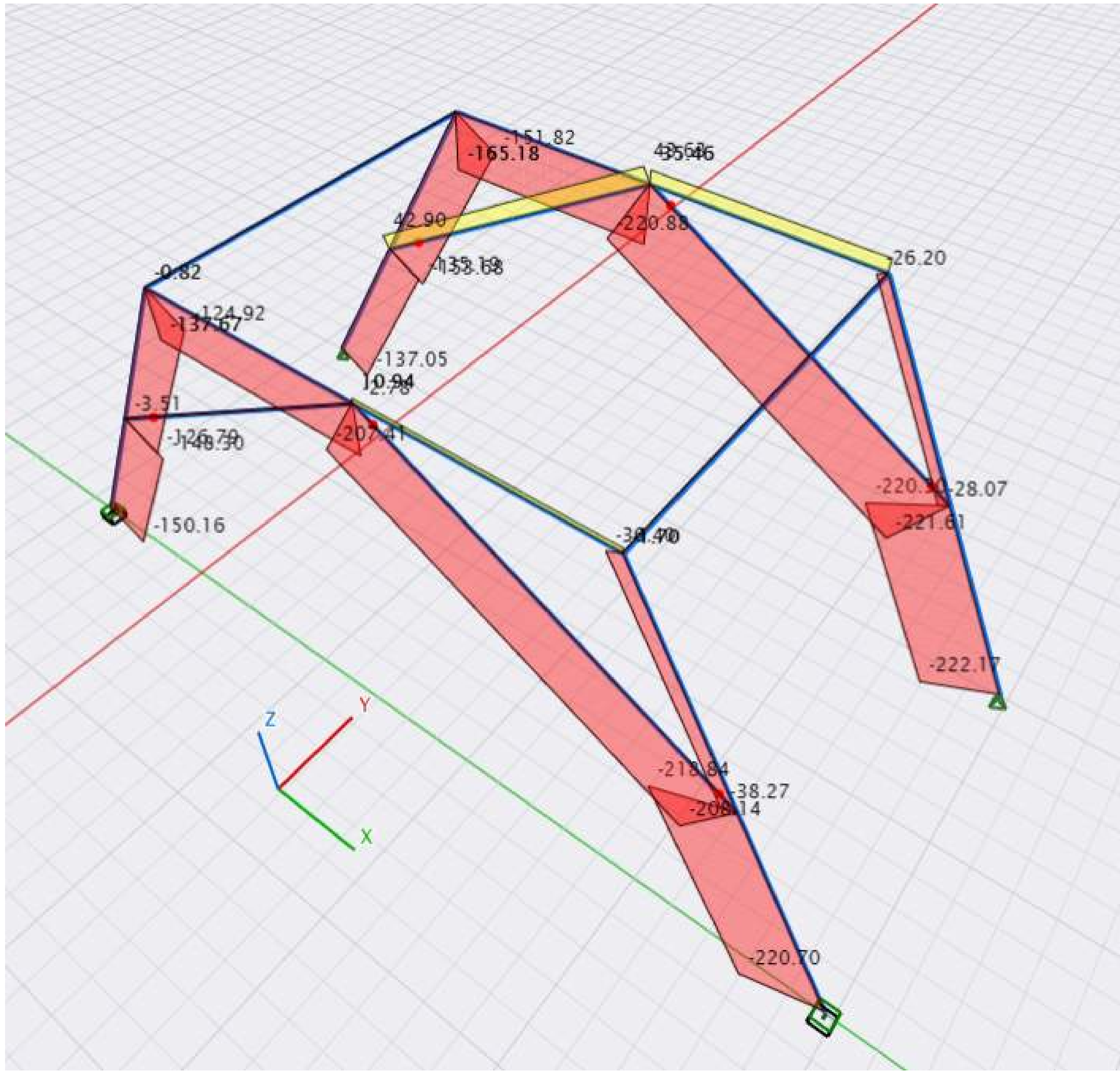
ETABS



Axial Force Diagram

Load Combo : 1.2DL + 1.5LL

FEAKalc 3D



Axial Force Diagram

Load Combo : 1.2DL + 1.5LL

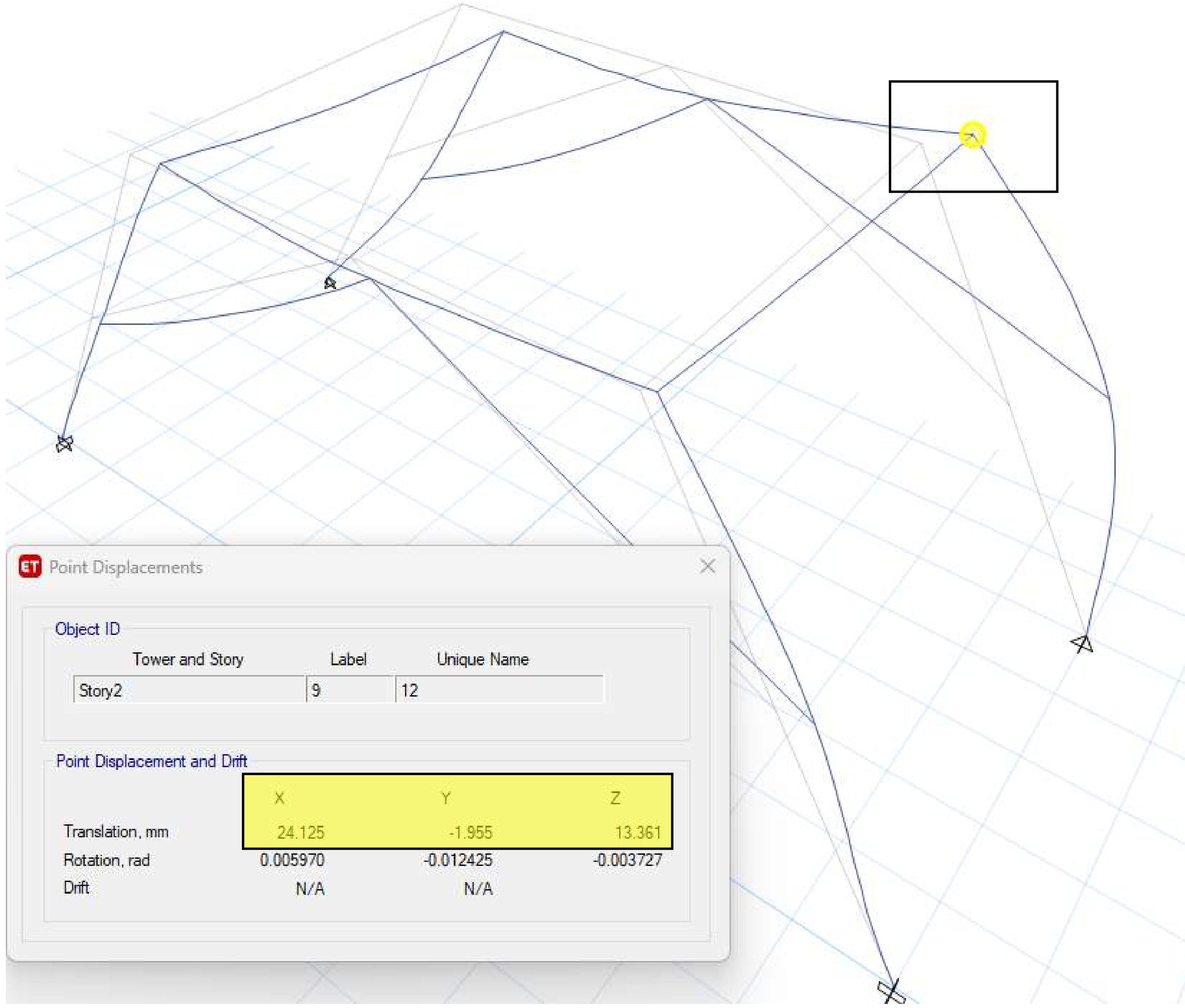
LEARNING CENTRE

RKALC

Analysis Verification

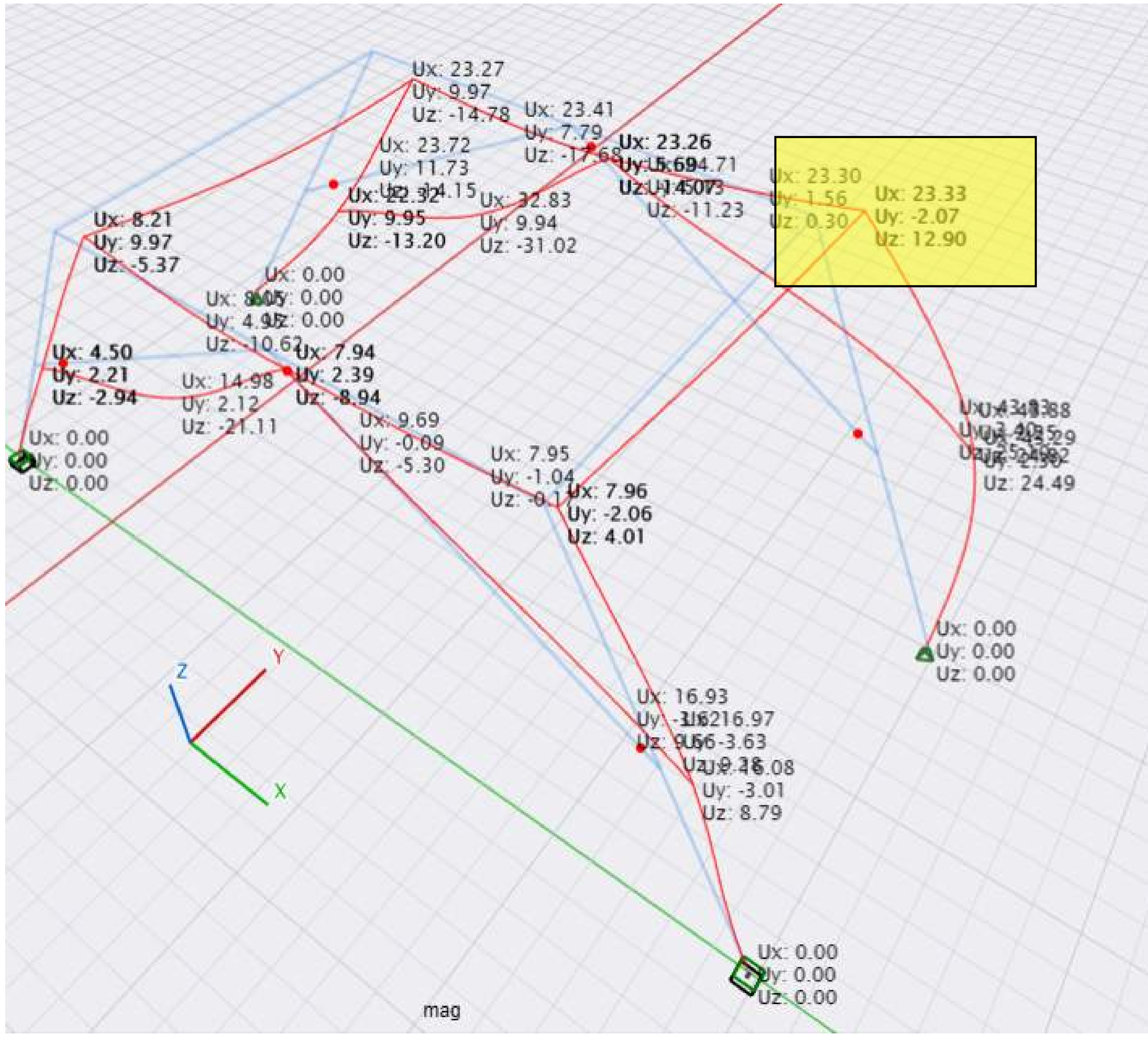
Concrete Frame	By	RK
FEAKalc 3D Verifications	Sheet No. 8	Date 7/26

ETABS



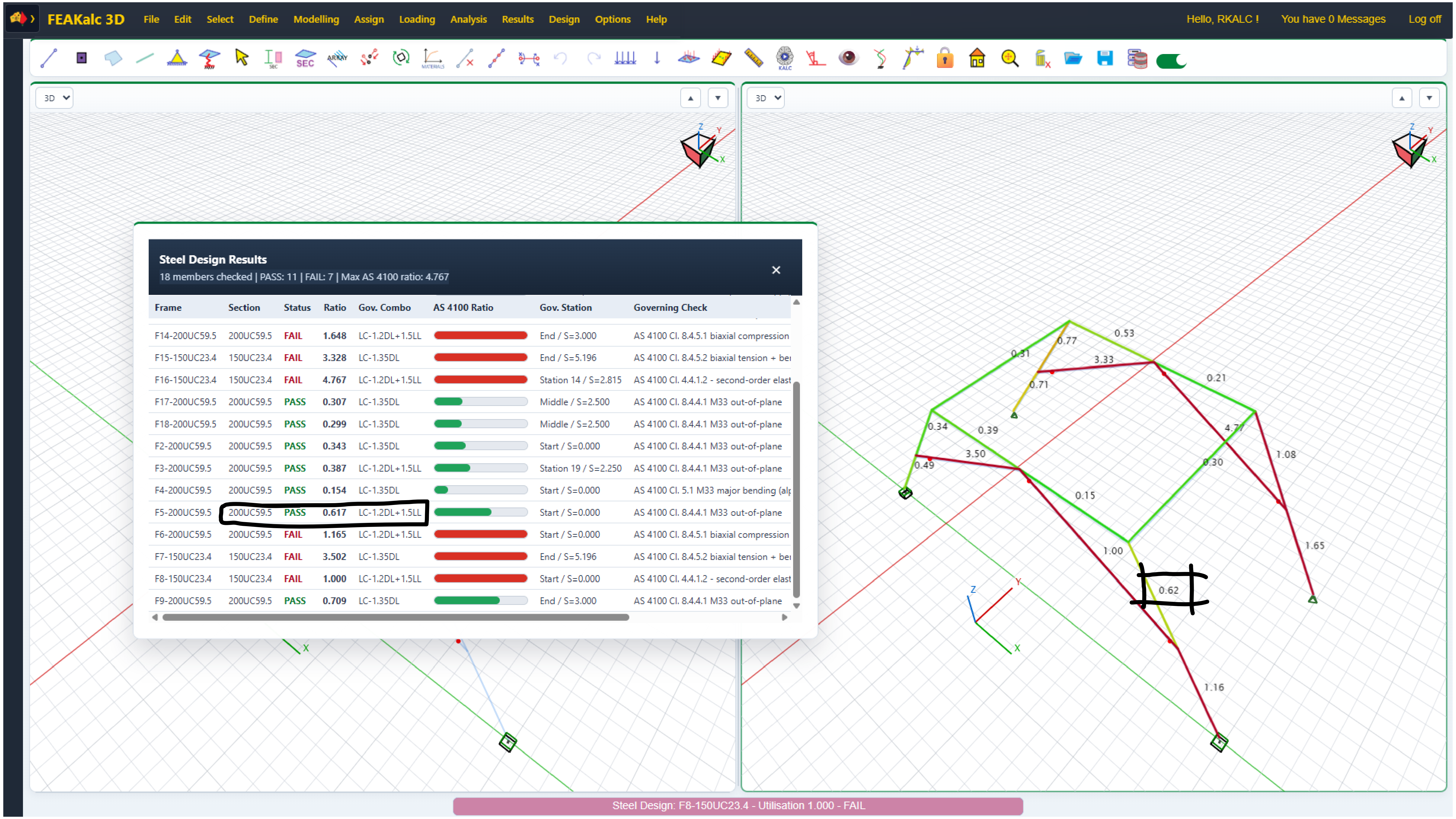
Load Combo : 1.2DL + 1.5LL

FEAKalc 3D



Load Combo : 1.2DL + 1.5LL

Following is user interface - design ratios shown below and deliberately left in case of over-stress, for example



Frame	Section	Status	Ratio	Gov. Combo	AS 4100 Ratio	Gov. Station	Governing Check
F14-200UC59.5	200UC59.5	FAIL	1.648	LC-1.2DL+1.5LL		End / S=3.000	AS 4100 Cl. 8.4.5.1 biaxial compression
F15-150UC23.4	150UC23.4	FAIL	3.328	LC-1.35DL		End / S=5.196	AS 4100 Cl. 8.4.5.2 biaxial tension + bei
F16-150UC23.4	150UC23.4	FAIL	4.767	LC-1.2DL+1.5LL		Station 14 / S=2.815	AS 4100 Cl. 4.4.1.2 - second-order elast
F17-200UC59.5	200UC59.5	PASS	0.307	LC-1.35DL		Middle / S=2.500	AS 4100 Cl. 8.4.4.1 M33 out-of-plane
F18-200UC59.5	200UC59.5	PASS	0.299	LC-1.35DL		Middle / S=2.500	AS 4100 Cl. 8.4.4.1 M33 out-of-plane
F2-200UC59.5	200UC59.5	PASS	0.343	LC-1.35DL		Start / S=0.000	AS 4100 Cl. 8.4.4.1 M33 out-of-plane
F3-200UC59.5	200UC59.5	PASS	0.387	LC-1.2DL+1.5LL		Station 19 / S=2.250	AS 4100 Cl. 8.4.4.1 M33 out-of-plane
F4-200UC59.5	200UC59.5	PASS	0.154	LC-1.35DL		Start / S=0.000	AS 4100 Cl. 5.1 M33 major bending (alp
F5-200UC59.5	200UC59.5	PASS	0.617	LC-1.2DL+1.5LL		Start / S=0.000	AS 4100 Cl. 8.4.4.1 M33 out-of-plane
F6-200UC59.5	200UC59.5	FAIL	1.165	LC-1.2DL+1.5LL		Start / S=0.000	AS 4100 Cl. 8.4.5.1 biaxial compression
F7-150UC23.4	150UC23.4	FAIL	3.502	LC-1.35DL		End / S=5.196	AS 4100 Cl. 8.4.5.2 biaxial tension + bei
F8-150UC23.4	150UC23.4	FAIL	1.000	LC-1.2DL+1.5LL		Start / S=0.000	AS 4100 Cl. 4.4.1.2 - second-order elast
F9-200UC59.5	200UC59.5	PASS	0.709	LC-1.35DL		End / S=3.000	AS 4100 Cl. 8.4.4.1 M33 out-of-plane

Member being checked is subject to N=38.27 / M22= 1.793/ M33=89.283 / V = 33.515

Member capacities shown below

Global Ratios (simplified checks by summing ratios)

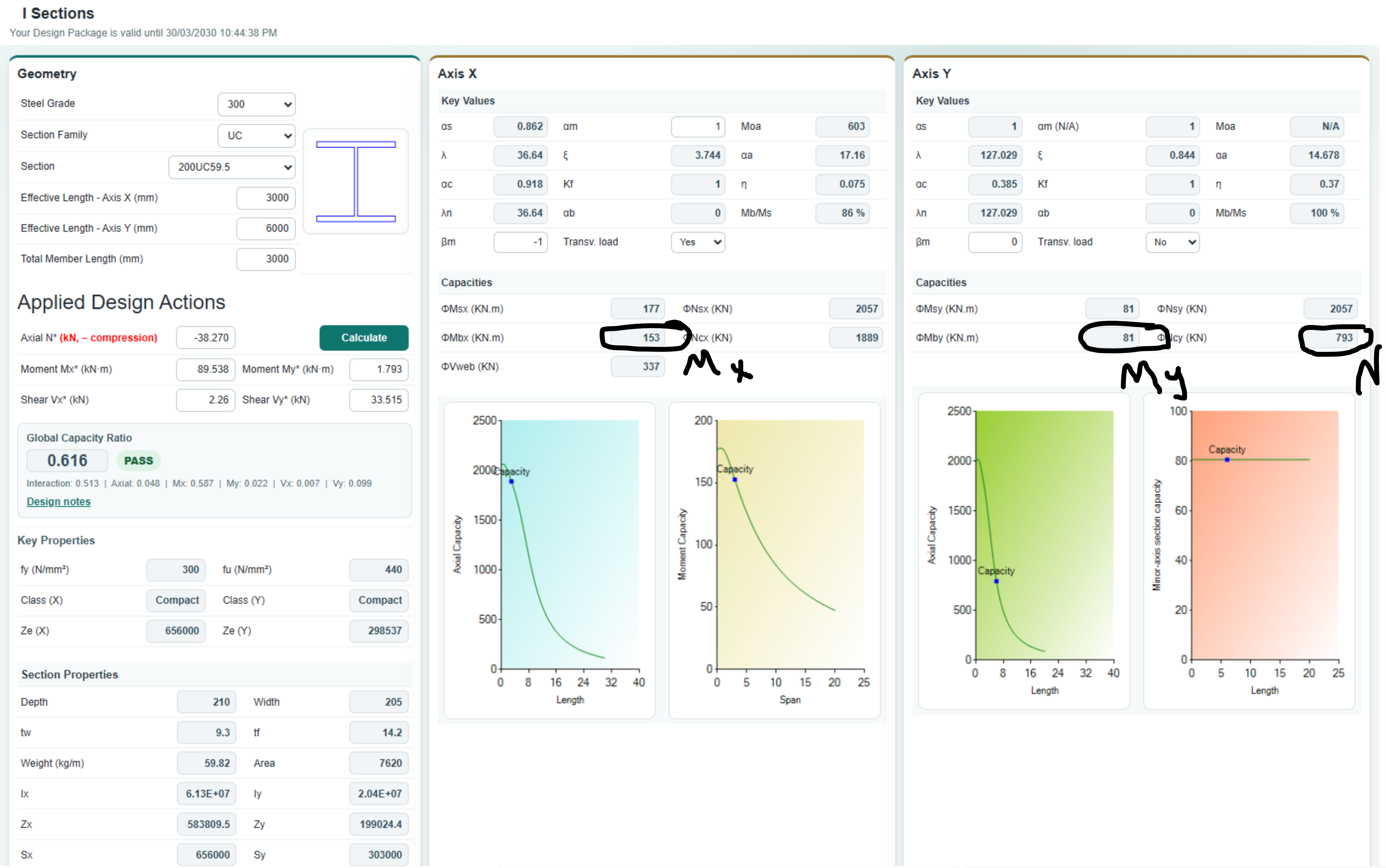
At M33 = 38.27 / 153 = 58.3%

At M22 = 1.793/81 = 2.2%

At N = 38.27 / 793 = 4.8%

≈66%

Note FEAKalc uses articulated AS4100 clauses for combined actions (section 8) therefore 62% utilisation



FEAKalc 3D Steel Design Memo

AS 4100 Steel Member Check - Combined Actions

PASS

Member **F5-200UC59.5**	Section **200UC59.5**	Governing Load Case **LC-1.2DL+1.5LL**
Member Length **3.000 m**	Effective Length 22 **6.000 m**	Effective Length 33 **3.000 m**
LTB Length **Program determined**	β22 **2.000**	β33 **1.000**
βm M33 **-1.000**	βm M22 **-0.209**	cm M33 **1.000**
cm M22 **0.684**	δb M33 **1.003**	δb M22 **1.000**
δm M33 **1.003**	δm M22 **1.000**	Second-order analysis required **No**
Section 8 Method **Compact-section alternative where permitted**	Axial Action **Compression**	AS 4100 Governing Ratio **0.617**
Governing Station **Start**	Governing Check **AS 4100 Cl. 8.4.4.1 M33 out-of-plane**	

Governing Design Actions

Action	Value
Station	Start
S	0.000 m
N*	-38.270 kN
M33 first-order	89.283 kNm
M22 first-order	1.793 kNm
M33* amplified design moment	89.538 kNm
M22* amplified design moment	1.793 kNm
V2*	-2.260 kN
V3*	-33.515 kN
T*	-0.001 kNm

AS 4100 Clause 4.4 Moment Amplification

Item	M33 / x	M22 / y
βm	-1.000	-0.209
cm	1.000	0.684
Nomb	13445.186 kN	1118.604 kN
δb	1.003	1.000
δs	1.000	1.000
δm = max(δb, δs)	**1.003**	**1.000**
Transverse member load detected	Yes	No
Second-order elastic analysis required by Cl. 4.4.1.2	No	

AS 4100 Combined-Action Checks

Check	AS 4100 Ratio
Axial capacity	0.048
Clause 8.3 section capacity / interaction (compact alternative)	**0.384**
Clause 8.4.2 M33 in-plane (compact alternative where eligible)	0.516
Clause 8.4.2 M22 in-plane (compact alternative where eligible)	0.023
Clause 8.4.4 M33 out-of-plane	0.617
Clause 8.4.5 combined member	**0.513**
Clause 5.12.3 M33 + V3 shear/bending	**0.099**
Clause 5.11 V2 shear	0.007
Clause 5.11 V3 shear	0.099
Governing Section 8 interaction	**0.513**

Clause 8.4.5 equation: (M33*/φMcx)^1.4 + (M22*/φMiy)^1.4 ≤ 1
AS 4100 ratio convention: Powered Clause 8.3.4 and 8.4.5 equations are reported as their actual left-hand-side value with a unity limit. No exponent-root normalisation is applied.
Section 8 method: Compact-section alternative where permitted.
Clause 5.12.3 shear/bending: $\varphi V_{vm} = \varphi V_v$ for $M^* \leq 0.75\varphi M_s$; otherwise $\varphi V_{vm} = \varphi V_v[2.2 - 1.6M^*/(\varphi M_s)]$ up to $M^* = \varphi M_s$. FEAKalc pairs M33 with local V3.
Second-order action effect: Clause 4.4 amplification is applied to the first-order moments before the Section 5 and Section 8 checks. $\delta_m = \max(\delta_b, \delta_s)$.
LTB moment modification: Clause 5.6 α_m = 1.000. This is a capacity factor and is separate from Clause 4.4 moment amplification.
Sway amplification: δ_s defaults to 1.0 unless a frame/storey sway factor is supplied. A sway frame still requires Clause 4.4.2.3 or a second-order elastic analysis where applicable.
For Clause 8.4.2.2, the in-plane compression capacities use k_e = 1.0 unless the supplied braced effective length is lower than the actual member length.

Design Capacities (φ already applied)

Capacity	Value
φNs - compression section capacity	2057.400 kN
φNt - gross tension yielding	2057.400 kN
φNcx - compression member, x	1889.297 kN
φNcy - compression member, y	793.045 kN
φNc - governing compression member	793.045 kN
φNcx - Clause 8.4.2 in-plane	1889.300 kN
φNcy - Clause 8.4.2 in-plane	1622.003 kN
φMsx	177.120 kNm
φMsy	80.605 kNm
φMbx - major-axis member bending	152.586 kNm
φMrx - Clause 8.3.2	177.120 kNm
φMry - Clause 8.3.3	80.605 kNm
φMix - Clause 8.4.2.2	173.532 kNm
φMiy - Clause 8.4.2.2	79.648 kNm
φMox - Clause 8.4.4	145.222 kNm
φNoz - torsional buckling capacity	0.000 kN
αbc - Clause 8.4.4.1 compact I-section	0.000
φMcx = min(φMix, φMox)	145.222 kNm
φMtx - tension major-axis combined capacity	152.586 kNm
φVv - web shear alone (Cl. 5.11)	337.478 kN
Cl. 5.12.3 shear reduction factor	1.000
φVvm - M33 + V3 shear/bending	337.478 kN
M33 exceeds φMs range of Cl. 5.12.3	No

Section Classification

Major axis class	Compact
Minor axis class	Compact
λ web	22.092
λ flange	7.549
Kf	1.000
Compact Section 8 concession eligible	Yes
Compact Section 8 concession used	Yes
M33 transverse load detected	Yes
M22 transverse load detected	No

Applied Actions at Stations

Station	S m	N* kN	M33* kNm	M22* kNm	V3* kN	V2* kN	T* kNm
Start	0.000	-38.270	89.538	1.793	-33.515	-2.260	-0.001
Station 2	0.125	-38.193	85.340	2.075	-33.470	-2.260	-0.001
Station 3	0.250	-38.115	81.147	2.358	-33.425	-2.260	-0.001
Station 4	0.375	-38.037	76.960	2.641	-33.380	-2.260	-0.001
Station 5	0.500	-37.959	72.778	2.923	-33.335	-2.260	-0.001
Station 6	0.625	-37.882	68.602	3.206	-33.291	-2.260	-0.001
Station 7	0.750	-37.804	64.432	3.488	-33.246	-2.260	-0.001
Station 8	0.875	-37.726	60.267	3.771	-33.201	-2.260	-0.001
Station 9	1.000	-37.649	56.109	4.053	-33.156	-2.260	-0.001
Station 10	1.125	-37.571	51.955	4.336	-33.111	-2.260	-0.001
Station 11	1.250	-37.493	47.807	4.618	-33.066	-2.260	-0.001
Station 12	1.375	-37.415	43.665	4.901	-33.021	-2.260	-0.001
Middle	1.500	-37.337	39.528	5.184	-32.976	-2.260	-0.001
Station 14	1.625	-37.260	35.398	5.466	-32.931	-2.260	-0.001
Station 15	1.750	-37.182	31.272	5.749	-32.886	-2.260	-0.001
Station 16	1.875	-37.104	27.153	6.031	-32.842	-2.260	-0.001
Station 17	2.000	-37.027	23.039	6.314	-32.797	-2.260	-0.001
Station 18	2.125	-36.949	18.930	6.596	-32.752	-2.260	-0.001
Station 19	2.250	-36.871	14.828	6.879	-32.707	-2.260	-0.001
Station 20	2.375	-36.793	10.730	7.161	-32.662	-2.260	-0.001
Station 21	2.500	-36.716	6.639	7.444	-32.617	-2.260	-0.001
Station 22	2.625	-36.638	2.553	7.726	-32.572	-2.260	-0.001
Station 23	2.750	-36.560	-1.527	8.009	-32.527	-2.260	-0.001
Station 24	2.875	-36.482	-5.602	8.292	-32.483	-2.260	-0.001
End	3.000	-36.405	-9.671	8.574	-32.438	-2.260	-0.001

Station-by-Station AS 4100 Check

Station	S	Status	Ratio	Axial	Cl. 8.3	Cl. 8.4.2 M33	Cl. 8.4.2 M22	Cl. 8.4.4	Cl. 8.4.5	Cl. 5.12.3 M33/V3	Governing Check
Start	0.000	PASS	**0.617**	0.048	0.384	0.516	0.023	0.617	0.513	0.099	AS 4100 Cl. 8.4.4.1 M33 out-of-plane
Station 2	0.125	PASS	**0.588**	0.048	0.361	0.492	0.026	0.588	0.481	0.099	AS 4100 Cl. 8.4.4.1 M33 out-of-plane
Station 3	0.250	PASS	**0.559**	0.048	0.337	0.468	0.030	0.559	0.450	0.099	AS 4100 Cl. 8.4.4.1 M33 out-of-plane
Station 4	0.375	PASS	**0.530**	0.048	0.314	0.443	0.033	0.530	0.419	0.099	AS 4100 Cl. 8.4.4.1 M33 out-of-plane
Station 5	0.500	PASS	**0.501**	0.048	0.292	0.419	0.037	0.501	0.390	0.099	AS 4100 Cl. 8.4.4.1 M33 out-of-plane
Station 6	0.625	PASS	**0.472**	0.048	0.271	0.395	0.040	0.472	0.361	0.099	AS 4100 Cl. 8.4.4.1 M33 out-of-plane
Station 7	0.750	PASS	**0.443**	0.048	0.250	0.371	0.044	0.443	0.333	0.099	AS 4100 Cl. 8.4.4.1 M33 out-of-plane
Station 8	0.875	PASS	**0.415**	0.048	0.230	0.347	0.047	0.415	0.306	0.098	AS 4100 Cl. 8.4.4.1 M33 out-of-plane
Station 9	1.000	PASS	**0.386**	0.047	0.210	0.323	0.051	0.386	0.279	0.098	AS 4100 Cl. 8.4.4.1 M33 out-of-plane
Station 10	1.125	PASS	**0.357**	0.047	0.191	0.299	0.054	0.357	0.254	0.098	AS 4100 Cl. 8.4.4.1 M33 out-of-plane
Station 11	1.250	PASS	**0.329**	0.047	0.173	0.275	0.058	0.329	0.229	0.098	AS 4100 Cl. 8.4.4.1 M33 out-of-plane
Station 12	1.375	PASS	**0.300**	0.047	0.156	0.252	0.062	0.300	0.206	0.098	AS 4100 Cl. 8.4.4.1 M33 out-of-plane
Middle	1.500	PASS	**0.272**	0.047	0.140	0.228	0.065	0.272	0.183	0.098	AS 4100 Cl. 8.4.4.1 M33 out-of-plane
Station 14	1.625	PASS	**0.243**	0.047	0.124	0.204	0.069	0.243	0.162	0.098	AS 4100 Cl. 8.4.4.1 M33 out-of-plane
Station 15	1.750	PASS	**0.215**	0.047	0.109	0.180	0.072	0.215	0.141	0.097	AS 4100 Cl. 8.4.4.1 M33 out-of-plane

Station	S	Status	Ratio	Axial	Cl. 8.3	Cl. 8.4.2 M33	Cl. 8.4.2 M22	Cl. 8.4.4	Cl. 8.4.5	Cl. 5.12.3 M33/V3	Governing Check
Station 16	1.875	PASS	**0.187**	0.047	0.095	0.156	0.076	0.187	0.122	0.097	AS 4100 Cl. 8.4.4.1 M33 out-of-plane
Station 17	2.000	PASS	**0.158**	0.047	0.082	0.133	0.079	0.158	0.105	0.097	AS 4100 Cl. 8.4.4.1 M33 out-of-plane
Station 18	2.125	PASS	**0.130**	0.047	0.071	0.109	0.083	0.130	0.088	0.097	AS 4100 Cl. 8.4.4.1 M33 out-of-plane
Station 19	2.250	PASS	**0.102**	0.046	0.060	0.085	0.086	0.102	0.073	0.097	AS 4100 Cl. 8.4.4.1 M33 out-of-plane
Station 20	2.375	PASS	**0.097**	0.046	0.051	0.062	0.090	0.074	0.060	0.097	AS 4100 Cl. 5.11 V3 shear
Station 21	2.500	PASS	**0.097**	0.046	0.044	0.038	0.093	0.046	0.049	0.097	AS 4100 Cl. 5.11 V3 shear
Station 22	2.625	PASS	**0.097**	0.046	0.038	0.015	0.097	0.018	0.042	0.097	AS 4100 Cl. 8.4.2.2 M22 compact in-plane
Station 23	2.750	PASS	**0.100**	0.046	0.039	0.009	0.100	0.010	0.042	0.096	AS 4100 Cl. 8.4.2.2 M22 compact in-plane
Station 24	2.875	PASS	**0.104**	0.046	0.047	0.032	0.104	0.038	0.053	0.096	AS 4100 Cl. 8.4.2.2 M22 compact in-plane
End	3.000	PASS	**0.108**	0.046	0.058	0.056	0.108	0.066	0.067	0.096	AS 4100 Cl. 8.4.2.2 M22 compact in-plane

Design Notes

AS 4100 Cl. 4.4.2 moment amplification: beta_x = -1, c_mx = 1, Nomb,x = 13445.186 kN, delta_bx = 1.003, delta_sx = 1, delta_mx = 1.003; beta_y = -0.209, c_my = 0.684, Nomb,y = 1118.604 kN, delta_by = 1, delta_sy = 1, delta_my = 1. No frame/storey sway amplification was supplied to the steel request, so delta_s = 1.0 is used. For a sway frame, a non-unity delta_s from Clause 4.4.2.3 or a second-order elastic analysis must be supplied/used where required.
GLOBAL CAPACITY RATIO BREAKDOWN
Actions: N* = -38.27 kN; M33* (Mx) = 89.538 kNm; M22* (My) = 1.793 kNm; V3* (Vx) = -33.515 kN; V2* (Vy) = -2.26 kN.
Standalone ratios: axial = 38.27/793.045 = 0.048; M33 = 89.538/152.586 = 0.587; M22 = 1.793/80.605 = 0.022; V3 = 33.515/337.478 = 0.099; V2 = 2.26/337.478 = 0.007.
Relevant design capacities: phiNc = 793.045 kN; phiNt = 2057.4 kN; phiMbx = 152.586 kNm; phiMsy = 80.605 kNm; phiMrx = 177.12 kNm; phiMry = 80.605 kNm; phiVv = 337.478 kN.
Clause 8.3 section interaction = 0.384. Calculation: (89.538/177.12)^1.419 + (1.793/80.605)^1.419 = 0.384.
Section 8 member interaction = 0.513. Calculation: (89.538/145.222)^1.4 + (1.793/79.648)^1.4 = 0.513.
Other interaction components: M33 in-plane = 0.516; M22 in-plane = 0.023; M33 out-of-plane = 0.617; M33 + V3 shear/bending = 0.099.
Global capacity ratio = max of all applicable checks:
AS 4100 Cl. 8.4.4.1 M33 out-of-plane = 0.617
AS 4100 Cl. 5.1 M33 major bending (alpha_m = 1) = 0.587
AS 4100 Cl. 8.4.2.2 M33 compact in-plane = 0.516
AS 4100 Cl. 8.4.5.1 biaxial compression + bending = 0.513
AS 4100 Cl. 8.3 compact section interaction = 0.384
AS 4100 Cl. 5.11 V3 shear = 0.099
AS 4100 Cl. 5.12.3 M33 + V3 shear/bending = 0.099
AS 4100 Cl. 6.1/6.3 axial compression = 0.048
AS 4100 Cl. 8.4.2.2 M22 compact in-plane = 0.023
AS 4100 Cl. 5.1 M22 minor bending = 0.022
AS 4100 Cl. 5.11 V2 shear = 0.007
Governing global capacity ratio = 0.617 from AS 4100 Cl. 8.4.4.1 M33 out-of-plane.
AS 4100 powered biaxial interaction equations are reported exactly as the left-hand side of the Standard equation; no exponent-root normalisation is applied. Clause 8.3 powered value = 0.384, exponent = 1.419. Clause 8.4.5 powered value = 0.513, exponent = 1.4.
I-section steel design to AS 4100. M33 uses EffectiveLengthLTB for lateral-torsional buckling; M22 uses section capacity.
AS 4100 Section 8 compact-section alternative provisions are applied where the section type, compactness and clause-specific conditions permit.
M33 transverse loading detected: beta_m = -1.0 is adopted conservatively for the Clause 8.4.2.2 compact in-plane alternative; the Clause 8.4.4.1 compact out-of-plane alternative is not used.
AS 4100 Cl. 5.12.3 shear/bending interaction is checked for M33 with its associated local V3 web shear, using the whole-cross-section method.
The Clause 5.6 moment modification factor alpha_m used for the major-axis member capacity is 1.
The M33*/M22* values used in the strength checks are the AS 4100 Clause 4.4.2 amplified design moments. FirstOrderM33Star/FirstOrderM22Star retain the unamplified frame-analysis actions for audit.
Powered Clause 8.3.4 and Clause 8.4.5 interaction checks are reported as the actual AS 4100 equation value with a unity limit; no exponent-root normalisation is applied.
Capacities returned by the steel API are design capacities with phi = 0.9 already applied.
Section 8 compact alternatives are reported separately from the standalone axial, bending and shear checks.
Clause 5.12.3 is checked without extrapolating its shear-reduction equation beyond M* = φMs; if that limit is exceeded, the Clause 5.1 bending failure remains explicit.
Governing result is the maximum utilisation from all checked stations for the governing LC-* combination.