Simulation Project: Building Subjected to Wind Loads

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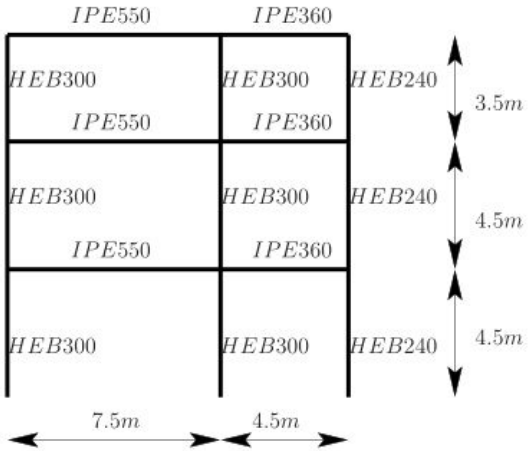
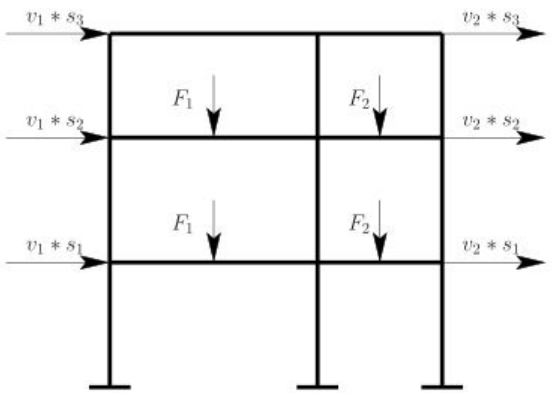
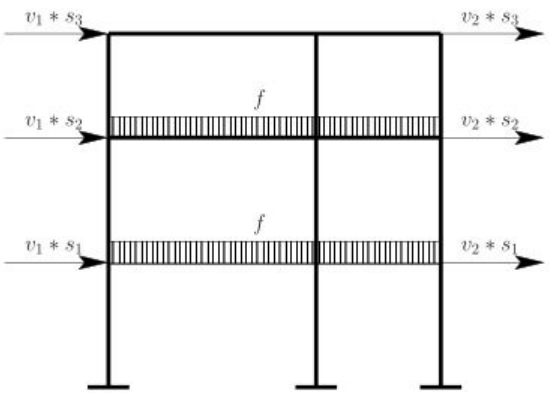
Problem statement

Property	Value
Density	$7.85{\cdot}10^{-9}\ kg/mm^3$
Young Modulus	$200\ GPa$
Poisson ratio	0.26
Yield Stress	$275\ MPa$





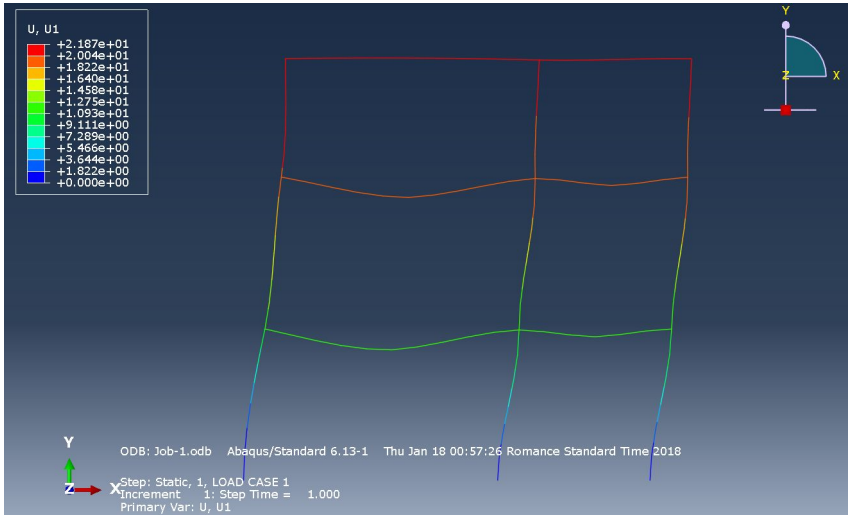
(a) Case 1



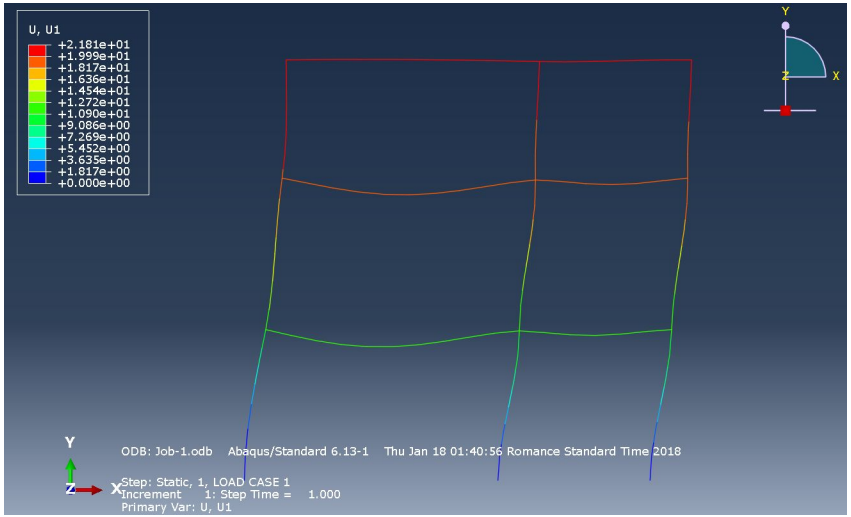
(b) Case 2

Static and Dynamic analysis using ABAQUS
2 types of boundary conditions: Clamped and hinged

Static Analysis: Horizontal Displacements Clamped

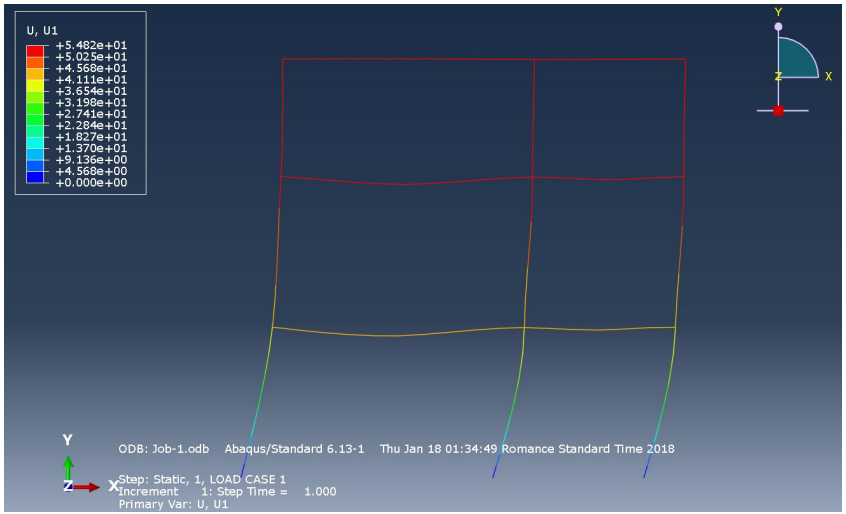


CASE 1



CASE 2

Static Analysis: Horizontal Displacements Hinged



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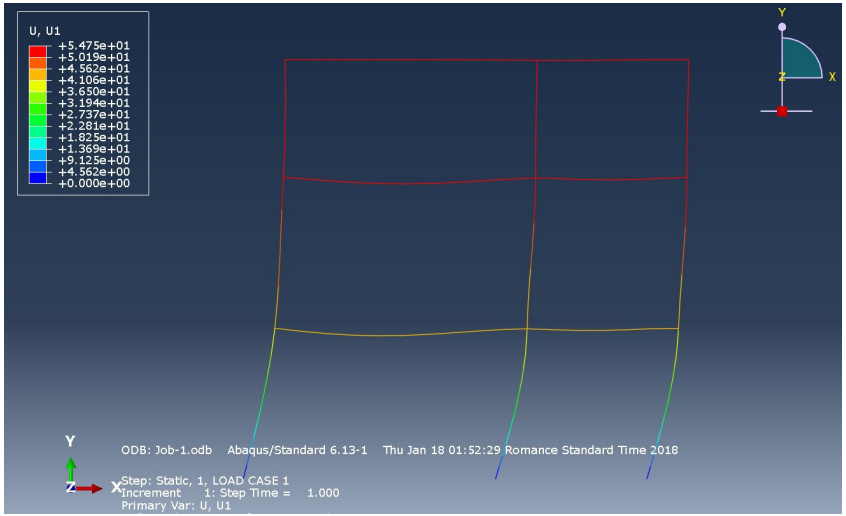


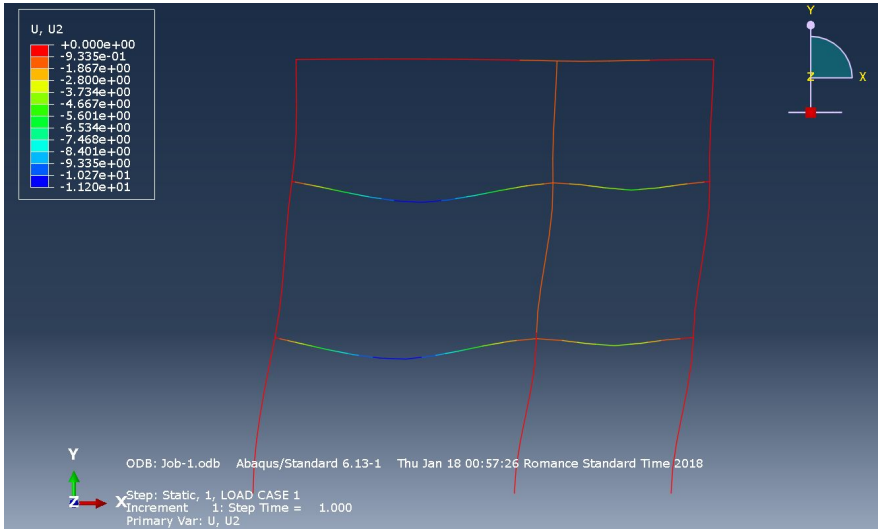
CASE 2

Static Analysis: Horizontal Displacements

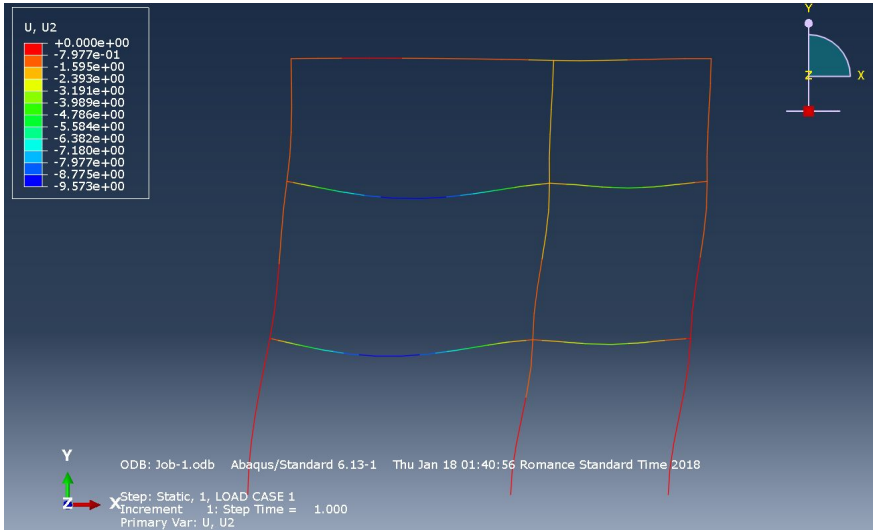
Admissible Displacement of 0.05H = 62.5 mm

	Case 1, clamped	Case 1, hinged	Case 2, clamped	Case 2, hinged
Max. displacement (mm)	21.87	54.82	21.81	54.75
Safety factor	2.86	1.14	2.87	1.14

Static Analysis: Vertical Displacements Clamped

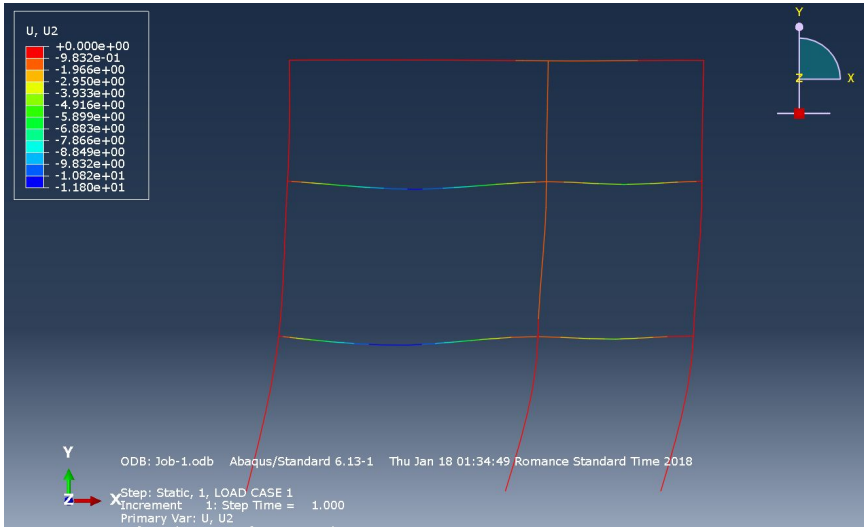


CASE 1

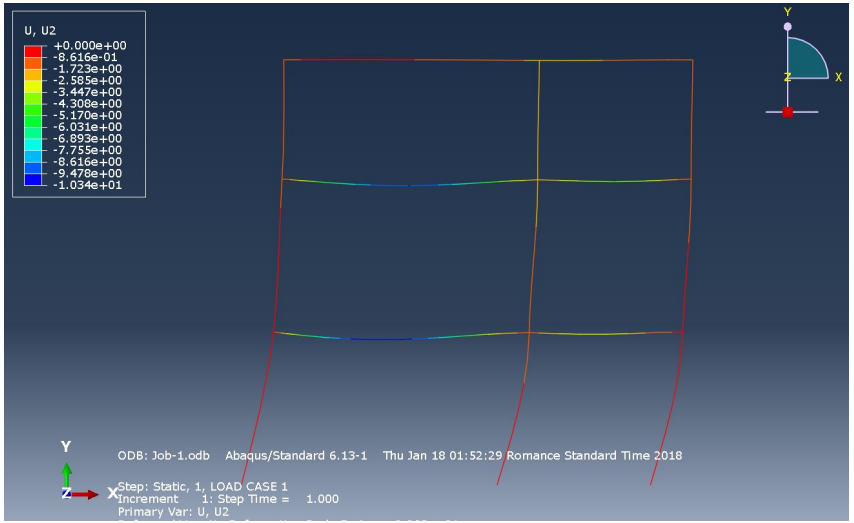


CASE 2

Static Analysis: Vertical Displacements Hinged



CASE 1



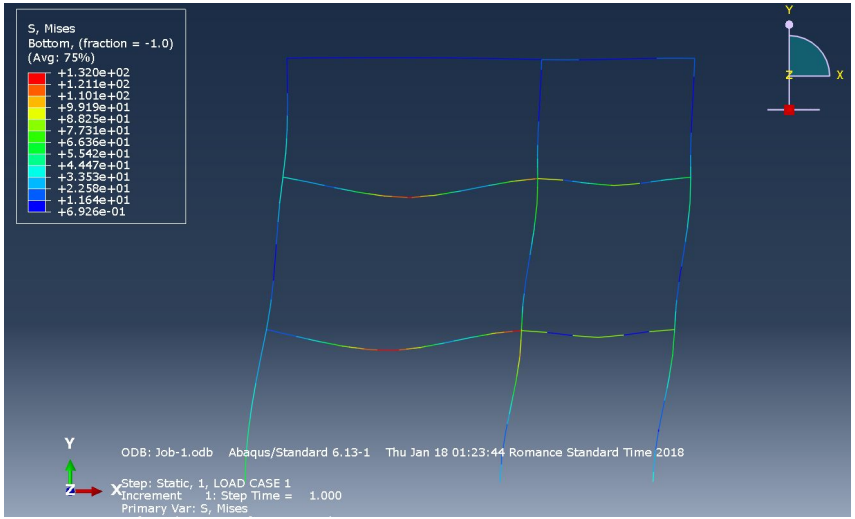
CASE 2

Static Analysis: Vertical Displacements

Admissible Displacement of L/480 = 15.63 mm

	Case 1, clamped	Case 1, hinged	Case 2, clamped	Case 2, hinged
Max. displacement (mm)	11.20	11.80	9.57	10.34
Safety factor	1.40	1.32	1.63	1.51

Static Analysis: Von Mises Stresses Clamped



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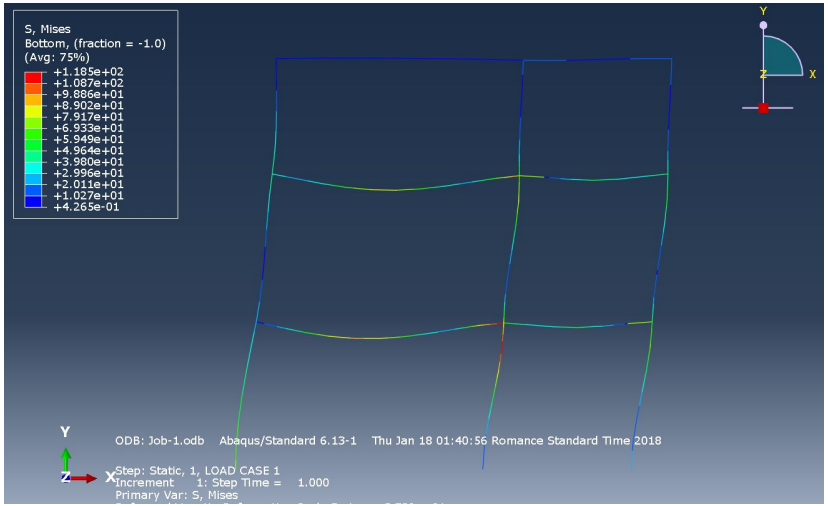
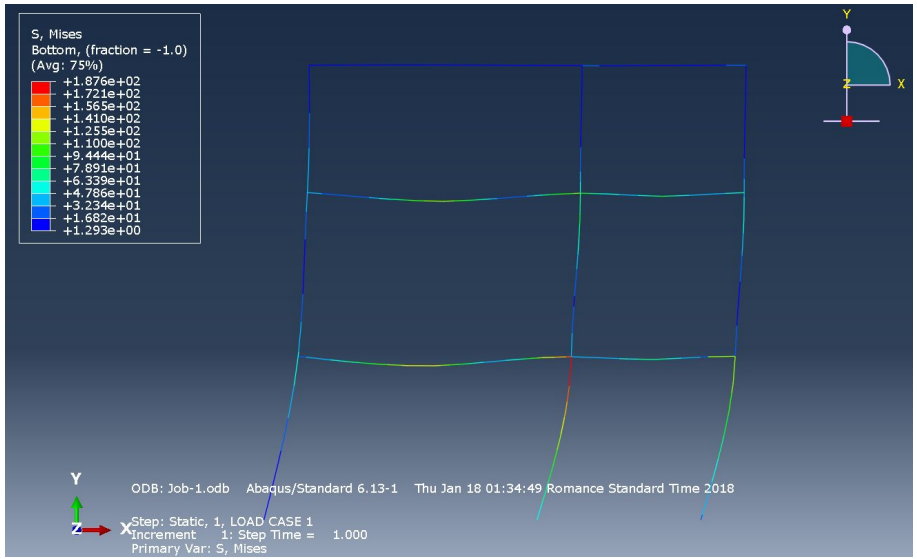


CASE 2

Static Analysis: Von Mises Stresses Hinged



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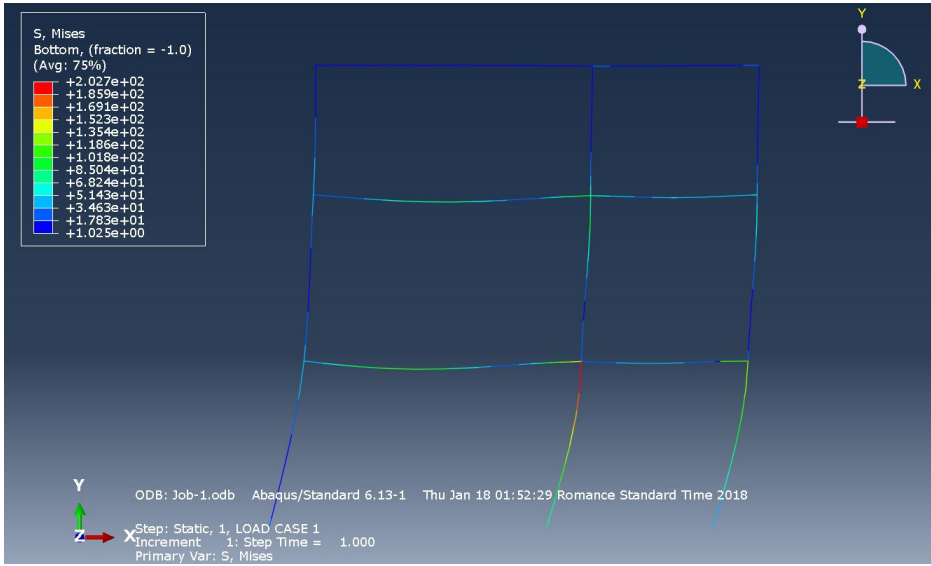


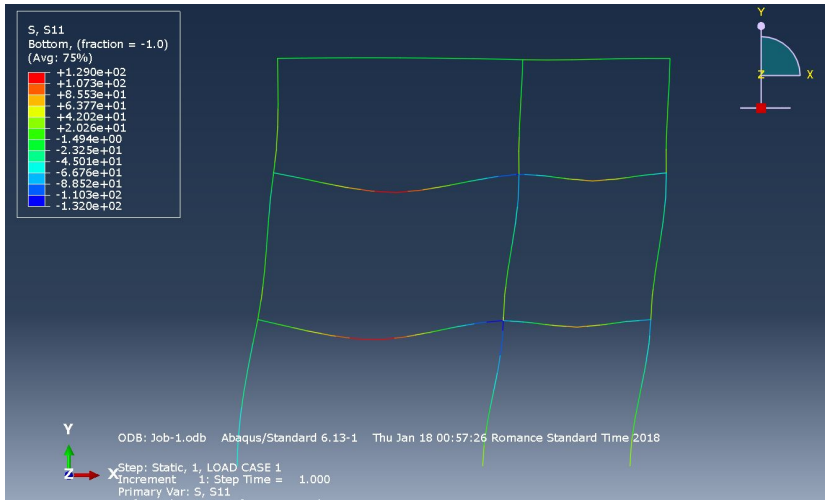
CASE 2

Static Analysis: Von Mises Stresses

Yield Stress of 275MPa

	Case 1, clamped	Case 1, hinged	Case 2, clamped	Case 2, hinged
Max. Stress (MPa)	132	118.5	187.6	202.7
Safety factor	2.08	2.32	1.47	1.36

Static Analysis: Axial Stresses Clamped



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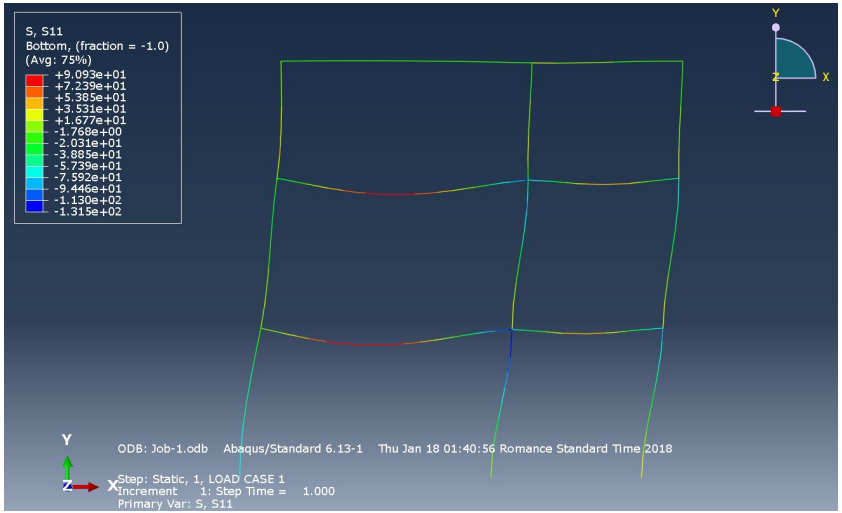
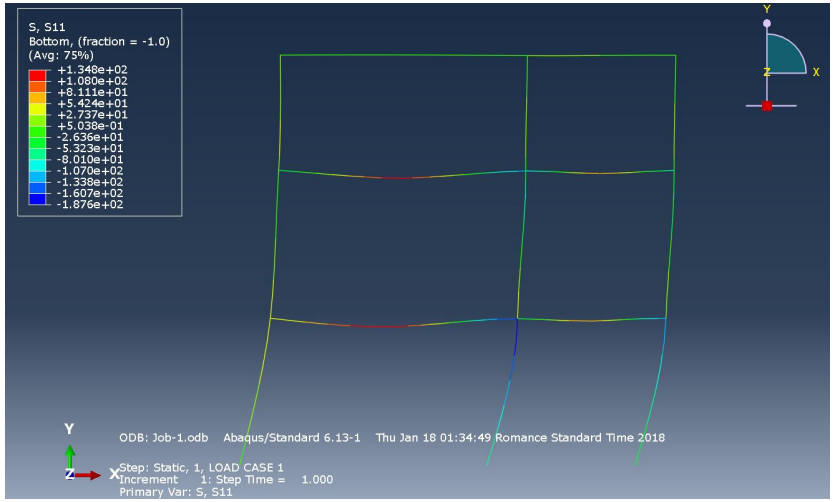


CASE 2

Static Analysis: Axial Stresses Hinged



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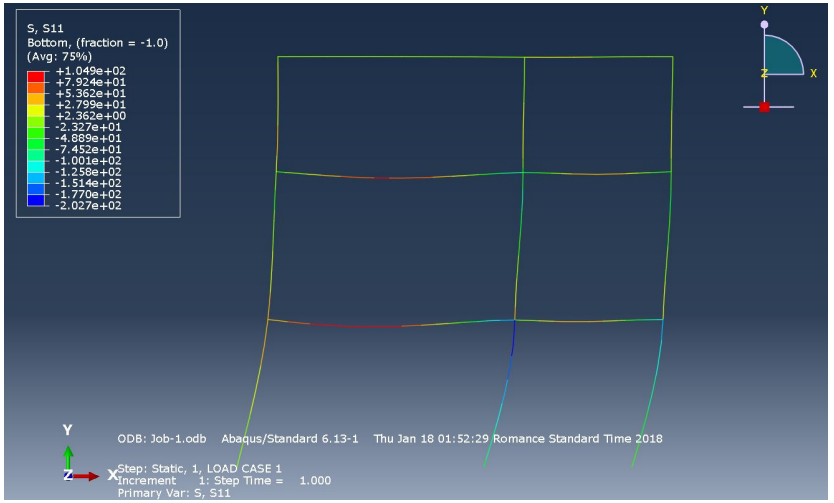


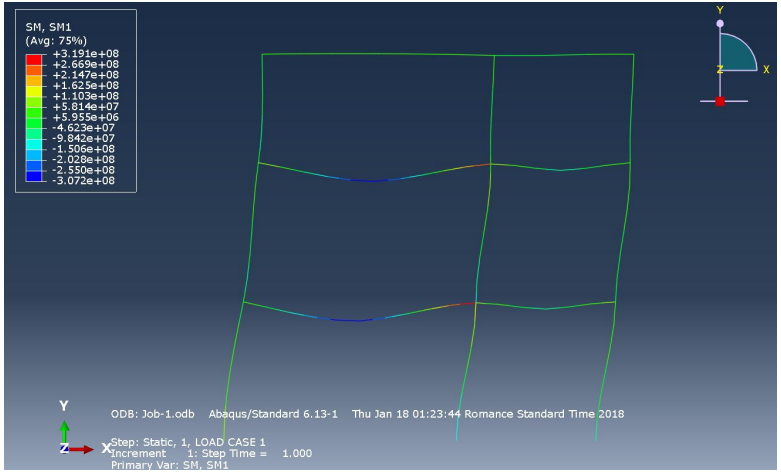
CASE 2

Static Analysis: Axial Stresses

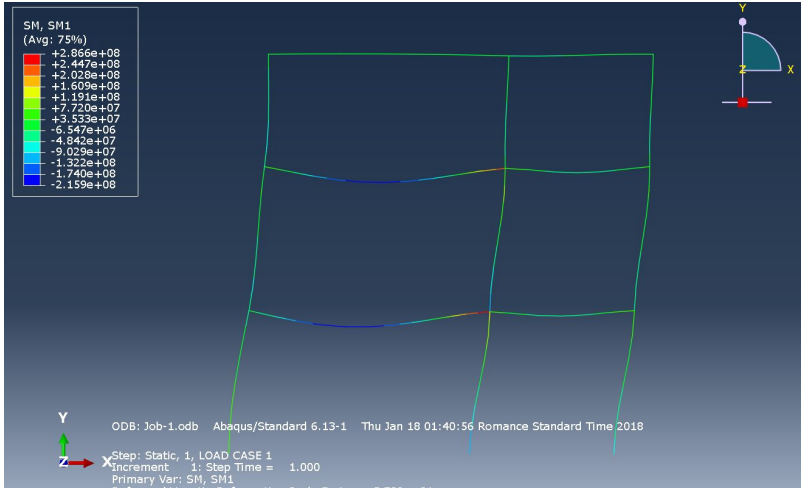
Yield Stress of 275MPa

	Case 1, clamped	Case 1, hinged	Case 2, clamped	Case 2, hinged
Max. Stress (MPa)	129.00	134.80	90.93	104.90
Safety factor	2.13	2.04	3.02	2.62
Min. Stress (MPa)	132.00	187.60	131.50	202.70
Safety factor	2.08	2.32	1.47	1.36

Static Analysis: Bending Moments Clamped

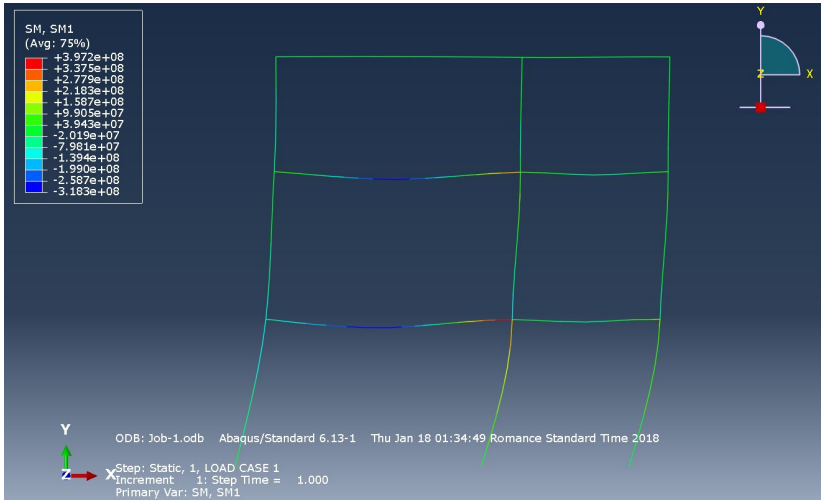


CASE 1

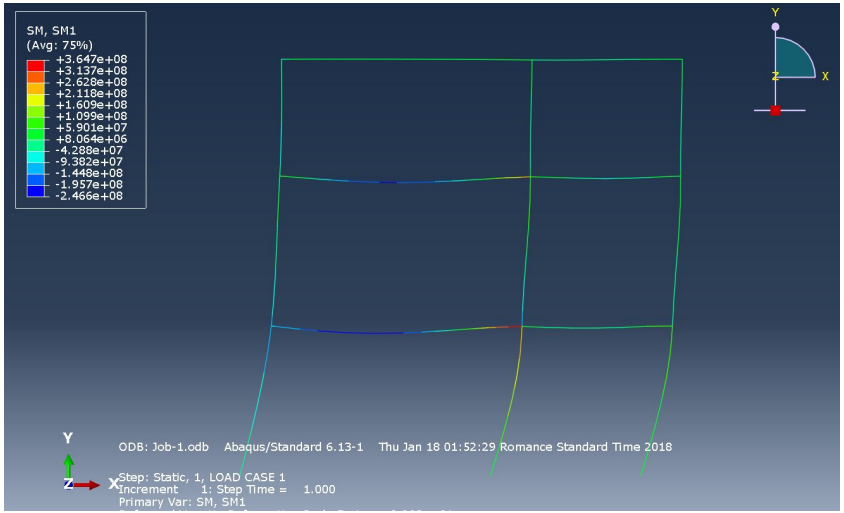


CASE 2

Static Analysis: Bending Moments Hinged



CASE 1



CASE 2

Static Analysis: Axial Stresses

Admissible values of the Bending Moment

Profile	$W_x\ (mm^3)$	$M_y\ (N \cdot mm)$
HEB240	$9.38{\cdot}10^5$	$2.58{\cdot}10^8$
HEB300	$1.68{\cdot}10^6$	$4.61{\cdot}10^8$
IPE360	$9.04{\cdot}10^5$	$2.49{\cdot}10^8$
IPE550	$2.44{\cdot}10^6$	$6.71{\cdot}10^8$

	Case 1, clamped	Case 1, hinged	Case 2, clamped	Case 2, hinged
HEB300 max moment $(N \cdot mm)$	$1.63{\cdot}10^8$	$2.78{\cdot}10^8$	$1.61{\cdot}10^8$	$2.28{\cdot}10^8$
Safety factor	2.84	1.66	2.87	2.02
IPE550 max moment $(N \cdot mm)$	$3.19{\cdot}10^8$	$3.97{\cdot}10^8$	$2.87{\cdot}10^8$	$3.65{\cdot}10^8$
Safety factor	2.10	1.69	2.34	1.84
IPE550 min moment $(N \cdot mm)$	$-3.07{\cdot}10^8$	$-3.18{\cdot}10^8$	$-2.16{\cdot}10^8$	$-2.47{\cdot}10^8$
Safety factor	2.19	2.11	3.11	2.72

Dynamic Analysis

Wind frequency 2Hz

Mode	Value	Frequency (Hz)
1	965.01	4.9441
2	11166	16.818
3	34921	29.742
4	58608	38.530
5	76105	41.849

CASE 1 CLAMPED

Mode	Value	Frequency (Hz)
1	371.91	3.0693
2	7149.5	13.457
3	32599	28.736
4	57340	38.111
5	66032	40.897

CASE 1 Hinged

Conclusions

- All the cases in the static analysis have admissible values for the structure to not collapse.
- Clamped constraints are preferable over hinged constraints for all cases.
- The dynamic analysis shows no resonance phenomena.
- Case 2, which considers distributed loads, is more realistic but more difficult to analyze.

Future work

- Safety factor should be improved since they are too close to 1.
- A further analysis could be computed considering distributed wind loads with different directions.
- Optimization of the structure is desired to reduce costs and improve safety factors.