# STRUCTURAL PERFORMANCE OF INTERMODAL STEEL CONTAINER STRUCTURES AT ELEVATED TEMPERATURES

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BUILDING CONTROL

SOCOTEC

# AGENDA

1. Introduction
2. Assumptions
3. Thermal analysis
4. Structural analysis
5. Conclusions

# 1 INTRODUCTION

# STEEL CONTAINER BUILDINGS

Multiple uses and occupancies:

- Single-storey and multi-storey structures
- Residential premises
- Student accommodation
- Hotels
- Temporary housing / disaster relief

Figure 1: Quadrum Ski and Yoga Resort , in Gudauri, Georgia (1)

Figure 2: Student accommodation [Image source Google Maps 2024]

Figure 3: Starbust House, Joshua Tree, California (2)

# OBJECTIVE

- Investigate if the prescriptive fire protection provisions are applicable for intermodular structures

- Performance of intermodular structures under natural fire conditions

→ **Structural fire engineering assessment**

# 2 ASSUMPTIONS

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# FIRE SCENARIOS


Figure 7: Floor plan for parametric fire curve

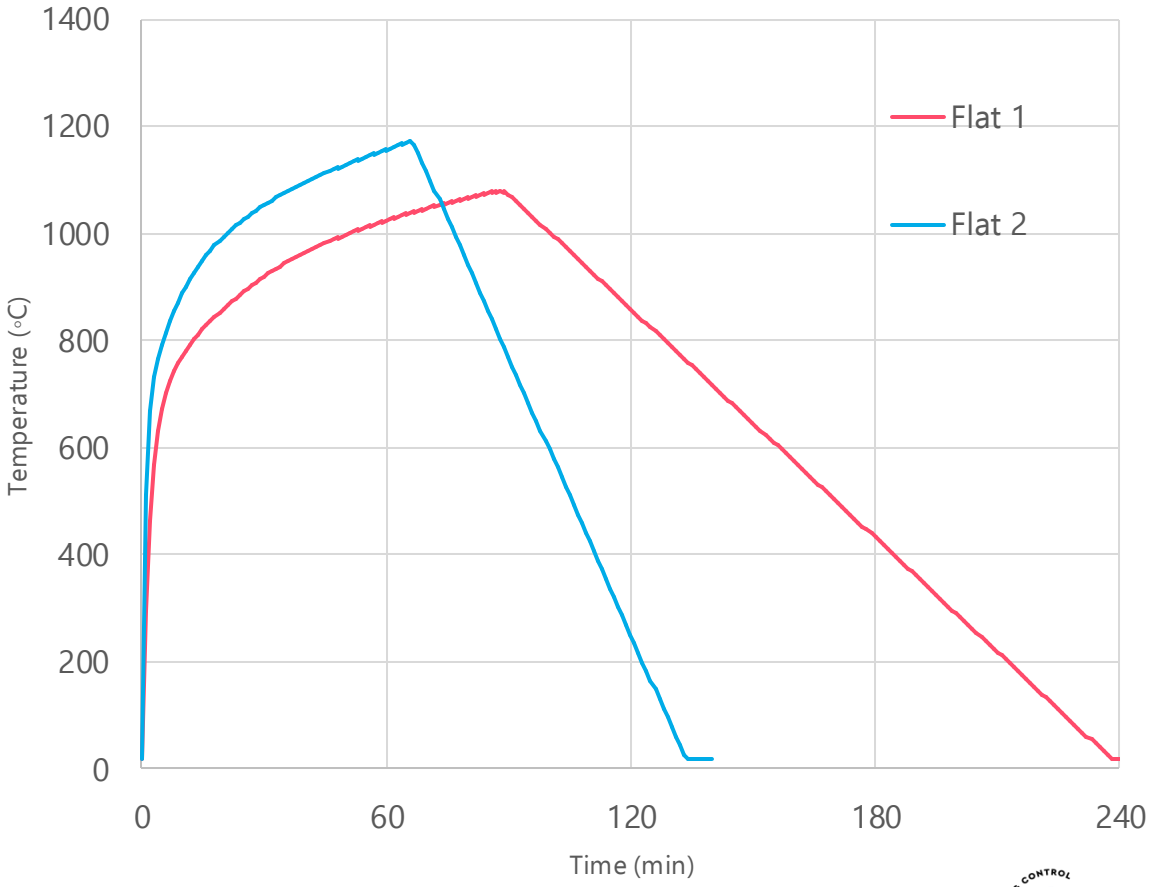


Figure 8: Temperature-time curves

# STEEL CONTAINER STRUCTURE

- Steel columns, longitudinal and transversal beams
- Cold-formed steel joists
- Dry-lined stud walls
- Plywood flooring

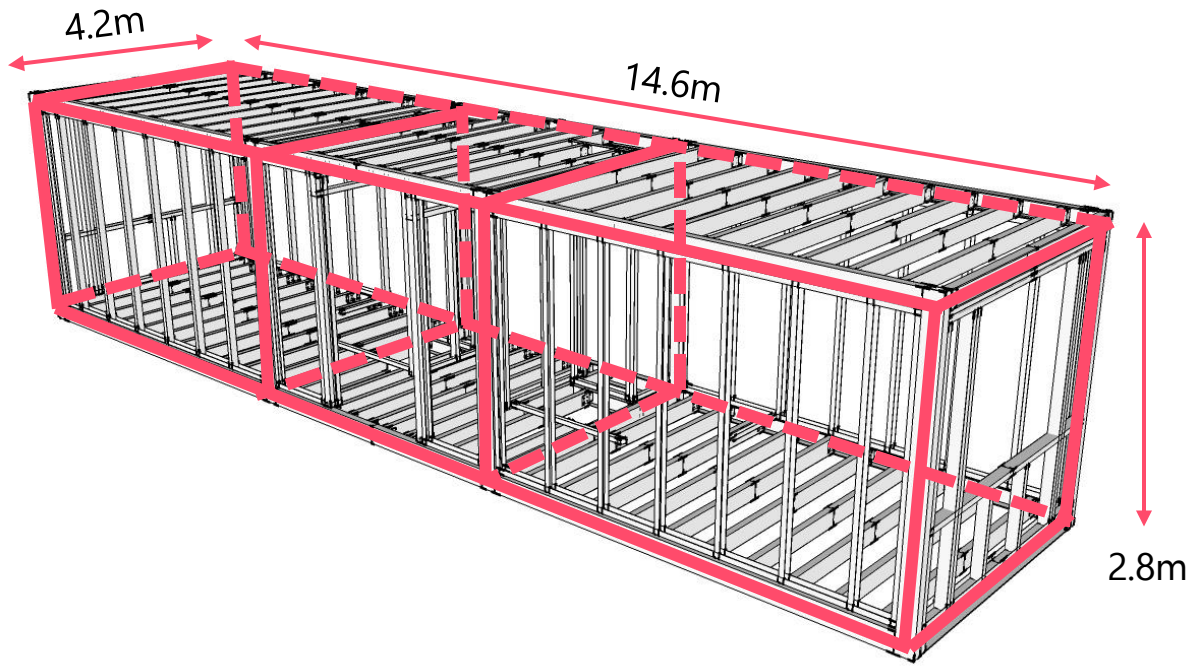


Figure 4: Container structure - Dimensions

# STEEL CONTAINER STRUCTURE

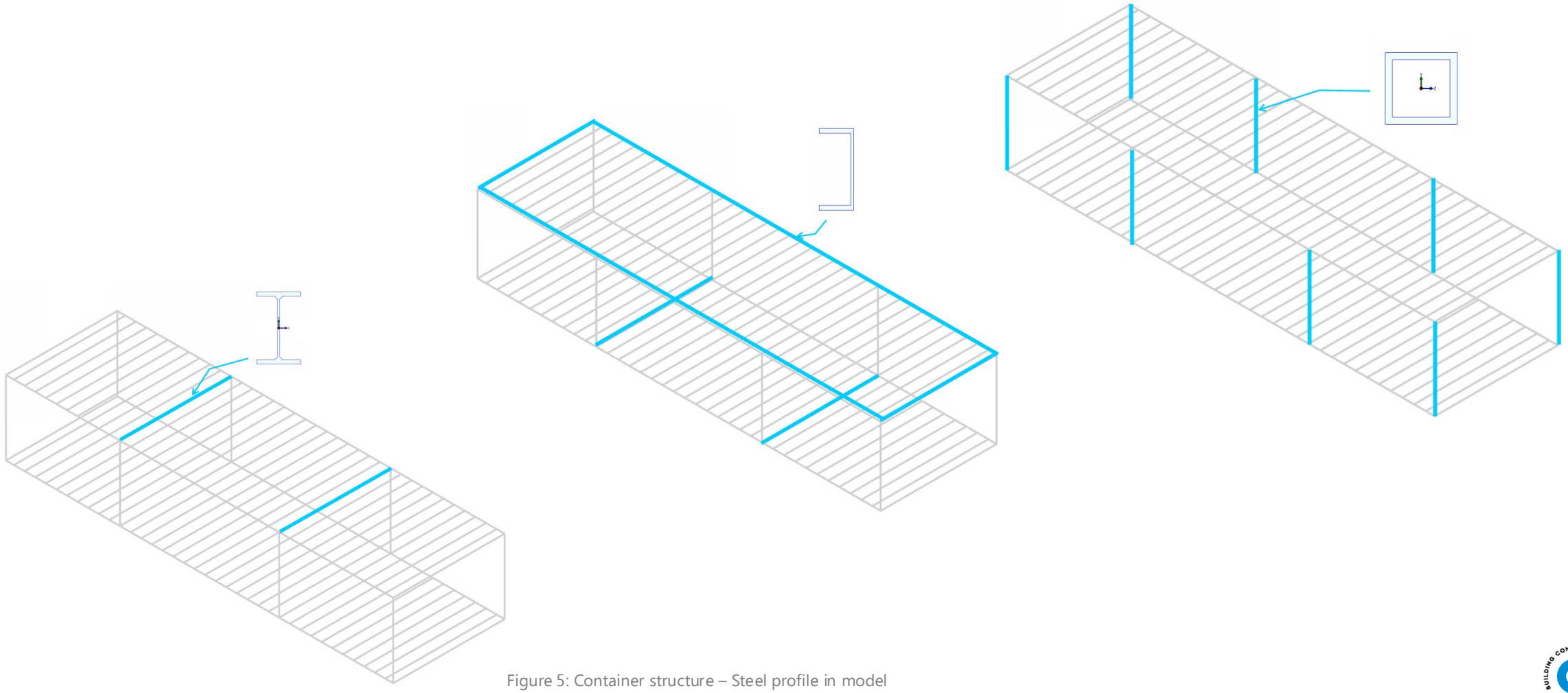

Figure 5: Container structure – Steel profile in model

# PRESCRIPTIVE FIRE PROTECTION FOR THE STRUCTURE

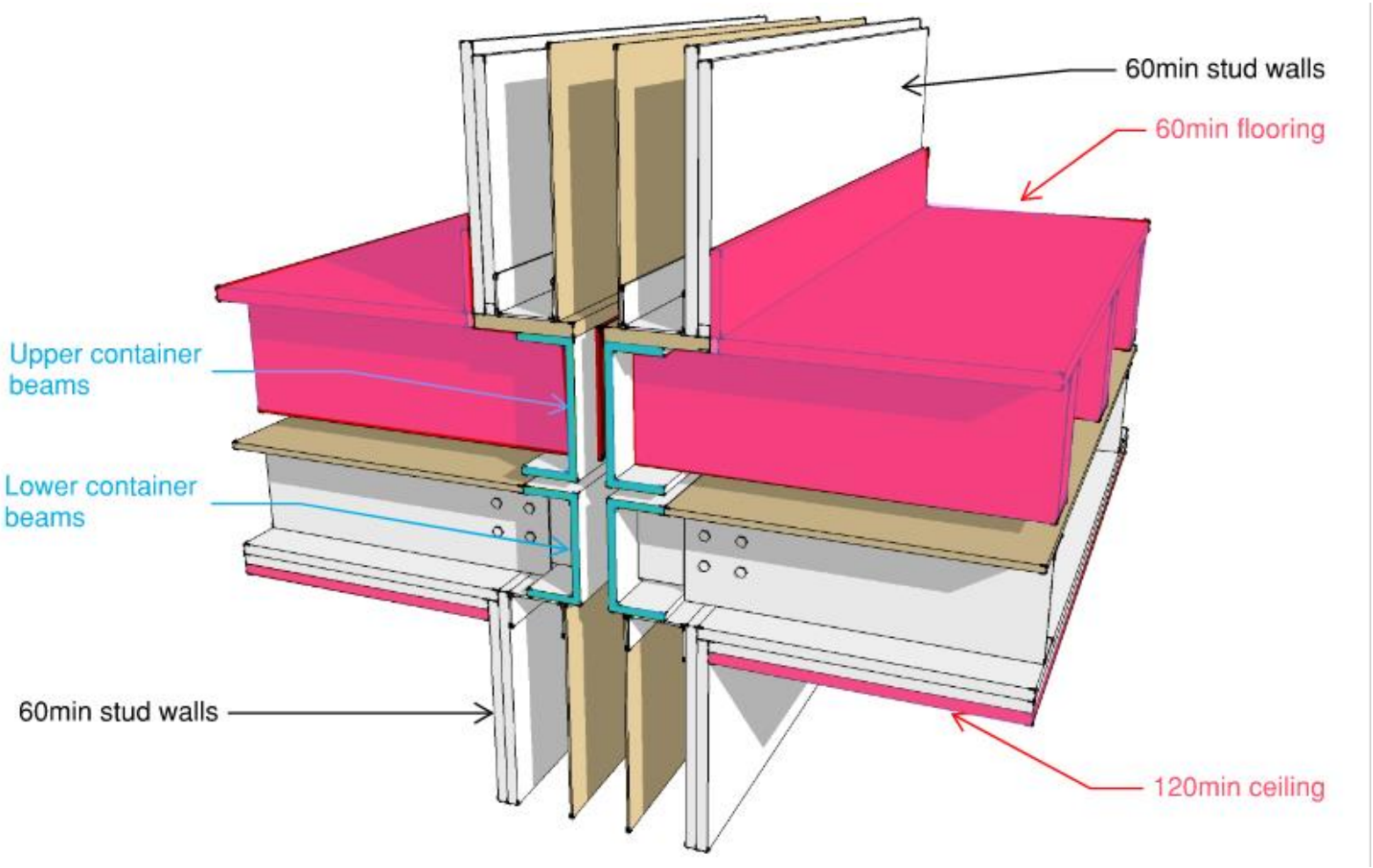


Figure 6: Connection point between four containers and protection of steel members

# 3 THERMAL ANALYSIS

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# TEMPERATURE RESULTS

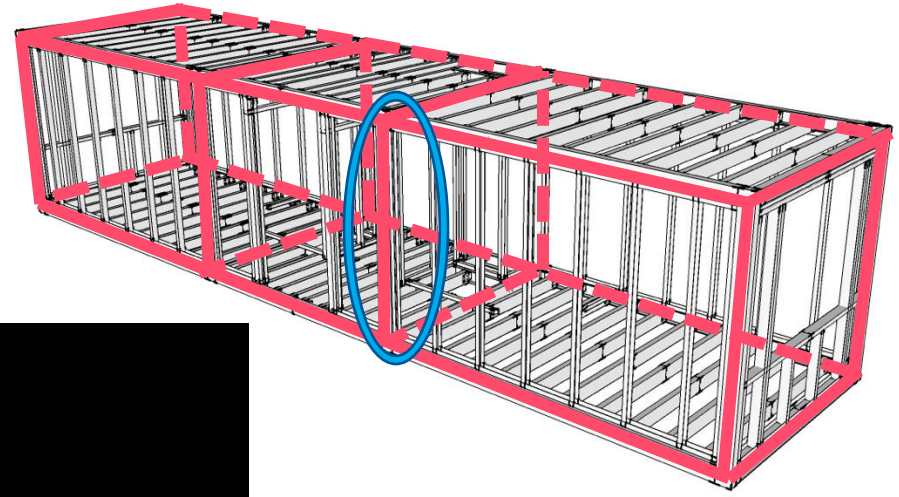

*Figure 9: Temperature distribution through a compartment wall between two flats*

# TEMPERATURE RESULTS

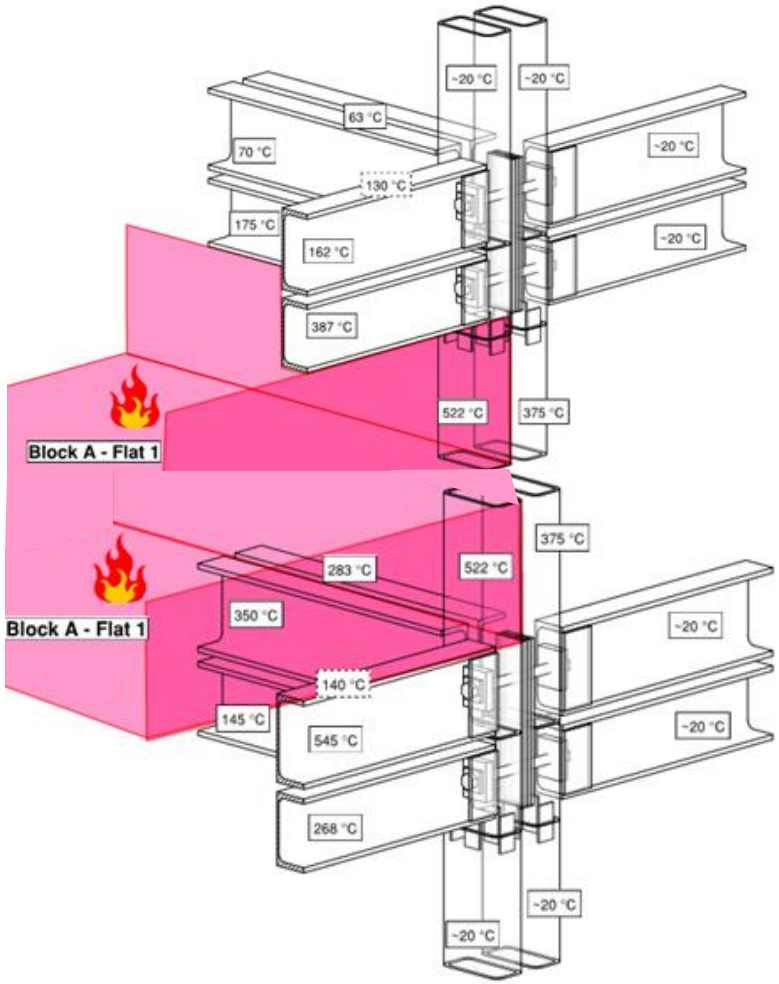


*Figure 10: Temperature differences between adjacent compartments (corner point)*

- Steel temperature in each member below 550 degrees (i.e. the critical temperature)

But:

- Expansion of the compartment and slower expansion in the adjacent compartment

- Cooling on the exposed side and heating of the adjacent compartment

# 4 STRUCTURAL ANALYSIS

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# RESULTS – 2D MODEL (3X3 ARRANGEMENT)

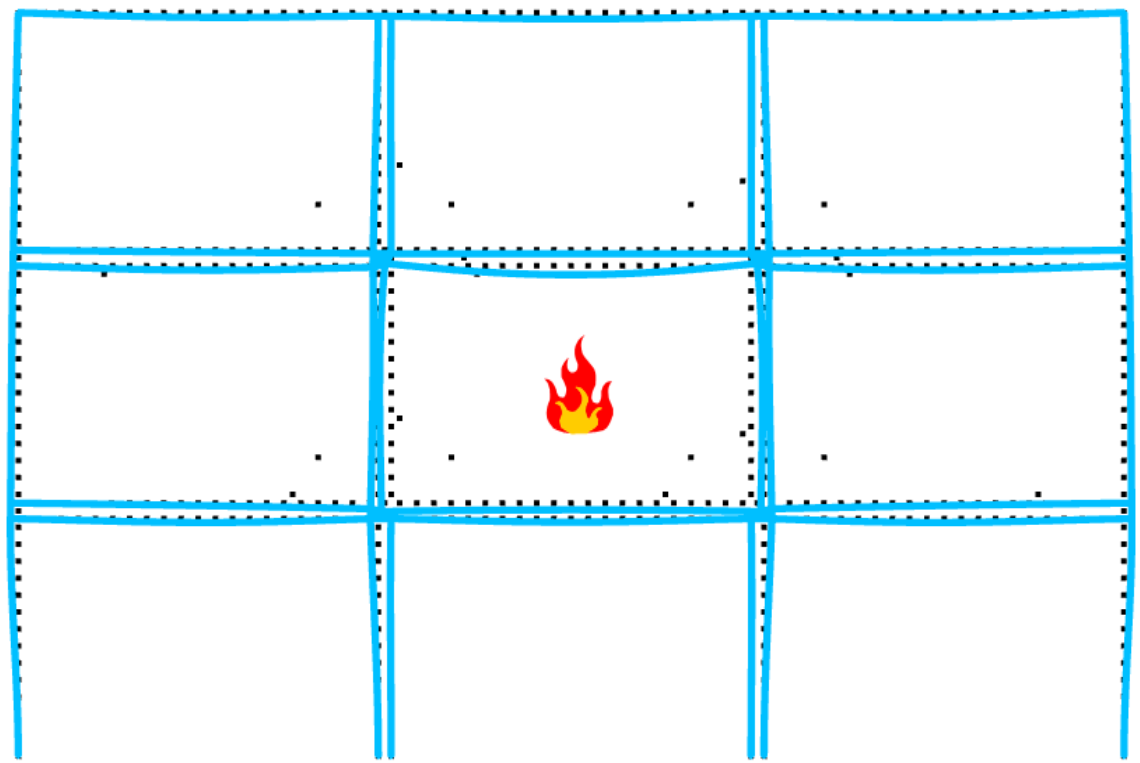
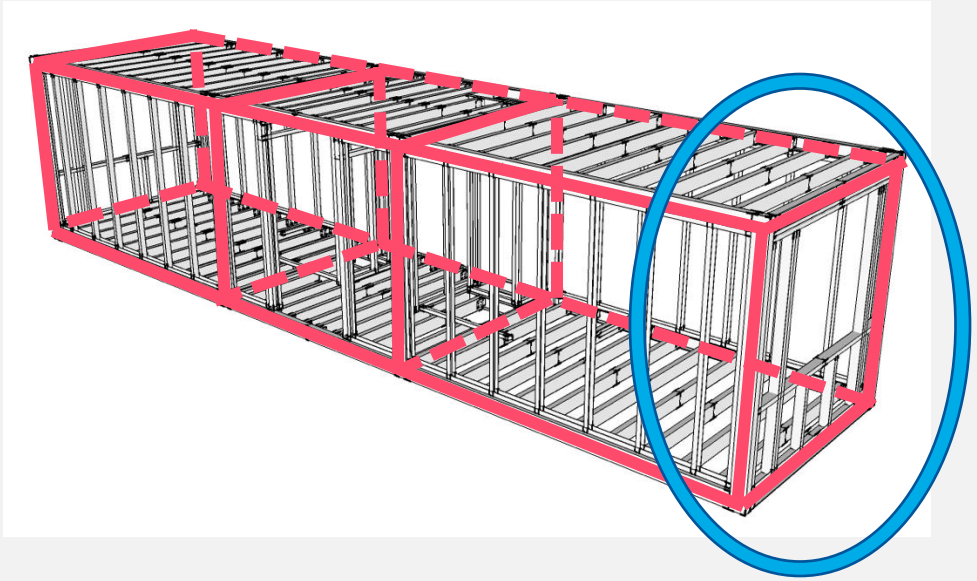



*Figure 11: Deformation of the XZ plane – Time: 150 min, Scale: x8*



# RESULTS – 2D MODEL (3X3 ARRANGEMENT)

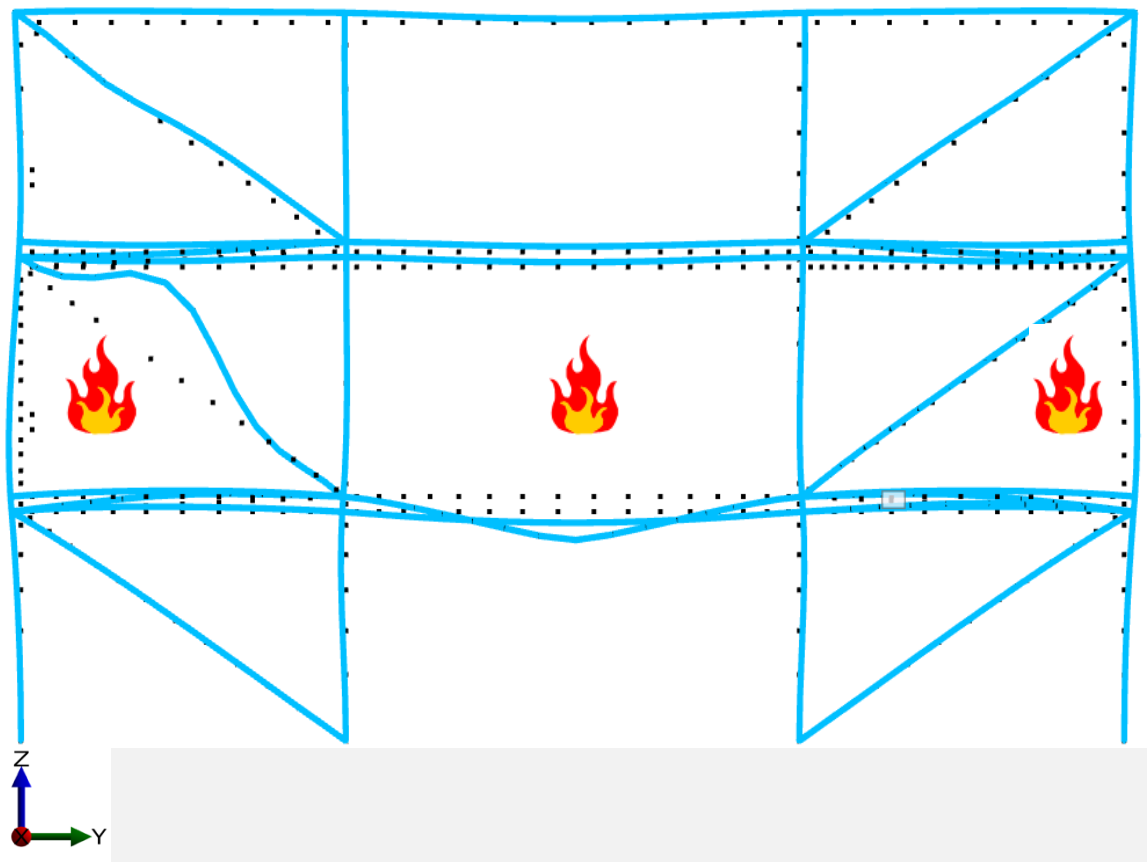
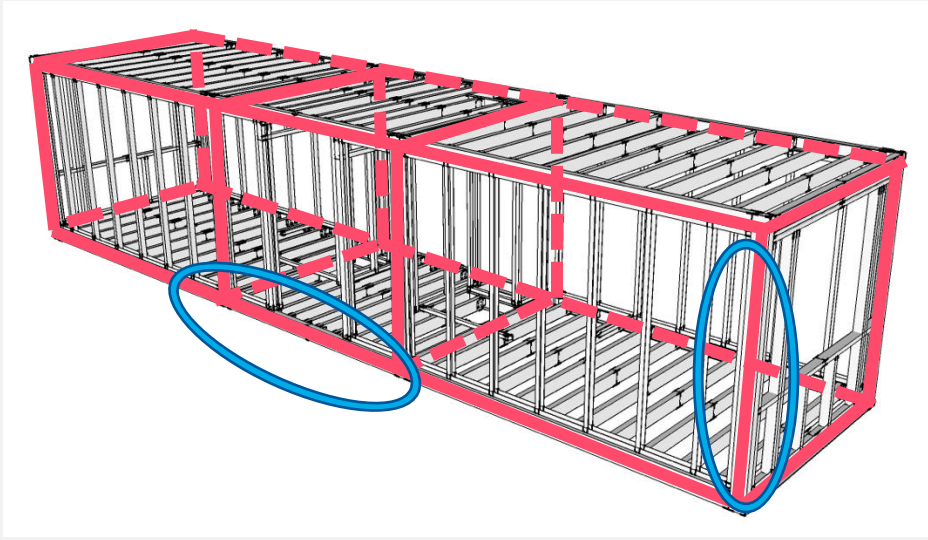



*Figure 12: Deformation of the YZ plane – Time: 150 min, Scale: x8*



# RESULTS – 3D MODEL (3X3 ARRANGEMENT)

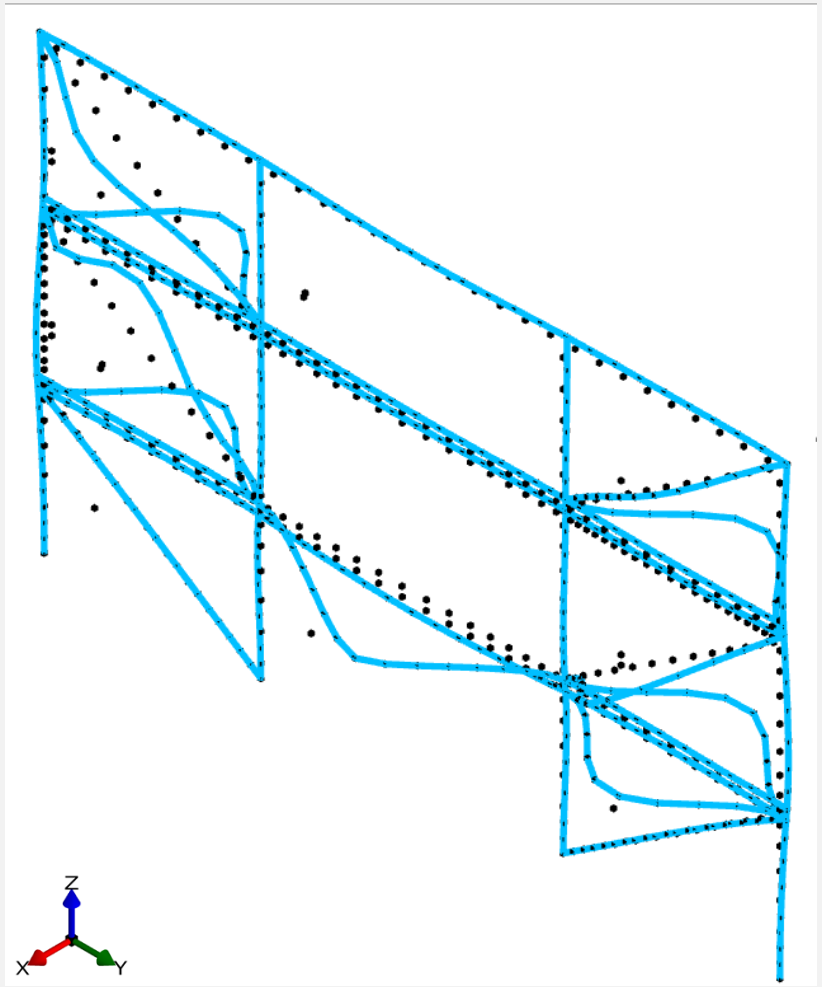
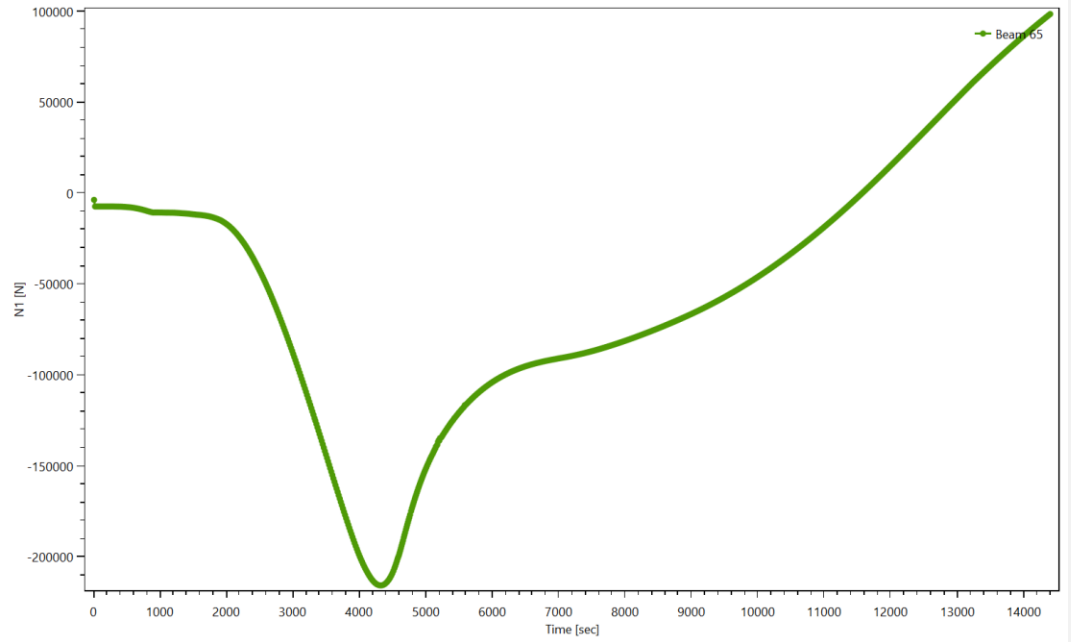



Figure 13: Deformation of the YZ plane (3D) – Time: 150 min, Scale: x8

- Significant failure of the central beam due to out-of-plane buckling around the weak axis




- Significant failure of the wind braces out-of-plane

# ASSESSMENT OF THE CONNECTION

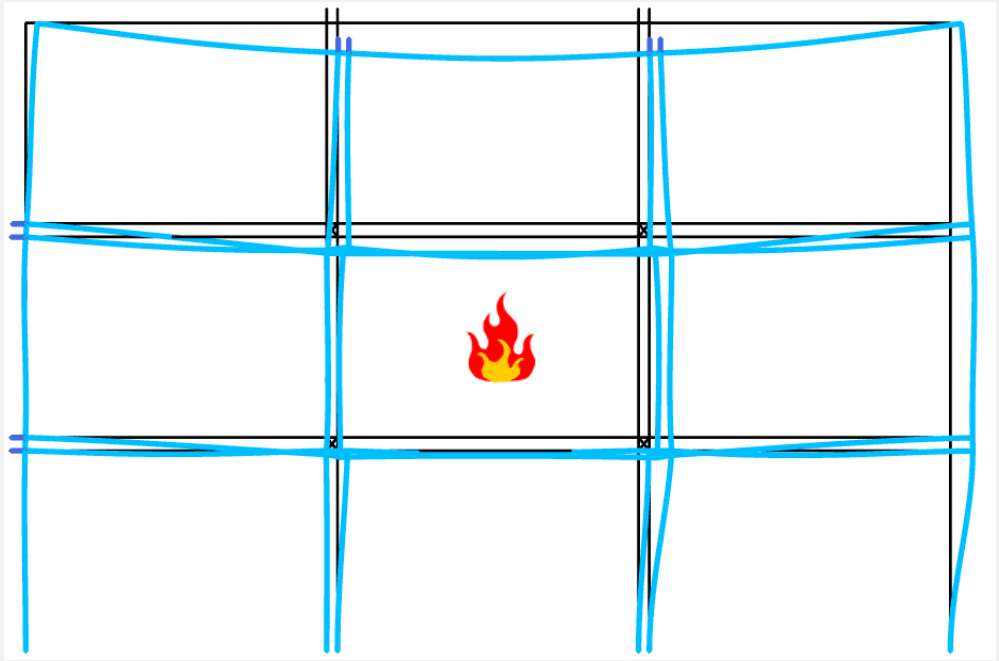


Figure 14: Deformation considering soft joints, Time: 150 min, Scale: x8

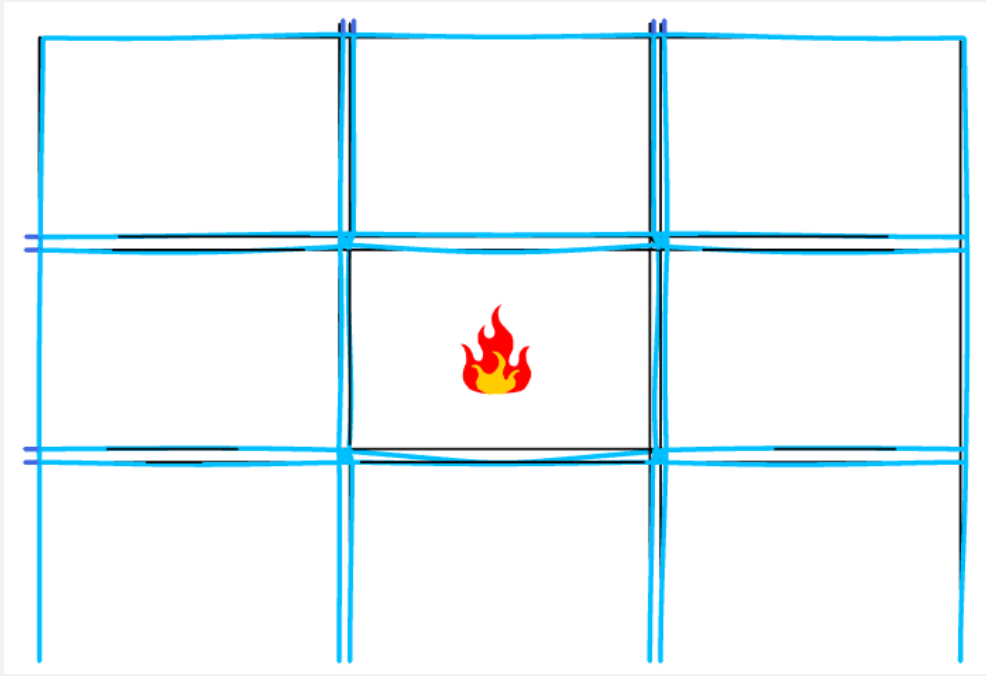


Figure 15: Deformation considering rigid joints, Time: 150 min, Scale: x8

# ASSESSMENT OF THE CONNECTION

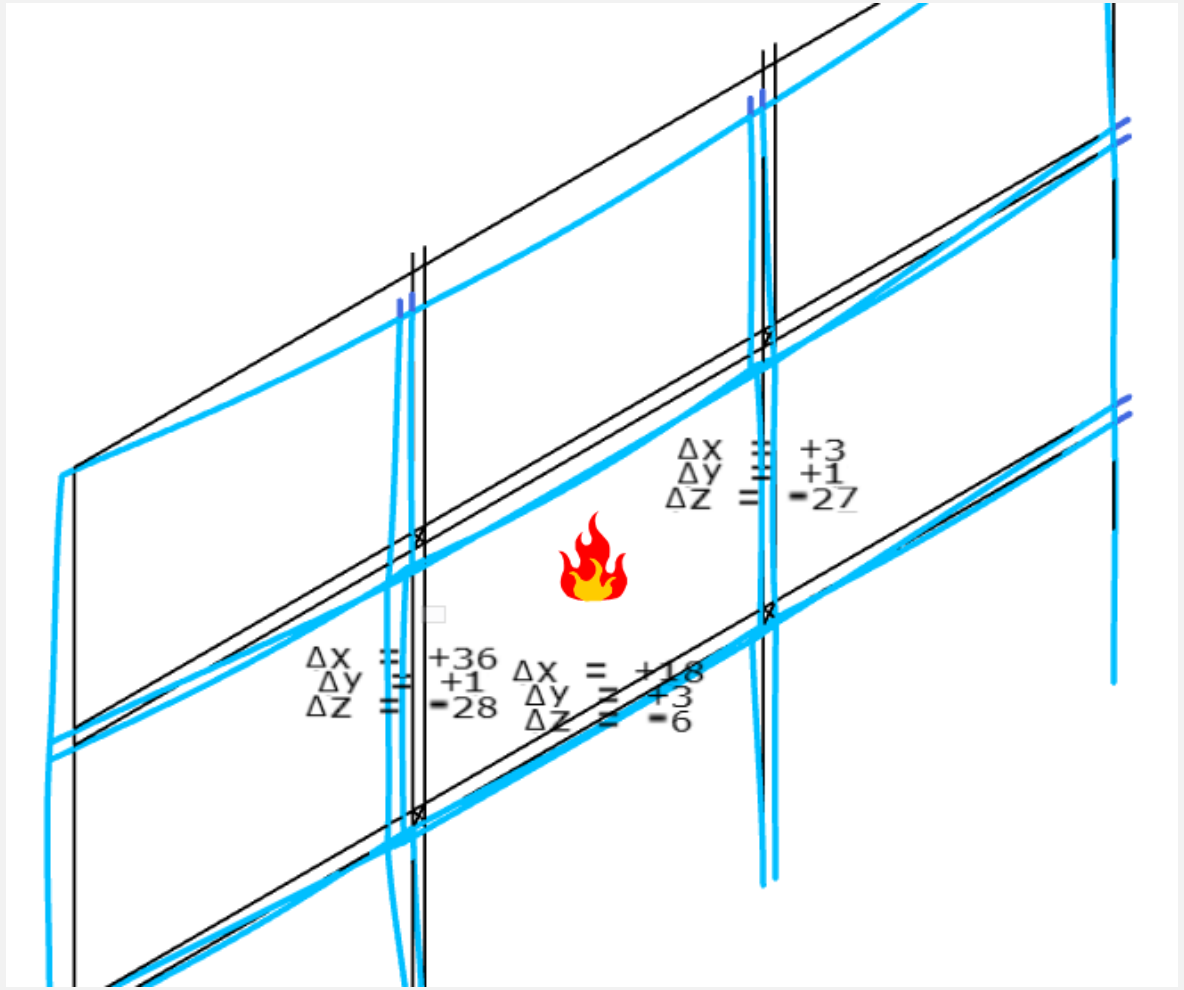



Figure 16: Deformation considering soft joints (3D), Time: 150 min, Scale: x8

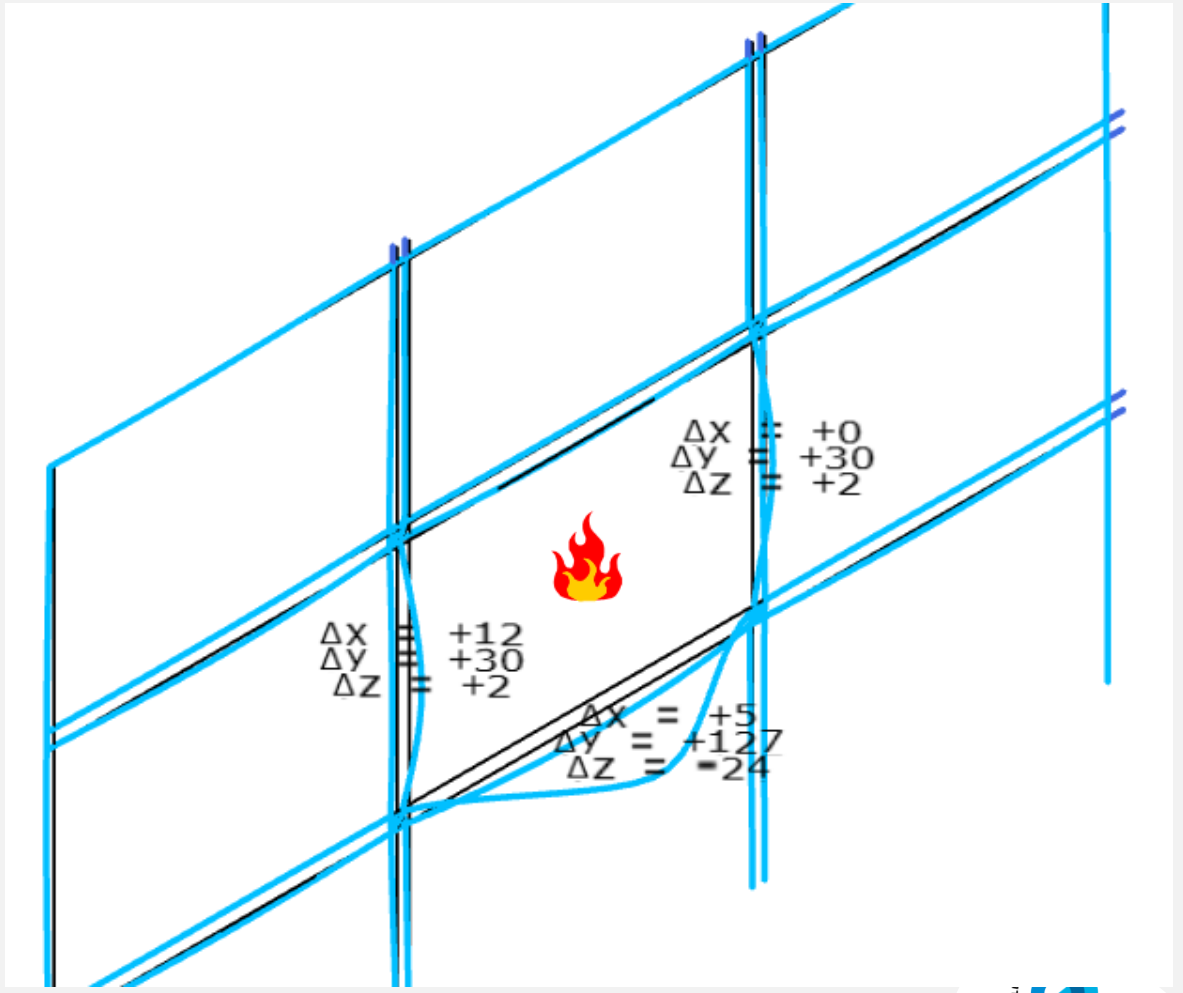



Figure 15: Deformation considering rigid joints (3D), Time: 150 min, Scale: x8

# 5 CONCLUSION

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# CONCLUSION AND SUMMARY

- Prescriptive guidance:
  - Critical temperature achieved; but
  - rate of deflection (mm/min) is not achieved.
- General observations:
  - Anticipated failure of connection points due to deformation or stresses;
  - Detailed research should be done on connections and interaction between modules.

# Thank you for your attention!
# Please feel free to ask questions!

# REFERENCES

(1) Quadrum Gudauri Ski & Yoga Resort official hotel website (quadrum-gudauri.com)

(2) Starburst House — WHITAKER STUDIO

# CREDITS TO:

Felipe Herrera and Gabriel Risco