

Numerical Simulation on the Fire Performance of Reinforced Concrete Flat Slab

David Tipton & Dr. Elias Ali, Civil and Environmental Engineering

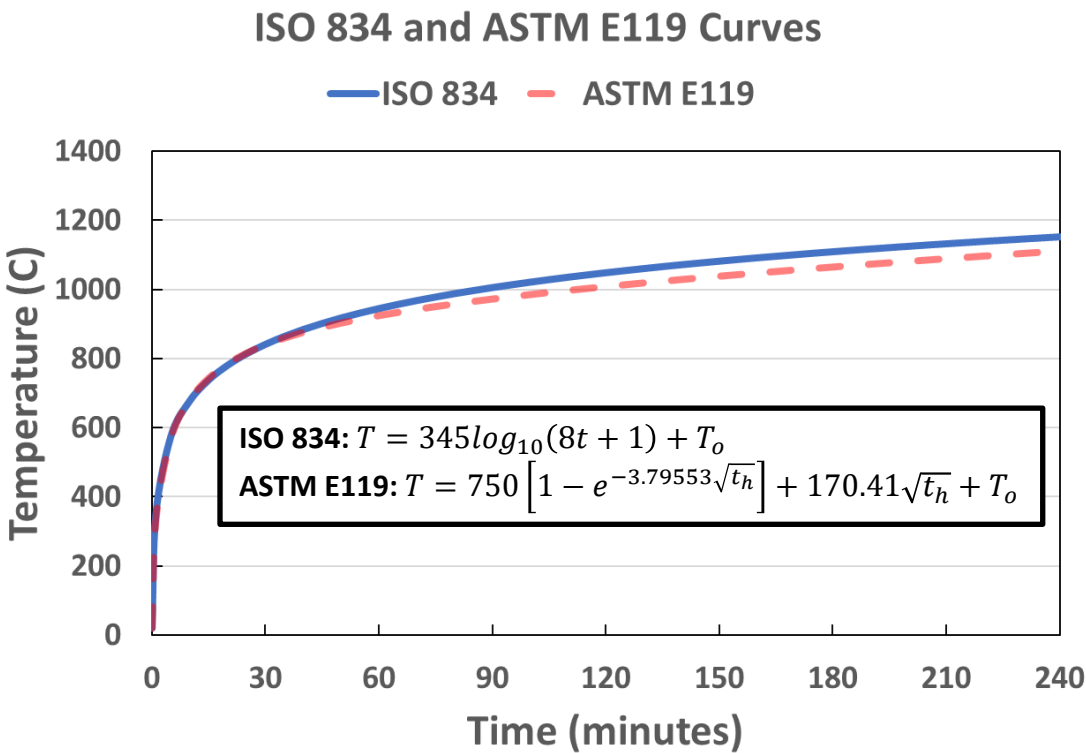
Overview

General Information

- This project investigates the fire performance of a reinforced concrete flat slab under standard fire using the Finite Element Software, ABAQUS.
- In order to investigate the performance of the slab, three analyses were performed: Heat Transfer, Structural Stability, and Load Capacity Analyses.

Fire Curves

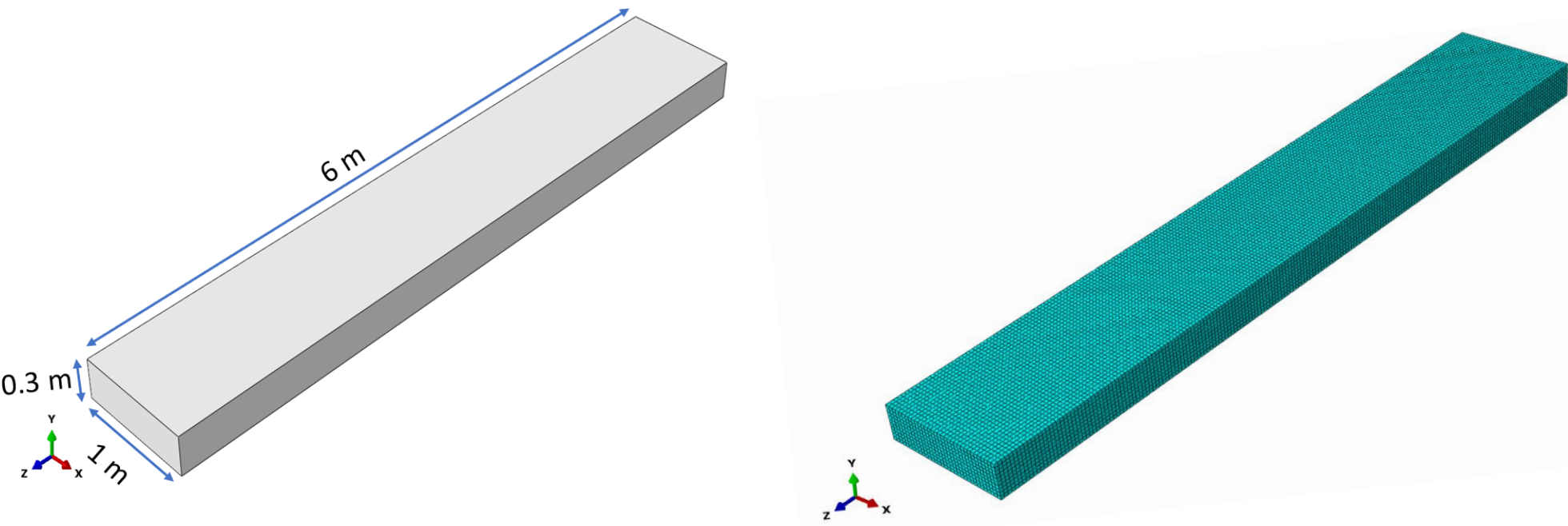
- In order to simulate the fire, two standard time/temperature curves were used: ISO 834 and ASTM E119 curves shown in the figure to the right:



Methodology

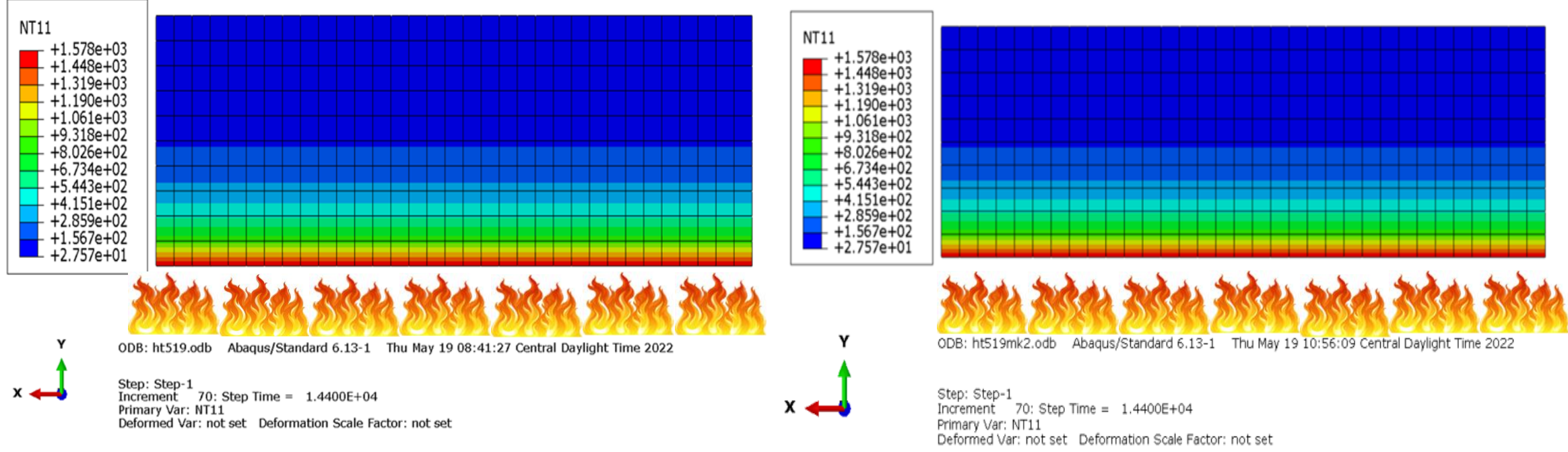
Slab Design

- The slab considered is a flat, concrete slab with dimensions: 6 m x 8 m x 0.3 m.
- However, to run the simulations in ABAQUS smoothly, the slab was reduced to a 1 m wide section of the slab with dimensions: 6 m x 1 m x 0.3 m.
- Material properties of concrete such as thermal conductivity, specific heat, and density are also applied to the slab at respective temperatures.
- The mesh is then applied to allow thermal analysis of the slab at different locations.

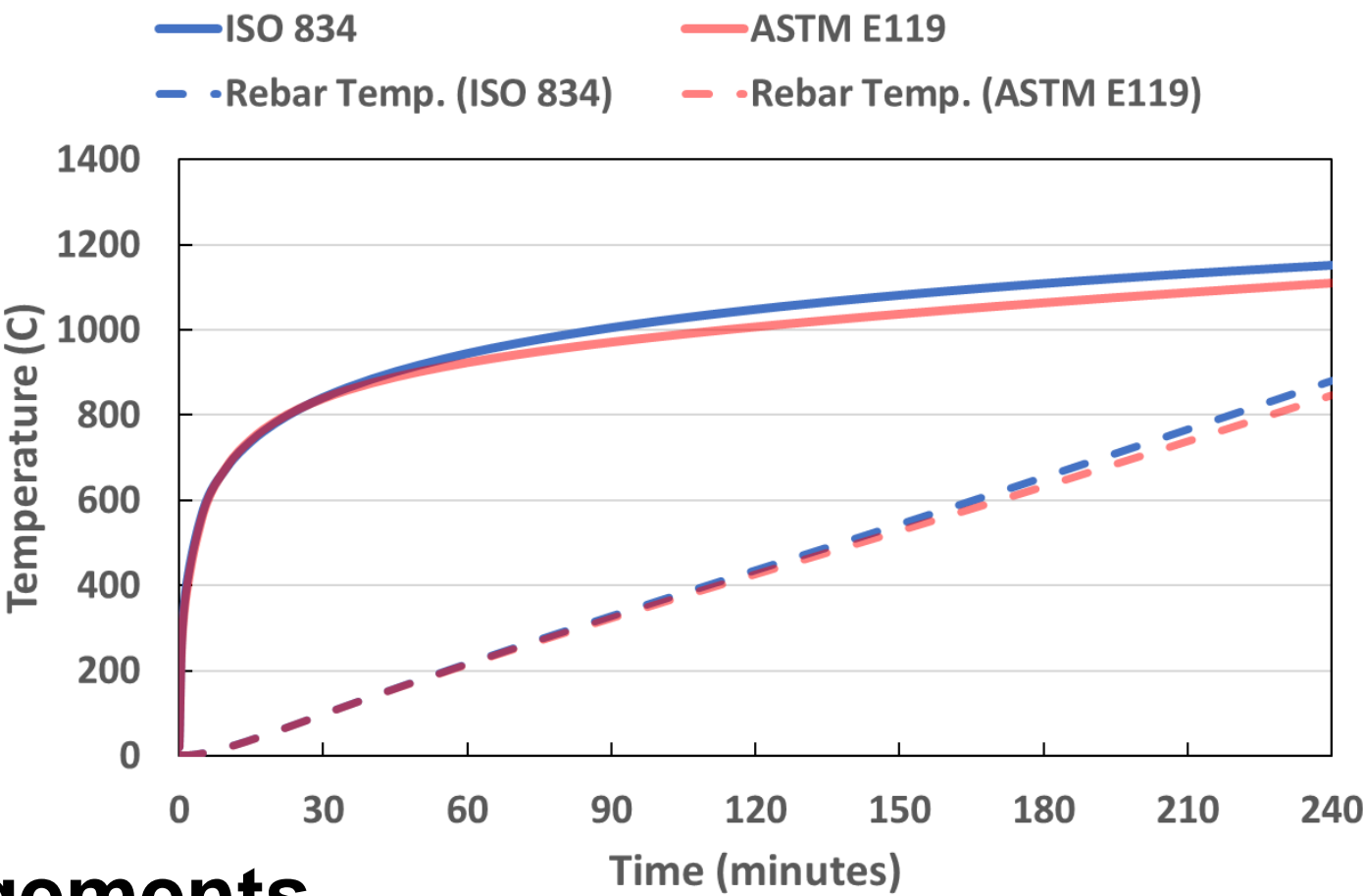


Thermal Analysis

- The thermal analyses of the slab were done in ABAQUS.
- The simulation analyzed the temperature at each of the slab's nodes over a period of four hours.
- This analysis was done for both ISO 834 and ASTM E119 fire curves shown respectively below:
- The temperatures along the first set of nodes are the rebar temperatures and can be seen alongside the original ISO 834 and ASTM E119 curves below as well:



ISO 834 and ASTM E119 Curves and Rebar Temperatures

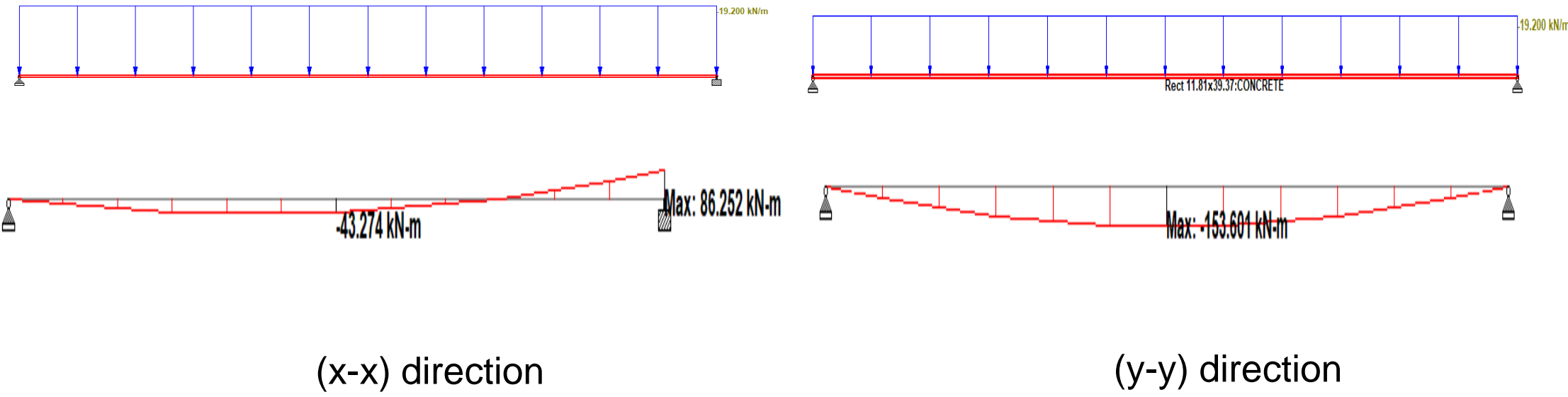


Acknowledgements

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Structural Analysis

- The structural analyses of the slab were done in STAAD PRO.
- The slab was divided into two beams running vertical and horizontally.
- The load applied to the slab was found to 19.2 kN/m and thus used in the analysis.
- The analyses in STAAD PRO provides the necessary data to perform the structural collapse analysis such as the maximum bending moment of the beams.
- The models used in this analysis can be seen below:

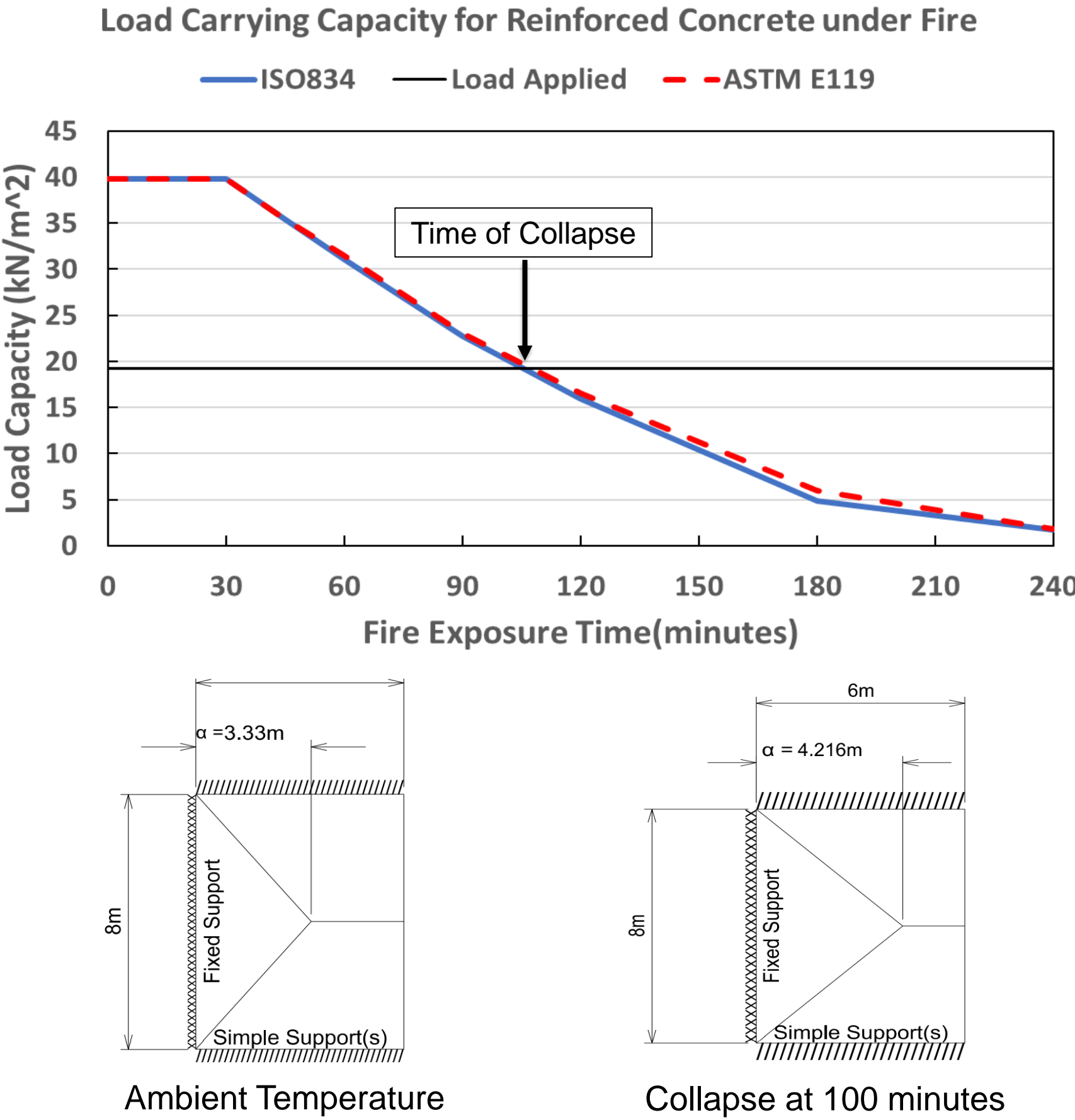


Load Capacity Analysis

- The data found in the structural analysis was used to determine the reinforcement needed in the slab.
- Then calculations were done in Microsoft excel to determine the load capacity of the slab at various temperatures.
- As the fire burns the load capacity of the concrete decreases. Once the load capacity of the concrete is less than the load applied the concrete will collapse.

Results & Discussion

- The results from the load capacity analysis shows that with both ISO 834 and ASTM E119 fires, the slab will no longer be able to support the load applied to it and ultimately collapse after roughly 100 minutes of fire exposure.



Discussion

- In order to prolong the time before the concrete would collapse, the concrete could be made thicker to increase the time it would take to reach the reinforcement.
- Passive fire suppression systems would be beneficial as well such as sprinklers and fire resistance coatings on floors and doors.

References

- Elias Ali (2010) Limit Analysis of R/C slabs exposed to standard fires: Application of the yield line method
- American Concrete Institute (ACI-318-19) Building Code Requirements
- ABAQUS CAE by Dassault Systems
- Staad Pro- structural analysis and design by Bentley Systems