

# Cooling Behaviour of Structures after a Fire

C Röben and M Gillie  
University of Edinburgh



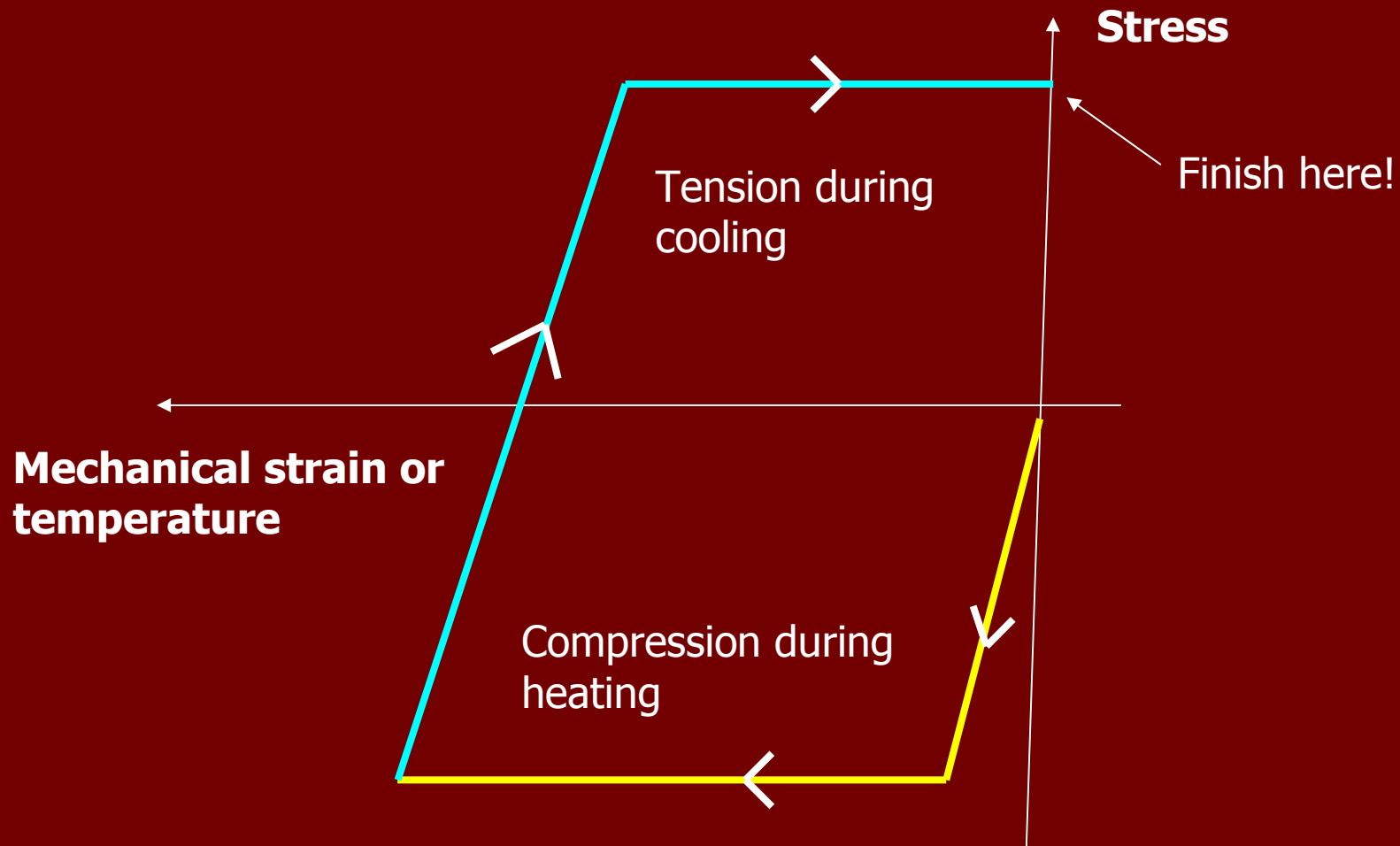
# Ambient Temperature

- Calculate peak predicted load (or several load cases)
- Check strength at this load
- Loads monotonic

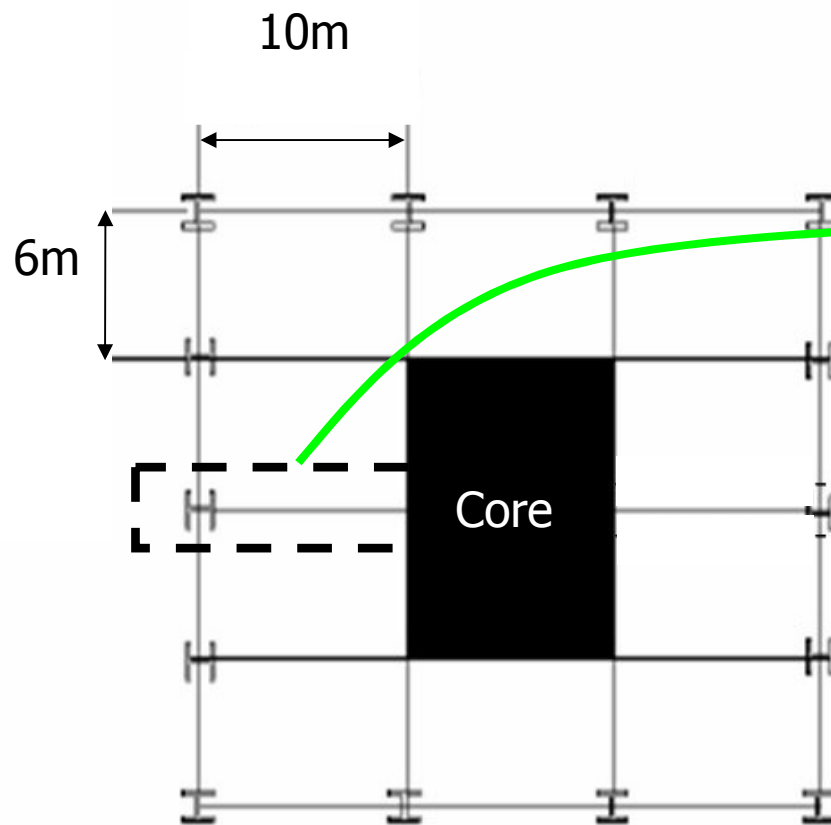
# At High Temperature

- Calculate gas temperatures
- Calculate structure temperatures
- Check strength
- BUT
  - Stresses and strengths are time-varying
  - Loading/Temperatures not monotonic
  - Therefore point at which strength should be checked not clear
- THEREFORE
  - Cooling may be important but often ignored

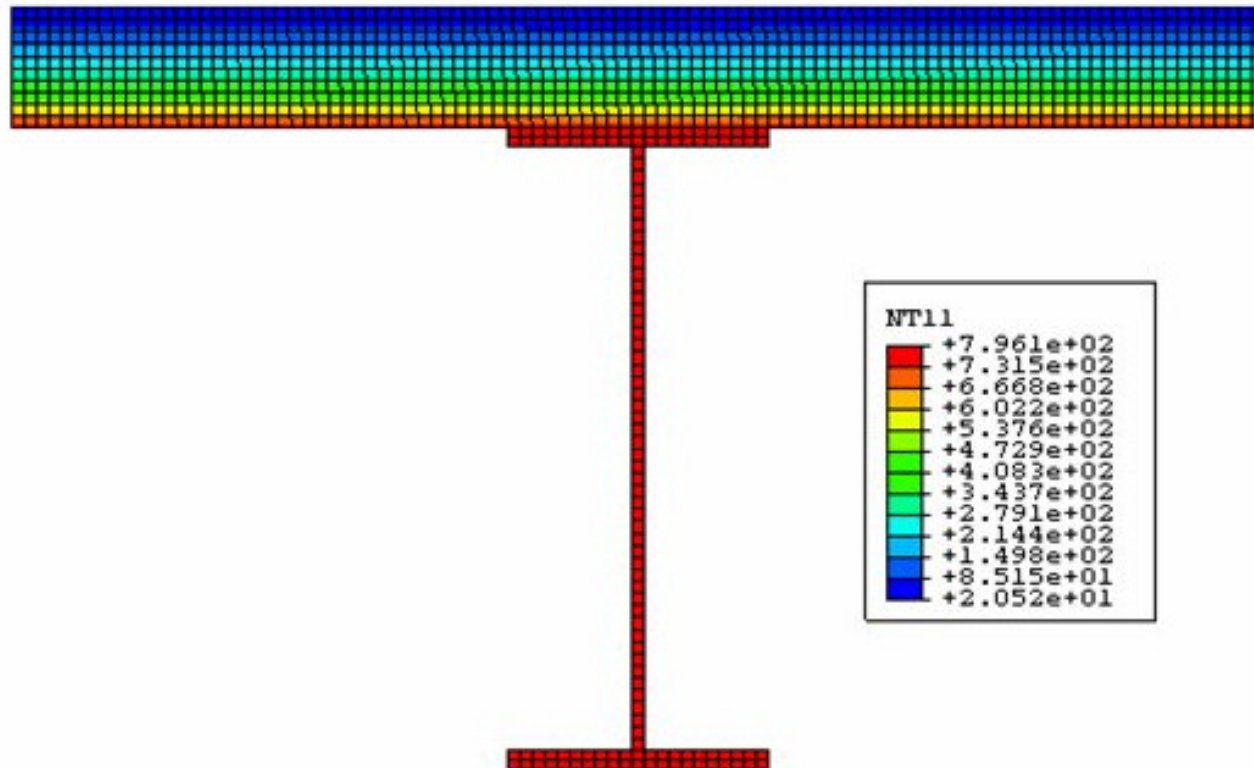
# Structural Cooling



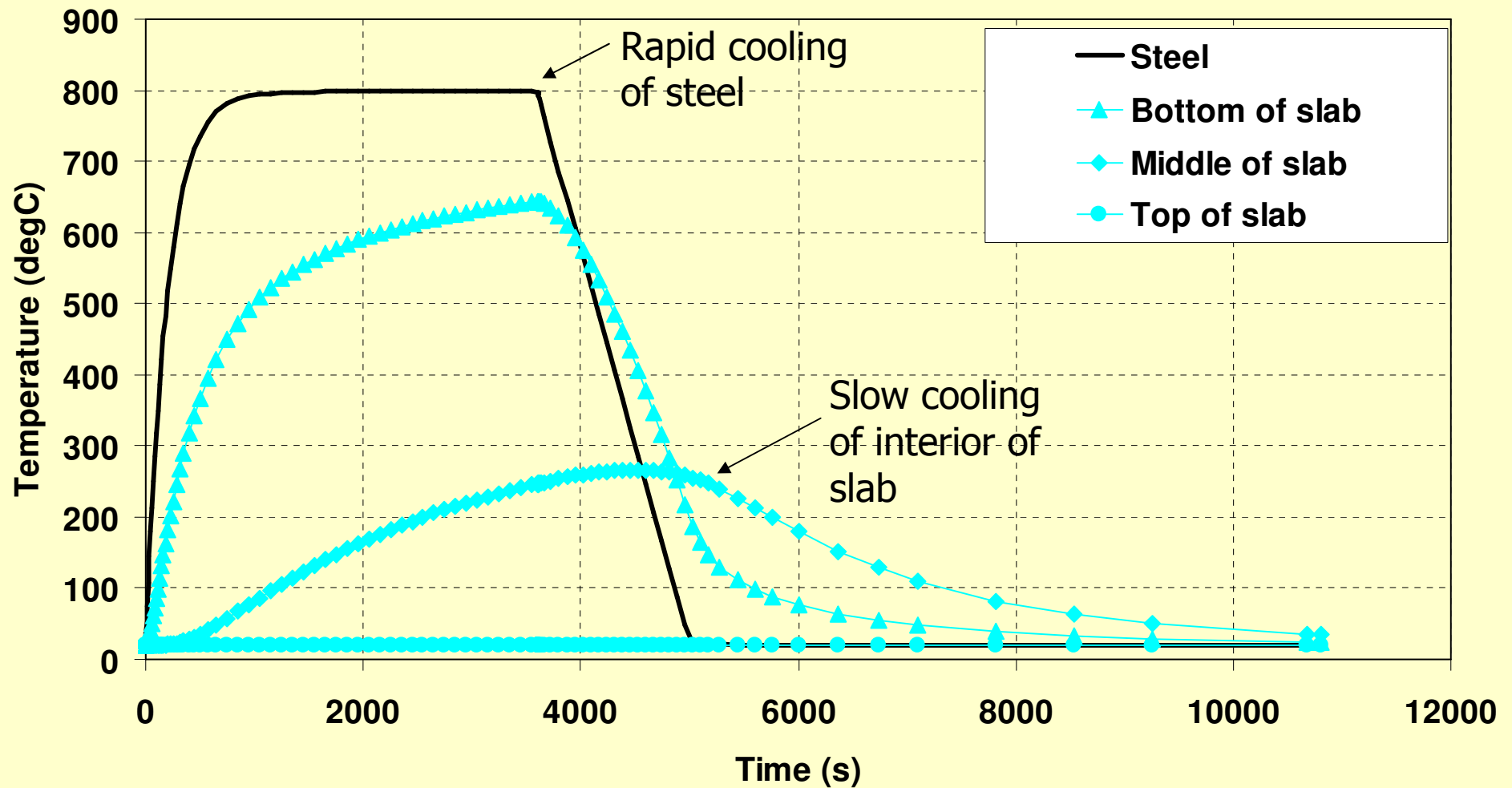
# Sample Structure



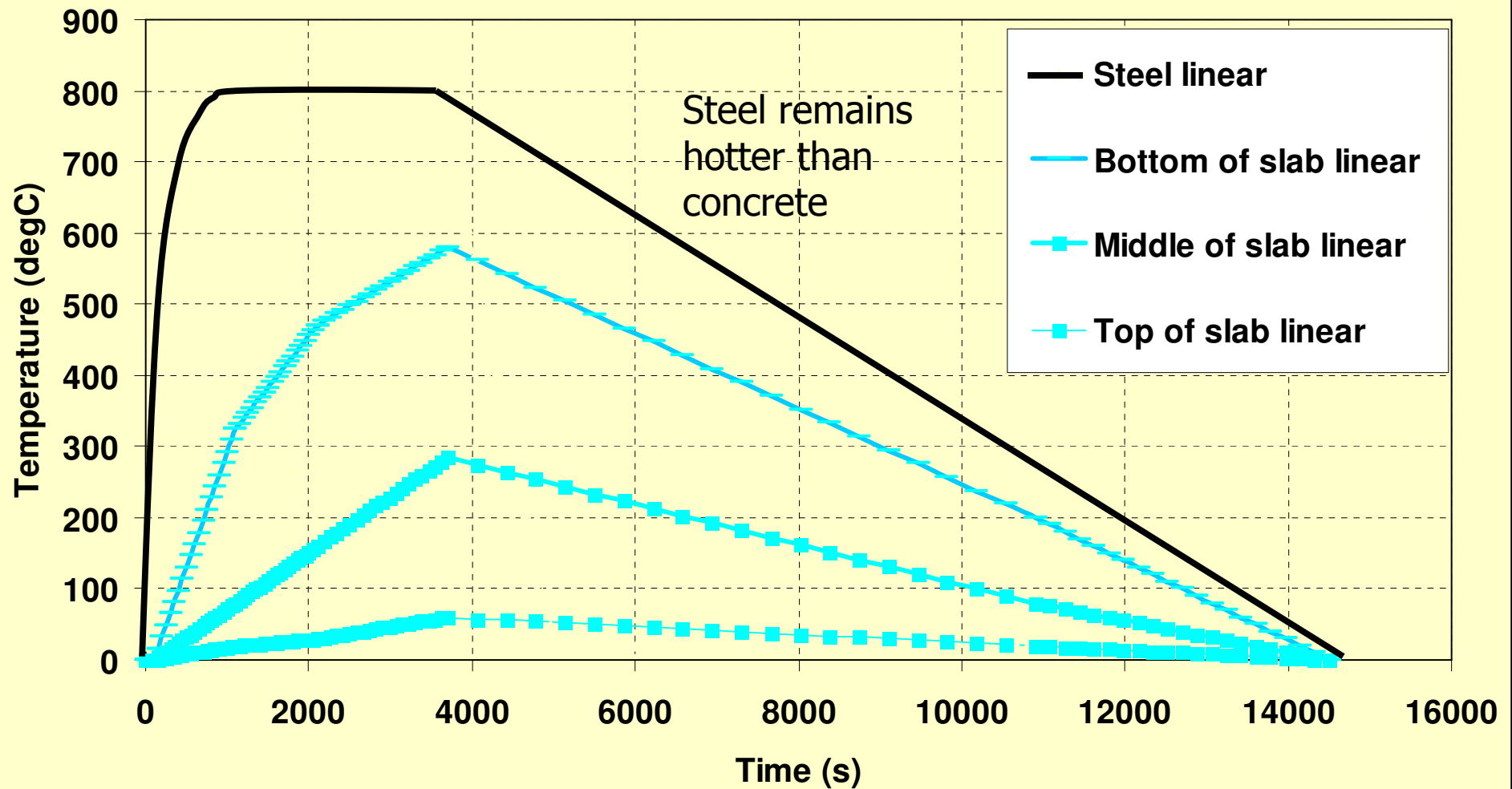
# Heat Transfer



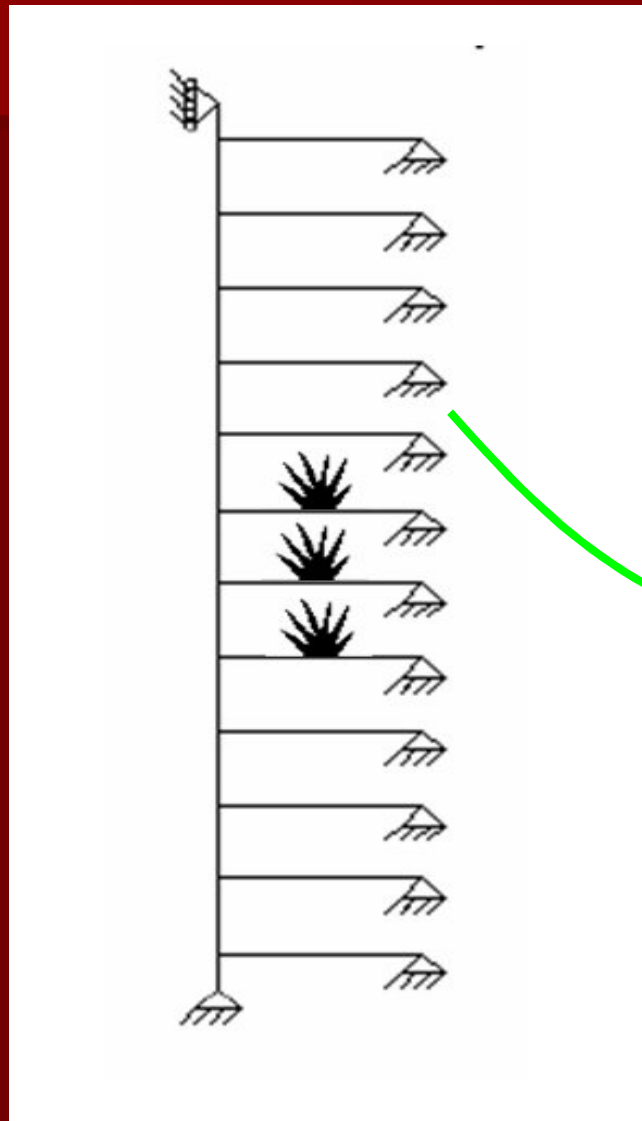
# Structural Temperatures -HT



# Structural Temperatures - Linear



# Structural Modelling



Column

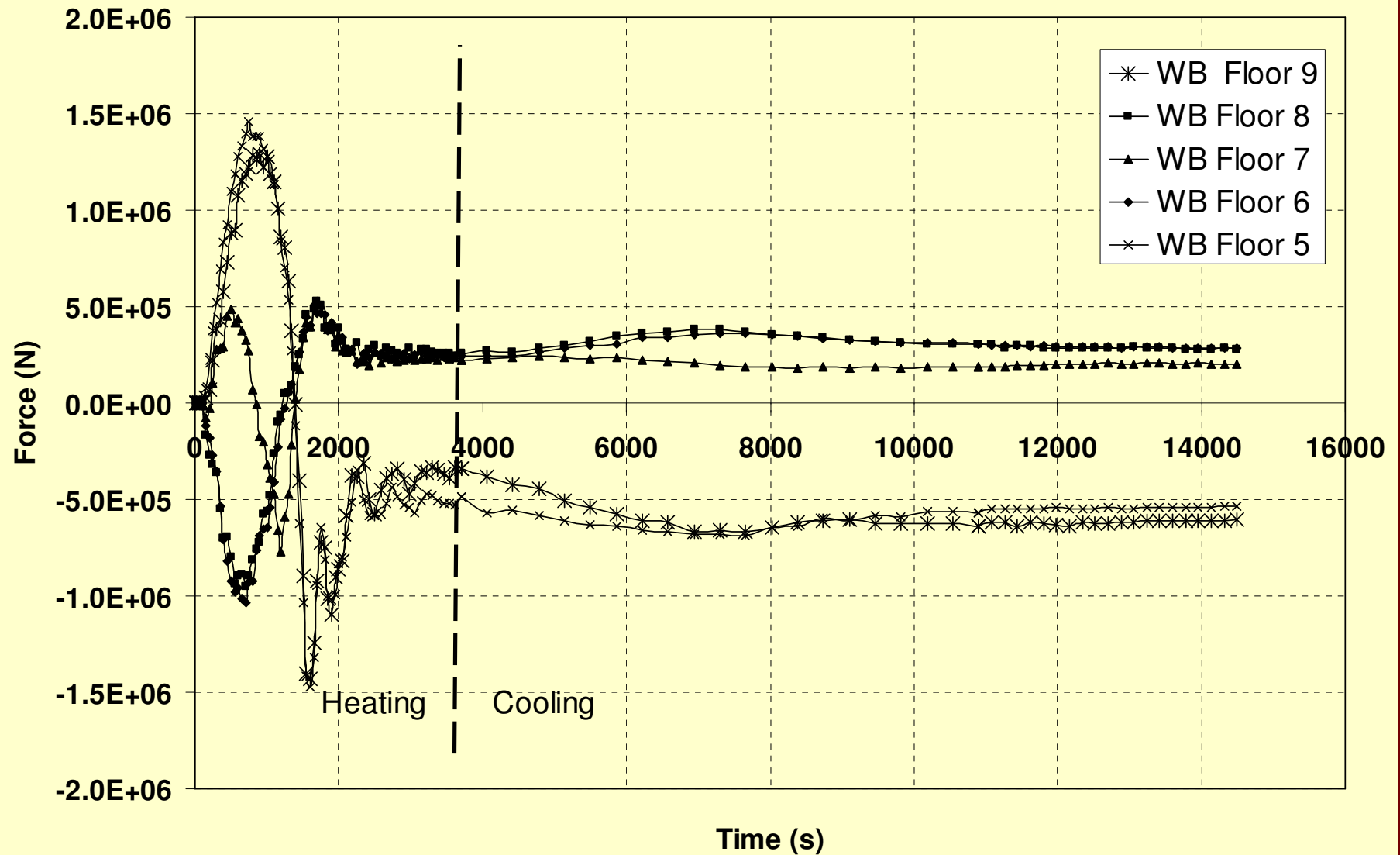
Concrete

Rigid connections

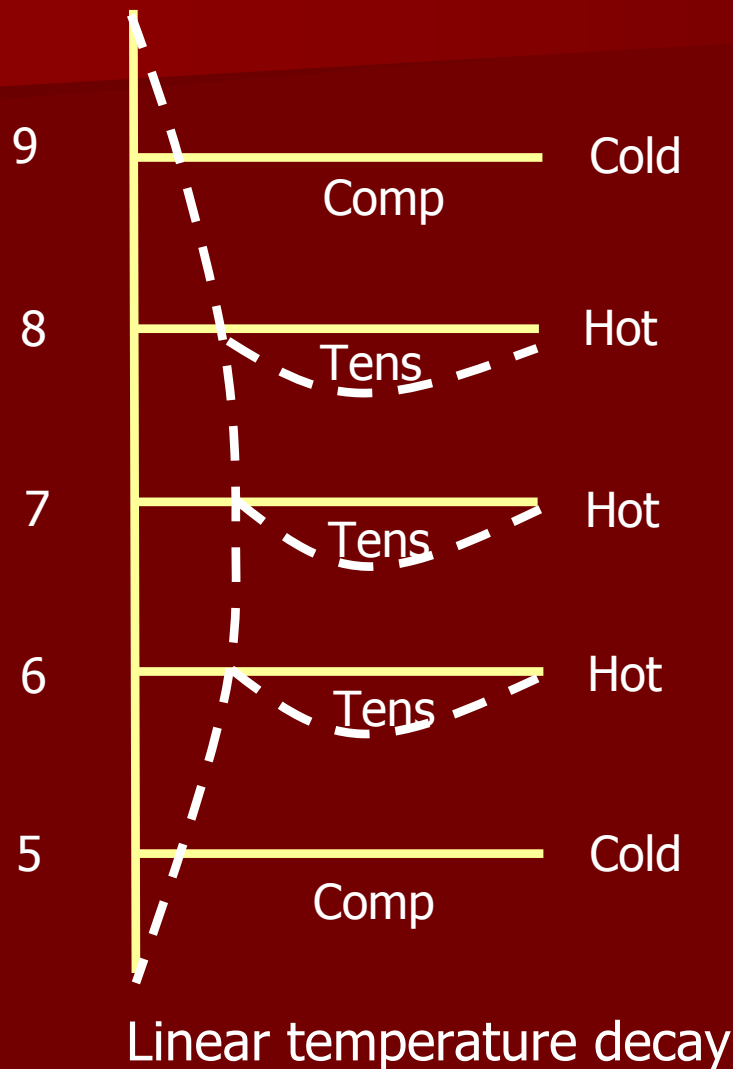
Steel

- Beam elements throughout
- Eurocode material behaviour
- Temperatures from thermal analysis or simple analysis
- Comparison of strong and weak steel beams

# Linear Cooling – Total Section Forces

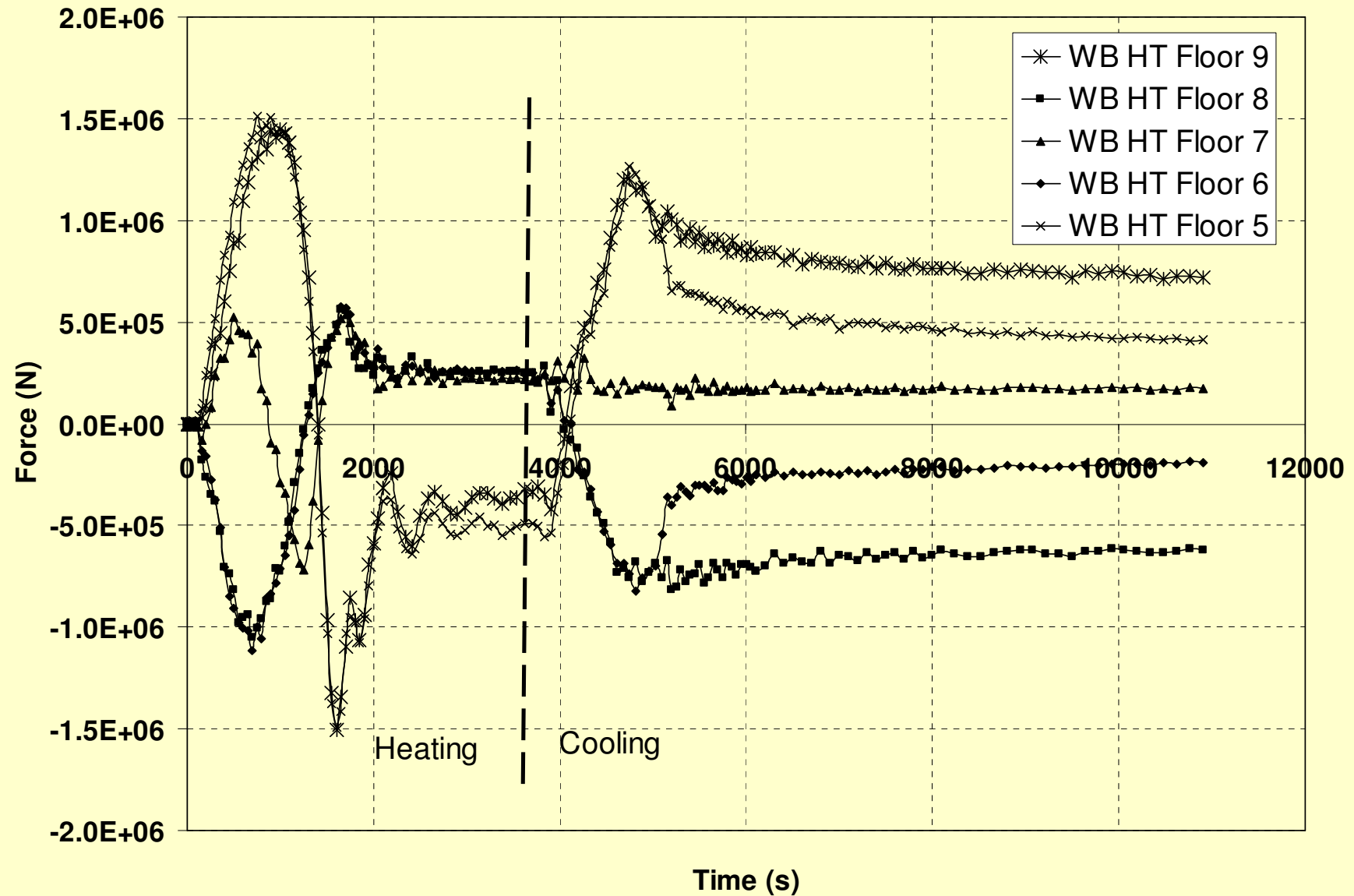


# Explanation



- Steel and concrete cool "together"
- Tension in fire floors
- Restraint from column and cold floors
- Cold floors in compression as a result

# Heat Transfer Cooling - Total Section Forces



# Explanation

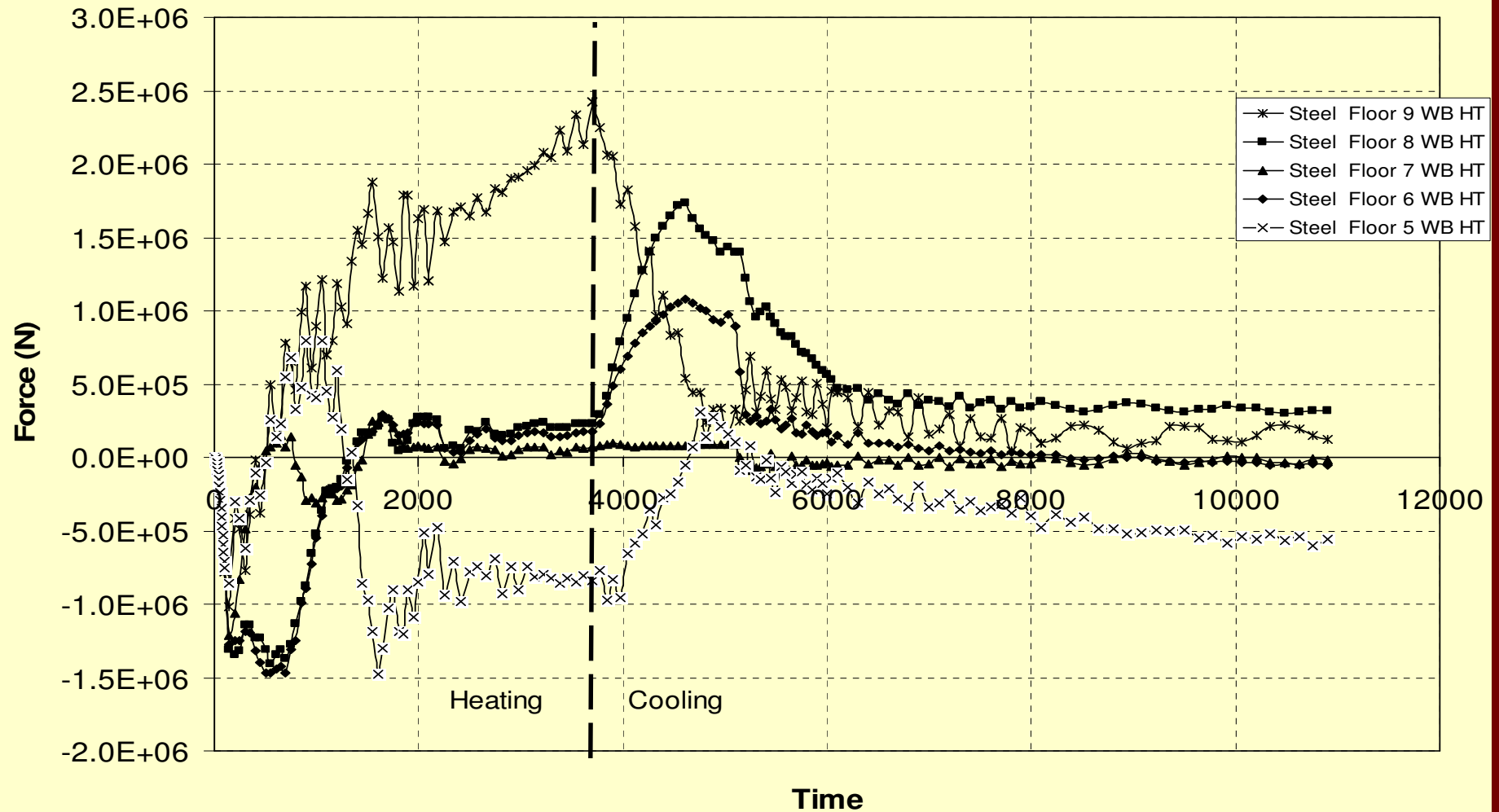


Heat transfer temperature decay

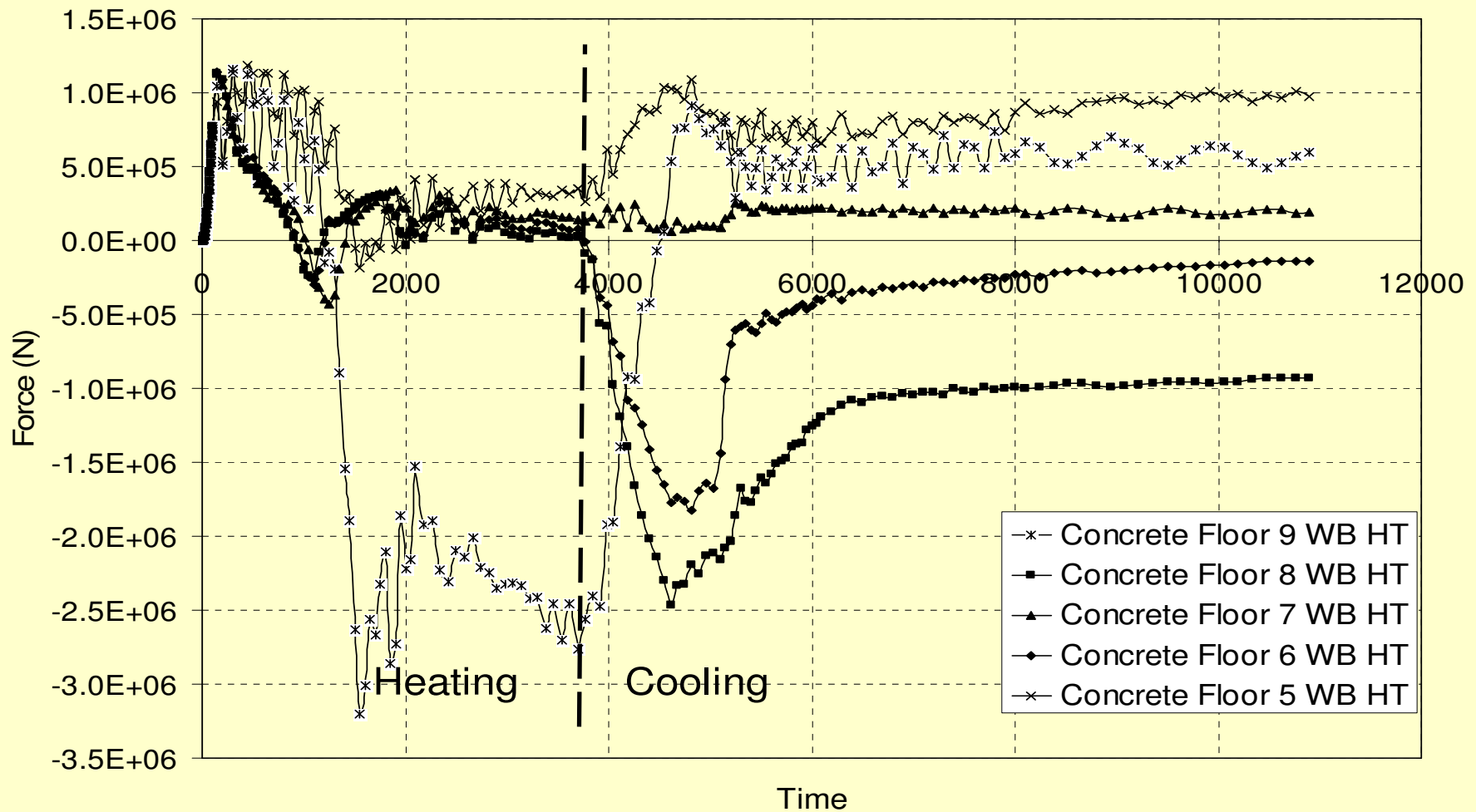
# Summary so Far

- In linear cooling
  - Steel and concrete cool at comparable rates
  - Whole section forces remain similar to end of heating
  - Overall tensile forces in fire floors
- In HT cooling
  - Steel cools rapidly – tension in steel
  - Concrete still expanding – compression
  - Overall compressive forces in fire floors

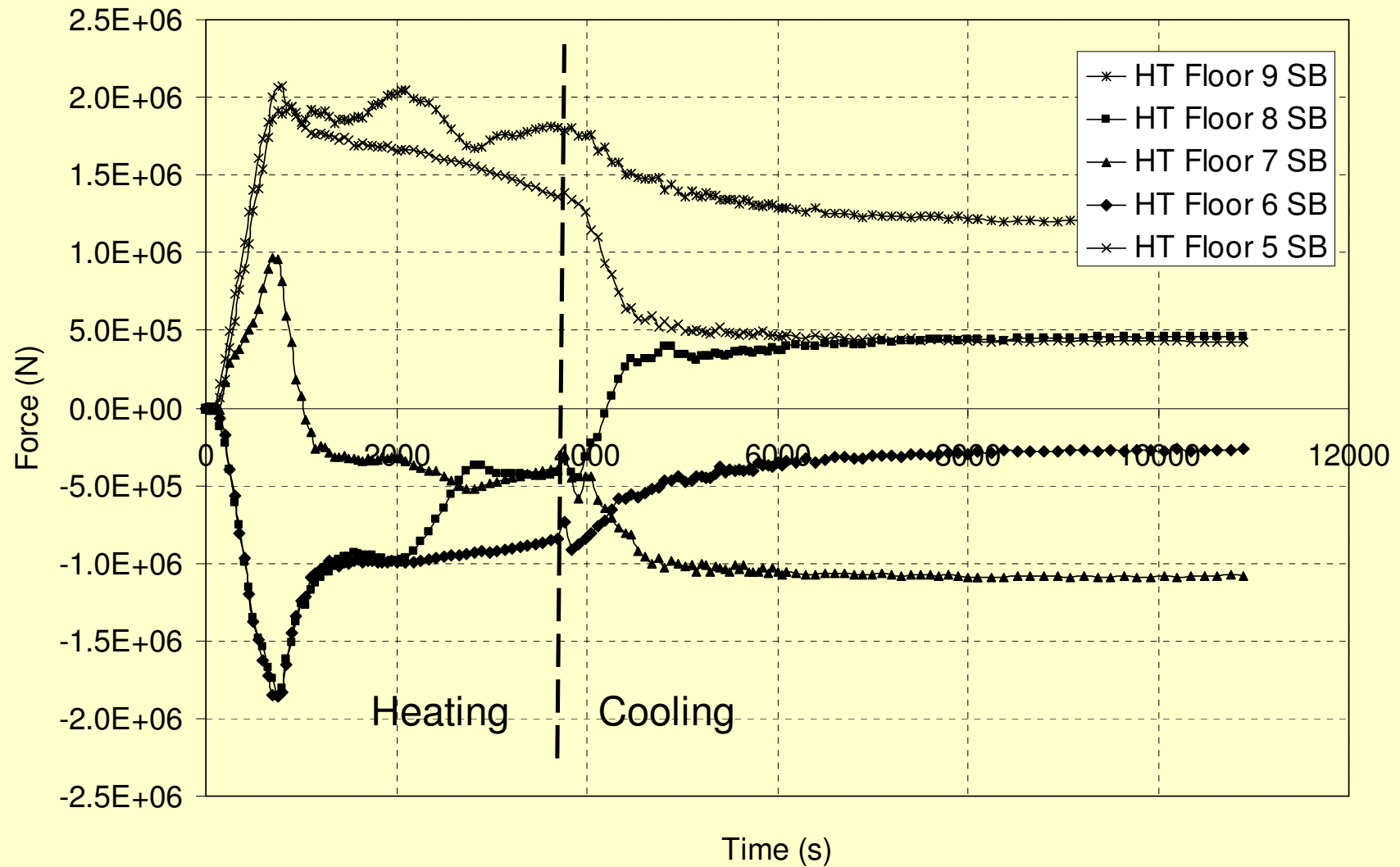
# Forces in steel-beam



# Forces in Concrete Section



# Increased Steel Area Section Forces



# Conclusions

- Large forces developed during cooling
- Cooling behaviour dependent on heating and cooling regime. Care needed
- Relative sizes of structural members may be important during cooling
- Forces developed important for connection design
- Work continues!