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Probabilistic collapse analysis of steel frame structures exposed to fire scenarios

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Introduction

- **Background**

  - **Steel structures need to maintain their stability for fire rescue and evacuation**

- **Purpose:**

  - **A probabilistic method to analyse the collapse time of steel structures in fires**

Research method

The steps of method

- Steel structures model
- Random variable distribution
- Monte Carlo sampling
- Fire time history analysis
- Collapse time fragility analysis
- Structural collapse resistance assessment

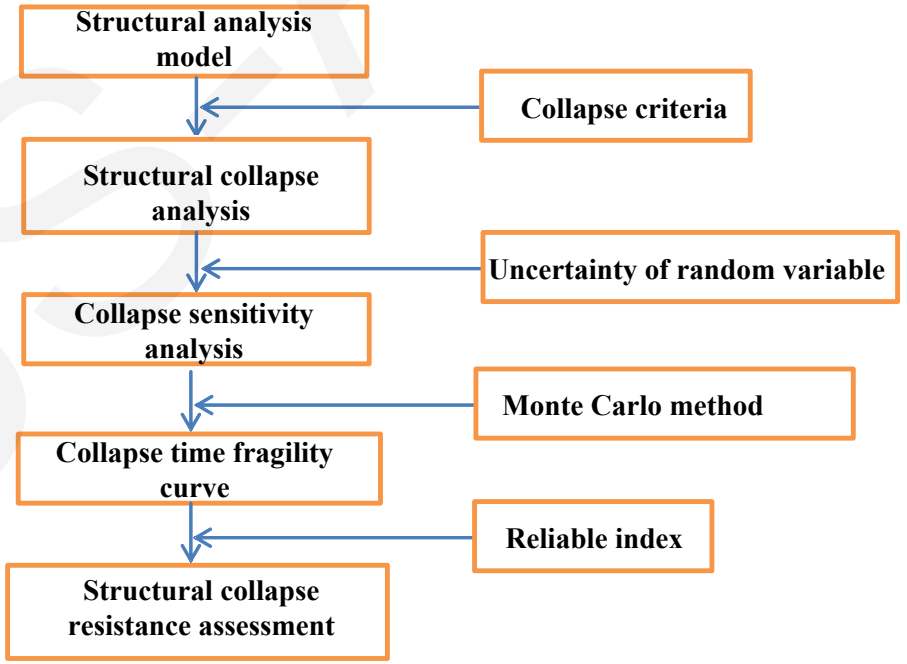

Fig. 1 A flow chart of the collapse probability analysis method

Case analysis

Fire protection

- Insulation material: CAFCO 300
- Three levels of fire protection (high, medium and low)

Fire scenarios

- Fire compartments: G1~G4 (in Fig.2)
- ISO 834 standard fire curve

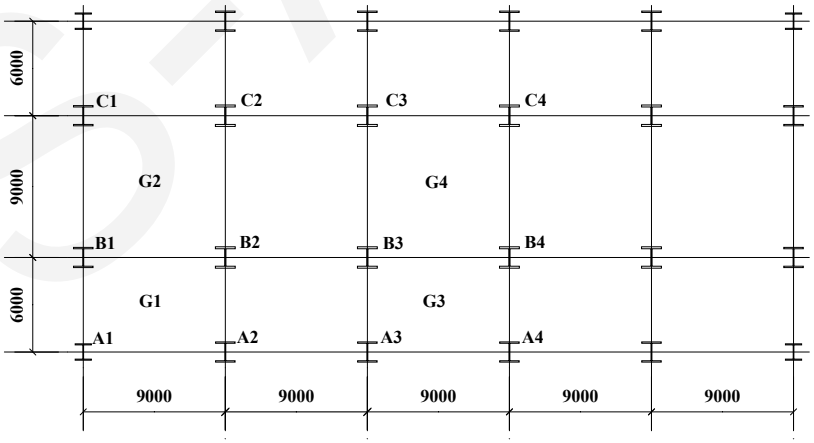

Fig. 2 The structural plan arrangement of the steel frame model (Units: mm)

Analysis results

■ Fire protection

Table1. The statistical parameters of the collapse time and reliability indexes of the structure in a corner compartment fire scenario

Fire protection level	Collapse time t_{cp}		95%reliability $t_{cp,95}$ (h)	Mean square deviation (h)	Reliability index β
	Mean value (h)	COV (%)			
High	3.17	3.80	2.97	0.12	1.41
Medium	2.22	4.50	2.06	0.10	2.20
Low	1.17	4.60	1.08	0.05	3.16

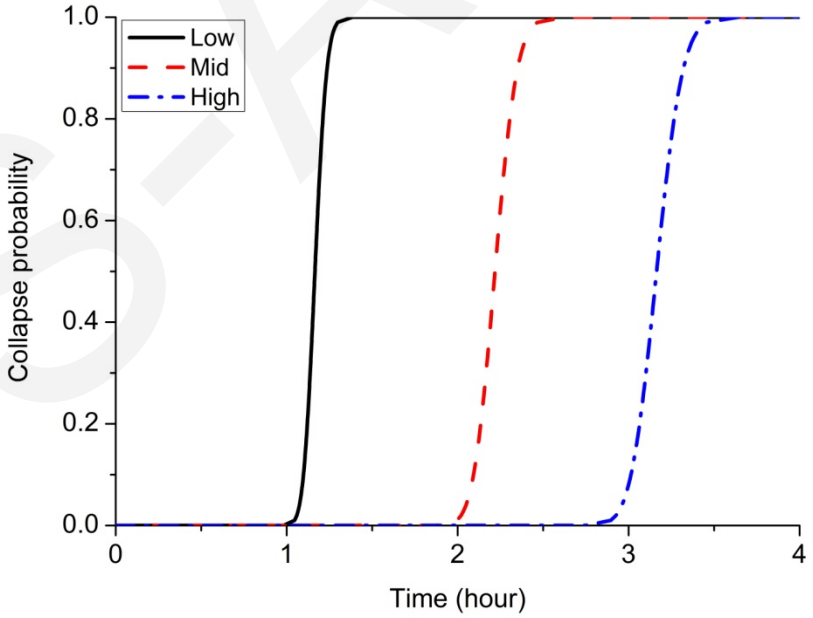

Fig. 3 Collapse time fragility curves at different fire protection levels in a corner compartment fire scenario

Analysis results

■ Fire compartments

Table2. The statistical parameters of the collapse time and reliability indexes of the structure at a high fire protection level

Compartment	Collapse time t_{cp}		95% reliability $t_{cp,95}$ (h)	Mean square deviation (h)	Reliability index β
	Mean value (h)	COV (%)			
Corner	3.17	3.8	2.97	0.12	1.41
Short span	3.22	5.7	2.93	0.19	1.16
Long span	3.39	4.9	3.13	0.17	2.29
Middle	3.41	6.9	3.04	0.24	1.74

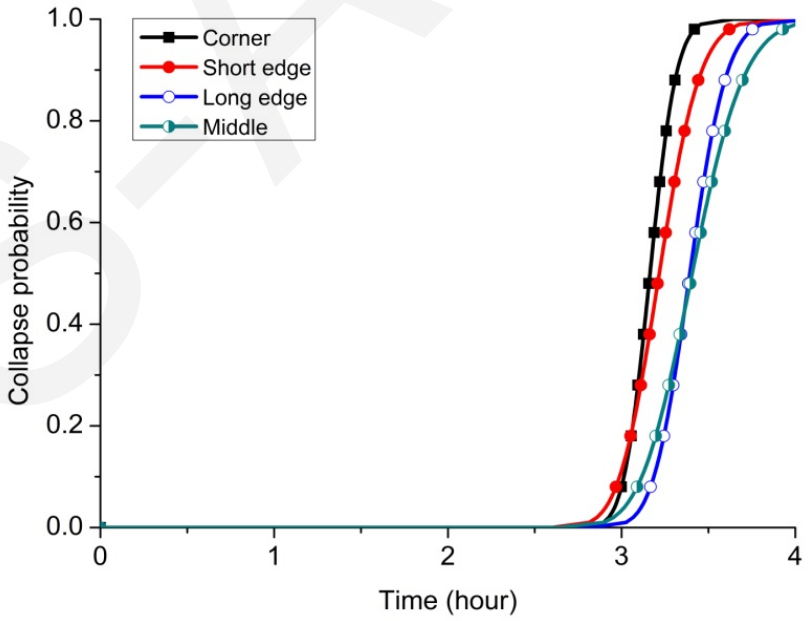

Fig. 4 Collapse time fragility curves at high fire protection levels in different compartment fire scenarios

Conclusions

- The yield strength of steel and fire protection of steel column have the greatest influence on the collapse time of steel frame structure in fire;
- The short span compartment and corner compartment fire scenarios are relatively dangerous for structural collapse. In these compartments, the fire protection should be enhanced to prevent the structure from collapsing in a fire;
- The collapse resistance of steel frame structures in fire could be quantitatively evaluated by the reliability indexes of structural collapse time.