SIMULATION OF CONNECTIONS USING COMPONENT-BASED MODEL

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- Development of Component Models
- Simulation of small-scale sub-frame test
- Simulation of WTC 7 Connections
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DEVELOPMENT OF A MODEL FOR ANGLE
COMPARISON WITH FEM

Displacement (mm)

Force (kN)

FEM

Simple model

$g=114$

$g=134$

$g=144$

$w=100$

$w=70$

$w=50$
DEVELOPMENT OF A MODEL FOR ENDPLATE

\[ E_{PH1} + E_{PH2} + E_{spring} = P \delta \]
VALIDATION AGAINST TEST

Displacement (mm) vs. Force (kN) graphs for Test T1, Yield line model, Test M20, Model M20, Test M16, Model M16, Test M12, and Model M12.
CONSTRUCTION OF THE MODEL

Flush Endplate Connection

Horizontal T-stub
Vertical T-stub
Horizontal T-stub
COMPARISON WITH TEST

Graphs showing the force and rotation results for different temperatures (T=20°C, T=450°C, T=550°C, T=650°C).

- Force in kN
- Rotation in °
SUB-FRAME TEST BY JUN DING
CONNECTION DETAILS
MODEL FOR THE FRAME

Beam element
TEST 1, FIN PLATE CONNECTION
TEST 2, T-STUB CONNECTION
TEST 3, EXTENDED ENDPLATE CONNECTION
WTC7- SUBFRAME

a. SB-C connection

b. PB-C connection
CONNECTION AND MODEL

a. K4 Connection
b. Fin Connection
connection and model

W24x55

L150×100×8

8mm

S1

S2

S5

S6

c. H4 Connection
CONNECTION AND MODEL

d. STC Connection
TEMPERATURE OF THE MEMBERS

![Graph showing temperature over time for various members.]
FINITE ELEMENT MODEL

External surface of the column flange
STC Connection

Graphs showing the relationship between time (min) and axial force, moment, and deflection for different connections (PB-C and SB-C) over a time period of 60 minutes.
K4

Axial force (kN)

Moment (kN.m)

Deflection (m)

Time (min)

0 5 10 15 20 25 30 35

0 100 200 300 400 500 600 700 800 900 1000 1100 1200

0 50 100 150 200 250 300

0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9

FEM

Component

strong

weak

strong

weak
Fin

Axial force (kN)

Time (min)

Moment (kN.m)

Deflection (m)

Component
FEM
PARAMETRIC STUDY WITH COMPONENT-BASED MODEL

\[ \delta = 0.6L_1 \]
H4 WITH STRONG RESTRAINT C1

![Graph showing deflection, axial force, and moment over time for different lengths (L=8m, L=12m, L=16m).]
H4 WITH WEAK RESTRAINT C3
STC WITH WEAK RESTRAINT C3
H4 - CONNECTION TEMPERATURE

- Deflection (m)
  - Time (min)
  - T=03
  - T=05
  - T=08

- Axial force (kN)
  - Time (min)
  - T=03
  - T=05
  - T=08

- Moment (kN.m)
  - Time (min)
  - T=03
  - T=05
  - T=08
STC- CONNECTION TEMPERATURE

Deflection (m) vs Time (min)

Axial force (kN) vs Time (min)

Moment (kN.m) vs Time (min)

Legend:
- T=03
- T=05
- T=08
H3-H4-H5

Deflection (m)

Axial force (kN)

Moment (kN.m)
Tf=8, 12, AND 14
DEVELOPMENT OF THE CONNECTION FORCES

- H4
- STC
DEVELOPMENT OF THE COMPONENT FORCES

![Graph showing axial deformation over time for different bolt rows.](image)
CONCLUSION

- Development of the axial force is related to the restraint stiffness, beam span, but is less sensitive to the connection characteristics, such as connection size, geometry and temperature, etc.

- The compressive axial force has the effect of enhancing the connection moment resistance, but also generating the second-order moment. Therefore, the effect of axial force is generally increase the fire resistance but can be harmful for beams with long span.

- Better connections should have good ductility. Connections with high stiffness, but low moment resistance should be avoided.

- Change of the connection geometry or connection temperature does not necessarily increase the connection fire resistance.