A fire safe future?

Influence of changing boundary conditions on the fire safety of buildings

Ir. Ruud van Herpen MSc. FIFireE

Nieman

TU/e Technische Universiteit Eindhoven University of Technology

Where innovation starts

Ruud van Herpen

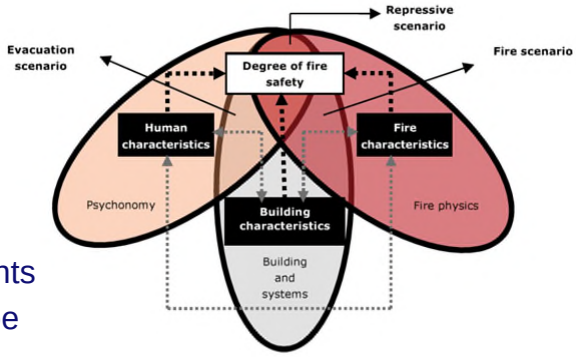
Eindhoven University of technology:
Fellow Fire Safety Engineering
(Dept. Built Environment – Unit BPS)

Saxion University of applied sciences:
Professor Fire safety in buildings
(Academy Built Environment)

Nieman consulting engineers

A fire safe future?

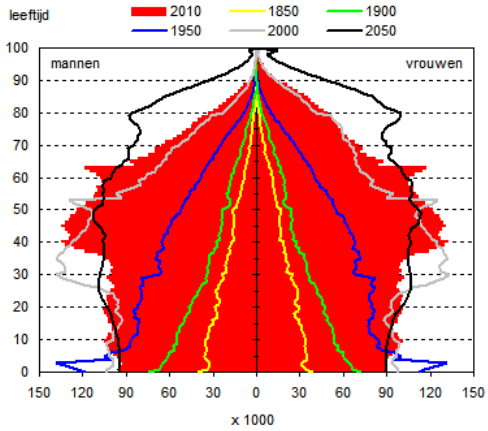
Are rules or regulations robust enough to take into account changes in boundary conditions?



- Fuel
- Building occupants
- Building envelope

Residential function: fuel

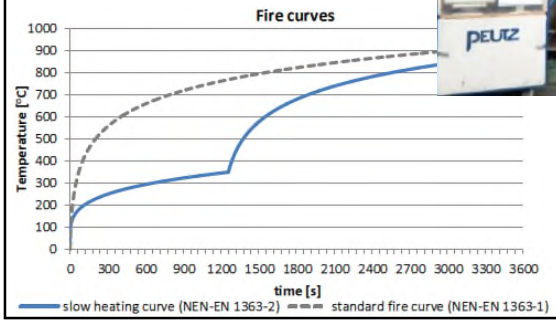
Residential function: building occupant



Residential function: building envelope

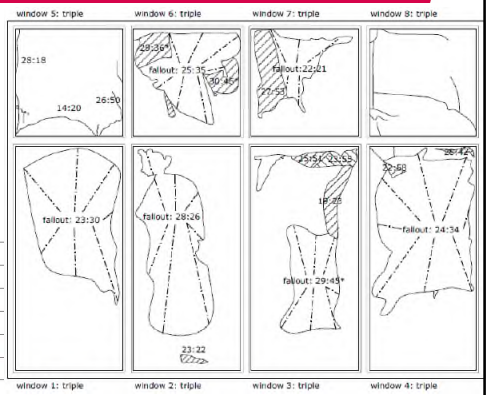
Building envelope: daylight openings

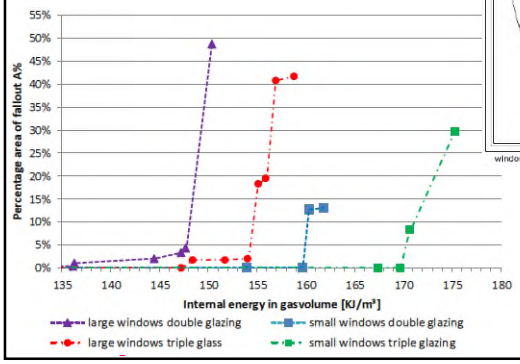
Experiments with double and triple glazing



Building envelope: daylight openings

Percentage of glass fallout related to specific internal gasenergy [kJ/m³]





Building envelope: daylight openings

Conclusions:

- Glass fallout after flashover
- Pre flashover:
  - Large uncertainty, depending on dimensions and glass quality
  - Possibility of underventilated localized fire, severe hazards for building occupants and fire service

Recommendation:

- Optical detectors in all rooms, instead of detectors in escape route

Building envelope: air tightness

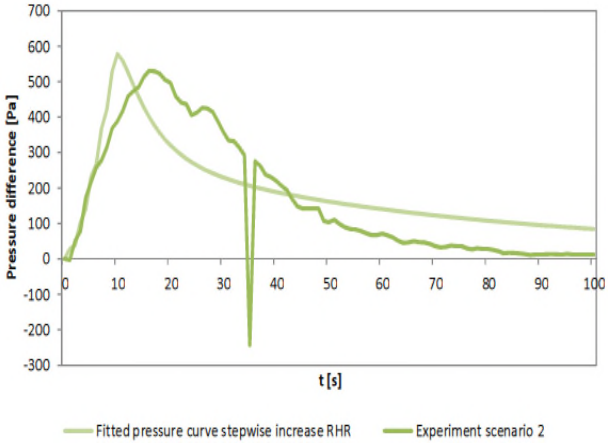
Adiabatic and airtight envelope without openings

Building envelope: air tightness

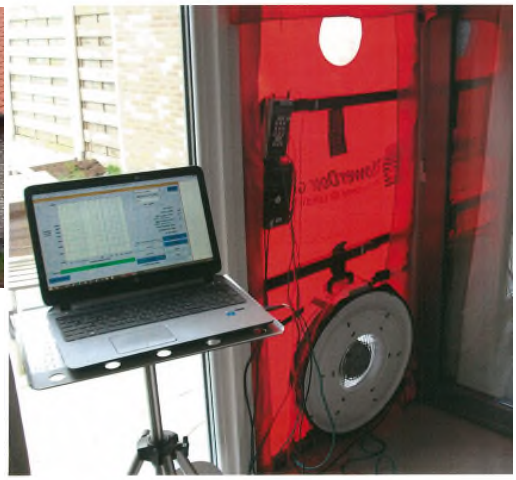
$Q_{v,10}$ = 0.15 dm³/s.m²

HRR = 70 kW, constant

A_{floor} = 9 m²



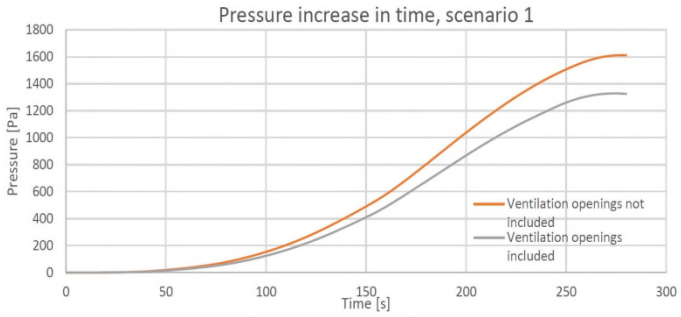
Building envelope: air tightness



'Blowerdoor' test in real dwellings ('passive houses')

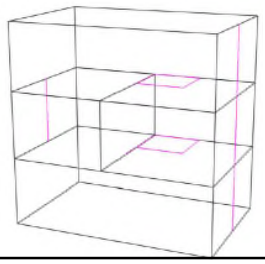
- Only building envelope
- Envelope incl. ventilation system

Building envelope: air tightness



Medium fire growth rate

Influence mechanical ventilation system



Building envelope: air tightness

Conclusions:

- Opening front door of a residential function (dwelling) is not possible during several minutes
- Escape route is obstructed by overpressure caused by the developing fire

Recommendation:

- Pressure relaxation valve?
- Open door in the direction of the escaperoute?

A fire safe future?

Are rules or regulations robust enough to take into account changes in boundary conditions?

Fuel / fire load?

Pre flashover fire?

Building occupant?

A fire safe future?

Rules don't anticipate on changing boundary conditions → safety level is not defined

Need for performance based fire safety

Objectives of the Building Code:

- Safe environment
- Safe building (load bearing structure) → LOD
- Safe compartmentation (limiting spread of fire and smoke) → LOD
- Safe escape and attack routes

Performance based safety

The concept of the Building Code:

Evacuation in case of fire!

Performance based safety

Is a fire safe building possible without escape routes?

Stay-in-place, only when the LOD's are extremely reliable:

- Building (load bearing structure)
- Compartmentation

Performance based safety

Is a fire safe building possible without escape routes?

Stay-in-place, only when the LOD's are extremely reliable:

- Building
  (load bearing structure)
- Compartmentation

LOD: fire compartmentation

Reliability of fire compartmentation

Example:

What is the failure probability of a 30 minutes fire resistant wall (EI=30 min, SFC) when the mean fire load is 30 kg/m^2 (whitewood equivalent)?

NOTE:
Ideal firewall, 1-dimensional
1 kg/m^2 whitewood equivalent = 19 MJ/m^2

LOD: fire compartmentation

Natural fire concept:

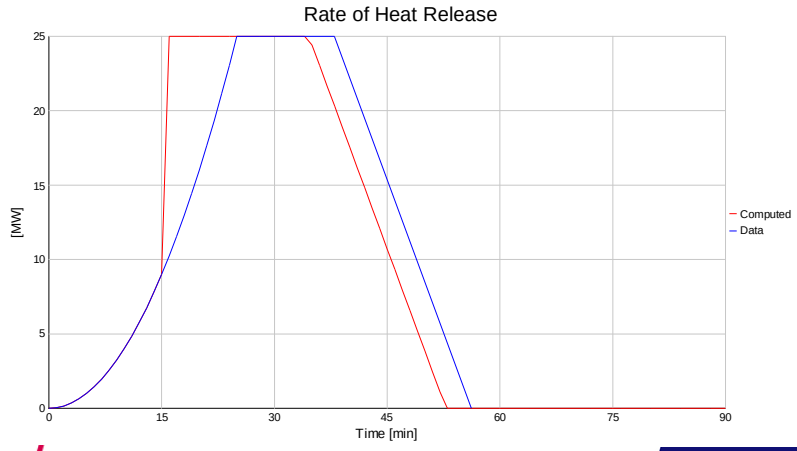
- Compartment: 100 m^2

Assumptions/boundary conditions:

- Localized fire: medium fire growth rate (300 s.)
- Separation constructions:
  - Floors: concrete;
  - Facades: adiabatic, 20% open
- Combustion model:
  - External flames in case of oxygen controlled fire

LOD: fire compartmentation

Natural fire concept:



LOD: fire compartmentation

Natural fire concept:

LOD: fire compartmentation

Available safe time and required safe time (SFC):

- AST : 30 min SFC
- RST : 33 min SFC

AST-RST = -3 min SFC

Safe compartmentation?

LOD: fire compartmentation

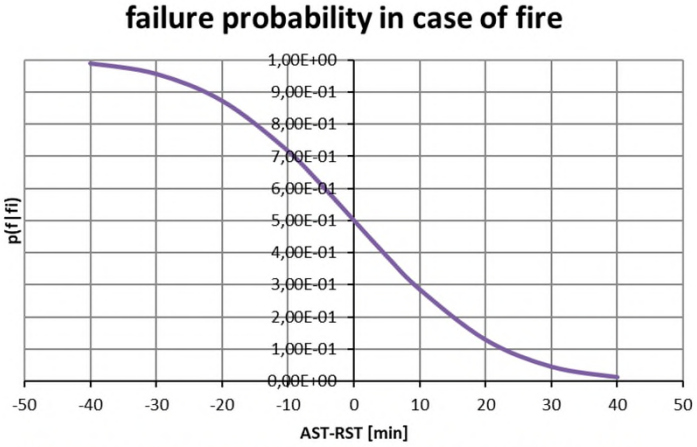
Available safe time and required safe time (SFC):

AST-RST = -3 min SFC

Sensitivity analysis RST:

- Fire load
- Max. RHR density
- Opening factor
- (Combustion model)
- (Heat transfer gas → separation constructions)

LOD: fire compartmentation



AST: 30 min SFC, RST: 33 min SFC → failure probability: 55 %

AST: 60 min SFC, RST: 33 min SFC → failure probability: 7 %

LOD: fire compartmentation

Preliminary conclusions:

Failure probability of a firewall depends on:

- Fire load (density)
- Opening factor
- Fire resistance firewall

Compartments with small openings:

- Oxygen controlled RHR increases thermal load!

Failure probability increases by:

- Adjoining constructions
- Doors, openings, ducts etc, through the firewall

LOD: fire compartmentation

Preliminary recommendations:

- Interval AST-RST > 30 min. SFC
- Fire service (defensive cooling)
- Automatic (offensive) suppression

Stay-in-place concept:

- No redundancy!
- Extreme reliability needed
  - compartmentation
  - loadbearing structure

A fire safe future?

Projectspecific concepts for personal safety:

- Redundant escape routes
  (self-reliant building occupants)
- Or stay-in-place concept without redundancy
- And everything in between…..

Projectspecific concepts for building resilience:

- Damagecontrol, continuity → Sustainability

Projectspecific concepts:

- Objective-based approach: safety interval AST-RST

A fire safe future?

Researchers and students needed:

- Fire safety concepts for building occupants
- Fire safety concepts for resilient buildings

www.fellowfse.nl