2.7 Research in the field of structural fire safety engineering at ETH Zurich (short version)

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Research in the field of structural fire safety engineering at ETH Zurich

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Research domains

Timber
- Material
- Connections
- Elements
- Assemblies

Fire
- Material behaviour
- Connections/Elements
- Global behaviour
- Large scale testings
- Statistics/Reliability
- Active Measures

Steel
Stability
Global behaviour
Intumescent systems

Concrete
- Material (spalling, residual strength, etc.)
- UHC und HPC
- Painting systems

Composite
Connectors/ductility
Material combinations
Slim Floor
Concrete filled hollow steel sections

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Research objectives

Timber
Enhance use of sustainable timber for structures

Steel
Improve sustainability and competitiveness
Better use of resources

Fire
- Trans-disciplinary theme interconnecting all materials
- Improve safety and economy of concrete, steel, timber and composite structures

Concrete
Improve sustainability and competitiveness
Better use of resources

Composite
Optimized use of materials in combinations

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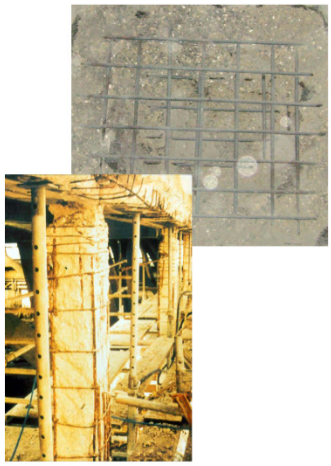
Concrete – Explosive Spalling

- Explosive spalling reduces the fire resistance of concrete structures
- Mechanisms of spalling are not fully understood
- Spalling can't be assessed accurately at the moment
- **Aim of project**
  Modelling the concrete's spalling behaviour



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Strength of concrete at high temperatures and after cooling

- New, blended, supersulfated slag cements (SSC) provide an opportunity of sustainable construction
- For a general application, there is a lack of basic knowledge, for example the fire performance
- **Aim of the project**
  Design model for concrete made of new supersulfated slag cement

The New York Times
COVER STORY OF **World Business** October 26, 2007

Cement Industry Is at Center of Climate Change Debate

A cement plant worker in China. Making cement to bind concrete produces carbon dioxide that causes global warming.

By ELISABETH ROSENTHAL
Published: October 26, 2007

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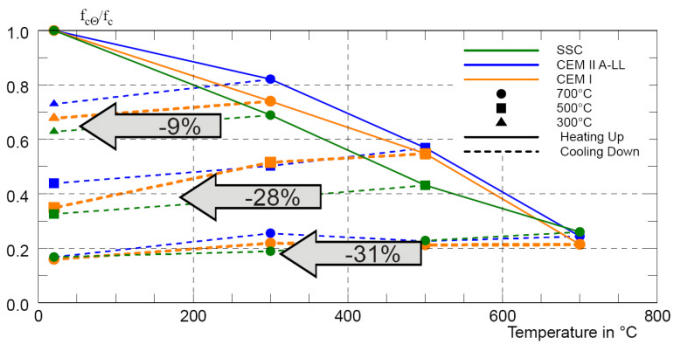
Test results – strength development for a full thermal cycle

- Additional losses in strength during cooling down phase, increasing with higher temperatures



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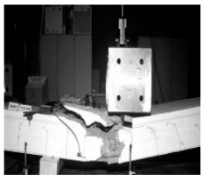
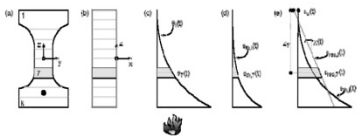
Composite structures under fire conditions

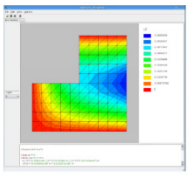


Bending test on slim-floor

Cardigton full-scale fire tests



Calculation model for slim-floor in fire



Developed finite element program for composite slabs in fire

Critical points of timber structures in fire

- Fire separating function of walls and floors
- Fire behaviour of small sections
- Fire behaviour of connections with steel elements
- Increase of fire load
- Fire propagation on combustible surfaces and in cavities

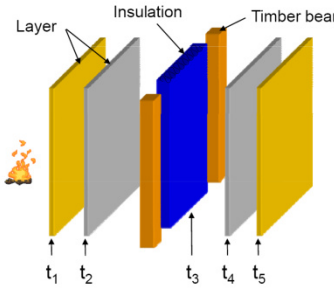
Research projects

Research projects at ETH Zurich Fire resistance of timber structures	Fire tests
Fire behaviour of slabs - Timber-concrete composite slabs - Timber slabs made of hollow core elements - Timber slabs with acoustic perforations - Cross-laminated timber slabs	Fire tests under ISO-fire exposure
Fire behaviour of walls - Light timber frame wall assemblies - STEKO modular wall assembly	Fire tests under ISO-fire exposure
Fire behaviour of Hotels of modular construction in wood	Tests under natural fire conditions
Fire separating function of walls and floors	Fire tests under ISO-fire exposure
Fire behaviour of connections with steel elements	Fire tests under ISO-fire exposure

Calculation model for fire separating function

- New model based on component additive method (EN 1995-1-2)
- Calculation of the time t_{ins} by adding the contribution to the fire resistance of the different layers t_i

$$t_{ins} = \sum_i t_i$$



$$t_i = t_{0,i} \cdot k_{pos,i} \cdot k_{j,i}$$

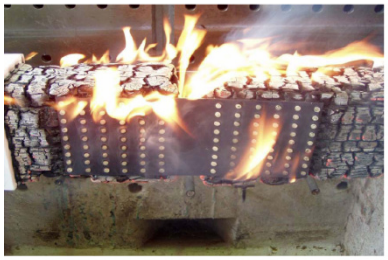
Basic protection value

Position coefficient

Joint coefficient

Timber connections with steel elements in fire

Connections with **side** steel plates



Connection with side steel plates and annular ringed shank nails

Connections with **slotted-in** steel plates

Multiple shear steel-to-timber dowelled connection

IBK, Group of Risk and Safety (Prof. Dr. M. Faber)

Generic fire risk assessment in residential and industrial buildings

- Considering uncertainties by probabilistic modeling of fire development and fire spread
- Quantifying the expected consequences consider all possible fire scenarios
- Evaluate cost efficiency of fire protection measures from a object related point of view

Economic optimization of fire safety measures

- Optimization from a societal point of view
- Build a portfolio fire risk model (economic risk & risk to life) based on data and engineering modelling
- Take into account different building characteristics & safety measures
- Evaluate the influence of possible changes in fire safety measures on a portfolio level