

# Failures of timber structures - Considerations on the causes of the fault

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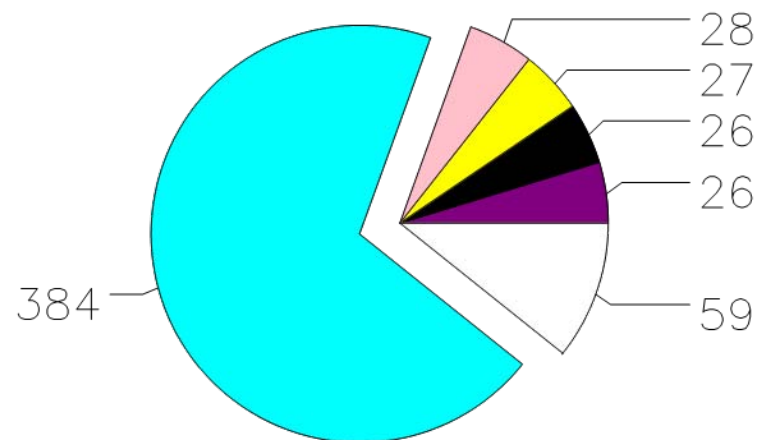


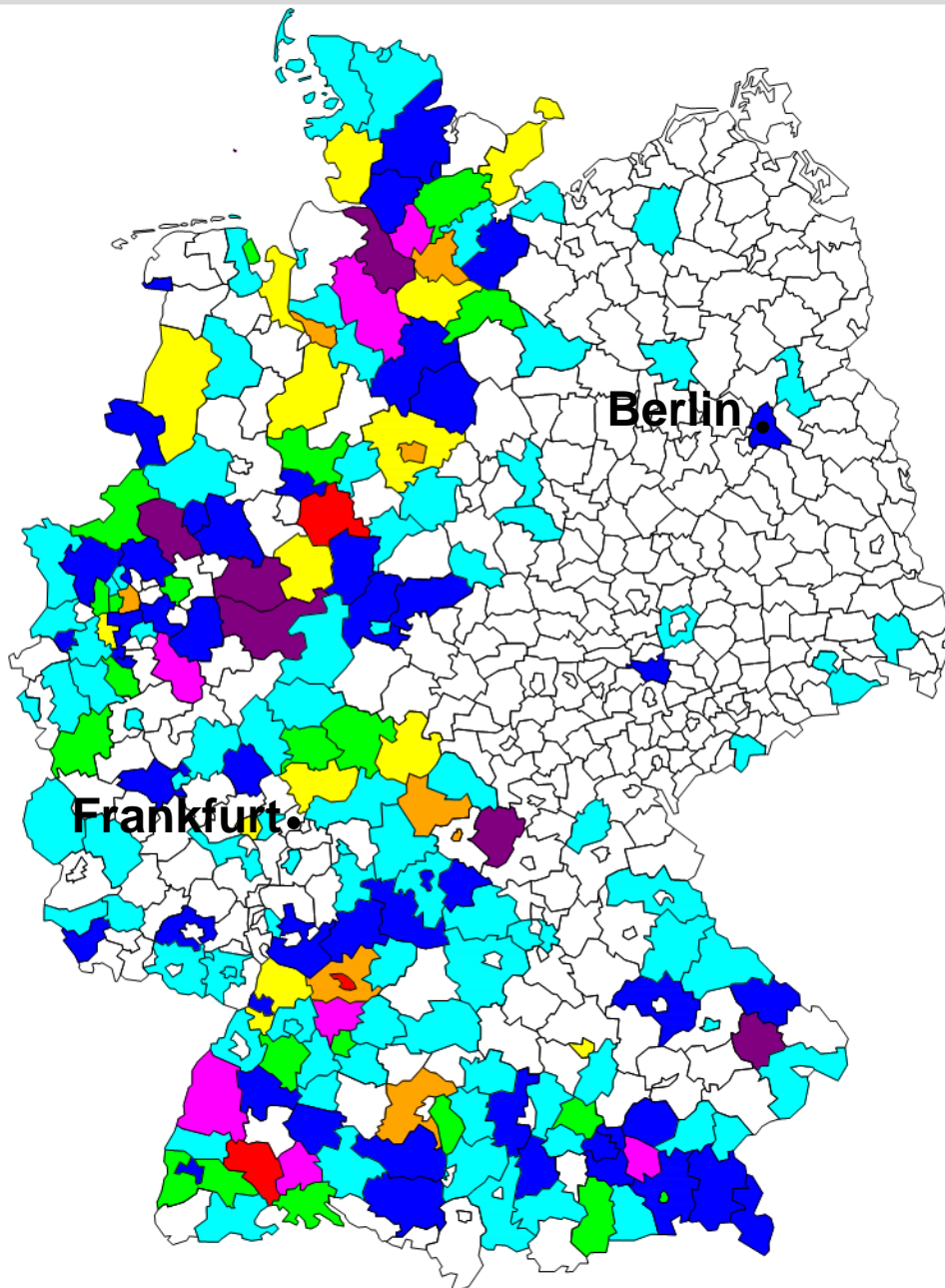
# Overview on the main steps of the failure analysis – content of the presentation

- 1<sup>st</sup> step: Collection of failures
  - Expert's and glulam manufacturers' reports
  - 428 timber hall structures damaged were analysed
- 2<sup>nd</sup> step: Identification of so called “primary damages”
  - crack in grain direction
  - decay
  - shear failure
  - tension failure...
  - 550 damages identified (→ pie chart)
- 3<sup>rd</sup> step: Determination of “causes of the fault” associated with “primary damages”
  - 985 causes determined (→ pie chart)
- Last step: Considerations on the relationships between “primary damages” and “causes of the fault”

# Distribution of "primary damages"

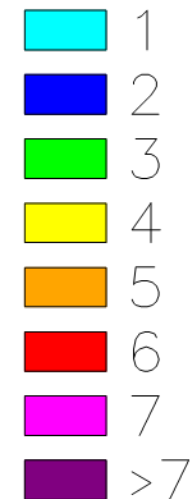
Total: 550



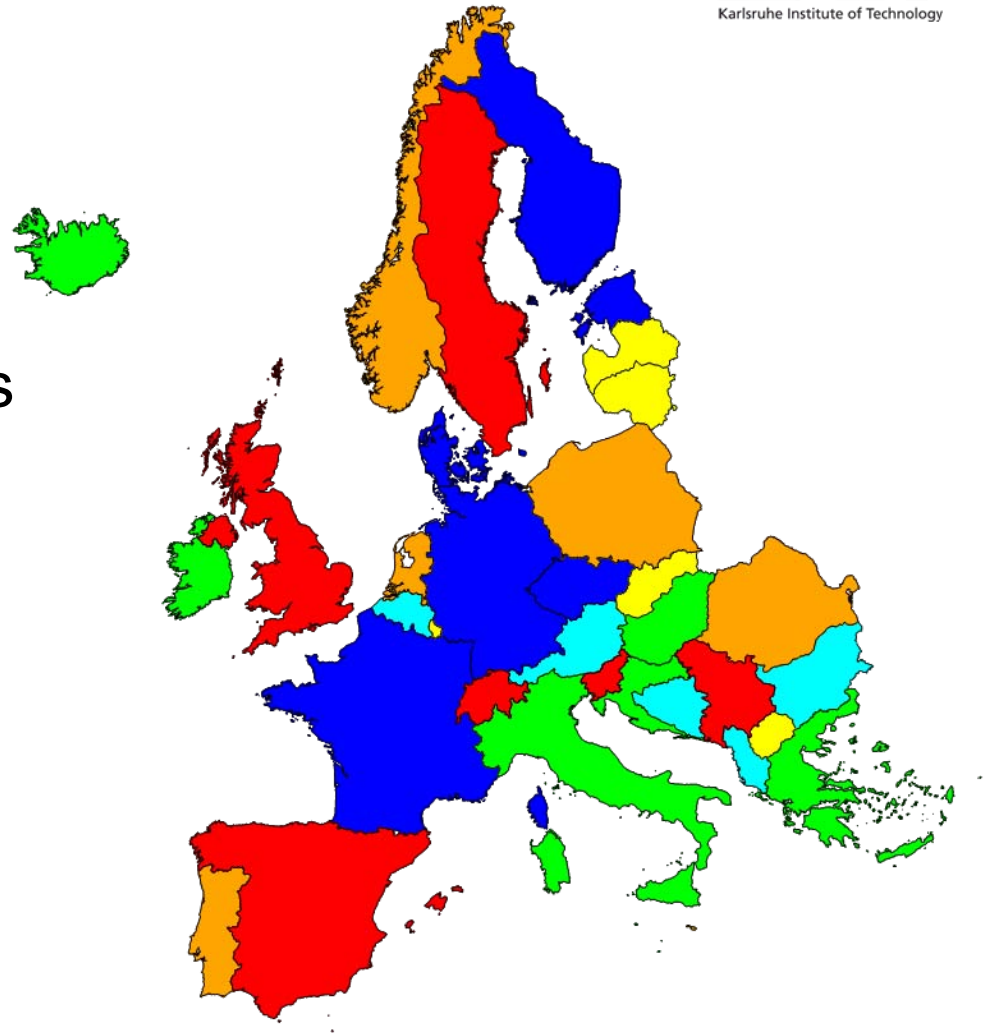


- The scatter shows a comprehensive data collection
  - Reliable conclusions

Number of damages



- Shortcomings:  
analysis and its results  
only on national level
- Rough idea the way things  
could be in Europe
- European failure  
analysis  
would be difficult

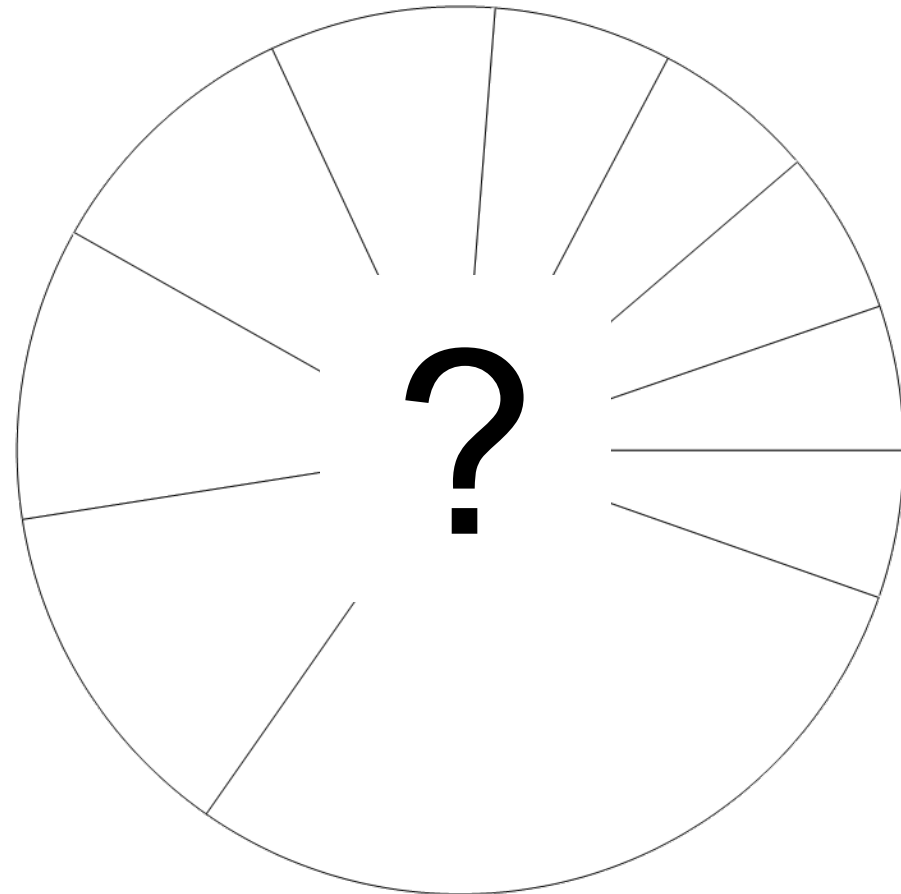


# “Causes of the fault” – headwords

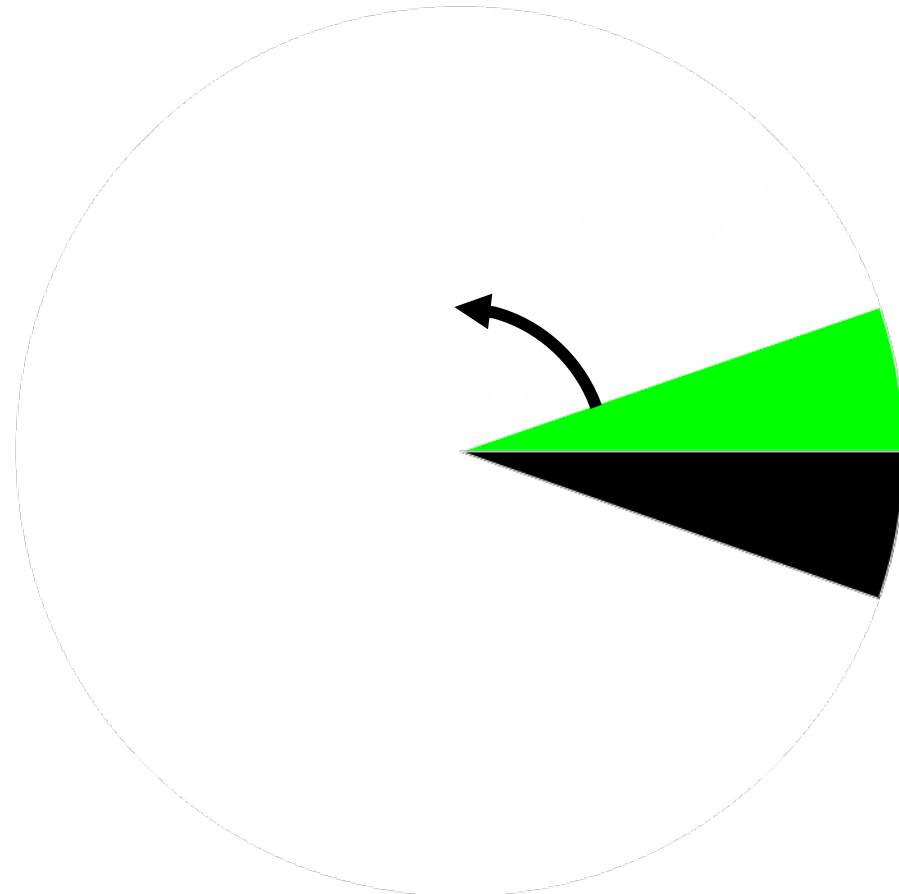
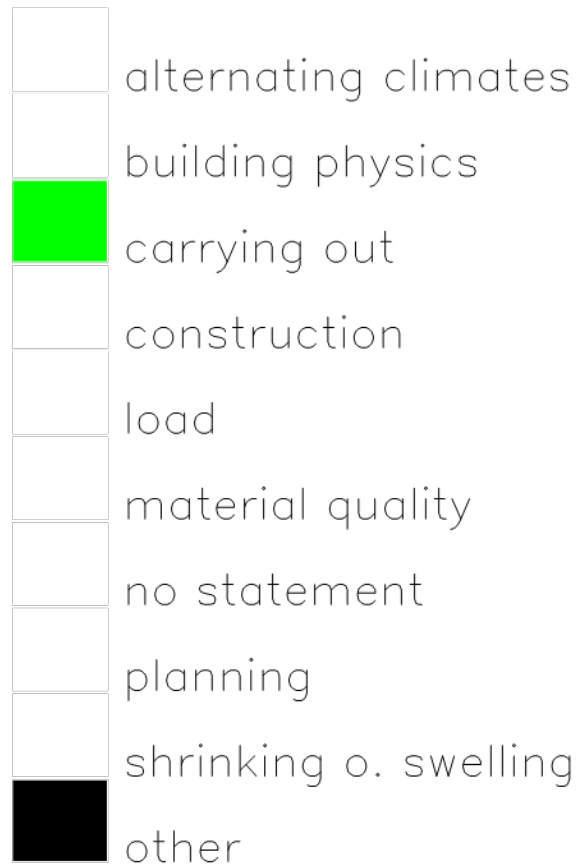
- Alternating climates
  - Result in moisture content variations
- Building physics
  - Includes e.g. condensation, direct solar radiation
- Carrying out
  - The way construction work is carried out
- Construction
  - Involves specific timber constructions e.g. curved or end-notched beams
- Load
- Material quality
- Planning
  - Concerning engineer’s work
- Shrinking or swelling

# Distribution of "causes of the fault"

- alternating climates
- building physics
- carrying out
- construction
- load
- material quality
- no statement
- planning
- shrinking o. swelling
- other



# Distribution of "causes of the fault"

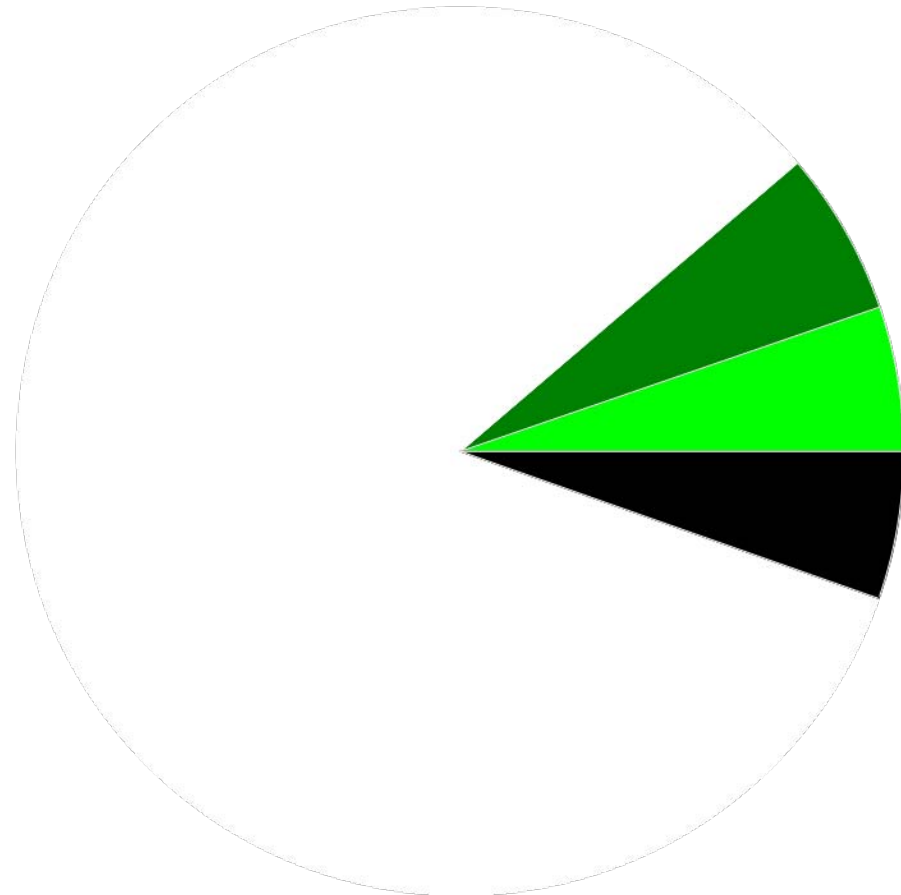
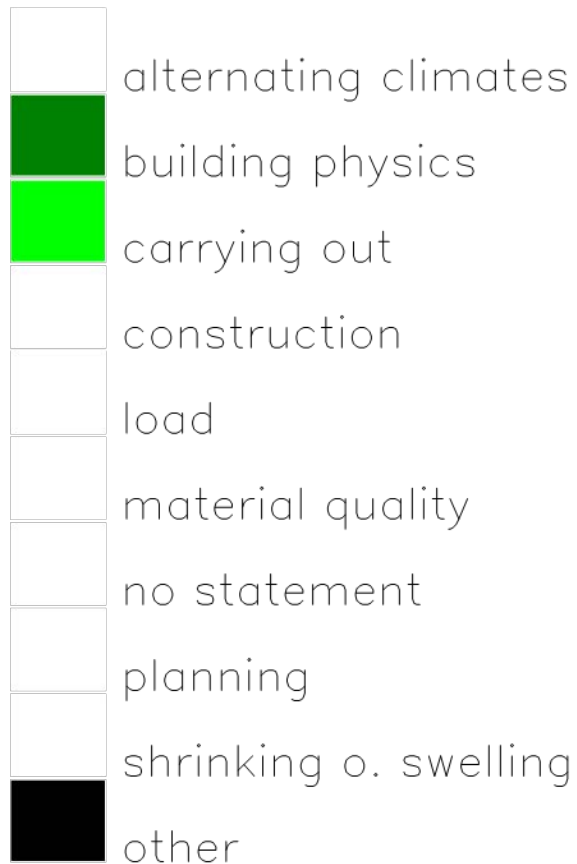




# Poor position of dowel type fasteners



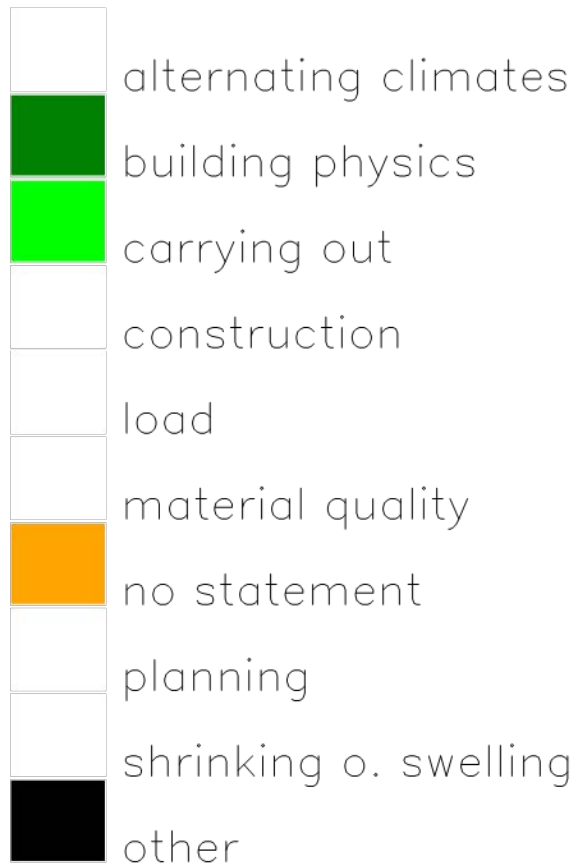
# Distribution of "causes of the fault"



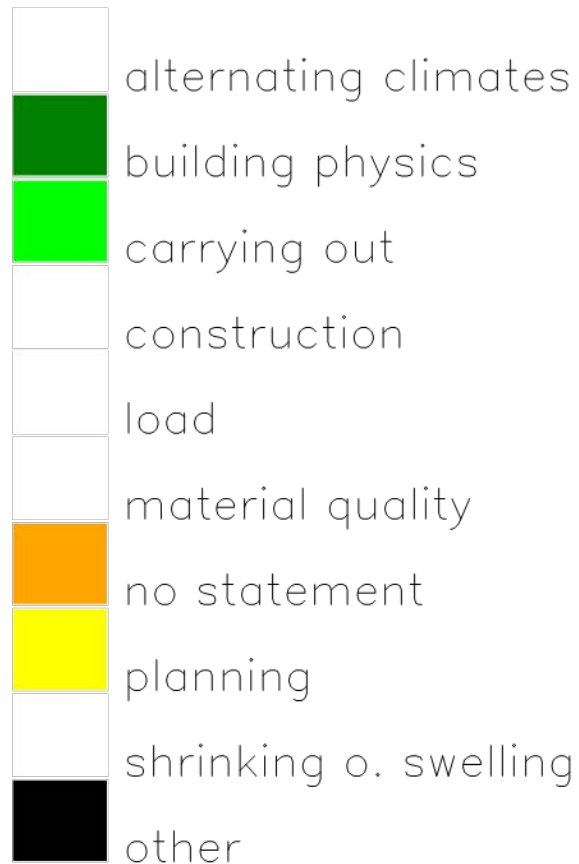
# Discoloration due to condensation



# Distribution of "causes of the fault"



# Distribution of "causes of the fault"



# Disregard for rules in design codes and for technical recommendations

DEUTSCHE NORM

Dezember 2008

DIN 1052

**DIN**

ICS 91.080.20

Ersatz für  
DIN 1052:2004-08

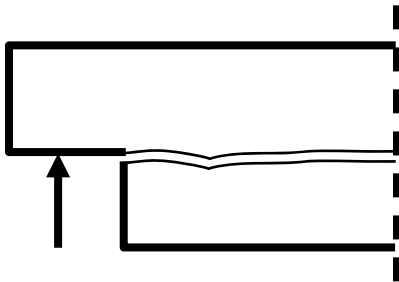
**Entwurf, Berechnung und Bemessung von Holzbauwerken –  
Allgemeine Bemessungsregeln und Bemessungsregeln für den  
Hochbau**

Design of timber structures –  
General rules and rules for buildings

Calcul des structures en bois –  
Règles générales et règles pour les bâtiments

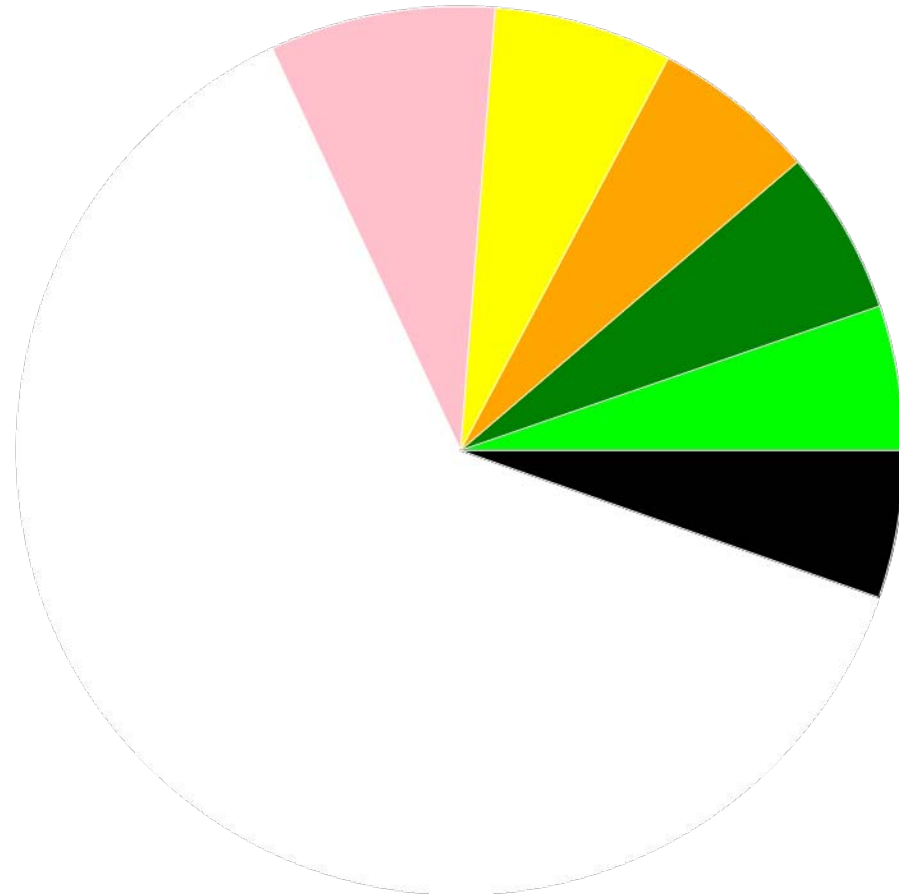


# Typical failure due to non-reinforcing end-notched beams



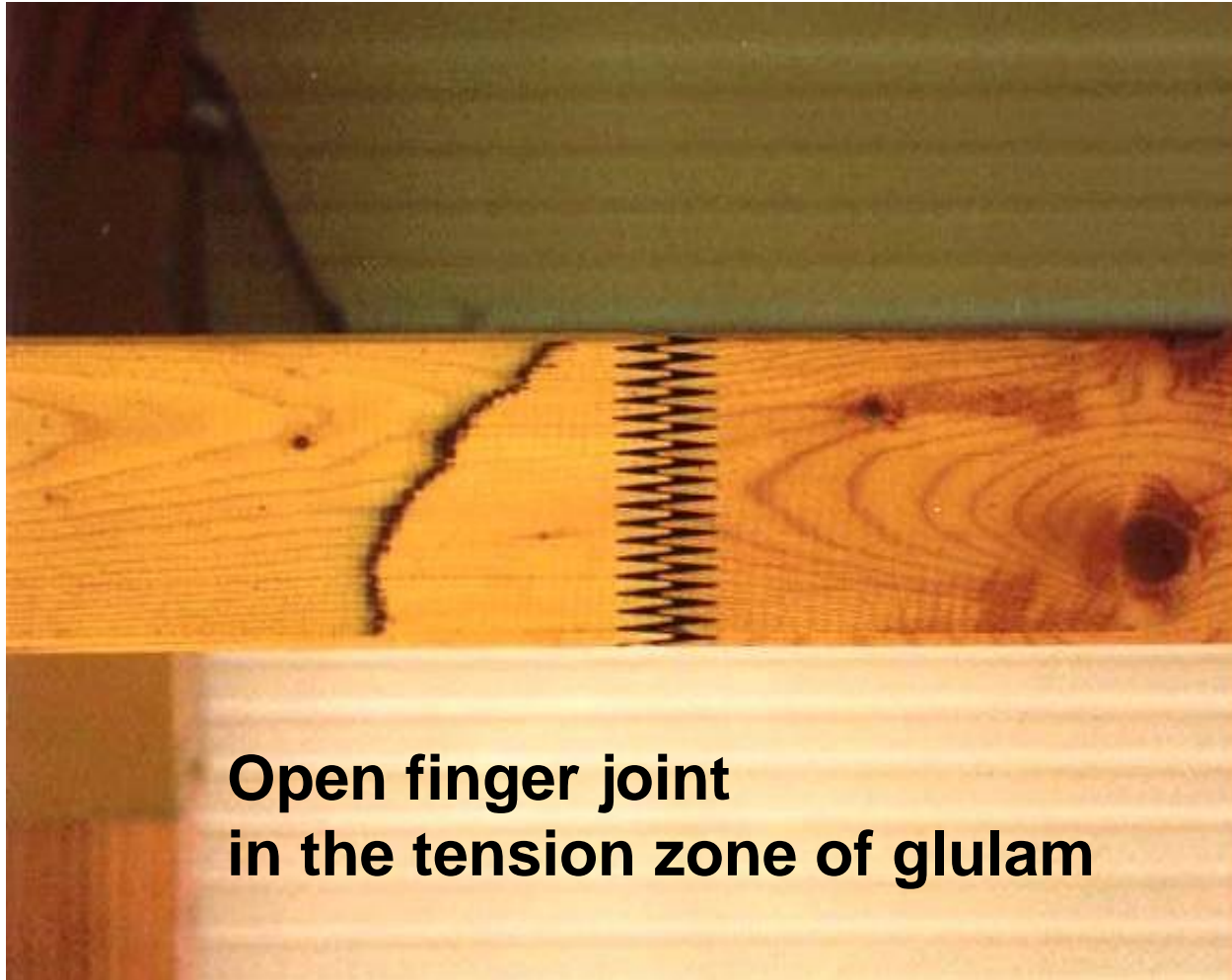
- Reinforcement missed due to poor structural analysis

# Distribution of "causes of the fault"





# Material quality



**Open finger joint  
in the tension zone of glulam**

# Material quality

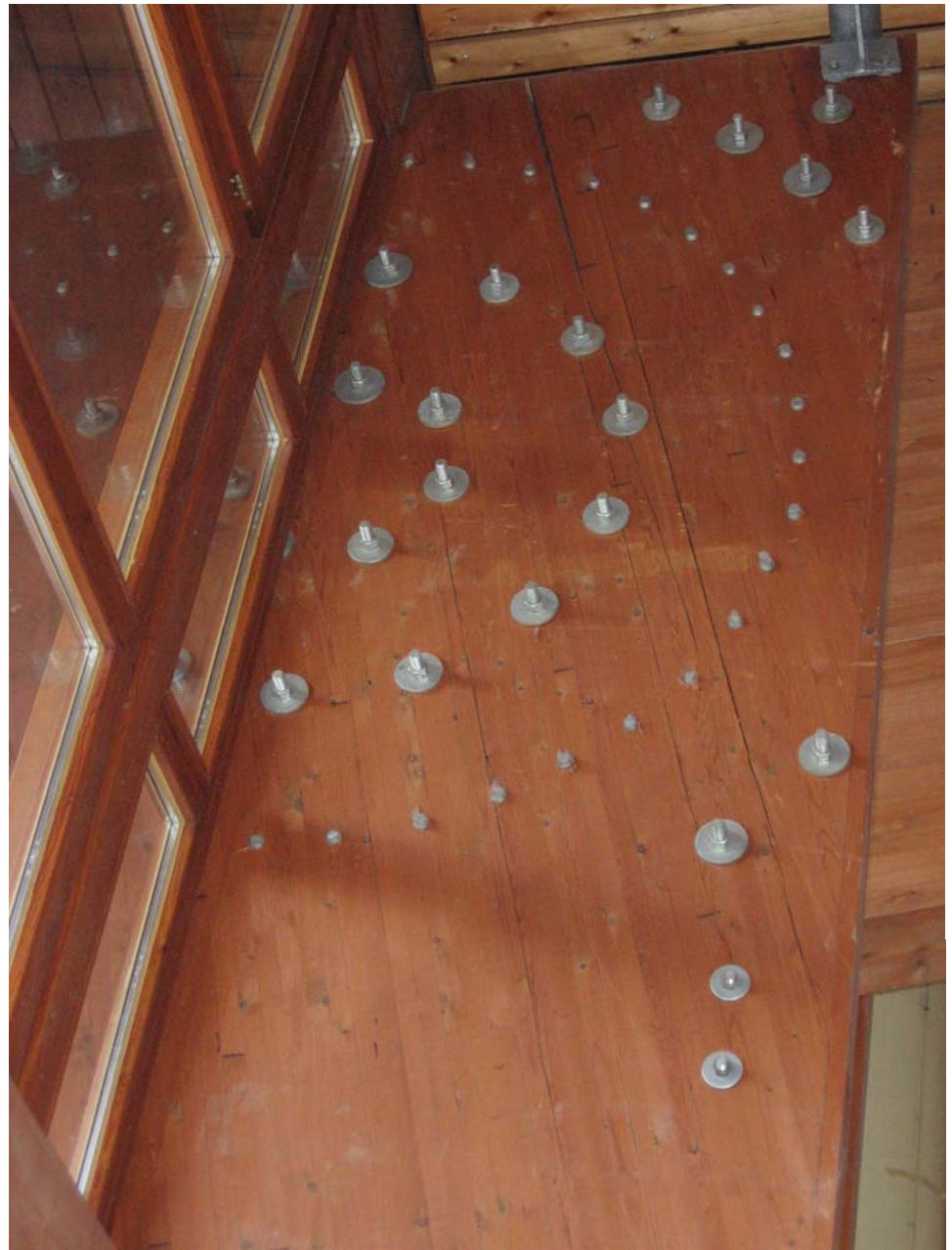
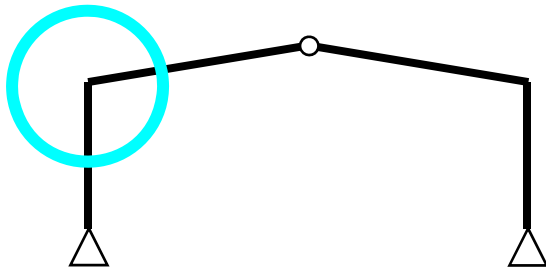


# Distribution of "causes of the fault"

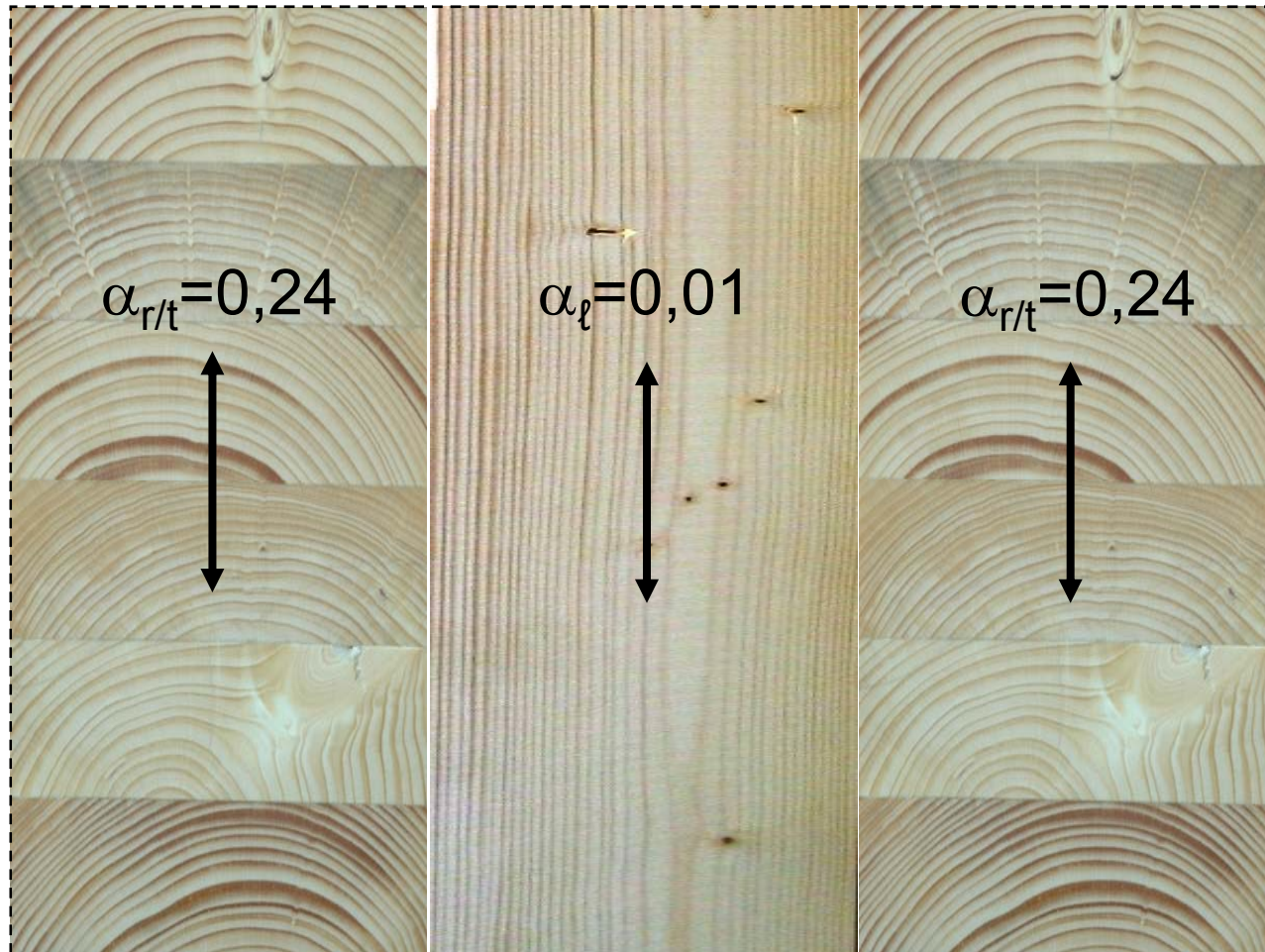


# Shrinking/swelling

- Moisture content decrease
- Differential shrinkage
- Hindrance of shrinkage



# Cross-section before shrinkage



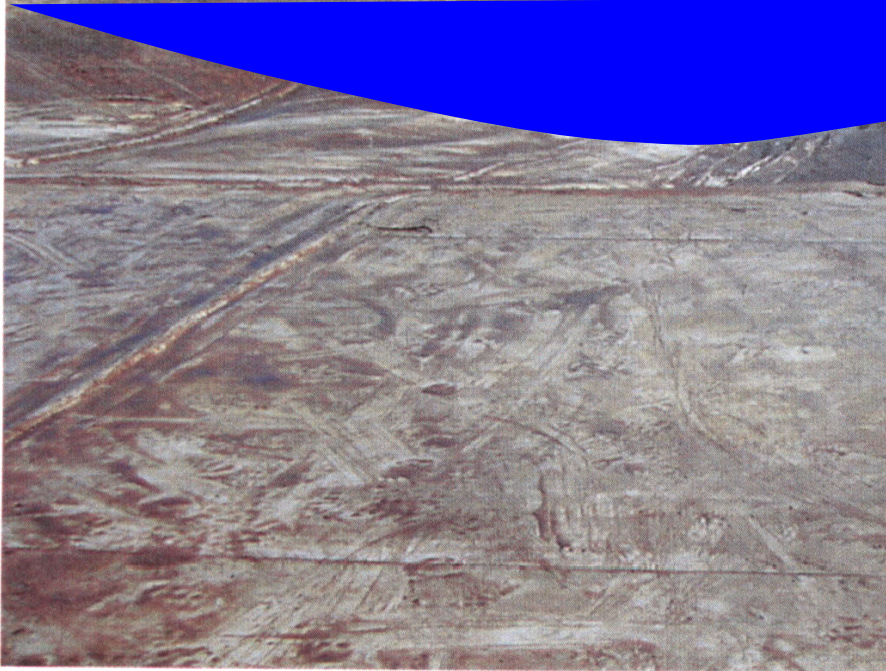
# Cross-section after shrinkage



# Distribution of "causes of the fault"

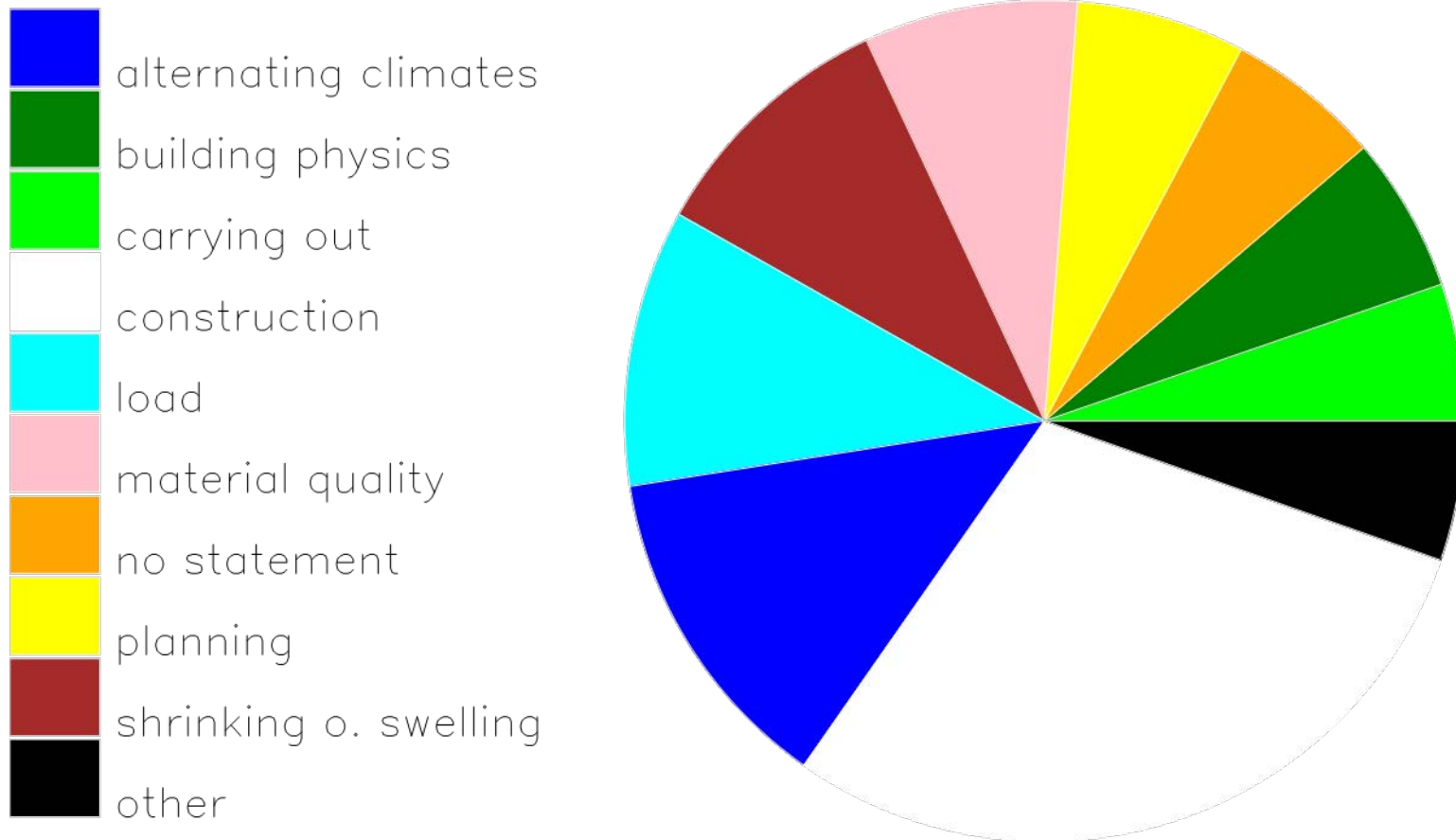


# Collapse due to accumulation of rain water





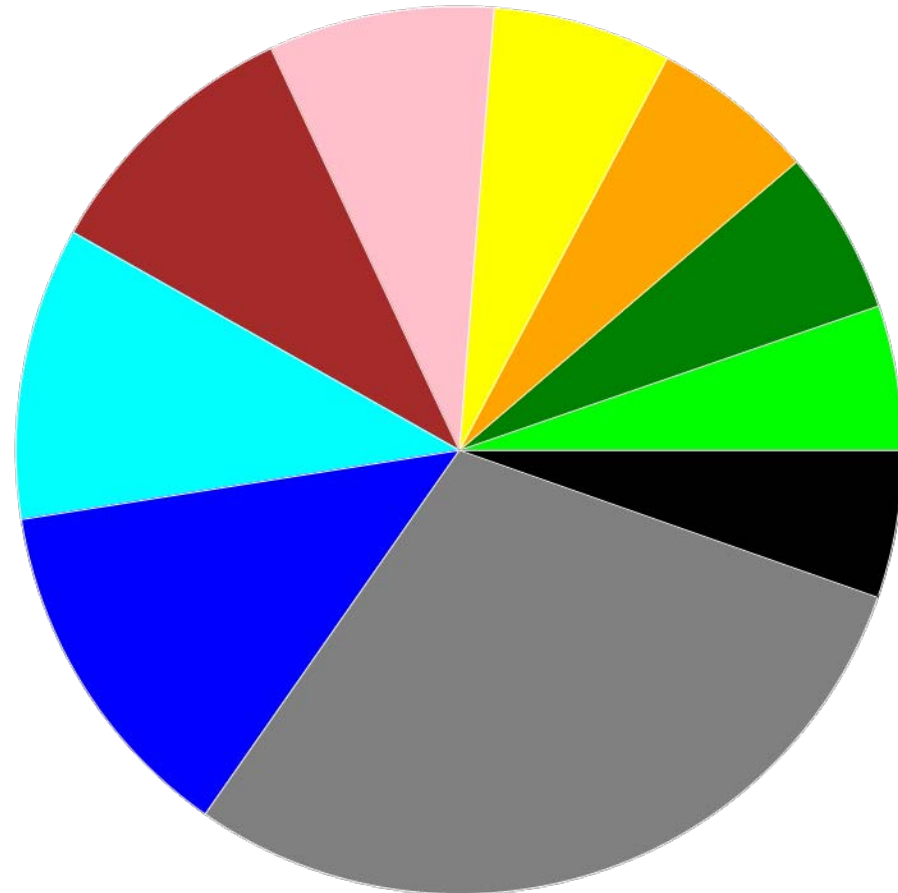
# Distribution of "causes of the fault"



- Alternating climates responsible for cracks in grain direction



# Distribution of "causes of the fault"



# Pitched cambered beams



# Changing one's ideas



# Timber bridge without cladding



# Closed due to decay



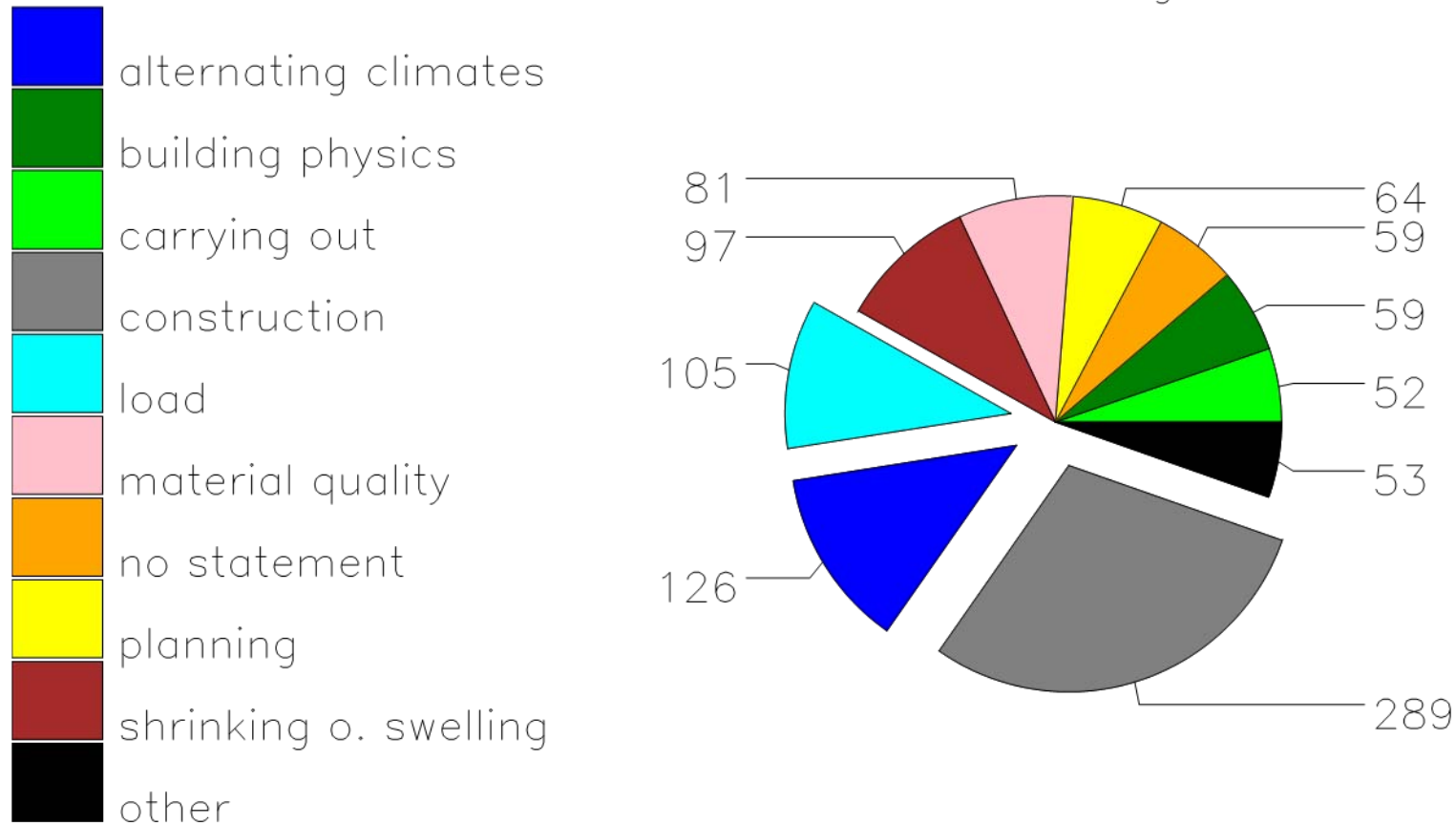
# Learning from failures





# Distribution of causes of the fault

985 relations distributed on 550 damages



# Thank you for your kind attention