A Proposal for a failure template

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Business from technology

Background

- Failure studies on timber structures have recently been carried out in various countries in Europe.
- These failure assessments have not been done in a uniform manner, which makes comparisons between the studies and the development of common procedures a difficult task.
- The purpose of this paper is to propose a common format on gathering information from failure cases of timber structures.
- This is a discussion paper for working group 1 of Cost E55.

Objectives of a Failure template

To help the expert carrying out the assessment to find the relevant questions that need answers.

Uniform quality and uniform level of detail of assessments

Produce material for further analysis to pinpoint weaknesses in the material/design/construction/use processes:
- design procedures perhaps need improvement,
- if our construction material is getting weaker
- if there are not enough human resources allocated for specific tasks such as for the structural design,
- lack of communication in the construction site or misunderstandings
- or other similar deficiency

Factors to keep in mind (1)

Durability cases

- It is clear that not all structural failures can be reached with these assessments.
- It is suspected that in many cases failures are simply not assessed and/or that very few persons know about them.
- It may be assumed that one such group of cases on timber structures could be the cases related to durability.
- This suspicion comes from the fact that there are not very many durability problems among, at least, the Nordic cases.
- It is here suspected that such cases are not always assessed and that these are often not even regarded as failures, but as normal end of service-life situations.

Factors to keep in mind (2)

Serviceability cases

- An aspect which has not been addressed in these failure studies (in at least the Nordic study), is the serviceability failure cases.
- There are many such failure cases related to excessive vibration of floors.
- Most often these cases are not public.
- Another problem with many of these cases are that floor vibration design procedures in the current codes are very liberal.
- Recent vibration studies in VTT on the subjective assessment of floors and measurements of floor vibrations due to walking have revealed that the Eurocode 5 design is not always satisfactory.
- In such cases neither the designer nor the constructor have done errors, but the floors clearly vibrates and the users are not satisfied.
- This brings up the question: if vibration failures are failures at all or is it simply due a problem because human requirements on floors increased.

Factors to keep in mind (3)

Publicity

- The template may be used in both public and confidential assessment situations.
- It is clear however, that further analysis of the data for 'public use', essentially require publicity on the assessment data or at least partial publicity .
- Whether the data is public, partially public or confidential is not at all addressed in the failure template procedures.
- This of course applies on how the information is utilized in further processing.

Failure cause classification

Related to structural design

- Poor design or lack of design related to strength or environmental actions
- Deficiency of code rules for prediction of capacity
- Extreme loading exceeding code values

Related to construction on-site

- Poor principles during construction on site
- Alterations on-site compared to design

Related to building materials

- Inadequate quality of (wood) material used in construction
- Poor manufacturing principles for wood products (glulam, finger-joints etc.)
- Manufacturing errors in factory on prefabricated products (elements)

Related to building use

- Was the building used as intended
- Was there lack of maintenance of the structure

Case name *Jyväskylä fair centre*
Case location *Jyväskylä, Finland*
My name *FÜLÖP Ludovic*

1. Type of building

- [ ] Residential
- [ ] Office
- [X] Public
- [ ] Sports Hall, which kind (eg. swimming, ice-skating, etc.)
- [ ] Industrial
- [ ] Agriculture.
- [ ] Shoping
- [ ] Other type, specify:

Number of storeys = 1

2. Structural system

- [ ] Timber frame system
- [X] Truss roof system
- [ ] Post and beam structure
- [X] Large scale glulam structure
- [ ] Large scale LVL structure
- [ ] Massive wood elements
- [ ] Other type, specify :

3. Occurrence of failure

At which phase did the failure occur

- [ ] Construction phase
- [X] Building use phase, give age of building at failure in years: _0_
- [ ] Time of the year of failure

- Describe loads at failure (snow or other loads)
- Describe humidity and temperature conditions at failure (and in the near past if information available)

Snow load was 25% (0.5kN/m^2) of the design snow load. The building was in use, so the interior humidity and temperature conditions were normal. Exterior conditions nearly calm, clear sky and temperature of -26°C.

4. Structural element or connection involved in the failure case

- [ ] Beam, span _____ m
- [X] Truss, span _55_ m.

Specify type (e.g. timber, glulam, tension rod type, trussed rafter etc.): glulam truss-roof on concrete columns

- [ ] Arch, span _____m
- [X] Column, length _ ≈6.5_ m
- [ ] Shear wall

Connections involved in the failure

- [ ] Nailed
- [ ] Screwed
- [X] Steel dowels
- [ ] Bolted
- [ ] Slotted-in steel plate
- [ ] Other dowel type joint, specify
  dowel connection acting in shear
- [ ] Punched metal plate fastener joint
- [ ] Glued joint
- [ ] Other type, specify:

Special Characteristics
E.g. notches, holes, reinforcement etc. in member,
toothed metal plate strengthening, reinforcement etc. of joints

5. Description of failure

a) triggering failure event and failure mode
b) secondary failure events
(free text and pictures)

The primary (triggering) failure was caused by a dowel connection of the roof-truss in the vecinity of the support. The failure of the connection caused the failure of the truss and the 2 trusses in the vecinity. Some concrete columns, and part of the wall was also destroyed

6. Assesment of the progressive nature of the failure and robustness

A. Was there a Collapse

X Yes
No
Not known

Explanation: Collapse is defined as one or more structural elements falling down as a result of the failure. Cases where collapse does not occur are e.g. excessive deflection, cracks or other visible damage.

B. Progressive nature of collapse

Classification levels:

X Large secondary damage
Medium secondary damage
Damage limited to the element where failure was initiated

Explanation: Large secondary damage could e.g. be seen as damaged area which is more than about three times larger than the area related to the element where failure was initiated.

C. Consequences

X High
Medium
Low

D. Nature of warning

No warning before collapse (order of seconds)
X Warning allowing evacuation (order of minutes)
Warning giving time for temporary strengthening
Not known (NA)

E. Degree of proportionality between consequences and cause

X Very disproportionate consequences
Moderately disproportionate consequences
Consequences in proportion to the triggering event

Explanation: This is included because it is how robustness is often interpreted. The difficulty here is to assess the denominator, i.e. to define “magnitude or extent” of the cause. Take as an example a case where the whole building falls down because bracing has not been provided at all in the building. Then the consequences are quite reasonable in view of the mistake by the designer. In the present investigation the assessment must be related to seriousness of the errors performed, since most of the cases are related to errors in design or construction.

F. Subjective assessment of the robustness of the structural system

High robustness
Medium robustness
X Low robustness

7. Cause(s) of failure according to investigations performed

Give one or more reason for the failure by writing one or several numbers as follows
1= primary reason
2= secondary reason
3 = tertiary reason. (The same figure e.g. 2 can be used for more than one reason)

Additional questions might apply under the failure cause as noted below:

Related to structural design

[ ] Poor design/lack of design related to strength or environmental actions
- Quality control measures performed on the design (eg. external design check), describe

[3] Deficiency of code rules for prediction of capacity
- Identify the code design equation and the building codes (and national annex) used

[ ] Extreme loading exceeding code values
- Identify the building codes (and national annex) used

Related to construction on-site

[ ] Poor principles during construction on site
- Describe quality control measures performed in construction
- Is the construction method known as best practice

[ ] Alterations on-site of intended structural or detailing design
- Describe quality control measures performed during the construction works (eg. construction inspections)

Related to building materials

☐ Inadequate quality of wood material used in construction
- Describe origin of material and quality control procedure applied on the material

☐ Poor manufacturing principles for wood products (glulam, finger-joints etc.)
- In this case best practice is not good, suggest improvements for best practice

[1] Manufacturing errors in factory on prefabricated products (elements)
- Quality control measures performed on manufacturing (eg. internal or external production control), describe

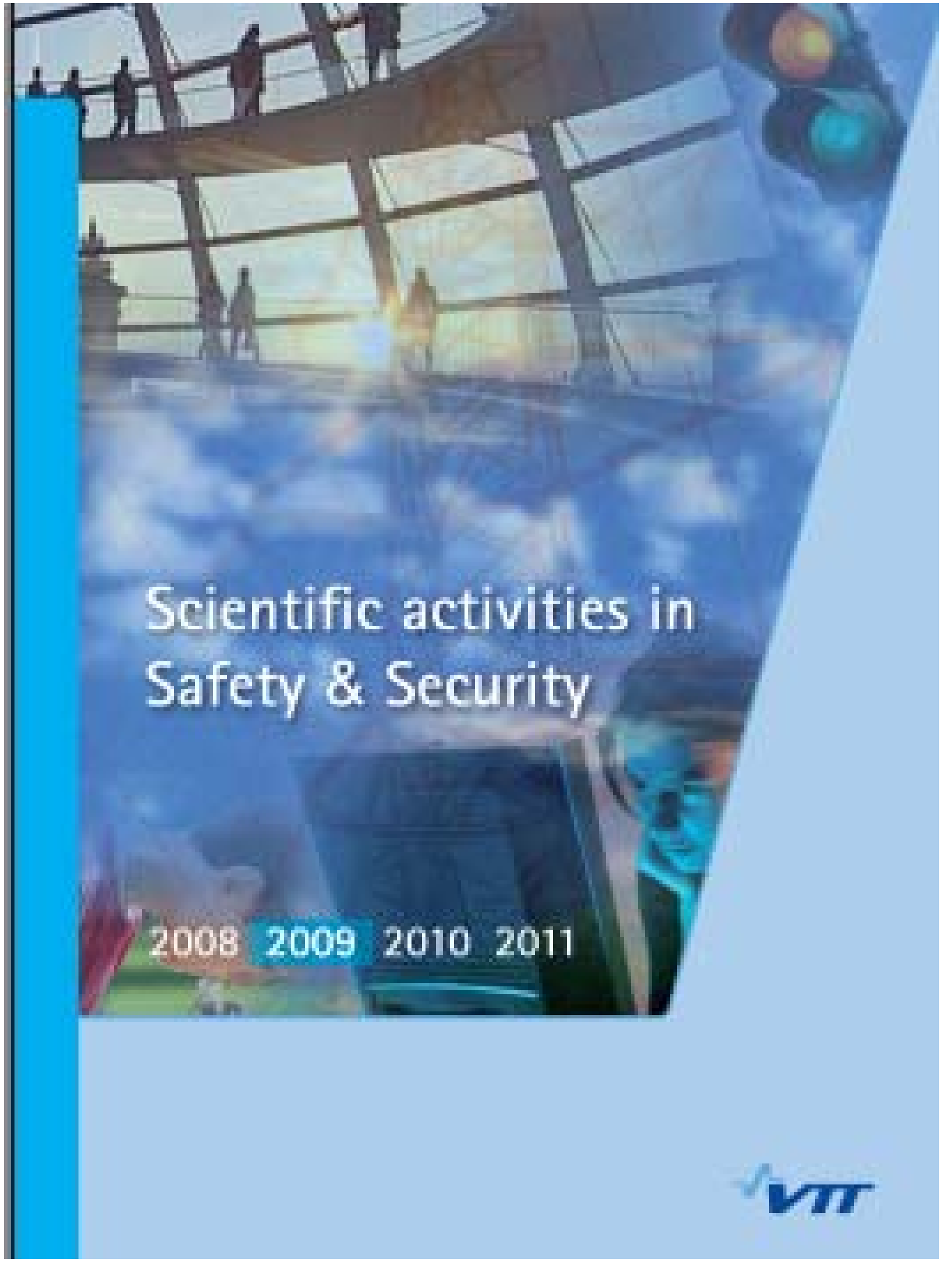
Related to building use

☐ Is the building used as intended (designed)
- Describe

☐ Is there lack of maintenance of the structure
- Was sufficient information on use or maintenance procedures given:

[2] Other, specify below

Lack/deficiency of quality control during the manufacturing process.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Services and the Built Environment research at VTT covers a broad spectrum of technologies, services and business processes, working for the benefit of all stakeholders in the information society. Our research aims at improving productivity, and providing customer and user-centred solutions that enable the sustainable development of society. The focus areas of research include services, safety and security, the built environment, and transport.

Service science, business and technology are developed for the renewal of production and service industries as well as for improving the operations of the public sector. Safety and security of the society, industry and products are enhanced by developing products, systems and business processes. The functionality, health and comfort of the built environment are improved and its environmental impact reduced by developing relevant building technologies and improving construction and facilities management processes. The development of transport systems, particularly by developing telematic services, aims at improving both traffic safety and the efficiency of transport systems.

Trends and challenges

The key drivers behind the research and development of services and the built environment are information and communication technology as an enabler and sustainable development as a societal need. Climate change acts as a catalyst for innovation, both through developing mitigation measures, such as energy efficiency, as well as adaptation measures in the built environment. Research needs also emerge from the pervasive transition of both public services and supporting services within the private sector to become more business-like either through outsourcing or through enhanced internal entrepreneurship. The built environment has gradually become a recognized platform for living, pleasure and business, and its value as an asset is going to be measured more and more in quantitative financial terms and quality of life in qualitative terms. The threats of terrorism and vandalism increase the need for novel and dependable technological solutions. Labour-intensive sectors, like public services and construction, are facing an increasing need for improved productivity by means of more efficient processes that make better use of information and communications technologies.

Additional information

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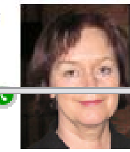

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See also

- Scientific activities in building and construction 2008
- Scientific activities in transport telematics 2008
- Scientific activities in Safety & Security 2009

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