Engineering Structures 33 (2011) 2958–2961

Contents lists available at SciVerse ScienceDirect

Engineering Structures

journal homepage: www.elsevier.com/locate/engstruct

Proposal for a failure assessment template

T. Toratti *

VTT Technical Research Centre of Finland, P.O. Box 1000, FIN-02044 VTT, Finland

ARTICLE INFO

Article history:
Available online 31 March 2011

Keywords:
Timber structures
Failures
Failure assessment
Template

ABSTRACT

The present paper describes the benefits of using a common failure assessment template when carrying out failure assessments of buildings. A common failure template is proposed. This template is targeted for failures which occur in timber buildings. This template has been tested by various experts in Europe and positive feedback has been received so far. However, it is foreseen that further developments on this procedure will probably need to be done.

1. Introduction

Previous studies on failures of buildings, mostly other than timber buildings, have been summarized in Ref. [1] and, in general it may be stated that about half of these failures were related to the design phase and the other half to the construction phase. Almost all cases were caused by human errors. Failure studies on timber structures have recently been carried out in various countries in Europe. One main Nordic study is presented in Ref. [1]. It became evident in early stages that these failure assessments have not been done in a uniform manner, which make 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. The origin of this paper date to a Finnish–Swedish project [1] and this has further been discussed in the research network Cost action E55 'Modelling the performance of Timber structures'.

2. Objectives of a failure template

The objectives of a failure template are as follows.

- To help the expert carrying out the assessment to find the relevant questions that need answers. This is mainly when new cases are assessed, but it may be used also for a re-evaluation of past failure cases.
- To produce a failure assessment that is more uniform and which is less dependent on human factors, professional involvement or personal characteristics of the expert carrying out the assessment. Clearly the human factor cannot be fully ruled out.
- Produce material for further analysis to pinpoint weaknesses in the construction process, which need attention or further research. This may be to identify whether, design procedures need improvement, our construction material is getting weaker, and there are not enough human resources allocated for specific tasks such as structural design, and lack of communication in the construction site or misunderstandings, or other similar deficiency.

3. Some points to clarify on failure data

Durability cases.

It is clear that not all structural failures have or can be reached with these expert 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 case related to durability. This suspicion comes from the fact that there are not many durability cases in 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.

Serviceability cases.

Another aspect which has not been considered in these failure studies (in at least the Nordic study) is those cases related to serviceability failures. There are many such failure cases related to, for example, excessive vibration of floors. These are troublesome in many ways: first, most often these are not public cases, and the assessment is carried out as a private commission and such material may not be used, except in a disguised way not revealing the building and sometimes not even the floor structure. Another problem with many of these cases is that floor vibration design procedures in the current codes are very liberal. Recent vibration studies in Finland [2] on the subjective assessment of floors and measurements of floor vibrations due to walking have revealed

* Tel.: +358 20 722 4631; fax: +358 20 722 7007.
E-mail address: tomi.toratti@vtt.fi.

0141-0296/$ – see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.engstruct.2011.02.047

that the Eurocode 5 design is not always satisfactory. In such cases neither the designer nor the builder have done errors, but the floors clearly vibrate and the users are not satisfied. A possibility is to compare the vibration levels to ISO recommendations on transient vibrations, but the procedures are not totally clear and the criteria are broad. In Ref. [2] assessment criteria has been produced, but these do not stand any legal status.

In any case this brings up the questions if vibration failures are failures at all or is it simply due to that the human requirements on floors have raised. This seems to be partly so, as similar floors are more accepted in small houses than in multi-storey apartments.

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 the further processing.

4. Benefit of the failure template

When an expert is called for a failure assessment, the template may be used in gathering the relevant information. It is not always important that the template is fully completed and certain information can be missing. This could possibly be due to that the information is simply not there or that a certain part is restricted from public for whatever reason.

The real benefit from a common template comes when a number of failures cases are investigated. This should reveal if there are deficiencies in the material, design, construction process etc. This provides the information needed to pinpoint where alerts and/or remedy actions are needed.

The failure causes are in this draft classified based on a slightly developed version of the classification used in the Nordic study. An additional question is posed under each failure cause class, in order to bring up further light on the backgrounds of the cause.

Additionally, questions related to progressive failure and robustness are added from Ref. [3], which is a paper presented in research network 'Robustness of Structures, Cost action TU0601'.

5. Failure cause classification used

The following failure cause classification is used, causes from (a) to (j). These are further grouped into 4 major headings as follows:

Related to structural design.

(a) Poor design/lack of design related to strength or environmental actions.
  – Describe the quality control measures performed on the design (e.g. external design checks).
(b) Deficiency of code rules for prediction of capacity.
  – Identify the code design equation and the building codes (and national annex) used.
(c) Extreme loading exceeding code values.
  – Identify the building codes (and national annex) used.

Related to construction works on-site.

(d) Poor principles during construction on-site.
  – Describe quality control measures performed in construction.
  – Is the construction method known as best practice.
(e) Alterations on-site of intended structural or detailing design.
  – Describe quality control measures performed during the construction works (e.g. construction inspections).

Related to building materials.

(f) Inadequate quality of wood material used in construction.
  – Describe origin of material and quality control procedure applied on the material.
(g) Poor manufacturing principles for wood products (glulam, finger-joints etc.).
(h) Manufacturing errors in factory on prefabricated products (elements).
  – Describe the quality control measures performed during manufacturing (e.g. internal or external production control).

Related to building use.

(i) Is the building used as intended (as designed)?
(j) Is there lack of maintenance of the structure.
  – Was sufficient guidance on use or maintenance procedures given?

6. Draft failure template

This proposed template on failure case description is intended for failed timber structures and it is based on the results of the Nordic study [1]. It is below presented as filled in with an example failure case from Finland. Besides the description of the failure itself, the most important information relate to the cause of the failure. Usually there are several causes found in an assessment and in such a case it is important to identify the prime cause out of the others. In this way Section 7 is very important. It is felt that the degree of detail in this proposal is a minimum in order to achieve the benefits described.

The questionnaire should be filled in for each individual failure case. The case should be given a title which is neutral as to the identity of the case. The template is as follows:

Case name Jyväskylä fair centre
Case location Jyväskylä, Finland
My name (expert name)

1. *Type of building*

☐ Residential
☐ Office
☒ Public
☐ Sports Hall, which kind (e.g. swimming, ice-skating, etc.)
☐ Industrial
☐ Agriculture
☐ Shopping
☐ Other type, specify:

Number of storeys = 1

2. *Structural system*

Primary structure:

☐ Timber frame system
☒ Truss–roof system, span: 55 m
☐ Post and beam structure
☐ Straight beam, number of support: ___ span(s): ___
☐ Single pitch beam, number of support: ___ span(s): ___
☐ Double tapered beam, span: ___
☐ Arch structure, span: ___
☐ Massive wood elements
☐ Other type, specify:

Structural material of primary structure:

☒ Glulam, Grade: GL32h
☐ LVL
☐ Strength graded timber, Grade:___ visual or machine grade:_____