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Measuring structural (un)safety in the Dutch building industry

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1. Introduction

The last 10 years the Dutch Building Industry was shocked by several major accidents. In 2001 the steel structure of a theatre in Hoorn collapsed during erection. No one was hurt, because it collapsed during the night. In 2002 part of the parking deck of a hotel collapsed just some time after a conference beneath was finished. In 2003 5 balconies of a resident building in Maastricht broke down, 2 persons were killed[1]. Besides several buildings showed major cracks in concrete elements and were evacuated, like the bos & lommer-complex in Amsterdam (2006).

The mentioned accidents received much media attention. The question arose whether these events were just incidents or indicators of a system problem in the building industry. Besides, questions on causes and measures to reduce the risks arose.

A committee: “Learning from disasters” was started in 2004 with several members from building industry, government and universities. It appeared that there had been no systematic collection of failure data unlike in some other countries. In these days TNO started a database with reported accidents and TUDelft joined this initiative in 2009 to get insight in the amount and causes of structural failures.

For the database TNO and TUDelft were looking for that cases from 1993-2008 with
-an unacceptable probability of structural failure of the building or of a structural member of a building
-a situation endangering people
-a building less than 50 years of age
-a building with loadings according to Dutch Building Code
A broad definition of buildings is applied, so information on bridges, dams, temporary structures and buildings were all included.

The goal of this paper is to explain how to set up and analyse a database on structural failures.

2. Setting up a database

2.1 Sources of Data

Probable sources for failure data are newspapers, journals, internet, files from (forensic) engineers, insurance companies, contractors, court of justice or the government and interviews or personal reports.
In the next table an indication of the characteristics for different datasources are summarized. The table is partly based on the work of Melchers, Baker and Moses[2].

Part of the mentioned datasources is not available to the public. People and companies are not inclined to show their failures. In some industries people are obliged to report incidents[3].

Table 1: Datasources and their characteristics

Datasources	*Number of consulted sources*	*Period after event*	*Type of description*	*Reliability of description event*	*Reliability of technical causes*	*Reliability of organisational causes*
Newspaper: news	1	Hours	Headlines (factual or sensational)	Medium	Low	No attention, very low
Newspaper: background	1-5	Days	Brief indication of technical / organisational backgrounds	High	Medium	Low
Technical papers	1-10	Months	Technical details	High	High	Low
Sociotechnical papers	1-10	Months	Organisational issues	High	Medium	Medium
Jurisprudence, insurance files, official investigation files/ reports	5+	Years	Technical and organisational description Focus on accountability	High	High	Medium
Personal reports/ interviews	1	Days-Years	Technical details/ sometimes organisational issues	Medium	Medium	Low

2.2. Chosen datasource

The purpose of the database determines the needed data. The purpose of the database is to improve the building sector with respect to structural failures. For this, it is of importance to get insight in the amount and causes of structural failures in The Netherlands during the period 1993-2008. To derive trends a noticeble amount of data is needed. There are just a few official detailed investigation reports, so these reports are not sufficient.
Therefore it is chosen to start with collecting the easy accessible newspaper information. For the Dutch database the digitally available information of Cobouw[4] is used, a newspaper focusing on the Dutch building industry. This data can give an answer to the question whether a reliable trend is visible on the amount of failures per year (compared to the total building volume in a year). The reported amount of failures should be a representative of the real amount of failures
The newspaper data give just a rough and usually unreliable indication of causes. To improve completeness and reliability, additional information was retrieved from internet and for some cases a phonecall will be made to the government for clarification. Research from TNO[5] proved that additional phonecalls improved the reliability of the information.

3 Analysis of data

3.1 possible classifications of causes

In the past several structural failure data was collected and categorised in various countries. The next table summarizes the characteristics of some of these researches.

Table 2: Failure researches and their characteristics

	Country	*Years of investigation (year of public.)*	*Amount of cases*	*Source*	*Type of structure*	*Responsible party*	*Involved elements*	*Type of failure*	*Materials*	*Phase with failure*	*Type of error**	*Levels **	*Effects/ consequences*
Schneider/ Matousek[6]	Switzer-land	1960-1975 (1976)	723	Insurance files	•	•	•	•	•	•	•	•	•
Eldukair/ Ayyub[7]	USA	1975-1986 (1991)	604	Engineering magazines	•	•	•	•	•	•	•	•	•
Hadipriono et al.[8]	USA	1977-2000 (2003)	386	Multi	•			•	•	•	•		
CROSS[9]	England	(2005)	?	Personal reports	•		•	•	•	•	•	•	
Frühwald et al.[10]	Sweden	Ca. 1960-2000 (2007)	127	Multi	•		•	•	•	•	•		
Learning from disasters[11]	The Nether-lands	Ca. 2000-2005 (2007)	8	Multi	•	•	•	•	•		•	•	
ABC-meldpunt[5]	The Nether-lands	2004-2009 (2009)	82	Personal reports	•		•	•	•	•	•		

*type of error: most of the researches give an overview of the phases where the primary error occurred: design-error, construction-error, maintenance-error or abuse of structure.
**levels: more refinement in categorisation or management causes indicated

In the TNO-report 2007-D-R1387/B the initiatives of some other industries on registration of accidents were summarized with the used categorisation[3].

3.2 Chosen classification

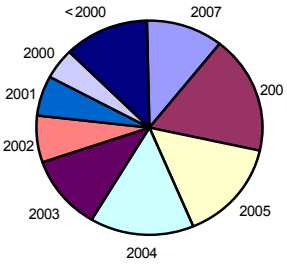
It can be concluded that with only newspaper information a simple classification is needed. Not sufficient data is available for a more sophisticated categorisation with various levels. Because buildings are made as projects, a classification with the phases (design, construction, operation, demolition) where the failure has its origin is useful. In this way it becomes clear which phases do need extra attention to avoid failures.
Besides the phase with the primary error leading to failure the name of the project, type of building, place, year of completion, year of event, element that was involved, material, name contractor and name engineer have been reported if available.

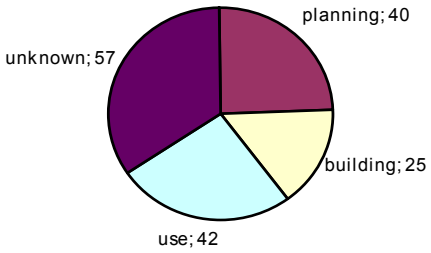
3.3 Preliminary results

For the years 2000-2008 TNO has published the preliminary results[12]. It appeared that most of the cases were related to buildings (66%), with usually failures on roofs, floors, facades and foundations. The roofs of swimming pools were strikingly often mentioned. The cause of failures was more often found in design phase than in the construction phase.

After 2002 significantly more cases were found than before. It is possible that more buildings have failures since 2002. On the other hand it is possible that there is a greater awareness of structural safety in the newspapers after a few major accidents.

Figure 1: year of occurrence of 196 cases Figure 2: Phases with origin of cause





The research will continue on the period before 2000 to search for a trend. Additional research is needed on other sources to refine the classification on causes.

4. Conclusions

For identifying trends and indicating rough causes of structural failures newspaper articles are a useful source of information. Because of the unreliable art of this data additional information is needed by other documents or interviews.
A simple but useful classification can be made for the phase with the triggering event of the failure. This could be the design, construction, operation or demolition phase.

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