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SAFETY BOARD

Summary

Hidden defects?

Lessons learned from the collapsed roof of the AZ stadium

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The Dutch Safety Board

When accidents or disasters happen, the Dutch Safety Board investigates how it was possible for these to occur, with the aim of learning lessons for the future and, ultimately, improving safety in the Netherlands. The Safety Board is independent and is free to decide which incidents to investigate. In particular, it focuses on situations in which people's personal safety is dependent on third parties, such as the government or companies. In certain cases the Board is under an obligation to carry out an investigation. Its investigations do not address issues of blame or liability.

Dutch Safety Board

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N.B. The full report is published in the Dutch language. If there is a difference in interpretation between the Dutch report and English summary, the Dutch text wil prevail.

CONTENT

SUMMARY

On Saturday 10 August 2019, part of the grandstand roof at the AZ stadium in Alkmaar collapsed. No audience was present at the moment of the collapse. At the time, the stadium had been in use for thirteen years. This occurrence led the Dutch Safety Board to examine how the structural safety of buildings is guaranteed during their use. This investigation report considers the causes of the occurrence at the AZ stadium and potential lessons to be learned for the structural safety of other buildings visited by large numbers of people.

Course of events and background to the collapse at the AZ stadium
The collapse of the grandstand roof was caused by the failure of welded joints in four roof trusses. The investigation into the occurrence revealed a number of different shortcomings. For example, the design of the roof construction had not been correctly tested according to the building standards. The complex transition in profile shape in the first joint to fail had not been correctly accounted for; in addition, the wind load was not appropriate for the roof design. Moreover, the finished welds were thinner than specified in the design, and there were welding errors. None of the parties involved in the construction recognized these shortcomings. The inspection of the safety of the design and construction of the roof structure was inadequate.

The investigation revealed that a crack had occurred in one of the failed welded joints shortly after construction was completed. As this crack grew over the course of time, the joints became ever weaker. There was also evidence of severe rust formation. During the period of use of the stadium, there were no further examinations of the technical condition of the joints. As a consequence, the owner had no clear picture of the declining structural safety of the building. The municipal authorities also carried out no active monitoring of structural safety during use. The roof eventually collapsed under a load which was far lower than the load which the structure was designed to withstand.

Structural safety of buildings in use in the Netherlands
There are clear shortcomings in the current method of ensuring structural safety. Shortcomings during the construction phase (such as gaps in the inspection of structural safety) were revealed by the Safety Board in 2018 in the report entitled *Constructing structural safety (Bouwen aan constructieve veiligheid)*.[1] Many of the risks identified at that time by the Board also apply to the construction of the AZ stadium.

1 Dutch Safety Board, *Constructing structural safety - Lessons from the Eindhoven Airport parking building collapse*, October 2018.

As regards the phase of use, this investigation has revealed that the structurally unsafe situation at the AZ stadium is not an isolated incident. An outline inventory has revealed that over the past twenty years, at least sixty serious structural problems have been identified during the use of a building.

This situation is a consequence of the manner in which the system for guaranteeing the structural safety of existing buildings is organized in the Netherlands. Although the owner[2] bears legal responsibility for the safety of his building, how this should be achieved is not further specified. For example, there are no statutory regulations for the periodic assessment of structural safety.

Moreover, there is no systematic approach to learning from occurrences involving structural defects in buildings while in use. Unlike the situation in the United Kingdom, there is no system in the Netherlands for recording and analysing occurrences of this kind. As a consequence, there is no clear overview of occurrences, causes and lessons learned. This limits the opportunities for systematic learning.

During the phase of use, the structural safety of buildings is considered by both national government and municipalities, mainly in response to incidents. Current developments, such as the Act on Quality Assurance for the Construction Sector (*Wet kwaliteitsborging voor het bouwen*), the action plan from the TOP Consultative Body on Safety (*TOPoverleg Veiligheid*) and the protocol for the evaluation of stadiums for professional football are all aimed at improving structural safety, but as yet do not offer a sufficient solution to the broader safety issues for buildings in use as identified in this investigation.

Examples from abroad show that there are possibilities for better managing structural risks in the phase of use. The United Kingdom and Germany both have national government guidelines for the periodic assessment of structural safety in existing buildings. Both guidelines operate according to an incremental and proportional approach, that ties in with the Dutch classification of buildings in consequence classes.

On the basis of this investigation, the Safety Board concludes that periodic attention for structural safety in buildings in the construction phase and the phase of use is insufficiently guaranteed, in the Netherlands.

2 Article 1b.2 of the Housing Act. This particular article does not specify an addressee but the Explanatory Memorandum reveals this to be the owner or another person authorized to make provisions in the building. Hereinafter we refer to the building owner, because that party is always present.

CONSIDERATION

The collapse of the grandstand roof at the AZ stadium on 10 August 2019 revealed that shortcomings in the structure of a building can remain undetected until things go seriously wrong. The collapsed roof fell onto a grandstand with seating for around 1,400 people. Fortunately, at the moment of the collapse, the grandstand was unoccupied.

At the time of the collapse, the stadium had been in use for thirteen years. The investigation by the Dutch Safety Board revealed that the collapse was the consequence of serious defects that arose during the design and construction of the stadium. In the intervening period, these defects went unnoticed, and were therefore not corrected. The owner had no clear picture of the condition of the structure. A thorough inspection could have uncovered the cracking in the welded joint which failed first. Following such discovery, the underlying defects could also have been detected, on time. No such inspection ever took place. Also not as part of the mandatory safety declaration from the Royal Netherlands Football Association (KNVB), despite the fact that an inspection of structural safety is required as part of that declaration. The annual declaration was signed by both the club director and the local mayor.

The investigation into the collapse of the grandstand roof at the AZ stadium has resulted in safety lessons for both the construction phase and the phase of use.

Structural safety in the construction phase

The way in which structural defects occurred during the construction of the AZ stadium fits into a pattern identified by the Safety Board in previous building accidents: the relevant stakeholders fail to sufficiently organize the process of design and construction in such a way that structural safety risks are effectively managed. The Safety Board has repeatedly drawn attention to this situation in its investigations into building accidents. In response to the collapse of the parking building at Eindhoven Airport, in 2018[3], the Safety Board issued recommendations to the sectoral organizations in the building sector to take joint responsibility for improving structural safety in the design and building process.

In 2019, this resulted in an action plan from the TOP Consultative Body on Safety (*TOPoverleg Veiligheid*), a collaborative venture between the various sector organizations in the construction industry. In this action plan, the stakeholders formulated their ambition: zero unsafe buildings or collapses and zero fatal accidents or accidents involving serious injuries. The occurrence at the AZ stadium once again underlines the necessity of fulfilling that ambition. The AZ case underlines the importance of firmly embedding attention for safety in the distribution of responsibility within a building

3 Dutch Safety Board, *Constructing structural safety - Lessons from the Eindhoven Airport parking building collapse,* October 2018.

project. It is up to the parties of the TOP Consultancy Body on Safety to include the lessons from the AZ case in the implementation of their action plan.

Structural safety in the phase of use

The recent attention for structural safety in the design and building phase does not influence the fact that existing buildings in the Netherlands can be subject to structural defects that are either never discovered or not discovered until it is too late.

An inventory by the Dutch Safety Board shows that it is not uncommon for structural defects to emerge during the use of a building. Over the past twenty years, there have been at least sixty occurrences. Although this inventory does not provide a detailed insight into the nature and scale of the problem, the result is worrying enough to urge far greater attention for structural safety in the phase of use.

This applies all the more since a number of the occurrences that emerged in the inventory affected buildings where large groups of people come together, such as stadiums, car parks, sports and event halls, office buildings and large shops. In the building regulations, buildings of this kind, in which a collapse potentially results in large number of victims, are classified in consequence class 3.[4] Visitors and users of such buildings are dependent for their safety on how the designers, builders and owners of the buildings approach their responsibility for structural safety.

Rules for the phase of use too non-binding

Any errors made during the design or construction phase of the above mentioned buildings can only be identified and corrected during the phase of use. In accepting ownership (handover, purchase) any building owner should therefore certainly seek thorough information about the construction of the building and the related safety risks that he is required to manage during use. Furthermore, as part of this responsibility, the owner can be expected to regularly check whether his building is still structurally safe, for example by carrying out periodic maintenance and inspections. This would increase the likelihood that structural shortcomings and deterioration of the structural integrity - whether or not as a consequence of structural shortcomings - will be identified and repaired in good time.

However, the current system of legislation and regulations is insufficient to require building owners to adequately accept their responsibility for managing structural risks. According to the Housing Act, although the owner[5] is required to ensure that his building is and remains safe, how that obligation should be fulfilled is not further elaborated. Moreover there rarely is preventive municipal supervision of compliance. The absence of both further elaboration and municipal supervision also applies to buildings in consequence class 3, the collapse of which can result in very serious consequences.

4 The Building Decree refers to the designation of three consequence classes in the NEN-EN 1990 standard. In this standard, the description of consequence class 3 states: high consequences for loss of human life (several dozen) and/or economic or social or environmental consequences are very great. Examples of such buildings are stadiums, exhibition galleries, concert halls, high-rise buildings higher than seventy metres and large public buildings.

5 Article 1b.2 of the Housing Act. This article does not specify an addressee but the Explanatory Memorandum reveals this to be the owner or another person authorized to make provisions in the building. Hereinafter we refer to the building owner, because that party is always present.

The Safety Board concludes that at present, the monitoring of structural safety in the phase of use does not enjoy the attention it deserves; neither from building owners nor in terms of municipal supervision.

New developments do not solve the safety shortcomings
The Safety Board has identified three current developments that could make a positive contribution to eradicating the safety shortcomings identified above. However, for the phase of use, the expected effect of these developments is too limited.

In response to the occurrence at the AZ stadium, together with the Royal Dutch Football Association (KNVB), the Ministry of the Interior and Kingdom Relations (BZK) drew up a protocol aimed specifically at evaluating the structural safety of professional football stadiums, by the owner. The Safety Board views this protocol as a step in the right direction, but points out that it is not compulsory. It would be beneficial to ensure a level playing field for all stadiums, so that the owners live up to their responsibility for structural safety in the same way.

The BZK/KNVB protocol is a public private arrangement that does contribute to the structural safety of professional football stadiums in use. However, the same arrangement does not apply to other buildings where large groups of people come together (in consequence class 3), such as other stadiums, exhibition galleries, concert halls, high-rise buildings higher than seventy metres and large public buildings.

A second development is the Act on quality assurance for the construction sector (*Wet kwaliteitsborging voor het bouwen, Wkb*), still to come into effect, the aim of which is to promote building safety. However, this Act is aimed at the construction phase and not at guaranteeing structural safety during use of a building. As a consequence, the safety shortcomings in the phase of use are not addressed. Moreover, for the time being, the Wkb applies only to single family homes and other smaller buildings in consequence class 1.

The third development is the action plan by the TOP Consultancy Body on Safety (*TOPoverleg Veiligheid*). This plan is aimed at improving structural safety in the design and building process, and not at managing risks in the phase of use. In that sense, the plan is important for the safety of future buildings, but will have no effect on the safety of existing buildings.

Need for mandatory guidelines
The owners of buildings in consequence class 3 represent a large and very diverse group. As a result, they are not easily collectively addressed with regard to better fulfilling their responsibility for structural safety in the phase of use. Public-private covenants that regulate these issues are not a realistic option given the heterogeneous nature of the group of owners. A statutory obligation imposing a periodic inspection and assessment of structural safety of buildings would force this group to accept their responsibility for structural safety in the phase of use, and would bring about a level playing field for all owners of buildings in consequence class 3.

Guidelines can assist owners in the proportional fulfilment of their responsibility for structural safety. The Safety Board also considers it essential that compliance with this responsibility be subject to municipal supervision. The combination of guidelines, statutory obligations and supervision will mean that the active and preventive management of structural safety risks for buildings in use will no longer be non-binding.

RECOMMENDATIONS

The investigation into the collapse of the grandstand roof at the AZ stadium has resulted in safety lessons for both the construction phase of buildings and the phase of use.

The Safety Board has in the past already identified shortfalls in guaranteeing structural safety in the construction phase (designing and building).[6] In the recent report following the collapse of the parking building in Eindhoven, among others the Safety Board pointed out risks of failing to recognize the consequences of design choices and of the poorly organized distribution of responsibilities between parties, whereby no single party oversees the entire picture. The Safety Board also called for attention for the risks of failing to respond in time to indications of shortcomings and of the decline in municipal supervision of building work. These factors also played a role in the collapse at the AZ stadium. For that reason, the Safety Board once again emphasizes the importance of following up on previous recommendations for improving safety in the construction sector.

Unlike in the majority of previously investigated occurrences, the collapse at the AZ stadium did not occur during construction but took place while the building was in use. Therefore, with its recommendations, the Safety Board now specifically focusses on managing safety risks in the phase of use.

The Dutch Safety Board issues the following recommendations.

To the Minister of the Interior and Kingdom Relations:

1. Introduce a statutory requirement for public access buildings in consequence class 3[7] according to which the owners must carry out periodic investigations into the structural safety of the building and take any measures necessary to improve the structural safety.
   - Have this periodic investigation undertaken by an independent certified expert.
   - Ensure that the scope and frequency of the investigation are proportional to the potential seriousness in terms of risk to humans.
   - Grant a role to municipal authorities in ensuring compliance with this statutory obligation.

6 *Constructing structural safety. Lessons from the collapse of the parking building in Eindhoven Airport,* October 2018; *Roof collapse during extension work at the stadium of FC Twente in Enschede,* July 2012; *Collapse of concrete floor B-Tower Rotterdam,* April 2012 and *Safety problems with falling facade slabs,* November 2006.

7 Consequence class 3 (NEN-EN 1990): high consequences for loss of human life (several dozen) and/or economic or social or environmental consequences are very great. Examples of such buildings are stadiums, exhibition galleries, concert halls, high-rise buildings higher than seventy metres and large public buildings.

- Specify that with each change of ownership, building owners must pass on the complete building file including reports of inspections, assessments and possible corrective measures, to the new owner.
- Include experience acquired abroad with guidelines for sporting accommodations (United Kingdom) and the periodic assessment of constructions (Germany).

2. In advance of the statutory obligation - issue a guideline to owners of buildings in consequence class 3 for the periodic assessment of structural safety, with an indication of the scope and frequency of the investigation.
   - As an example for this guideline, make use of the *Protocol for Assessing Structural Safety of Professional Football Stadiums.*

To the parties in the TOPoverleg Veiligheid (Bouwend Nederland, the Forum for Commissioning Parties in the construction sector, VNconstructeurs, Governance Code Safety in Construction, Koninklijke NLingenieurs):

3. Ensure that the lessons learned from the collapse of the grandstand roof at the AZ stadium are included in your recently launched action plan aimed at structurally improving safety in the construction sector. In particular, focus attention on:
   - Quality control for the construction of and maintenance on the structures of buildings used by large numbers of people (NEN-EN 1990 consequence class 3);
   - Issuing, upon handover of a building to the owners, a carefully compiled and complete building file, including instructions and points for attention for use, periodic inspection and preventive maintenance;[8]
   - A system for recording and analysing occurrences relating to structural safety with the aim of learning lessons from those occurrences. It is essential that the resultant lessons for construction and use be actively distributed among parties in the construction sector and among building owners.[9] Consider joining international initiatives such as CROSS International.[10]

To the KNVB:

4. In advance of the statutory obligation as outlined in recommendation 1, encourage all licence holders to comply within the shortest possible timeframe with the *Protocol for Assessing Structural Safety in Professional Football Stadiums*.

8 This ties in with a recommendation from the investigation *Safety problems with falling facade slabs* from 2006.
9 As above.
10 Confidential Reporting on Structural Safety; www.structural-safety.org/international.

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