

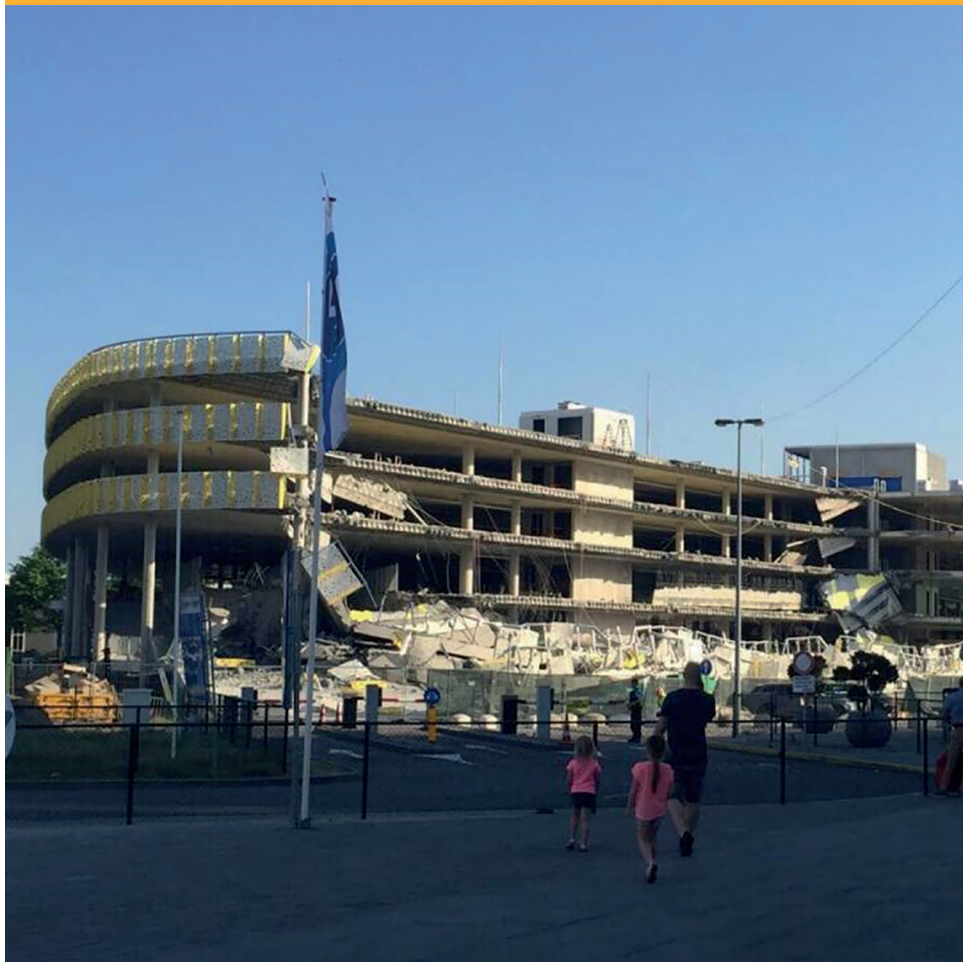


DUTCH
SAFETY BOARD

Summary

Constructing structural safety

Lessons from the Eindhoven Airport
parking building collapse



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The Hague, October 2018

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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.

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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 will prevail.

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SUMMARY AND CONSIDERATION

Construction is a complex process involving multiple parties at various times. Each party is responsible for a part of the construction process. However, responsibility for safety across the entire process is borne by all parties collectively. These parties are responsible not only for occupational health and safety and safety for the surrounding environment, but also for the structural safety of the building.

The ultimate consequence of taking insufficient care with regard to structural safety is that a building may collapse. This was the case on Saturday 27 May 2017, when part of the parking building near Eindhoven Airport collapsed. The building, which stood right beside the entrance to the airport, was one month away from final delivery. Workers had been working on the level that later gave way only a few hours before the incident; fortunately, they were unharmed. It was also a miracle that no passers-by were struck by debris, some of which fell outside the perimeter of the construction site.

Cause of the parking building collapse

Based on its investigation, the Board concludes that the collapse was the result of the design decision to rotate the 'BubbleDeck' slabs in the floor of the parking building one quarter-turn in respect to the orientation in which they are normally used, without recognising the consequences of this change.

The main result of the decision to rotate the slabs was that particular attention needed to be paid to the seams between the floor slabs. Such attention was not paid, however, with the result that insufficient reinforcement was given to the connections between the floor slabs at the level of the slab seams. The floor was thus unable to bear the loads. The floor was so vulnerable that the slight increase in the load on the floor resulting from the high temperatures on 27 May 2017 was enough to cause the floor to partially buckle. Failure to understand the consequences of the floor design was therefore the direct cause of the collapse. There were also failings in the implementation phase that were not recognised, but these were not a direct cause of the collapse of the parking building.

Accordingly, the parking building at Eindhoven Airport collapsed because the decision was made in designing the floor to rotate the floor components by one quarter-turn without considering the consequences. However, there were clear signs during the tendering process and in the implementation phase (including the formation of cracks and puddles) to indicate the presence of structural safety failings. At that time, none of the parties saw these signs as a reason to call the structural safety into question, although they could and indeed should have done so.

After the collapse, Eindhoven Airport and BAM, the main contractor, each conducted an investigation into the cause of the collapse. Both of these investigations stated that the direct cause was a defect in the wide slab floor; namely, imperfect adhesion between the floor slabs and the concrete that was subsequently poured over the top. However, the Board's investigation revealed that this imperfect adhesion was not the cause, but rather the consequence of the floor design selected for this building.

In response to the two investigations mentioned above, the Minister of the Interior and Kingdom Relations drafted the information document *Assessing the Safety of Wide Slab Floors in Existing Buildings*, which contains a step-by-step procedure for assessing the structural safety of buildings with similar flooring systems. Based on the conclusion of the Safety Board, the focus in the step-by-step procedure on the failure mechanism in the floor should be shifted to the design of the floor and the specifications of the slab seams.

The industry is not adequately learning from incidents

In recent years, the Board has conducted a number of investigations into (structural) safety incidents in the construction industry. It concerns the Board that the findings from these investigations and the lessons arising from those findings have still not led to substantial changes in the construction industry. Clients and contractors in the industry still too often treat each construction – and thus each incident – as unique, meaning that they think the lessons do not apply to them. Because of this, the same underlying processes can result in (structural) safety incidents over and over again. In addition, it is apparent to the Board that a blame culture exists. After an incident, parties in the industry appear to be more concerned with deflecting blame than with focusing on how they themselves can contribute to improving safety. The often defensive and legalistic form and undertone of the responses received by the Board to its draft report exemplify this attitude.

To actually succeed in constructing (structural) safety, the blame culture must be replaced by a learning culture. That will require the parties in the sector to draw lessons from accidents also for themselves, and raise these matters with each other. In its investigations, the Board has observed that the construction sector is still not successfully organising the design and implementation process in such a way that the safety risks are being properly managed.

Organising process responsibilities for safety

Construction projects are carried out by several different companies, and increasingly there seem to be more companies involved in each project, rather than fewer. This division of labour increases the likelihood of mistakes, particularly if, at any given moment, the individual parties are doing their work without having a view of the big picture. For this reason, the Board considers it important that, for every construction project, the parties in the construction process appoint one central party to be responsible for ensuring safety. This party, the process manager, is responsible for a systemic and continuous process of risk management, with a well documented risk register that includes safety aspects. Specifically, this means that throughout the construction process, from idea to delivery, the process manager collects and records any discrepancies and signs of potential (structural) safety risks, and organises professional discussions to consider them. The appointment of a process manager does not release the other parties from their individual responsibility for all kinds of safety. The process manager keeps all of the parties involved on task and supervises the work as a whole.

This message is not new; the Board has highlighted the need to organise process responsibilities in its previous investigations, and has also made recommendations on this topic. Yet this type of overarching responsibility for safety has still not been implemented in the construction sector. The fact that at Eindhoven, as in previous construction incidents investigated by the Board, the lack of this overarching responsibility was one of the key explanations for the insufficient control of the safety risks, is a stark illustration of the urgency of implementing this recommendation.

The Board also identifies a number of other issues that must be resolved to better ensure (structural) safety:

Diffuse distribution of responsibilities

The construction process is extremely fragmented. Clients and contractors need to realise that the organisational complexity associated with that fragmentation is a choice. If they opt for a complex project organisation structure, they must ensure that, in practice, tasks and responsibilities are coordinated in such a way as to guarantee (structural) safety. This obviously means that it must be clear to all parties who is responsible for what. When the distribution of responsibilities is unclear, vulnerabilities can go unnoticed, which also means that measures to mitigate these vulnerabilities are not implemented. Based on its investigations, the Board observes that the likelihood of an unclear distribution of responsibilities is increased when a mixed contract structure is used. The Board sees this confirmed in the responses it received to its draft report, which showed that the parties involved were convinced that one of the other parties was responsible for the floor design, not them. In addition, uncertainties arise when the attitude and behaviour of the parties do not correspond to the responsibilities as set down on paper.

Focus on the lowest price

Parties in the construction sector recognise that it is the collective responsibility of the client and the contractor to arrive at a price that is commensurate with the scale of the work, the schedule, the desired quality and the identified risks. However, in its investigations the Board observes that in practice, the lowest price is usually paramount in the tendering process, while the risks are insufficiently understood, not mentioned and/or unpriced. A heavy focus on price can have undesirable consequences for the (structural) safety of a building. From an economic point of view, too, an unsafe building can create a significant financial burden for the parties involved, not to mention the damage to their reputations. If the client gives significant weight to safety when comparing tenders, substantial safety gains can be achieved.

Safety net function disappears

The project organisation is primarily responsible for producing a safe construction. In principle, the government monitors construction projects to protect the public interest. The numerous safety incidents, and the fact that the construction sector is not adequately taking on board the lessons learnt, show that this sector cannot do without public supervision. However, with the introduction of the Quality Assurance in Construction Bill, the Minister of the Interior and Kingdom Relations is seeking to introduce a new system of quality assurance. This system will give greater responsibility to the construction sector, while the role of public (municipal) supervision will be reduced. The bill was tabled in April 2016, and although it has not yet been put to a vote in the Senate,

in practice it has already begun to have an effect. Anticipating the consequences of this bill for the supervisory role of municipal authorities, many municipalities have made cuts to their Building and Housing Inspection departments. The reduced monitoring role that municipal authorities are now performing in practice has been implemented before the bill has even been passed. At the same time, because the bill has not been passed, no alternatives have been put in place. The result is that in a sector in which there is insufficient social responsibility for safety, a vacuum has been created.

Constructing structural safety

The analysis of the partial collapse of the parking building at Eindhoven shows that collective attention to structural safety was insufficient at all stages of the construction process. Previous construction investigations by the Board have reached similar conclusions. It is high time for the construction sector to shoulder its social responsibility and make the necessary improvements. That will require a willingness to learn and to engage in profound self-reflection. It is favorable that the construction sector is currently doing well, economically speaking; when the sun is shining, it's a good time to fix the roof. In other words, now is the time to take substantial steps to construct structural safety.

RECOMMENDATIONS

When the investigation of the Dutch Safety Board into the partial collapse of the parking building at Eindhoven Airport is examined in the context of previous construction incidents investigated by the Board, striking similarities are evident. Collective attention to safety does not happen as a matter of course in the construction sector.

This is concerning to the Board, especially given that the safety net of public supervision is increasingly being lost as a consequence of the plans for privatisation of construction monitoring. At the same time, the sector has not yet demonstrated that it is ready to personally take responsibility for safety, which underscores the urgency of implementing the recommendations in this report.

In its recommendations, the Board focuses on parties that, due to their linking or driving role, can encourage parties in the construction sector to make changes. After all, it is crucial that the recommendations be implemented sector wide. The ball is in the construction sector's court.

The Safety Board expects the main players in the incident – Koninklijke BAM Groep N.V., Eindhoven Airport N.V., BubbleDeck, Archimedes Bouwadvies B.V. and Adviesburo Opzeeland B.V. – to become actively engaged in implementing the recommendations set out below.

Better risk management in the construction sector

In the opinion of the Safety Board, better risk management is needed in the construction sector to move towards actual safety improvements. With this in mind, the Board makes recommendations in three areas.

1. The Safety in Construction Governance Code should be less informal
The Board considers the participants in the Safety in Construction Governance Code to be ambassadors in the transformation to a learning, safe construction sector. Jointly drawing up principles to contribute to that, promoting these principles and keeping them permanently on the agenda are efforts that will result in a much-needed strengthening of safety.
2. Ensuring safety
The Safety Board is of the opinion that safety would benefit from a clear distribution of responsibilities and coordination. The Board considers this to be the collective responsibility of both clients and contractors.

3. Organising professional discussions

When new applications or products are introduced the Board expects structural engineers to thoroughly apply the principles of mechanics and the associated schematics, instead of automatically following previous practice. The Board also expects structural engineers to conduct themselves as professionals, to have the courage to collectively address their feelings when 'something's not right' and to critically reflect on their own actions, separately from the formal distribution of tasks and responsibilities in a project.

The Safety Board makes the following recommendations:

1. To the Safety in Construction Governance Code core group

Work together to draw up principles that promote safety (structural safety, occupational health and safety and safety for the surrounding environment) in construction, and incorporate these principles in the Safety in Construction Governance Code. Ensure that these principles are promoted by and reflected in the conduct of both clients and contractors at the company level and at the project level.

Consider working on the following principles at a minimum:

- ensuring all forms of safety in construction projects;
- the importance of organising professional discussions;
- the principles of systemic risk management;
- transitioning from a blame culture to a learning culture;
- embedding safety in tendering procedures.

And hold participants explicitly accountable for complying with these principles.

2. To the Commissioning Authorities Forum for the Building sector and to *Bouwend Nederland*

a. Ensure that your members, regardless of the contract model, take care of the following:

- making clear agreements about which party – the client or the contractor – bears responsibility for the final design and will retain that responsibility throughout the construction process;
- ensuring a thorough demarcation of the tasks and responsibilities of all (sub) structural engineers involved in the project; and
- making clear agreements about which of these structural engineers will be monitoring structural cohesion.

Investigate how this can be imposed, and show how you will deal with members that do not comply.

- b. Support the efforts of the Minister of the Interior and Kingdom Relations to include clear and coherent rules for risk accountability and cooperation obligations in general conditions documents.¹

3. To the *Vereniging Nederlandse Constructeurs*

Actively communicate the lessons from this investigation, including how structural engineers as professionals are expected to act to prevent a collapse such as this one, and explore the possibilities for drawing up a Code of Conduct.

¹ This specifically relates to the following general conditions: the *Uniforme administratieve voorwaarden voor de uitvoering van werken en van technische installatiewerken 2012 (UAV 2012)*; the *Uniforme administratieve voorwaarden voor geïntegreerde contractvormen (UAV-gc 2005)*; and the *algemene voorwaarden voor raadgevend ingenieurs en architecten (DNR 2011)*.

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