



THE DUTCH
SAFETY BOARD



SUMMARY

**Roof collapse during extension work
at the stadium of FC Twente in Enschede,
the Netherlands**

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FC Twente in Enschede, the Netherlands**
7 July 2011

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The aim in the Netherlands is to reduce the risk of accidents and incidents as much as possible. If accidents or near-accidents nevertheless occur, a thorough investigation into the causes of the problem, irrespective of who is to blame for it, may help to prevent similar problems from occurring in the future. It is important to ensure that the investigation is carried out independently from the parties involved. This is why the Dutch Safety Board itself selects the issues it wishes to investigate, mindful of citizens' position of dependence with respect to public authorities and businesses. In some cases, the Dutch Safety Board is required by law to conduct an investigation.

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* Due to involvement in his capacity as director of the COT Institute for Safety and Crisis Management, professor E.R. Muller, board member of the Dutch Safety Board, has decided, pursuant to Section 15(2) opening words and (c) of the Dutch Safety Board Act, not to participate in the discussion of the investigation into roof collapse during extension work at the stadium of FC Twente in Enschede.

This report is published in Dutch, German en English. In the event of any discrepancy between these versions, the Dutch text shall prevail.

CONSIDERATION

Reason

On 7 July 2011, during work to extend the De Grolsch Veste stadium, the roof of the extension collapsed. As a result of this accident, two workers were killed and nine injured, a few of them critically,. The incident received considerable attention, especially because football stadiums are locations at which people gather in very large numbers. These visitors assume that their safety is guaranteed. At the time of the incident, the Dutch Safety Board was already investigating the collapse of part of an upper floor of a combined residential and retail building that was under construction, the B-Tower in Rotterdam, on 21 October 2010. During its preliminary investigation of the incident at De Grolsch Veste stadium, the Dutch Safety Board found parallels with the B-Tower incident.

Roof collapse during extension work at the stadium of FC Twente

FC Twente wanted to increase stadium capacity by further extending the L-shaped extension completed in 2008 into a U-shaped one. FC Twente was the commissioning party and awarded the contract for the performance of the construction work on the basis of the design applied earlier to a contractor group, hereinafter referred to as 'the main contractor', that had been specially formed for the purpose. To support its commissioning role, FC Twente engaged a company that acted as a delegated commissioning party. The main contractor outsourced work and engaged subcontractors for the construction (in concrete) of the stand and the construction (in steel) of the roof structure. The subcontractors engaged to perform the work were the same as those that performed the work in 2008.

Construction work on the extension started in February 2011. The project was at an advanced stage on the date of the incident. At the specific time of the incident, workers were working at various locations both on and underneath the roof. These workers became the victims of the roof collapse.

The steel roof structure was still very much under construction and was therefore not yet independently stable. Nevertheless, further completion work was proceeding apace. The steel structure had not been fully completed, which would have ensured its stability. Rather, further completion work was carried out on the as yet incomplete roof structure, which was subjected to loading as a result. In other words, the sequentiality of the construction process had been replaced by simultaneity.

The investigation revealed that the roof structure's insufficient stability, and therefore the risk of collapse, was caused by several factors. The main factor was the absence of essential coupling pipes at the back ends of the roof beams and stabilising connections in the roof structure. During assembly of the roof beams, steel cables were used as a temporary stabilising measure. The last stabilising cable was removed on the day of the incident. In addition, the roof structure was already being subjected to additional loading by a video wall, suspension bridges, piles of roofing sheets and the workers present. The investigation also revealed that the roof structure was being subjected to additional loading as a result of dimensional differences between the concrete beams of the stand, the foundation of the steel structure and the steel structure itself. These dimensional deviations in combination with insufficient adjustment options meant that parts of the roof structure could only be inserted by exerting deforming force. That deformation caused additional tension that reduced the load-bearing capacity.

The combination of tensions in the structure as a result of its own weight, dimensional deviations, the load already present and the absence of stabilising measures caused one of the roof beams to fail as a result of the forces to which it was subjected, which initiated a total collapse. It is clear that shortcomings occurred in terms of ensuring the structure's integrity and safety during the construction process: a situation had arisen in which work was being performed both on and underneath a roof structure that proved to be insufficiently stable. The investigation revealed that:

- the construction work was inadequately coordinated and checked;
- duties, and therefore responsibilities, in the construction process had not been properly assigned or were not properly performed;
- decisions were not made at the right level within the organisation.

Coordination and checking of the construction work

The law states that the commissioning party must conclude agreements and ensure that the main contractor performs the work in a safe and orderly manner. The obligation to coordinate and check performance for the work as a whole was a responsibility of the main contractor. The investigation revealed that the main contractor did not check the order and way in which the roof structure was being assembled. Problems were solved by the subcontractors at implementation level. The building control officers appointed by FC Twente checked whether the extension would meet the requirements of the commissioning party following its completion. They did not check how the construction work was being executed and whether it was being executed safely.

Decision-making with respect to the construction work

During construction of the roof structure, there were no clearly defined moments of transfer at which it was decided, at the right level, whether or not the next phase of construction could commence. The steel construction specialist had not yet completed the steel roof structure. The main contractor nevertheless put the structure into use and instructed subcontractors and other contractors to start completion work. The consequences in terms of structural safety were not a separate point of attention for any of the parties involved.

Performance of responsibilities

In the De Grolsch Veste project, responsibilities relevant to structural safety were set out in contracts, which included the 'construction subspecifications', concluded between the parties engaged to carry out the construction work. These responsibilities were performed only to a limited extent, however. In the planning stage, for example, the design was not assessed in terms of feasibility and none of the parties involved calculated the strength of the roof structure as it would be while under construction. As a result, the level of stability in the course of the construction process was unknown, which in turn meant that the necessary preconditions for assembly were likewise unknown.

In the contract with the steel construction specialist, the main contractor should undertake action to ensure the correct dimensions of the stand and carry out the necessary checks in this regard. However, responsibility for ensuring compliance with this contractual arrangement was not explicitly assigned to an employee by either of the parties. The main contractor did not record any measurement data and the steel construction specialist started building the steel structure without checking the dimensions of the stand.

In the contract with the main contractor, the steel construction specialist should undertake action to perform the assembly work in accordance with the applicable standard.¹ However, the assembly plan of the steel construction specialist as accepted by the main contractor did not meet that standard. It did not address, for example, the strength of the roof structure as it would be in interim phases while under construction and also did not deal with the parts critical to stability. The assembly plan therefore did not prevent that parts that were important to stability were left out of the construction process, nor did it prevent that completion work started before the roof structure was independently stable.

The contracts concluded for the De Grolsch Veste project were not used to create, from commencement of the work, an unambiguous framework in which it was clear to all parties what was expected of them and what they could expect of others. The investigation revealed that parties cooperated on the basis of trust in each other's professional abilities without establishing or checking the necessary preconditions. This approach was adopted because the parties involved in the construction project had previously performed similar work together during the first expansion

1 NEN-ENV 1090-1:97

of the stadium in 2008. Ultimately, it led to a situation in which the performance of a number of responsibilities critical to structural safety during construction was not monitored.

Overtaken by time

From the outset, the main contractor's definitive plan, adopted on 31 March 2011, deviated from that of the steel construction specialist. Assembly of the steel structure had originally been scheduled to start on Monday, 23 May 2011. Because of a delay in the construction of the extension's concrete element, the steel construction specialist started a week later. In addition, it is striking that the steel construction specialist would place the roof beams in two weeks in accordance with the main contractor's plan, whereas its own plan assumed six weeks for the performance of this task. According to the plan adopted, the construction and completion work would be performed in a specific sequence. The two staircases were to be completed before the steel construction specialist started assembling the roof beams of the straight section. In reality, however, the staircases had not yet been completed at that time. Assembly of the roof was continued nevertheless. In addition, the main contractor stuck to its plan for completion work so that the necessary items would be 'football-ready' on 2 August. These necessary items included the staircases, seats and the roof.²

The plan for the construction of the extension was tailored to the desired inauguration of the stadium in connection with FC Twente's match and training sessions schedules. Because of FC Twente's football successes and the resultant new match schedules, the original completion date of 12 August was brought forward to 26 July 2011.

The work did not have to be completed in full for the stadium to be 'football-ready'. Although the planning schedule provided for such a situation, there were parts that were nevertheless compulsory in nature by reason of, among other things, requirements that apply to European football.

The building contract signed by the commissioning party and three representatives of the building consortium on 23 June 2011 included a 'football-ready list'. Based on the state of affairs as at 17 June 2011, the various parts of the extension were qualified as 'feasible', 'critical' and 'unfeasible'. Because the staircases had not yet been completed and the steel construction specialist had yet to complete its work, the main contractor abandoned the original sequence set out in the plan. From that point on, various construction and completion tasks were performed simultaneously rather than in sequential steps. The investigation revealed that the main contractor did not assess whether these changes would affect the safety of the workers performing the work.

Parallels with the B-Tower incident of 2010

As was the case in the De Grolsch Veste incident, a lack of proper control with respect to structural safety during the construction phase was a factor in the collapse of part of an upper floor of the B-Tower in Rotterdam, a building that was under construction at the time. In both cases, the structure lacked parts that were essential to stability. The investigation into the B-Tower incident identified three factors that explained why the supporting structure was put into use while still in an incomplete state. These factors were (1) the lack of a joint approach to safety, (2) inadequate coordination and checking, and (3) a diffuse allocation of responsibilities.

As stated above, the underlying factors of inadequate coordination and checking, the lack of a balanced allocation of duties and associated responsibilities and the lack of a joint approach to safety also played a major role in the collapse of De Grolsch Veste stadium's roof structure.

Commissioning parties in the construction sector usually focus on the functionality of the structure to be built, costs and completion time.³ Guaranteeing safety at the construction site is a matter that the commissioning party leaves to the main contractor on the basis of the latter's role as a contractor on the one hand and, on the other, its role as a commissioning party in relation to the

2 Note concerning the football-ready part of the FC Twente Building Consortium building contract, 23 June 2011.
3 Pilot study into guaranteeing structural safety in construction processes (K+V study commissioned by the Inspectorate of the Ministry of Housing, Spatial Planning and the Environment, 2007).

different parties at a construction site. However, the parties performing the construction work are under pressure from the market to operate as efficiently as possible and keep the costs as low as possible. An instrument to identify and control risks is therefore often seen as an administrative obligation rather than as means to truly manage safety. In these circumstances, it is not surprising that unsafe situations arise at construction sites.

As it did with respect to the B-Tower incident, the Dutch Safety Board therefore concludes once again that a greater awareness of safety and a stronger sense of responsibility must be developed in the construction sector. To guarantee safety, it is very important that there is a clear and practicable matrix of duties and responsibilities in place and that commissioning parties and contractors remain aware at all times of the interdependence of all work-related activities.

Following the publication of the report on the B-Tower incident, the State Secretary for Social Affairs and Employment and the Minister of the Interior and Kingdom Relations indicated in their reply to the President of the Lower House that they shared the findings and conclusions of the Dutch Safety Board.

*".....In closing: We acknowledge the conclusions of the Dutch Safety Board concerning the responsibilities assumed and to be assumed in the construction sector. The report specifies how parties are being urged to improve, particularly in the area of safety awareness and construction quality."*⁴

The Dutch Safety Board calls on responsible parties and parties involved, such as commissioning parties, contractors and representatives of the sector, to take genuine steps towards assuming responsibility for a safe workplace.

4 Note of P. de Krom dated 16 May 2012 to the President of the Lower House of the States General, G&VW/VW/20912/6053.

CONCLUSIONS

The roof of an extension of the De Grolsch Veste, the stadium of FC Twente in Enschede, the Netherlands, collapsed during construction work on 7 July 2011, at around 12:00. As a result of this accident, 12 workers fell from a great height. Two workers were killed and nine injured, a few of them critically. One worker escaped bodily injury.

Direct causes

The investigation revealed that several factors combined to create a situation in which the roof structure of the De Grolsch Veste could collapse at any time. Three key factors were:

Parts were missing

1. The stability of the roof structure was insufficient for the load that it was already being subjected to. Essential coupling pipes and stability connections in the roof structure were missing and this was not compensated for by temporary stabilising measures.

The incomplete roof structure was subjected to excessive loading

2. The incomplete, as yet unstable roof structure was subjected to the load of a video wall, suspension bridges, roofing sheets and ten workers. The roofing structure was therefore subjected to greater loading than it could bear at the time.

Dimensional deviations of the concrete structure

3. Because of the dimensional deviations of the concrete stand in combination with the limited options of the steel structure, the concrete and steel elements of the extension did not fit in a proper way. The steel structure therefore had to be made to fit by force, as a result of which the structure in place was deformed and had less load-bearing capacity.

Organisation of the construction process

A situation in which the risk of roof collapse was not controlled could arise as a result of the way in which the construction process was proceeding.

Use of instable steel structure

4. The main contractor put the incomplete steel structure into use. Although the main contractor assumed that this structure was stable, it did not check whether this was indeed the case.

Load exceeded load-bearing capacity: the structure collapses

5. The primary structure could only bear limited loads because the steel construction specialist had left out parts that were important to stability. The steel construction specialist had not yet assembled these parts because they would have hindered the construction of the staircases. In addition, it had not taken temporary alternative measures.
6. The main contractor had an obligation to coordinate and check all of the work being performed. The absence of parts from the primary structure was clearly visible. Nevertheless, the main contractor did not take any measures to ensure stability or ensure that the missing stabilising parts were placed.
7. The steel construction specialist wrongly assumed that the main contractor had involved the structural engineer in the decision to start completion work while the roof structure was as yet incomplete.

8. The main contractor did not monitor the assembly method of the steel construction specialist because it relied on the latter's professionalism and structural knowledge.
9. Based on earlier experiences with the L-shaped extension, the Labour Inspectorate and Municipality of Enschede had no reason to inspect the manner in which the construction work was being performed.

Signs of the roof structure's reduced load-bearing capacity were not recognised

10. Dimensional deviations arised during the construction of the concrete stand structure. It was not possible to adjust the steel structure to a sufficient degree to compensate for these dimensional deviations. The roof therefore did not automatically fit with the stand. The steel construction specialist therefore used force to deform the steel structure so that it could be placed on the stand. The steel structure was therefore under strain and its load-bearing capacity was compromised. The steel construction specialist, the main contractor and the consultancy firm engaged for the structure failed to recognise the consequences of the roof not automatically fitting on the stand. According to these parties, the work did not have to be adapted to this situation.

Stand with measurement differences

11. The main contractor failed to check whether the design and contract documents could be implemented. As a result, it was not recognised in time that ensuring the correct dimensions was critical to the joining of the steel structure with the stand. The problems that arose during implementation when the parts did not fit were resolved during performance of the work.
12. The commissioning party concluded individual contracts with the firm of architects, the structural engineer, the main contractor and the delegated commissioning party. In doing so, however, it did avoid ts full responsibility for safety during construction. The parties involved that worked together as members of a construction team failed to notice.
13. The main contractor did not adhere to the construction subspecifications. Supervision to ensure that these subspecifications were complied with was not exercised because no site manager had been appointed for the purpose.

Underlying factors

In summary, the following underlying factors determined the course of the construction process:

14. Responsibilities that were set out on paper, in contracts and the contract documents, were not assigned to individuals by the main contractor and steel construction specialist. These responsibilities were therefore not performed.
15. The responsibility for guaranteeing design's feasibility was not performed.
16. Decisions relevant to structural safety were not made at the right level in the organisation.
17. The commissioning party did not set out who was responsible for ensuring compliance with the construction subspecifications. As a result, no one noticed that they were not being complied with.
18. When preparing for the implementation phase, the main contractor and the steel construction specialist did not assess whether the design was feasible.

In spite of the fact that the construction of the roof had been delayed, the main contractor started completion works on the basis of the original plan. In doing so, it abandoned the plan's initial sequentiality. Different tasks were thereafter performed in parallel rather than according to a specific sequence. The investigation revealed that the main contractor had not considered whether these changes would affect the structure's safety. And so it came to pass that the roof collapsed while 12 employees of the main contractor's subcontractors and three volunteers were working at an not as such recognised unsafe workplace.

RECOMMENDATIONS

The Dutch Safety Board directs its recommendations at the commissioning party, the main contractor, the steel construction specialist and the trade association.

To the commissioning party FC Twente and the delegated commissioning party The Stadium Consultancy:

1. With respect to future work, identify in advance the circumstances under which all parties can realistically perform the planned work.
2. As a commissioning party, ensure in the context of work that all agreements concerning safety are actually performed and enforced.

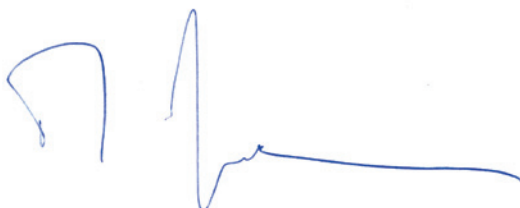
To Te Pas Bouw, Dura Vermeer, Trebbe and Voortman Staalbouw:

Because the building consortium was an ad hoc consortium for the project under consideration, the Dutch Safety Board puts its recommendations directly to the parties involved in the incident.

3. Inform the Dutch Safety Board of the weaknesses in cooperation in the construction process as a result of which safety is compromised. Give genuine substance to a contractor's responsibility to obviate these weaknesses:
 - a. Create the preconditions that enable parties and workers at the construction site to build the structure in a safe manner during each phase of the construction process.
 - b. Appoint the responsible individuals and assign responsibilities to them in a way that is unambiguous and clear to all implementing parties in a construction process.
 - c. Organise a systematic and full transfer between the parties within a project. Ensure that each party clearly accounts for the activities that it has performed.

To the Dutch Construction and Infrastructure Federation Bouwend Nederland:

4. Take the initiative, in the form of an action plan, to organise the way in which explicit duties are to be assigned to the implementing parties in a construction process. In this context, in addition to the proposals for improvement set out in previous studies into structural safety, incorporate the existing knowledge and expertise contained in the structural safety code of practice of the Netherlands Association of Property Developers and Investors (NEPROM).
5. Take the initiative to also include parties that are not members of the trade association in this improvement process.



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