

SUMMARY IN ENGLISH

Tarfalahallen was a sports hall located in the district of Lombolo in Kiruna. In the hall, various sports such as football, athletics and climbing could be practiced. The hall was built of wood and had a pulpit roof. This means that the roof was flat and it had a slope of three degrees. The supporting roof design consisted of trapezoidal profiled sheet metal that rested on sub-tensioned glulam roof trusses with a span of 54 metres.

On the evening of March 7, 2020, parts of the hall's roof collapsed. In the event, about half the building collapsed. The rest of the building remained without significant damage.

Two people were inside the hall when it collapsed. Both survived without injuries. They were able to get out of the hall themselves and call 112. Personnel from the rescue service searched the demolished parts around the hall and were able to establish that no one was injured.

There was a lot of snow in the area at the time of the collapse. However, the SHK's investigation shows that the snow load on the roof did not exceed the building's estimated load-supporting capacity.

The stability of the trusses had not been correctly considered when the roof structure was dimensioned. The design principle for sub-tensioned trusses is sensitive to geometric deviations and in need of secondary bracing systems to be made stable. The roof design had also been modified in relation to the original design.

The investigation also shows that there were shortcomings in the inspections carried out during the design and construction of Tarfalahallen. The developer had the obligation to ensure that the building met all the requirements in the plan and building legislation. The developer did not carry out any inspections, but relied on the engaged turnkey contractor. The developer's inspection plan lacked both in detail and inspection points of the roofs design and construction. No remarks on defects in the design or construction could be deduced from the inspections carried out. The building committee had no remarks on the inspection plan or on the construction work.

Early in the investigation, the SHK was able to establish that stability deficiencies could also be found in similar roof structures. A notification was therefore sent to the building committees in Sweden's 290 municipalities about risks related to this type of roof design.

From the responses received in connection with the SHK's notification, it appears that deficiencies in dimensioning and design are common and they are not limited to Tarfalahallen. This is also apparent in previous investigations of building collapses that the SHK has studied. Deficiencies in dimensioning and design have also occurred in various designs and materials and have not only been connected to a design with a sub-tensioned glulam roof truss.

The information in the municipalities responses shows that stability deficiencies have been identified in a number of existing buildings with the current type of design. Measures have been taken in several buildings. A number of buildings were closed pending further action.

The Swedish National Board of Housing, Building and Planning's investigation of about 180 roof collapses during the winters 2009/2010 and 2010/2011 showed errors in design and construction in at least 75 percent of the collapses surveyed. Of these, 40 percent were dimensioning errors. The most common technical fault was lack of lateral stabilization and there were deficiencies in several different types of roof designs.

Deficiencies in the dimensioning was also identified in the SHK's investigation of a newly built multi-storey building in Ystad, which collapsed in 2013.

The SHK has identified systematic shortcomings in the Swedish planning and construction process. Since 1995, the obligations of the developer have been clarified. As a result, the building committee's inspection of how a building is designed and dimensioned has been removed. No other official inspection has been introduced in the legislation. According to the Swedish planning and construction process the responsibility for compliance with the design standards rests on the developer. Thus, the ambition and competence of the developer and the contractors will determine whether a building is designed correctly or not.

Safety should be given greater focus in the planning and construction process. With the current system deficiencies, it appears likely that new building collapses will occur. There is a significant risk that people will die or be seriously injured. Improvements to the planning and construction process can be made in different ways. The SHK's opinion is that e.g. the inspections regarding the design of a building need to be strengthened.

Causes of the accident

The cause of the accident was that the stabilizing structures were not calculated and dimensioned correctly. Contributing factors were:

- A formula that was not intended for sub-tensioned structures was used to calculate the need for stability.
- The flexibility of the roof construction was not considered.
- It was assumed that the connection between the pressure strut and the primary beam could be stabilized by means of torque absorption in the nail plate.
- The nail plates in the joint between the beam and the pressure strut had been overused in the stress calculations.

The deficiencies were not identified because the inspections during dimensioning and execution were deficient.

A contributing cause to the accident was that the roof structure had not been constructed correctly with regard to the type of nail pattern in the nail plates. Also, modifications had been made to several of the horizontal pressure bars. This was not discovered due to the lack of details and inspection points in the inspection plan. This led to an insufficient inspection of the assembly procedure and the building's final status. The interpretations of the requirements made by the developer and the building committee led to the inspections not being sufficiently comprehensive.

Deficiencies at system level:

- The construction process is in several respects not sufficiently regulated.
- The level of requirements for competence and inspections does not correspond to potential consequences of any faults in buildings.
- There are no specific requirements for inspections with the aim of maintaining the load-supporting capacity of a structure after the building has been completed.

Safety recommendations

Measures need to be taken to prevent buildings from collapsing due to lack of load-supporting capacity.

According to the SHK the safety of buildings with building parts corresponding to safety class 3 according to BFS¹ 2019: 1 (EKS 11) should be improved. This means, among other things, that the following measures need to be taken as further described in section 2.10:

- Requirements for an evaluation of the design by an independent actor whose competence is verified, e.g. through accreditation or certification.
- Requirement for building inspections, by an independent actor, of the building before the final clearance is given. The inspection shall verify that the building has been constructed in accordance with the design documentation.
- Requirements for recurring inspections and maintenance measures to ensure that the load-supporting capacity is maintained throughout the life of the building. The requirements should also be applicable for existing buildings. Inspection results and maintenance measures shall be submitted to the supervising authority upon request.

The Government is therefore recommended to:

- Initiate necessary changes in the planning and building legislation, to achieve and maintain sufficient safety with respect to the load-supporting capacity in buildings. (*RO 2021:01 R1*)

The Swedish National Board of Housing, Building and Planning is therefore recommended to:

- Take necessary measures in order to achieve and maintain sufficient safety with respect to the load-supporting capacity in buildings. Such measures may, for example, include changes in regulations and guidance. (*RO 2021:01 R2*)

¹ BFS – Regulations of the National Board of Housing, Building and Planning.

Martinsons Byggsystem AB is recommended to:

- Take necessary measures to ensure that the stability is appropriately considered when the load-supporting capacity of sub-tensioned glulam structures is dimensioned. *(RO 2021:01 R3)*
- Examine the dimensioning calculations for the stabilizing secondary structures in glulam frames already delivered to customers. *(RO 2021:01 R4)*
- Inform the property owner of any deficiencies in order to enable the necessary measures. *(RO 2021:01 R5)*

Recommendations made during the ongoing investigation

Before the investigation was completed, the SHK identified possible safety risks with the type of roof design used in Tarfalahallen. The risks were judged to be so serious that an early notification of this to the supervising authority and the Swedish National Board of Housing, Building and Planning was required. The notification was combined with the safety recommendations set out below and was sent to the Swedish National Board of Housing, Building and Planning and Sweden's 290 building committees on 3 July 2020.

The Building Committee or the corresponding municipal board was recommended that within the framework of its supervisory assignment and before the winter of 2020/2021:

- Identify buildings with sub-tensioned glulam trusses, including buildings under construction and such buildings projected in the supervising area.

If such buildings were located in the supervising area:

- Ensure that an assessment of the load-supporting capacity of the roof structure, especially with regard to instability, was carried out on any such buildings.
- Ensure that an inspection was carried out to ensure that the load-supporting structure of the building was constructed in accordance with the construction drawings.
- Ensure that possible failure mechanisms were analysed and that identified problems with instability in the design were remedied.
- Check that property owners and building managers have routines for removing snow from the roofs of identified buildings.

The Swedish National Board of Housing, Building and Planning was recommended to:

- Assist the municipal building committees with general guidance in the above-mentioned supervisory work.
- Appropriately inform about the identified risks with the current type of roof design.

Responses have been received from the Swedish National Board of Housing, Building and Planning and 242 of the building committees (see section 1.15.1).