Collapses and Damage to Swedish Farm Buildings Due to Snow Loads

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Abstract

Many roof constructions of farm buildings collapsed or were damaged in the winters 2009/2010 and 2010/2011 due to high snow loads. The work presented in this paper aimed at analyzing the causes and propose ways to avoid damages in future. Eighty-five damaged farm buildings were studied and 10 of them more thorough analyzed.

It could be concluded that although very heavy snowfalls, snow was not the main cause of the failures, but revealed errors and shortcomings. The main causes of the collapses were poor design, errors made during erection, and insufficient maintenance.

Key words: Farmbuilding, roof, snowload, collapse, damage

1. Introduction

In the winters 2009/2010 and 2010/2011 a large number of roofs collapsed or were damaged in Sweden in connection with heavy snowfalls. Many farm buildings were affected but failures also took place in e.g. stores, schools, sport halls and warehouses.

For a farm building outside detailed development plan areas in Sweden, the building owner is exempt from a building permit and from duty of notification to the authorities but still has the responsibility for the design and construction. It is the same technical rules that apply regardless of whether the measure needs a building permit/notification or not. The European construction standards (Eurocodes) and the national application of them (EKS, 2011) are to be followed when calculating load capacity, stability, and durability.

The main objectives of the investigation were to analyze the causes of occurred damages to farm buildings and to propose ways of how to avoid damages in future.

2. Materials and Methods

During the two winters information of 232 damaged buildings was included in a national database (Johansson et al., 2011). Eighty-five of these were related to farm buildings. Information concerning these damaged farm buildings was compiled regarding geographical place, age, construction, erection, utilization, weather conditions etc. The work consisted of analyzing and compiling reports of occurred damages. These reports were put together by consultants, loss adjusters at insurance companies etc. Additionally, 10 of the damaged objects were chosen for more thorough analyses in order to clarify preconditions and causes. These analyses included visits and personal interviews with the affected house-owners.

3. Results

During the winters in question the insurance companies in total got about 3000 reports concerning various types of roof damages in Sweden. It was estimated that about 60% were

related to farm structures. Consequently this means that about 2000 farm buildings related to or of agricultural origin were affected. Included in this figure are also depreciated buildings and structures that have only been intended for temporary use but have been left behind and included in the insured building stock.

Nothing could be found indicating that the number of collapses or damages would have been lower if building permit or building notification regarding farm buildings had been required. E.g. in Denmark where farm buildings also require building permits a great number of collapses and damages also occurred due to snow loads during the winters in question. Additionally, in Sweden also a large number of building permit duty buildings were affected by damages due to snow loads.

In most cases no immediate danger for injuries to man had occurred. However, in some cases animals were killed as a direct or indirect consequence of damage.

The majority of the damaged buildings had been built in the 1970s or later. About 85% of the cases reported had a wooden structural framework and about 80% of these were constructions with trusses (often with nail plate joints). Around 15% of the cases had a steel structural framework.

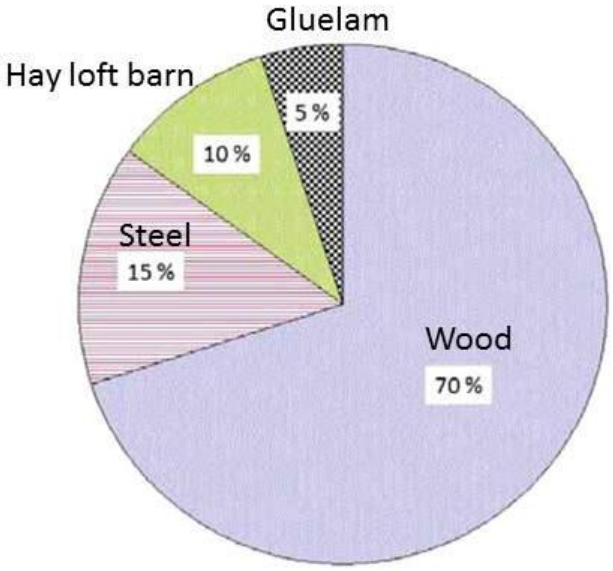

FIGURE 1. Material in the structural element of the analyzed farm buildings (58 of 63 objects).

FIGURE 2. Unsymmetrical roof snow load due to prevailing wind from the left side in the picture when snowing, resulting in collapse.

About 50% of the damaged buildings had been built with own labour and organization (entirely by the farmer or divided contracts) and the other 50% using general or all-in contract. In several cases constructional calculations were defective or non-existent.

Normative ground snow quantities were only very occasionally exceeded. However, for many objects it could be verified that unsymmetrical snow load had occurred on the roof, mainly due to prevailing, continuous wind in combination with temperature below zero. Also snow pockets in the roof valley between attached houses could be shown to have resulted in damages. Unsymmetrical snow load had also occurred when the snow had not been well thought-out shoveled away from the roofs.

FIGURE 3. Left: Roof collapse caused by high snow load in the roof valley. Right: Collapsed roof of a riding arena due to undersized 3-hinge frame structure. The frame was dimensioned for too low snow load (wrong snow zone).

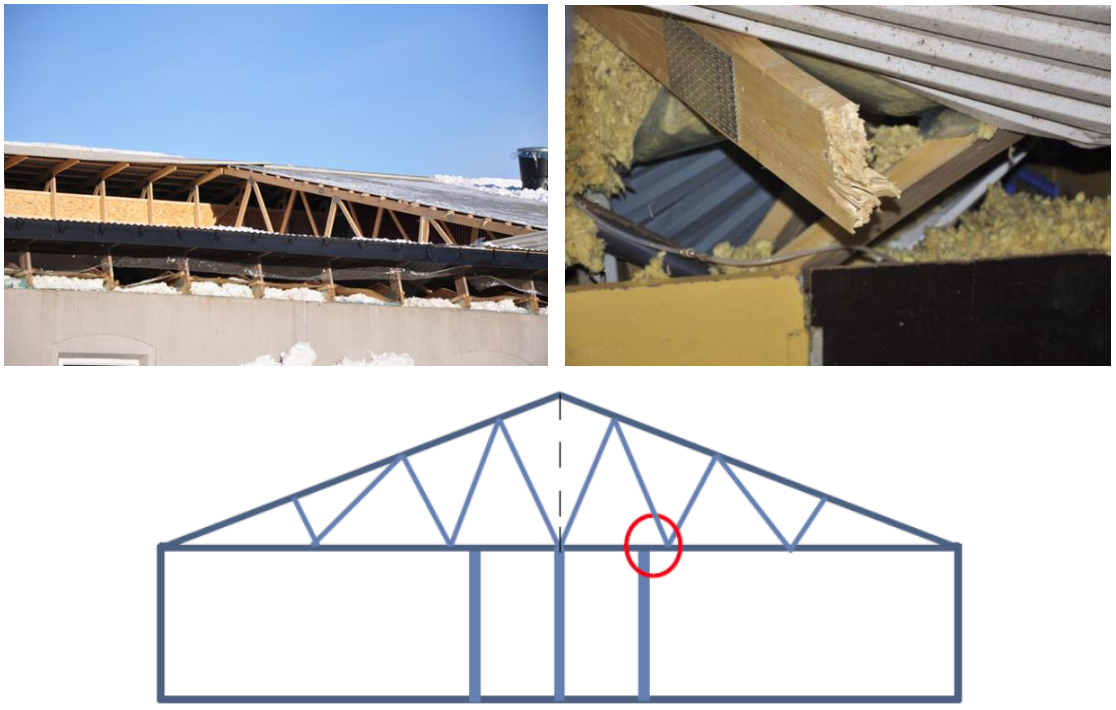

FIGURE 4. When exposed to high snow load the ceiling joists of the W-trusses deflected downwards so much that they unintentionally were supported by a non-loadcarrying interior wall. This resulted in bending ruptures in the ceiling joists.

FIGURE 5. Insufficient braced compressed diagonals of W-trusses. Progressive collapses of the trusses has also been initiated.

Additionally, lack of maintenance e.g. leaking roofs resulting in decay or corrosion could be shown to be, at least contributing, grounds for damages.

FIGURE 6. Insufficient ventilation of the livestock house has made the roof ridges become rotten resulting in decreased strength. Extreme snow load revealed the bad conditions.

It was also obvious that many farmers who are building did not realize or had not acquired knowledge of the responsibilities resting on them as a building employer according to the Building Regulations.

4. Conclusions

It can be concluded that although very heavy snowfalls, snow was not the main cause of the failures, but revealed errors and shortcomings. The main causes of the collapses were poor design and errors made during erection.

A need to change and complete roof snow coefficient should be investigated. The effects of roof size, geometric design and local lee giving structures probably have to be refined.

When the building or part of it is imported or bought from places with other climatic conditions it is important to make sure that correct snow load is assumed. Future research and development work related to the agricultural building process is of importance.

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