

Failures in large-span roof structures in Switzerland

René Steiger

PhD, Civil Engineer
Empa ¹⁾
Dübendorf, Switzerland
rene.steiger@empa.ch

Andrin Herwig

PhD, Civil Engineer
Empa ¹⁾
Dübendorf, Switzerland
andrin.herwig@empa.ch

Robert Widmann

Civil Engineer
Empa ¹⁾
Dübendorf, Switzerland
robert.widmann@empa.ch

Gabor Piskoty

PhD, Mechanical Engineer
Empa ²⁾
Dübendorf, Switzerland
gabor.piskoty@empa.ch

¹⁾ Structural Engineering Research Laboratory

²⁾ Mechanical Systems Engineering

Summary

The present paper describes collapses and failures of three large-span roof structures in Switzerland:

In February 2009 the steel roof of a three years old gym in eastern Switzerland collapsed. Based on visual findings and on a detailed investigation it could be found that the cause of the collapse was a deficient detailing in each of the seven 26 m long, simply supported main steel plate girders. The collapse was triggered by increasing snow load although at the day of collapse the load was 25% lower than the characteristic value according to the Swiss design code.

In November 2003 the roof of a timber multi-purpose hall partly collapsed after a period of rain. The investigations showed that the most relevant reason for the collapse was the incorrect execution of welds at the joints of supporting shoes in conjunction with the marginal design of that detail. From other factors that contributed to the collapse an insufficient drainage system of the roof could be identified as having played an important role.

In 2011 a 180 x 1120 mm² glued-laminated timber beam with a span of 18 m being part of the secondary structural system supporting the flat roof of a DIY superstore near Zurich failed in bending. The failure had been triggered to a considerable extent due to overloading of parts of the roof by a gravel layer compared to other parts of the roof being of higher depth and specific weight.

From all three incidents it could be concluded that a closer orientation of the design to available design codes and a strict quality control during design, execution and use of the building would have reduced the probability of collapse / failure of the roof structures considerably.

Keywords: welded steel plate girder, web buckling, glued-laminated timber, flat roof, quality of welds, box girder, stiffener, compression perpendicular to the wood grain, roof drainage

1. Introduction

This paper describes investigations performed by the Swiss Federal Laboratory for Materials Science and Technology, Empa, on recent collapses or failures of large-span roof structures in Switzerland, namely a 1300 m² gym the steel roof structure of which totally collapsed, a multi-purpose hall suffering from partial collapse of the roof supported by wooden box girders and a superstore that had to be closed immediately due to a failure of a glued-laminated timber beam.

On site and laboratory investigation methods for identifying the causes of the collapses are presented and conclusions with respect to mistakes in design or construction and to future avoidance of similar collapses or failures are drawn.