

Failure Analysis of a Total Damage by Hail Impact of an External Thermal Insulation Composite Systems

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1 Introduction

On August 1st, 2017 a heavy thunderstorm accompanied by hail passed the region of Winterthur, Eastern Switzerland. The façade of a family house was heavily damaged. Because the damage was unexpected, a case study has been initiated with the idea that the façade, which was 17 years old, may have lost its hail resistance due to ageing. During the course of the study, additional factors have been considered as well, such as the thickness of the render and the amount of reinforcement. Observations stated hailstones of as large as 32 mm. This hailstorm was not an exceptional weather event; such a hailstorm has to be expected once in 5 to 20 years in this region. According to CFIA standards (ACFI, 2020), the façade should have survived this event undamaged. The façade was of a classical ETICS design on a brick wall. A detailed visual inspection showed 147 locations where the rendering was damaged. They were classified in three categories: cracks, full circle fracture and breakout of the render with uncovering of the reinforcement, s. Fig. 1. 71 locations showed a crack, 51 a full circle fracture and 21 locations a breakout. Analysis of material probes show, that the rendering was a typical high strength mineral render for thin layer application containing a glass fiber mesh as reinforcement. The measurement of the layers show a thickness of only 1.5 mm of the base coat whereas Swiss standards demand at thickness between 2 mm and 7 mm: Though the rendering was not carried out in accordance with the state of the art.

The hail resistance of the façade was determined onsite as well as on large specimens in the laboratory, according to CFIA guidelines (ACFI, 2020). First, the façade was bombarded with clear ice balls with a launcher, see Fig. 2. This test equipment allows to provoking damages by a controllable impact. The shot with the lowest kinetic energy for a damage was a 30 mm ice ball with 2.5 J. It resulted in a dent and a full circle fracture in the façade similar to the damage introduced by the natural hail. When the façade was bombarded with 40 mm ice balls and with an energy beyond 10.0 J also breakout of the render was observed. Second, two reference specimens representing the rendering with reinforcement built up on the thermal isolation plate were fabricated. Both specimen had two sections: The first section was fabricated with a base coat of only 1.5 mm thickness, representing the façade under investigation. The second section

was fabricated according to SIA standard, e.g. with a base coat thickness of approx. 4 mm. Hail tests were carried out in the laboratory. Both specimens were bombarded with ice balls in order to reproduce the damage caused by the bombardment on the façade and to determine the threshold values for a crack, a full circle fracture and breakouts.



Figure 1. Representations of the damage classes: crack (left), full circle fracture (center) and breakout (right).



Figure 2. On-site determination of the hail resistance with an ice ball launcher

The damage to the façade by the natural hail event of August 1st 2017 could be reproduced by bombardments with ice balls of 30 mm and a kinetic energy of at least 2.5 J. An effect of ageing is weakly recognizable, both for full circle fractures and for breakouts: Both threshold values decrease with age, but only by approx. 15%. However, the tests in the laboratory did not show a thickness effect. Such an effect might be present in mineral rendering, in the aged condition, but not when it is new.

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References

ACFI. (2020). Hagelregister. Retrieved from <https://www.hagelregister.ch/>