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Comment on nhess-2022-93

Anonymous Referee #1

Referee comment on "Back analysis of a building collapse under snow and rain loads in Mediterranean area" by Isabelle Ousset et al., Nat. Hazards Earth Syst. Sci. Discuss., https://doi.org/10.5194/nhess-2022-93-RC1, 2022

The article describes the collapse of a large hall with a flat roof in southern France after heavy snowfall turned into rain. The analysis of such cases is very valuable on the one hand to check the design snow loads and on the other hand to identify structural weak points of a structure. The study was carefully prepared, but unfortunately no quantitative data was available on important input parameters such as the amount of snow load at the time of the damage or the condition of the structure before its collapse. Therefore, the main statements of the article are somewhat speculative. In order to finally answer the question what was the exact cause of the collapse of the building, the collapsed structure would have to be investigated in more detail (e.g. material technology tests). In several building collapses, such as the ice rink in Bad Reichenhall, material deficiencies were partly responsible.

The beginning of chapter 1 Introduction has only a small relation to the main content of the article. Dynamic effects of gravitational natural hazards on a building have completely different consequences than static effects such as snow load. I recommend making only a reference to snow loads in the introduction.

The collapse of the building would need to be described in a bit more detail:

- Time of the collapse?
- Weather at the time of the collapse: wind effects?
- Snow depth and snow distribution on the roof? Equal amount of snow on the ground as on the roof?
- Overview sketch with details of damage to the structure?
- Were there any eyewitnesses?

The building and the supporting structure would also need to be described in a more precise way:

- is it a spatial supporting structure (Fig. 7a only shows the truss construction of the supporting structure; Figs. 8 and 11 do not allow to see the necessary details of the truss.)?
- Roof pitch according to plan (line 145: nearly flat; line 151: about 1%; Fig. 9: less than 1%? What is the correct slope?)
- Drainage of the roof: location and number of outlets – along the edge of the roof? Were there emergency outlets for the water?
- Steel properties of the various structural elements - was only S235 used?
- Further, when analyzing a building collapse, comment on the loading history (e.g. max. snow loads since construction, line 329: 42 cm on 22 Jan 1992) and any adjustments made to the building (e.g. alterations to the structure).

The assumed snow depths and snow densities appear to be somewhat speculative:

- According to Fig. 4, Montpellier is in the zone with 20 to 30 cm of snow. However, in the following, a snow depth of 30 to 35 cm is used for the analysis: a justification is missing.
- The assumed new snow density of 250 to 350 kg/m3 seems too high. I would expect a maximum of 250 kg/m3. It would be interesting if the snow depth and density could be quantified with measurements.
- The SAFRAN simulation with a SWE of 35 mm seems plausible.
- The consequences of rain on the snowpack should be discussed in much more detail. A 30 cm layer of snow is unlikely to retain 50 to 60 mm of rain. Typically, snow is saturated with about 15% water. The rain that cannot be stored runs off on the roof surface. The assumed "wet" snow density of 600 kg/m3 seems to be too high.

The calculated bearing capacity of the supporting structure seems to be rather high:

- At best, e.g. stability analyses (buckling) of the columns or the tubular truss elements could provide further insights.
- In the damage analysis of a large flat roof after a rain on snow event with questionable drainage, the assumed uniform load distribution is rather simplified. The important question is, where was the water, which could not be absorbed by the snow cover, before the collapse? The roof was sloped, I assume that a large part of the water flowed to the edge of the roof. The maximum water load would therefore be along the edge of the roof. This can be simulated with an additional load case with a trapezoidal load distribution (minimum snow/rain load roof center and maximum snow/rain load roof edge).
- The snow load can cause a sag in the middle of the roof, which may be greater than the overheight due to the roof pitch of less than 1°. This would result in the water not

absorbed by the snow cover flowing to the center of the roof. This could also be studied with a load case with trapezoidal load distribution (maximum snow/rain load in the center of the roof, minimum snow/rain load at the edge of the roof).

Section 4.3 is not directly related to the damage analysis presented and is somewhat speculative. Measurements of the temporal development of snow loads in the Mediterranean region are practically non-existent. I recommend to omit this chapter. Instead, to give further hints on how such rain on snow events can be better managed on a flat roof (slope of roof? arrangement of drainage? emergency outlets?). Further, it would be helpful to indicate what information would be useful for a more complete damage analysis in future (e.g. photos immediately after damage? Snow depth measurements? Snow load measurements? ...).

Further comments:

Line 42/43: deficient building, better: insufficient material strength?

Line 53: Determining the ultimate bearing capacity of a building is similar to or more difficult than determining the possible snow load.

Line 56: What is the AROME numerical model?

Line 64: What changes are expected about the characteristic snow loads…. not clear what is the meaning.

Lines 79 – 95: Add precipitation data.

Lines 97: Why is the rain-on-snow event exceptional? Return period of event?

Fig. 4: add the location of the collapsed structure

Line 129: Explain why 30 – 35 cm were chosen (see Fig. 4: 20-30 cm). Give some reference values for new snow density: 250-350 kg/m3 seems to be too high.

Line 134: The rain on snow event should be discussed in more detail. How much water can the snowpack absorb? What can be the density of a wet snowpack?

Fig. 5: How was snowfall measured? Where is the meteo station Lavalette?

Line 145: (nearly) flat – the slope of the roof is in a rain-on-snow event very decisive. What means nearly? 1°? 3°?

Line 154: The drainage system should be explained in detail.

Line 157: central part of the structure: where is that? Indicate the location on a Fig. e.g. 11; The western and eastern facades were "heavily" (not hardly) damaged.

Line 161/162: was there an element that was clearly the weakest?

Tab. 1: Steel quality of the different structural members?

Line 178: "dead" weight

Line 204: better snow load not snow pressure

Tab. 3: Better snow load instead of pressure value

Line 208-209: …by construction the applied pressures. Difficult to understand.

Line 232: snow load on the ground was estimably 30-35 cm – how was the snow load on the roof? Was a shape factor of 0.8 applied? Was there wind during the snow fall event which reduced the snow height on the roof?

Line 255: difficult to understand: the highest height scenario…

Line 278: which were the detected structural weaknesses?

Line 285: “a maximum range of span to be on the safe side”…difficult to understand: If the planned geometry of a building is taken into account in the design of the load-bearing structure, a structural failure should not occur. In connection with the drainage, the roof pitch and the sags in the service state would need to be checked.

Line 334: Is there some evidence that the drainage openings were blocked by ice? With temperatures around 6° C might be hardly the case?