Response to Anonymous Referee #1

We would like to thank the reviewer for taking the time to review our manuscript and for the constructive feedback, which will help improve its quality. Below, we list each comment verbatim, give our response, and describe how we address it in the revised manuscript.

General comments

The presented manuscript introduces a new approach determining the influence of granular flows on mast-like structures. It addresses an important question in the structural designing process: How high does an avalanche run up and what pressure acts on a structure? The concept of separating run up height from the hight of relevant pressure is described and well justified. Although simplifications were necessary, these are stated on the one hand and, on the other hand, the results demonstrate an improvement over existing approaches. Relating to this only Swiss guidelines are referenced, while a similar approach is also defined in a recently published Austrian standard (OENORM B 4801). Including this standard could further emphasize the importance of the topic.

- We thank the referee for pointing this out.

  The assumption that run-up height defines the vertical extent of the design pressure is indeed not a Swiss particularity but occurs in guidelines across the Alpine countries. We include ÖNORM B 4801 alongside the other references where this is introduced to further emphasize the broad relevance.

Specific comments

1. Title: The authors could reconsider the title of the publication to clearly indicate that their results are based on numerical simulations.
    - We agree that the numerical basis of the work should be unmistakable.

      We change the title to: “Distinguishing run-up height from pressure distribution during avalanche impact on narrow obstacles: mechanisms and semi-empirical prediction from three-dimensional simulations”.
2. Line 16: In this sentence the authors define snow avalanches as natural granular flows. In my opinion granular flows are conceptual models that provide an approximaton to nature.
    - We agree; the granular-flow description is a modeling idealization rather than a true analogy.

      In the revised manuscript, the opening sentence refers to gravitational mass movements, and the granular-flow concept is explicitly mentioned as an idealized analogy at its first use.
3. Line 110; 391: How was the value of 25kPa choosen?
    - The reference pressure is a normalization constant, and its choice affects only how compressibility is labeled, not the results. For a given hardening parameter, Eq. (A2) maps monotonically onto a density-increase factor, so a different reference pressure would re-scale the numerical values of the parameter but leave the one-to-one

correspondence with the hardening parameter, and therefore every result and fit, unchanged. Within that freedom, 25 kPa was selected for three reasons: (i) consistency with our previous study (Kohler et al., 2026), which uses the same reference; (ii) it lies above the initial pre-consolidation pressure of 10 kPa, so the parameter characterizes plastic compaction rather than the elastic response; and (iii) it is low enough that the softest hardening parameter considered does not yield an unrealistically large density increase. We add this justification to Appendix A1, which we move to supplementary material in the revised manuscript.

4. Line 118: What is meant by "...sufficiently large to minimize boundary effects and adjusted based on the compressibility"? It would be helpful to clarify the underlying assumptions.
    - The numerical setup is identical to our previous study (Kohler et al., 2026), where the sensitivity of the results to the domain width was tested directly. Side wall effects were assessed through a sensitivity analysis on the total force. Compressibility had a principal effect on the setup width required to minimize side wall effects. Thus, the required setup width grows with the hardening parameter, which is why the width is prescribed through the relation given in the caption of Fig. 2. In the revised manuscript, we state this rationale briefly.
5. Figure 3(a): It would be helpful to explain the pronounced drop of the upper envelope of FR=5 at t/tmax = 0.55.
    - In the revised manuscript, we add a brief explanation to the caption.

      The drop is an artifact of the run-up sampling rather than a physical event. Run-up height is defined as the maximum vertical position of the material points within the centered 1.5 m-wide strip upstream of the obstacle (Fig. 2). At high velocity, material is ejected upward and follows a largely ballistic trajectory; when the highest such particle leaves the sampling strip, the maximum falls discontinuously to the next-highest particle inside the strip. In this context, we note that this is precisely the reason why our analysis is based on steady-state means rather than on instantaneous extremes.

Technical comments

1. Some full stops are missing at the end of figure captions.
    - We correct this in the revised manuscript throughout.
2. Parts of the text in figure A1 is hard to read ("2.5 dx"). Adding a halo or outline around the text could improve readability.
    - In the revised manuscript, we add a halo to the annotation.
3. Figure 8: Since lambda is mentioned before zeta in the text (Line 293), the panels a and b could be swapped for consistency.
    - We agree that the inconsistency should be resolved.

      The panel order follows the order in which the two coefficients are introduced in the derivation, with the quasi-static magnification factor defined in Eq. (8) and the dissipation factor in Eq. (10). Swapping the panels would put the figure at odds with the equations. In the revised manuscript, we therefore reverse the order of the two coefficients in the sentence so that text, equations, and figure are consistent.

4. Line 340-341: Please check sentence structure
    - We agree that the sentence is long and cluttered. In the revised manuscript, we rewrite the sentence and split it into two.
5. Figure A2/A4: The variable phi is presented in different styles to Figure 1. A uniform notation is recommended.
    - In the revised manuscript, we regenerate the appendix figures using the notation of the main text.

References

Austrian Standards International: ÖNORM B 4801: Technischer Lawinenschutz – Einwirkungen, Bemessung und Instandhaltung, Austrian Standards International, Vienna, 134 pp., 2024.

Kohler, M. J., Gaume, J., Ancey, C., and Sovilla, B.: 3D Numerical Modeling of Compressible and Cohesive Granular Flow Impact on Narrow Obstacles, Computational Particle Mechanics, 13, 79–96, https://doi.org/10.1016/j.cpms.2025.11.005, 2026.