

# ***Interactive comment on “Influence of extreme long-term rainfall and unsaturated soil properties on triggering of a landslide – a case study” by Håkon Heyerdahl***

## **Anonymous Referee #2**

Received and published: 12 January 2018

This manuscript describes the investigation and interpretation of a natural slope failure in eastern Norway.

The quality of English is good and the figures are clear. The content of the manuscript fits within the NHESS scope and is a topic of interest to an international audience.

The purpose and the aims of the paper are unclear to me and need to be more clearly defined. The manuscript describes the problem quite holistically. There are details of laboratory investigations, in situ observations and also modelling to back-analyse the failure. However, none of these aspects of the investigation are fully developed.

If the purpose of this paper is to outline different methods for slope stability interpreta-

tion, then I do not believe that this has been achieved. The methods used (laboratory and numerical modelling) are mainly routine and the novelty of the approaches is not demonstrated. Nor is there a particularly critical evaluation of their success or appropriateness when considering slopes in Norwegian soils.

If the purpose of the paper is to document and describe a case study for the academic community then I believe that further details of the site are required. Many of the details of the field investigation and many of the laboratory testing results are not included and instead the reader is directed to references. This suggests that much of the information that would constitute a case study is already published. The modelling aspects of the manuscript are not described in detail. As a reader I am not sure what the modelling proves or what new insight it provides into understanding slope failures in Norwegian soils.

The aims of the manuscript need to be more clearly outlined. I can see that the purpose is to 'fill in some gaps when it comes to unsaturated soil behaviour for Norwegian soils'. This needs to be clarified and more specific. The results also need to more clearly demonstrate this. At present, I believe that the manuscript is trying to cover many aspects of the case study and therefore presents a large number of different analyses and investigations but doesn't develop any new methods or interpretations. Nor does it provide enough detail for others to learn from, explore or build on the work. For example, I wonder if the slope stability analysis could be omitted.

I did not find a clear set of conclusions which relate directly to the described investigations. Nor did they give new insights into slope failures in Norway. I believe that there needs to be a clearer link between the aims, methods, results and conclusions presented in the manuscript. I have listed my comments relating to each of the conclusions below:

1) "Unsaturated shear tests. . .shear strength" [lines 5-10 on page 14]: The laboratory results are compared with prediction models. This sections states what happened and

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how they compare (useful for the results section) but nothing is concluded. What does this show and why? 2) “Numerical seepage. . . compared to normal ground-water conditions” [ lines 12-15 on page 14]: The fact that rainfall can lead to elevated groundwater levels is a well-documented result and didn’t require a numerical model to demonstrate this. Also, the model doesn’t definitively prove that this was the cause of the landslide in 2000. What new behaviour did the unsaturated analysis show that wouldn’t have been apparent in a saturated analysis? 3) “However, to reach critical slope stability. . . destabilize the slope” [lines 15-18 on page 14]: I’m not clear what this section is concluding. Please re-phrase to clarify. 4) “During the last decade. . . rainfall intensities and durations” [ lines 19-23 on page 14]: This seems like new information or summary/introductory information. It doesn’t seem like a conclusion and I don’t think that the work (as it is presented) indicates that an understanding of unsaturated soil properties will be increasingly important. This could be true, but I don’ think that it is demonstrated in the current text.

In its current format and with the current focus, I believe that this manuscript should be rejected. This could be a useful and informative case study, but more detail and a clearer focus is required.

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