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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Significance of substrate soil moisture content for rockfall hazard assessment" *by* Louise M. Vick et al.

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We would like to thank Mr Mark Eggers for such a detailed and critical review of the manuscript. The suggested changes have increased the scientific standard of the manuscript greatly- it was especially helpful to follow the track changes. We have accepted most of the suggested changes to the text, and responded to the key points raised that require a more detailed response:

1.Why were the samples taken from this location on the other side of the hill ie the reader will want to know why the samples and testing wasn't done at Rapaki Bay. A sentence saying something like this would help: "Unfortunately no sub-surface investigations could be undertaken at Rapaki Bay. As such testing was carried out on

samples taken on similar soil types from a site investigation that was underway at the time of the study", or something like that. Were the samples/testing undertaken specifically for this study or were they part of a separate study (ie Chris White's thesis?). If part of another study and you are using the results you should state this and give a reference? By the way, if the Ramahana Rd and Centaurus Park sample sites are closer to the bottom of the hillslope where more colluvial soil content could be expected compared with Rapaki Bay/Mt Vernon (more upper to mid-slope??) could the grainsize distribution/clay content be different? Just trying to judge how relevant the Ramahana Rd and Centaurus Park test results are to the study sites on the other side of the hill.

Response: This amendment to the text has been added. Yes the soil sample locations were closer to the bottom of the hillslope, however we think that the range of clay contents within the samples shows the changes in mechanical behaviour depending on the clay content, and therefore reflects a range of different actual soil types. This is explain in the text (page 5, line 3-4): Samples were taken from a range of soil profile depths (Table 2), and as such reflect a range of clay and natural moisture content and therefore mechanical properties.

2.It would be useful to know where these 14 samples were taken relative to Rapaki Bay; so the reader can judge their relevance to helping make assumptions about NMC at Rapaki Bay at the time of the earthquake/rock fall event eg do the samples come from SE facing slopes as well? On a slope or on flat ground etc etc

Response: The samples were taken from the northern side of the hills (Lucas Lane, Maffeys Road, Redcliffs, Deans Head, Clifton Hill, Richmond Hill, Wakefield Avenue). This has been added to the text page 5 lines 13-14. Although it would be more ideal to have data from the southern aspect of the hills, as this is the only data that exists from the time period we have to make do.

3. I have a bit of an issue with use of the word 'dry' in this context. This applies throughout the paper. Dry to most people means no water or free from any moisture.

While no natural moisture contents (NMC) were tested at Rapaki Bay you have relied on the testing by Carey et al 2014 on samples taken during a similar time of year and similar monthly rainfalls. This testing shows NMC's were low but likely not totally without moisture (3-11% NMC from the Carey et al testing)? Perhaps when 'dry' is first used in the main text some context can be provided (see comment in last paragraph of intro below)?

Response: We agree with the comment, and in this context dry is used as an over-simplification of a sliding scale of behaviours. An amendment to the text has been added in the introduction, lines 11-12 page 2: In this paper the term 'dry' is used to indicate a soil with low natural moisture content, typically well below the plastic limit.

We have added typical atterberg limits of the soil at the end of page 3, start of page 4.

4.Think about two new figures showing the topo/slope morphology of each site eg hillshade maps of the lidar data as used as base maps in Figs 5 and 6 but without the other stuff over the top and with ground surface contours added.

Response: done, these are now figure 2.

5.You should probably elaborate on the test method used for the direct shear testing especially the procedures used for preparation and testing the samples. Given the samples were disturbed the testing must have been on remoulded material. So how was the material placed into the shear box/ring shear, in particular, how much compaction, any pre-shearing ie to simulate residual strengths given the sample is disturbed/remoulded etc etc. An issue with this testing is that the internal structure/fabric of the soil will be lost due to the disturbance. Given the importance of the internal structure of loess in-situ/undisturbed with regard to it's strength properties, does testing on disturbed samples give a realistic estimate of the shear strength changes with moisture content? I suggest you add a short discussion on the limitations of testing the shear strength of loess using disturbed, remoulded samples.

Response: The text has been added/rearranged to read as follows (page 5-6): Testing was in accordance with ISO/TS 17892-10:2004 Direct shear tests and NZS 4402:1996 Test 2.1 Determination of the water content. Samples selected displayed a spread of both clay contents (Table 1; 5-19%) and natural moisture contents below, near, and above their 16-19% plastic limit (Table 1; 8-22%). The samples were reconsolidated by means of tamping, using the Standard Procter test within the shear-box test sample rings. Twenty-five blows from the hammer were used to compact the soil directly into the shear-box test sample ring, and the method repeated with a fresh sample if the blows from the hammer caused the soil to be compacted to below or >5 mm above the height of the sample ring. The method was considered satisfactory, however there was an unavoidable amount of variation in the density of the samples: the dry density varied between 1658-1954 kg/m3, with an average of 1750 kg/m3. This variation can be attributed to the variable moisture contents of the soils that were compacted, which would have allowed greater or lesser compaction depending on the optimum moisture content for compaction, and the soil's particle-size distribution. The samples were subjected to 20kg, 50kg, and 100kg applied weight (corresponding to 26, 64 and 126 kPa normal stress and overburden depths of 1.45 m, 3.64 m, and 7.28 m respectively with consideration of the average sample density (1750 kg/m3)), and sheared at a constant rate.

The discussion (page 10 lines 13-20) has also been edited to read the following: The method of linking direct shear test results with soil performance under boulder impact is limiting, as the method of compacting disturbed soil during shear testing means that the internal structure of the soil is lost due to the remoulding. The strength values are therefore not wholly representative of in-situ conditions and greater accuracy in the strength properties of the loess would be achieved by performing similar tests on undisturbed samples. Furthermore, representing soil conditions as only either dry or wet is a crude representation of actual conditions. Realistically the mechanics of soil behaviour will change continually with incremental increases in moisture content, and we recommend this contribution is further developed to explore the effect a range of moisture

conditions will have on rockfall runout. In the future rockfall model parameterisation should be fine-tuned to a range of soil properties.

6.Any further details about the sampling? Where on the site/slope were the samples taken eg next to impact scars? How were the samples collected (small hand dug pit or hand auger?), what depth (especially relative to the depth of the impact scars) etc etc

Response: The text has been edited (page 6, lines 10-12) to read: Thirteen soil samples were taken at the time of the experiments and analysed according to NZS 4402:1996 Test 2.1 Determination of the water content to obtain the natural moisture content. Samples were collected as 30 cm tube samples from the base of 13 impact scars equally distributed down the slope.

7.Some simple graphs would really help here with understanding the soil test results eg plot the Mt Vernon NMC results against the testing by Carey et al which will help illustrate the differences between the two datasets. Secondly could plot the monthly rainfall data comparing the Dec-Feb 2013, 2014 data when the Caery et al samples were taken against the Dec 2010-Feb 2011 data when the earthquake/rock fall event occurred. If you do the plots then you can change the text discussing the compare-and-contrast without having to quote strings of numbers.

Response: These have been added as Figure 3a and b.

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