

Interactive comment on “Development of fragility curves for railway ballast and embankment scour due to overtopping flood flow” by R. Tsubaki et al.

Anonymous Referee #1

Received and published: 23 June 2016

Comments to the Authors:

In this paper, fragility curves for railway ballast and embankment scour are developed based on two different real-life examples. The topic is interesting, however, I cannot say the paper is clear and well written. In fact, in many cases sentences are not clear and the same terminology changes in each section thus undermining the readability of the paper. I found very difficult to follow the methodology section. In particular, I have many doubts about the method used to estimate the fragility curve which doesn't not consider geometrical and geotechnical characteristics of the systems and it is looks strongly based on the specific case study considered in this paper. Considering the importance of a proper estimation of the overtopping water depth in case of fragility curve, a detailed description of the hydrological and hydraulic model and flood events, which is extremely poor in this manuscript, has to be provided for both cases study. I

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cannot recommend the manuscript for publication in NHESD in the present form. To help the authors to improve their manuscript, I have provided a set of comments and suggestions.

Introduction:

- Line 73: Piping it is not only sensitive to the height of the embankment but also to its width. In fact, narrow embankments are more prone to failure than large ones;
- I found the review of fragility curve method very short and sloppy. The Authors should provide more references referred to the embankment breach due to overtopping;

Cases study:

- In figure 2.a the Authors referred to “Ballast breach”. Is there any difference between Ballast breach and scour? I would suggest to write “Ballast scour” since a breach is referred mainly to the embankment itself;
- Line 118: change “causing” with “caused”;
- Line 118: change the text in “Asa River including section M (see Figure 3) in the basin, caused.”
- Line 121 “A hydrological model”. No detail about such hydrological model is reported. The Authors have to describe the type of hydrological model they are using. In fact, since the method used to estimate the fragility curve is based on the overtopping water depth, an appropriate description of the hydrological model is fundamental in order to understand the uncertainty behind the water depth estimation. In addition, is the maximum flow rate related to the boundary condition or the river itself (hydraulic model)?
- Line 122: It is not clear to me if the value of 811m³/s comes from the model or from a personal communication. How the inflow value of 110m³/s was estimated?
- Lines 123-125 are not clear, and I do not understand how this information can add more value to the estimation of the fragility curve;
- Line 142: Which type of hydrologic and hydraulic analyses?

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- Replace Bounrady with Boundary in Figure 3;

Methods:

- Line 150: the Authors referred either to surcharge and overtopping water depth. Please homogenize the terminology within the manuscript;
- Lines 155-158 are not clear, rephrase;
- One of my main concern is related to the method used to estimate the fragility curve. In line 177 the Authors mentioned that damage level is expresses as overtopping water depth. Does this means that for each recorded damage, the corresponding overtopping water depth generating such damage was also available? In hydrology/hydraulic damage is expressed as the consequence of water level on the floodplain area while in this study it is related to the specific damage on ballast and/or embankment. How the observed damage probability was assessed?
- The proposed method is based on observed damages values obtained from the two cases study. Such study is interesting but I believe that the Authors have to propose a general method to estimate fragility curve also in case of no damage observations. Such approach should use physically-based equation (as equation 9 of this manuscript) related to the scour processes in case of overtopping. In addition, the geometrical and geotechnical characteristics of the system (roughness of the embankment, type of ballast, embankment cover quality, etc.) are key factors in the fragility curve estimation;
- Lines 180-189: the estimation of the damage level is fundamental in this study to estimate the fragility curves. The Authors has to provide additional information about the damage level and in particular on the approach used to assess such damage;
- Line 191: Estimation of the overtopping water stage. No indication about the hydrologic model is provided. How the upstream boundary conditions of the hydraulic model are estimated?
- Line 211: Asa River was always described as first one while now is Sayo River the first. Please, invert the description putting first Asa and then Sayo river in order to be

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consistent within the paper;

- Line 219: $n=0.02$. How the Authors estimated this value? Was it compared to literature values? Model calibration is an essential step in order to reduce model uncertainty and it has to be properly addressed in this manuscript;
- Line 221: Again, which type of hydrological model was used? Hydraulic model results are influenced by the upstream boundary conditions and a detailed description of the hydrological model used in this study has to be provided;
- Line 224: is this precipitation or direct runoff? Please explain;
- Line 232: Also in this case, the value of the manning coefficient has to be properly motivated;
- Line 240: from where it comes the recorded inundation area? Remote sensing observation or in-situ measurements?
- Line 252-254: where are these 2 locations in figure 3? What do the Author mean with presence of vortices over the floodplain?
- Line 263: this section should be called 3.3.3 and not (c);
- Lines 271-279: I do not think this is the reason of the uncertain results. Instead, the reason might be connect to the inappropriate calibration of the hydrological and hydraulic model. Please provide more information about such models and their parameter estimation;

Results:

- Line 282: is H the head loss (as reported in line 206)?
- Line 289-290: How the Authors defined damage? It is still not clear to me how the Authors estimated the damage from water level. I think this is an important point that is unclear within the all manuscript.
- Line 295: Are these numbers of samples related to both case studies? Please specify and describe the calibration and validation samples in the case study or method description;
- Line 296: Is embankment fill scour indicating a probability equal to 1? Is this case

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related to the embankment breach? What is the difference between embankment scour damage and embankment fill scour?

- Lines 302-304: I think it would be nice to show this comparison;
- Lines 304-306: The Authors has to explain why fragility curve for ballast scour has a larger mean and smaller standard deviation. Is this because ballast scour is more sensitive to water depth overtopping and a small variation of it might significantly increase the probability of damage?
- Figure 8: In figure 7 the observed samples used to assess the fragility curve are reported while this is not the case of figure 8. However, in line 319 the Authors mentioned that a limited number of samples (7) of ballast damage was used. I suggest to add a figure similar of figure 7 in case of ballast damage;

Discussion:

- Line 328: Why in case of only ballast scour such experimental bound (critical flow rate) does not corresponds to the initial rise? I would expect both curves starting at the same point to then have different gradient and achieve higher probability of damage for short water depth in case of only ballast scour;
- Line 338: I am confused. The upper limit (double line) indicates already a probability of damage of about 0.8-0.9 while the authors mentioned that no-damage was observed. Please, clarify this sentence providing additional information;
- Line 370-371: are the “actual damage records” the same used to assess the fragility curve? Is this a new sample? As I stated in my previous recommendation, please specify and describe both calibration and validation samples in the case study or method description;
- Line 372: how such distribution was assessed as most feasible? According to what? Please provide details motivating this sentence
- Line 373: Is this a probability of damage or failure? The previous fragility curves were estimated based on observed damage and they do not relate the water depth to the probability of failure. If so, provide additional details and try to clarify this aspect in the

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manuscript;

- Figure 10 refers to probability of damage while in the text is probability of failure, be consistent with the term across the whole manuscript;
- Line 375: Does damage curve mean fragility curve? Why it is lumped? Please explain
- Lines 374-375: This sentence it is not clear, please rephrase;
- Lines 376-377: I do not agree with Author comment. It can be seen that higher damage probability is located in the area where ballast failure occurred while just few points has high damage where embankment failure occurred. Which fragility curve was used? The log-normal for ballast and embankment scour?
- Line 405: The Authors are mixing the concept of hazard with damage, be consistent across the paper;
- Line 406: it is not clear to me how uncertainty in hazard level can be accounted using fragility curves. The explanation in lines 405-407 it is not clear, provide more details;

Conclusion:

- Line 424: What do you mean with “type of curve”? Probability distribution?
- Line 426: What do you mean with “the least serious type of damage investigate”? Please rephrase;

Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., doi:10.5194/nhess-2016-167, 2016.

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