Modification Notes

nhess-2023-136
Title: Optimization strategy for flexible barrier structures: Investigation and back analysis of a rockfall disaster case in southwestern China
Author(s): Li-Ru Luo et al.
MS type: Research article
Special issue: Natural hazards' impact on natural and built heritage and infrastructure in urban and rural zones

Dear editor and reviewers,

We appreciate the time and effort you and reviewers expended in providing valuable feedback on our work. We considered and addressed all the suggestions. The following is a point-by-point response to the comments, and all changes has been marked in the revised manuscript.

Sincerely,

Zhi-Xiang Yu
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2024-1-5

- **Response to CC1:**

1. Revise the caption of Figure 5. For example: (c) Details of column head; (d) Failure of column base at the mid-span; (e) Failure of column base at the edge bay

Response： We have revised the caption of Figure 5.

2. The notes under Table 1 "The content of this table …". No full title of the reference required. Please follow the standard reference format.

Response： We have modified this sentence to "The content of this table adopts the coding structure required by JT/T 1328-2020, 2020."

3. Revise the caption of Figure 7: Rock mobility analysis

Response： We have revised the caption of Figure 7.

4. "4.2 Results and Comparison" should be "4.2 Results and Discussion".

Response： We have modified this caption.

5. "4.2.3 Energy consumption pathways are optimized" should be "4.2.3 Optimization of energy consumption pathways".

Response： We have modified this caption.

- **No modifications proposed in CC2 and RC1**

- **Response to RC2:**

1. Line 52: please specify what you mean with damage characteristics.

Response： We have modified this sentence to "A series of field investigations were conducted to recognize the trajectories of the rockfalls and gather information on the rockfalls and flexible barrier damage."

2. Line 74: the sentence "This paper provides …" is not clear, please rephrase;

Response： We have modified this sentence to "This paper provides a detailed investigation and analysis of one of the three disaster sites where the intercepted rockfalls were still inside the protection system, so that more information can be gathered at that site. (Figs. 1b & 4)."

3. Line 81: Bentley 2021: the year is different from the reference. Please correct one of it;

Response： We have modified “Bentley 2021” to “Bentley 2023”.

4. Line 158: Please rephrase the sentence “… rockfall was simulate to “,. “… rockfall was used to “.

Response： We have modified this sentence.

5. Line 161: What do you mean “were in line with”?

Response： We have modified this sentence to “the slope characteristic parameters employed in this study refer to Hu et al. (2018)”

6. Line 168: what do you mean with “10,000 computation cycles”? Do you refer to 10,000 block movement was simulated?

Response： We have modified this sentence to “The number of rocks to throw was 10000 in this simulation.”

7. Line 504: Yu et al. (2019a) is in the reference list but the authors did not cite in the manuscript. Please remove it.

Response： We have remove it.

8. In general in the text the acronyms are note specified please add a figure or a table specifying the meaning of them, otherwise some figures and some text portion are not understandable. Furthermore, it is need a table to specify the model parameter values used in the numerical simulations.

Response： Tow figures and an appendix of abbreviations have been added in order to enhance the understandable of the acronyms and symbols. Furthermore, Table 3 has been updated to show the parameter values used in the numerical simulations.

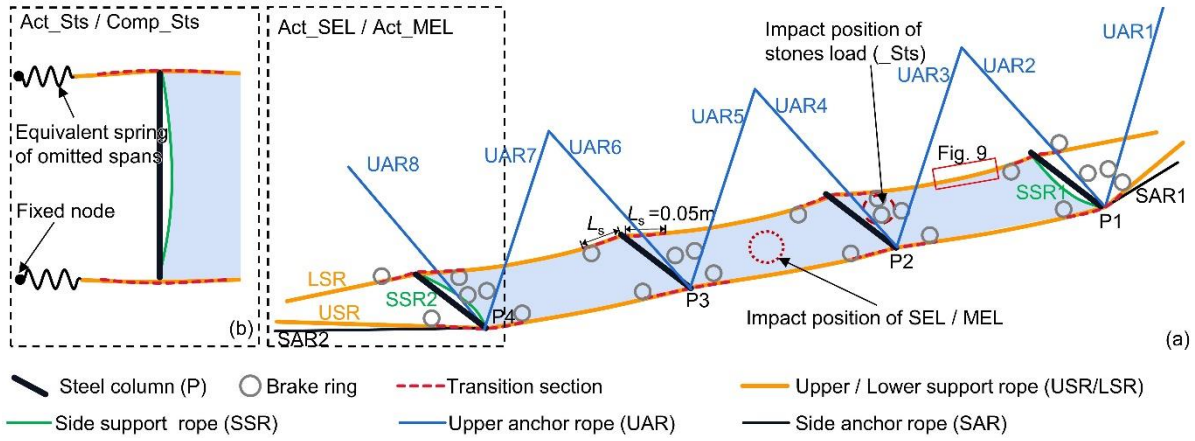

Figure 1: Structure representation of the actual model (Act_) and the comparative analysis model (Comp_). (a) Act_SEL and Act_MEL. (b) Act_Sts and Comp_Sts.

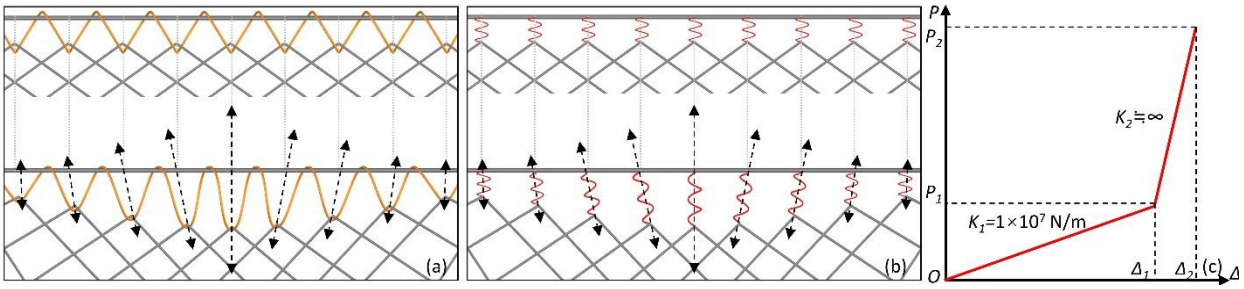

Figure 2: Spring equivalent model for winding rope. (a) Before and after winding rope deformation. (b) Before and after spring equal model deformation. (c) Bilinear constitutive model of the winding rope spring.

Appendix: Abbreviations

_MEL: Maximum Energy Level load

_SEL: Service Energy Level load

_Sts: 4 stones load

Act_: actual structure in survey case

Comp_: structure of the comparative analysis

EDD: Energy Dissipating Device

FE: Finite Element

HN: narrow flange H-beam

LSR: Lower Support Rope

Opt_: optimized structure

P: pillar, steel column

PPS: Passive Protection System

S: span, the barrier unit between two columns is one span

SAR: Side Anchor Rope

SSR: Side Support Rope

UAV: Unmanned Aerial Vehicle

USR: Upper Support Rope

Table 3: Summary of parameters used in the numerical simulations

Items *Material *Section	**Material parameter [units]**	**Values**	**Reference**
Steel wire rope &	Mass density [kg/m^3]	7900	(Yu et al., 2021)
Steel wire rope net	Young's modulus [MPa]	1.5×10^5	
*071_CABLE_DISCRETE_BEAM			
* BEAM discrete beam			
Steel column	Mass density [kg/m^3]	7900	(Zhi et al., 2018)
*024_PIECEWISE_LINEAR_PLASTICITY_2D	Young's modulus [MPa]	2.06×10^5	
* SHELL	Poisson's ratio	0.3	
	Yield stress [MPa]	235	
	Tangent modulus [MPa]	600	
	Strain rate parameter, C&P	5000 & 1.2	
Column base	Mass density [kg/m^3]	7900	(Zhi et al., 2018)
*024_PIECEWISE_LINEAR_PLASTICITY	Young's modulus [MPa]	2.06×10^5	
* SOLID	Poisson's ratio	0.3	
	Yield stress [MPa]	235	
	Tangent modulus [MPa]	600	
	Strain rate parameter, C&P	5000 & 1.2	
Rockfall	Mass density [kg/m^3]	2500	(Yu et al., 2021)
*020_RIGID	Young's modulus [MPa]	3.0×10^4	
* SOLID	Poisson's ratio	0.2	

- **Response to editor:**

1. The paper lacks a discussion part. For this discussion I propose to discuss which are the particularities of the mountain range in this study and where could be therefore the conclusions of the study be generalised. For example, is it applicable to the European Alps?

Response： In “4.2 Results and discussion”, we have compared and analyzed the dynamic response of the flexible barrier before and after optimization from three aspects, which emphasize the importance of the

component connection relationship on the actual project performance of the protection system. And we have added the following at the end of this section: The results show that, without changing the specification of the components, only modifying the connection relationship of the components can significantly improve the performance of the flexible barrier, such as the internal force curve of the components tends to be smoothed, the percentage of energy consumption of the brake rings rises, and the stability of the components is enhanced. Therefore, the correct connection relationship of the components is very important during field installation and is a key factor in the full realization of the system's large deformation. Although this should have been a consensus in this field, this paper is the first to analyse a disaster site by reappearing the impact process and quantify it. This is of non-negligible engineering significance for mountainous regions where flexible barrier is in great demand, such as the Alpine region in Europe, south-central Africa, Central Asia, and western America.

- **Other modifications:**

1. Line3: Change in author order. Because Li-Jun Zhang did a lot of work during the manuscript revision process, all authors unanimously agreed that Li-Jun Zhang could be the third author of this paper. The new order of authorship is: Li-Ru Luo, Zhi-Xiang Yu (corresponding author), Li-Jun Zhang, Qi Wang, Lin-Xu Liao, Li Peng.

2. Line18: “The calculation results indicate that the optimized model’s performance in terms of complete protection is three times better than the actual project’s.” have been modified to “The calculation results indicate that the optimized model’s impact resistance is three times better than the actual project.”

3. Line25: Typos correction, “defense” corrected to “defence”. There are many other similar revisions which have been highlighted in the manuscript and will not be listed here.

4. Line45: Citation format corrections, “Among them, (Yu et al., 2019b) and (Zhao et al., 2016) particularly studied…” corrected to “Among them, Yu et al. (2019) and Zhao et al. (2016) particularly studied…”.

5. Line51: Expressive polish, “A flexible rockfall barrier was damaged…” modified to “This paper presents that a flexible rockfall barrier was damaged…”.

6. Line78: Expressive polish, “Tape measure, vernier caliper, and a standard scale with 1-millimeter and 0.1-millimeter precision were used for measuring.” modified to “A 1-millimeter standard scale tape measure and a 0.1-millimeter standard scale Vernier scale were used for measuring.”

7. Line119: Expressive polish, “… brake rings were used to connect the upper anchor rope…” modified to “brake rings were connected to the upper anchor rope”.

8. Line122: Expressive polish, “Steel wire rope net was woven by winding ropes to the support ropes and hooking to the end of the column.” Modified to “Steel wire rope net was woven by winding ropes to the support ropes, and was hooked to the end of the column.”

9. Line 149: Expressive polish, “The impact energy of rockfalls on the system is estimated to be minimal because the brake rings lack an evident working phenomenon, the wire rope connecting it is unbroken, and the steel wire rope net is intact.” modified to “The impact energy of rockfalls on the system was estimated to be a low value because the brake rings lacked an evident working phenomenon, the wire ropes connected with the brake rings was unbroken, and the steel wire rope net was intact.”

10. Line157: Spelling correction, “coefficient of normal restitution (Rn), coefficient of tangential restitution (Rt),” revised to “coefficient of normal restitution (R_n), coefficient of tangential restitution (R_t),”
Similar corrections also appear in **Table 2 \ Line 175 \ Line 211 \Line 272 \Table 4 \Line 331 \ Line 353-355 \Table 6**, and these amendments will not be enumerated.

11. Line167: Revision of the caption of Figure 6, “Figure 6: Damage phenomena of the flexible barrier. (a) The damaged two-span structure; (b) Column P2; (c) Column P3; (d) The connection relationship between the brake ring and the support rope and the steel wire rope net.” revised to “Figure 6: Damage phenomena of the flexible barrier. (a) The damaged two-span structure; (b)Failure of column P2; (c) Non-working brake rings on both sides of the column P3 end; (d) Connection relationship between the brake ring and the support rope and the steel wire rope net.”

12. Line227: Expressive polish, “The connection damage in Act_Sts was corrected, and the same impact condition calculation as in Act_Sts—noted as the control model Ctrl_Sts—was carried out to determine the primary source of the damage to this protection structure.” modified to “A comparative model (Comp_Sts), where the connection damage in Act_Sts was corrected, and the same impact condition calculation as in Act_Sts, was carried out to determine the primary source of the damage to this protection structure.”

13. Caption revision. “4 Optimization and comparison” revised to “4 Structural optimizations”, “5 Summary and conclusions” revised to “5 Conclusions”

14. All figures have been replaced with higher quality versions