

Technical Notes

Impact Force of Boulders Conveyed in Debris Flows on Bridge Piers and Collision Protection Measures

Quancai Wang¹, Jian Chen^{1,2*}, Hao Wang³, Qunli Zhang⁴

¹Key laboratory of Mountain Hazards and Earth Surface Process, Chinese Academy of Sciences, Chengdu, China; Institute of Mountain Hazards and Environment, Chinese Academy of Sciences, Chengdu, China

²University of Chinese Academy of Sciences, Beijing, China

³School of Civil Engineering and Architecture, Henan University, Kaifeng, China

⁴School of Water Resources and Environmental Engineering, East China University of Technology, Nanchang, China

Abstract: It is quite common in highway engineering that building a bridge across a debris flow gully to prevent roadbed from damage by strike of debris flows. As bridges are designed with the purpose to protect their piers against debris flows, it is crucially important for engineers to determine the magnitude of the Impact Force Exerted by Boulders Transported (IFEBT) in rush torrents. In view of the theory of energy conservation, a formula is introduced in this paper to calculate the IFEBT with appreciable improvement compared to the commonly used equations, in which only the two types of structures (cantilever and simply supported) are taken into account in modelling. The Thornton elastoplastic contact criterion is included in the formula in consideration of buffer effect of two-phase debris flow on bridge piers and dynamic responses of bridge upper-structure. Comparisons on calculation accuracy are elaborately made between our improved formula and previous methods in a case study of Den Jigou Bridge. It is found that according to our proposed method the values of IFEBT obtained in circumstances of varied velocity and boulders sizes are lower than the ones calculated by previous methods. Providing the depth of debris flow body in the two-phase condition is up to 2.4 cm, there is a considerable decrease of 21% in the value of IFEBT. In the meantime, a decrease of 1.4% in the IFEBT value is attained in consideration of the inertia force of the bridge's upper-structure. In addition, it is feasible to dissipate impact energy of IFEBT when low elasticity modulus and high decrement material are used in practical engineering.

Keywords: debris flow, impact force, boulders transport, bridge pier, energy dissipation

1 Introduction

There are numerous occurrences in mountainous areas of Southwestern China that bridges are ruined or seriously damaged at piers by boulders transported by debris flows. The debris flow occurred in Suo Tong gully along Sichuan-Tibet highway in 1991 is a typical example, during which bridge piers at the eastern side of the gully

were completely destroyed, and the upper section of the bridge at a height of ten meters above the gully floor were broken (Pan et al 2009). Another tragic incident occurred on July 9, 1981, in Li Ziyida Gully in Guo Luo County, Sichuan Province, where sediments were discharged out of the gully mouth in a volume of $8.4 \times 10^5 \text{ m}^3$ and the bridge piers were cut utterly by tremendous boulders riding on the crest of waves of debris

* Corresponding Author: Jian Chen, email: chenjiancug@163.com, Tel: +86 185 8386 0089

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