中国岩石力学与工程学会

Chinese Society for Rock Mechanics and Engineering (CSRME)

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Nomination of the ISRM Science Achievement Award

Jianping Zuo obtained his B.S from Central South University in 1999, and M.S and Ph.D. from China University of Mining and Technology (Beijing) in 2003 and 2006. He currently is a professor of Engineering Mechanics at the China University of Mining and Technology (Beijing) where he is Head of School of Mechanics and Civil Engineering. He has been involved in rock mechanics and mining engineering research, consulting and teaching for more than 20 years. Prof. Zuo's major research interests are micro/meso failure mechanics of rocks and its application in coal mining engineering. He is the author or co-author of more than 130 peer review scientific papers and 20 conference papers. Total citation is 1632, H index is 20 and i10 index is 50 (Google scholar). He has received 15 patents, and 10 Natural Science and Technology Progress Awards. He is in charge of and/or participates in 12 scientific research projects, funded by National Natural Science Foundation of China, National Basic Research Program of China (973 Program), Beijing Major Scientific and Technological Achievements into Ground Cultivation Project, the 111 Project and Coal Mines Corporations.

One of the great contributions made by Prof. Zuo is to provide a basis and derivation of the Hoek-Brown criterion for intact rock using a fundamental, mechanically rigorous, fracture mechanics approach, which proves that the Hoek-Brown constant m_i is not just a curve fitting parameter, but has physical meanings and can be derived from micro-mechanics principles.

It is known that the failure in brittle materials, such as concretes and rocks, always generate from micro-cracks in the intact materials. In rocks, these micro-cracks or flaws

are usually inter-granular cracks or grain boundaries and tensile cracks that propagate from their tips when frictional sliding occurs along the flaws. Based on the Griffith failure criterion, Hoek and Brown (1980) proposed an empirical equation to fit a wide range of triaxial tests on intact rocks, and then it was extended to rock masses by introducing geological strength index and blasting damage factor. Currently, the Hoek-Brown failure criterion is one of the most broadly adopted failure criteria to estimate rock mass strength in rock mechanics and mining engineering. Over the past 40 years, the HB criterion has been applied successfully to a wide range of intact and fractured rock types. The Hoek-Brown failure contains two intact rock properties, namely, the uniaxial compressive strength (UCS) of the intact rock σ_{ci} and the HB constant m_i. In general, m_i is considered as a curve-fitting parameter for getting the HB failure envelope.

Prof. Zuo and his co-authors adopted 2D (Zuo et al. 2008) and 3D (Zuo et al. 2015) crack models to theoretically derive the Hoek-Brown rock failure criterion. Based on micro-failure phenomena of brittle rock-like material, linear elastic fracture mechanics and mathematical analysis, Prof. Zuo proposed a failure characteristic factor, which is a product of a micro-failure orientation angle (characterizing the density and orientation of damaged micro-cracks) and the changing rate of the angle with respect to the major principal stress (characterizing the microscopic stability of damaged cracks) to relate the evolution of microscopic damaged-crack characteristics to macro-failure. He demonstrated that this failure characteristic factor mathematically leads to the empirical Hoek-Brown rock failure criterion. Based on our theoretical development, Prof. Zuo also presented a clear interpretation of the brittleness and ductility of rock on the micro scale. A quantitative relationship between the brittle ductile transition point and confining pressure was derived and shown to be consistent with experimental observations.

The work has been done by Prof. Zuo were widely cited by researchers in rock mechanics, which includes Evert Hoek and Ted Brown who proposed the Hoek-Brown failure criterion. Currently, there are 91 citations of these two papers as shown in Google scholar.

Hoek and Martin (2014), Hoek and Brown(2019) noted that the work done by Zuo et al. (2008) examined the growth of micro cracks in rock-like materials on the basis of fracture

mechanics considerations, they pointed out that the substitution of $m_i=\mu\sigma_c/\kappa\sigma_t$ their failure criterion leads to the Hoek-Brown criterion for intact rock, which demonstrates that the constant m_i is not simply an empirical constant but that it has real physical meaning。

Brown (2015) also noted that the paper by Zuo et al. (2015) is one of a great many that have appeared in the rock mechanics literature over the past 25-30 years dealing with the Hoek-Brown empirical strength criterion for rocks and rock masses. Zuo's paper is one of the best and most valuable of those papers. The work has been done by Prof. Zuo shows how the Hoek-Brown criterion for intact rock material may be derived from first principles using micro-mechanics principles. Zuo's work also makes a significant contribution to the understanding of the brittle-ductile transition concept, which shows that the confining pressure, at which internal micro-failure processes are completely constrained and the brittle-ductile transition is triggered. It is also shown that the value of the ratio σ_c/σ_t influences the value of the confining pressure at the brittle-ductile transition.

Represented Publications

Jianping Zuo, Huihai Liu, Hongtao Li. A theoretical derivation of the Hoek-Brown failure criterion for rock materials. Journal of Rock Mechanics and Geotechnical Engineering, 2015, 7(4): 361-366 (Google Scholar Citation 37)

Jianping Zuo, Hong-tao Li, He-ping Xie, Yang Ju, Su-ping Peng. A nonlinear strength criterion for rocklike materials based on fracture mechanics. International Journal of Rock Mechanics and Mining Sciences, 2008, 45(4): 594-5991 (Google Scholar Citation 54)

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Hoek E, Martin CD. Fracture initiation and propagation in intact rock-A review. Journal of Rock Mechanics and Geotechnical Engineering, 2014, 6 (4): 287-300

Zuo J, Li H, Xie H, Ju Y, Peng S. A nonlinear strength criterion for rocklike materials based on fracture mechanics. International Journal of Rock Mechanics and Mining Sciences, 2008, 45(4): 594-5991.

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