俞 缙1，2，3，宋博学1，2，钱七虎3*

(1. 华侨大学 岩土工程研究所，福建 厦门 361021；2. 中国科学院武汉岩土力学研究所 岩土力学与工程国家重点实验室，湖北 武汉 430071；3. 中国人民解放军理工大学 工程兵工程学院，江苏 南京 210007)

STUDY OF PROPAGATION OF P-WAVES IN DUAL NONLINEAR ELASTIC ROCK MEDIUM WITH ONE SET OF JOINTS

YU Jin1，2，3，SONG Boxue1，2，QIAN Qihu3*

(1. Geotechnical Engineering Institute，Huaqiao University，Xiamen，Fujian 361021，China；2. State Key Laboratory of Geomechanics and Geotechnical Engineering，Institute of Rock and Soil Mechanics，Chinese Academy of Sciences，Wuhan，Hubei 430071，China；3. Engineering Institute of Engineering Corps，PLA University of Science and Technology，Nanjing，Jiangsu 210007，China)

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摘要 为研究含单组节理的双重非线性弹性岩石介质中的P波传播规律，在空间域内设置许多间距极小、刚度极大的假节理。对特定节理位置赋予节理非线性变形BB模型，结合非线性波传播的特征线方程，得到一维P波传过含单组不同条数节理的双重非线性弹性岩石介质时透射波的时域半数值解。编写有限差分程序，利用已有计算实例对程序进行验证，并通过计算模拟作进一步参数研究。详细讨论P波参数、节理力学参数、节理条数、节理间距和岩石非线性系数对透射波首波与后续波波形、首波透射系数、首波与后续波能量的影响。研究结果表明，随着传播距离的增大，大振幅且低频的P波波形发生畸变；小振幅且低频的P波对岩石的非线性作用不敏感。节理间距和岩石非线性系数对首波透射系数、首波能量和后续波能量产生不同程度的影响。振幅较小、频率较高的P波传过条数较多的单组节理时，节理表现出明显的滤波和分解能量的作用。

关键词： 岩石力学 数值分析 单组节理 双重非线性弹性岩石介质 P波 节理非线性变形

Abstract： In order to study the transmission law of P-wave across the dual nonlinear elastic rock medium with one set of joints，numbers of imaginary joints with small spacing and large stiffness were set in spatial domain. The nonlinear deformation BB model of rock joint was applied to certain joint location. Combined with the characteristics line equation of nonlinear wave，the time-domain numerical solution of transmitted wave from one-dimensional P-wave across rock with various numbers of joints was obtained. The computational program with finite difference method was developed. Then，the program was validated by using previous computation result；and the parameters were further discussed through simulation. The relationships between the parameters of P-wave and joints，joint number，joint spacing，the nonlinear coefficient of rock and waveforms of the first wave and the follow-up wave，transmission coefficient of the first wave，energies of the first wave and the follow-up wave were investigated. The study results show that when the transmission distance increases，P-waveforms distortion with larger amplitude and lower frequency occurs，while P-waves with small amplitude and low frequency are not sensitive to the nonlinear interaction of rock. Transmission coefficient of the first wave，energies of the first wave and the follow-up wave are influenced by joint spacing and nonlinearity coefficient of rock. When P-waves with small amplitude and high frequency cross the large number of joints，the joints showed the role of high frequency filtering and energy decomposition.

Keywords： rock mechanics numerical analysis one set of joints dual nonlinear elastic rock medium P-wave nonlinear deformation of joint

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