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远场地震波辐射能计算以及对近断层地面运动的约束

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The calculation of far-field radiated seismic energy and constraint on near-field ground motion

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摘要 从圆盘断层模型出发,根据地震波能量表象定理推导出了滑移弱化过程中远场S-波辐射能量表达式,并同已有的动力学模型作了比较.结果表明,得到的模型能量值或视应力的取值强烈地依赖于断层上的动态、静态应力降和破裂传播速度,而破裂速度则对应了断层带模型中断层破坏过程所耗散的能量.动摩擦应力上调和应力下调力学机制在能量求解中得到了充分考虑,弥补了D-模型和M-模型的不足.结合近断层滑移所作的功或应变能的释放,得到了近场能量辐射的一般表达式,并讨论了其物理意义以及对近断层强地面运动预测的潜在意义.采用近场地震波辐射能量同加权滑移速率的关系,给出了估算近断层质点运动速度的近似解,由此计算了2008年5月12日 M_W7.9中国汶川地震和1999年9月21日的M_S7.6中国台湾集集地震的加权滑移速率,结果同早期Brune模型给出的瞬态解和近断层台站的真实记录相似.需要强调的是,所得能量解可应用于对未来强地面运动预测新的物理约束参数.如果对真实地震远场能量求解达到相当的精度,则对未来强地面运动模拟中包括地震矩、静态和动态应力降在内的物理参数选取就可以给出一个合理的估计.

关键词: 滑移弱化 地震波辐射能 视应力 应力降 加权滑动位移

Abstract: For a circular fault model, we re-derive the mathematical expression for calculating the far-field radiated S-wave energy based on the slip-weakening model. Radiated energy and apparent stress depend on the static and dynamic stress drop, as well as the rupture velocity for Madariaga model; while the rupture velocity corresponds to the dissipated energy in the fault rupture process of fault zone models. Fault frictional overshoot and undershoot mechanisms described by slip-weakening constitutive relation are involved in the consideration of estimate of radiated energy without any assumption. Combined with near-fault work associated with permanent deformation of the medium due to fault slip, we also propose a new technique to restrain the bound of peak ground velocity (PGV) and peak ground acceleration (PGA), respectively. Take 2008 M_W7.9 Wenchuan earthquake and 1999 M_S7.6 Chichi earthquake as examples, with a comparison to the McGarr and Fletcher approach and Brune model, we found that the values of near-fault particle velocities we obtained for these two earthquakes are generally smaller and closer to the values derived from real data. In other words, if the far-field energy solution can reach a considerable accuracy, it would be a straightforward way to constrain the near-fault ground motion or to estimate source parameters including rupture speed, static and dynamic stress drops.

Keywords: Slip-weakening Radiated seismic energy Apparent stress Stress drop Slip-weighted average slip rate

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