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# 地震作用下松散体斜坡崩塌动力学特性离心模型试验研究

杨庆华，姚令侃，任自铭，高召宁

(西南交通大学 土木工程学院，四川 成都 610031)

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摘要　基于拟静力离心模型试验原理，采用砂堆模型离心试验的崩塌性状来概化和模拟地震作用下松散体斜坡崩塌的动力学特性。设计并开展了均匀砂和非均匀砂两类3种不同颗粒级配砂石的离心模型试验，试验中模拟了在V，VI，VII度3种烈度的地震作用下3种级配砂堆的崩塌动力学特性，试验再现松散体斜坡崩塌的破坏规模、形式和机制。进一步对比分析试验结果表明：(1) 粒径为0.5～1 mm的均匀砂在3种烈度的地震作用下崩塌规模均服从准周期分布；(2) 粒径为8～10 mm的均匀砂和非均匀系数f = 3.10的非均匀砂在V度地震烈度作用下崩塌规模服从负幂律分布，呈现自组织临界性特征；(3) 粒径为8～10 mm的均匀砂和非均匀系数f = 3.10的非均匀砂在VI，VII度地震烈度作用下的崩塌规模则服从正态分布。认为粒径为0.5～1 mm的均匀砂在临界状态下大规模崩塌进行相对准确的预测预报是可行的，而粒径为8～10 mm的均匀砂和非均匀系数f = 3.10的非均匀砂在临界状态下，进行相对准确的大规模崩塌预测预报存在很大困难。研究成果能为松散体斜坡的抗震设计提供可靠依据，具有重要的理论和现实意义。

关键词　边坡工程；地震荷载；松散体斜坡；离心模型试验；动力学特性；自组织临界性

分类号



# CENTRIFUGAL MODEL TEST ON DYNAMICAL CHARACTERISTICS OF LANDSLIPS OF LOOSE SLOPE UNDER SEISMIC LOADING

YANG Qinghua，YAO Lingkan，REN Ziming，GAO Zhaoning

(School of Civil Engineering，Southwest Jiaotong University，Chengdu，Sichuan 610031，China)

**Abstract**

Based on the principle of pseudo static loading and centrifugal model tests，the dynamical characteristics of landslips of loose slope under seismic loading are analyzed by means of the landslips of sand-pile models with one slope，which are used as simplification pattern of loose slopes. Firstly，three centrifugal model tests of uniform sand with size distribution of 0.5–1 mm and 8–10 mm and non-uniform sand with a heterogeneous coefficient f = 3.10，are designed. In these centrifugal model tests，the dynamical characteristics of landslips of loose slopes are simulated under seismic loadings with three magnitudes，i.e. V，VI and VII. The test results show：(1) landslips of uniform sand with size 0.5–1 mm obey quasi-cyclical distribution under seismic loadings with magnitudes V，VI and VII；(2) landslips of uniform sand with size 8–10 mm and nonuniform sand with f = 3.10 obey negative power distribution law under seismic loading with magnitude V，displaying self-organized criticality(SOC)；and (3)

landslips of uniform sand with size 8–10 mm and nonuniform sand with f = 3.10 show normal distribution under seismic loading with magnitudes VI and VII. As for the three dynamical characteristics，it is indicated that the landslips of uniform sand with size 0.5–1 mm under seismic loading with magnitudes V，VI and VII are predicted；but the landslips of uniform sand with size 8–10 mm and nonuniform sand with f = 3.10 under the three earthquake magnitudes can not be accurately forecasted. The research conclusions can offer some favorable references to aseismic design of loose slopes.

**Key words** slope engineering；seismic load；loose slope；centrifugal model test；dynamical characteristics；self-organized criticality(SOC)

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