

Postprint: Landslide-Controlling Mechanism of Structural Planes in Red Beds Landslides Based on Physical Model Tests

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Abstract

The Neogene red beds widely distributed in the Loess Plateau region of China constitute typical disaster-prone strata for large-scale landslides due to their complex structural characteristics and pronounced water sensitivity. As the most representative and extensively studied disaster type in this region, research on the catastrophic mechanisms of red bed landslides has become a frontier scientific issue requiring urgent breakthrough in engineering geology. Various types of structural planes are ubiquitously developed within red beds. These geological interfaces, with diverse origins, scales, and morphologies, represent products formed during prolonged geological history through the combined effects of original deposition and subsequent modification. The presence of structural planes, on the one hand, induces discontinuity, heterogeneity, and anisotropy in rock and soil masses; on the other hand, they constitute preferential pathways for material and energy exchange between slopes and the external environment, thereby becoming controlling factors influencing red bed slope stability. Taking this as the entry point, this study investigated the influence effects and mechanisms of landslide-controlling structures on red bed landslides through physical model tests under three different structural plane combination conditions. The results demonstrate that under experimental conditions, the hydraulic response and failure modes of red bed slopes exhibit significant variations with changing structural plane conditions. Vertical joints, acting as preferential seepage conduits, accelerate rainfall infiltration, resulting in earlier responses of volumetric water content and pore water pressure within the slope; with progressive development of vertical joints, the slope failure mode transitions from shallow-seated failure to deep-seated failure. Bedding structural planes in red beds exert significant control over landslide kinematic characteristics; compared with interlayer contact surfaces, the presence of weak interlayers substantially increases the movement velocity and sliding distance of the sliding mass. Variations in slope failure extent and deformation characteristics induced by structural differences

further modify the spatiotemporal distribution patterns of volumetric water content and pore water pressure. The synergistic effects between different types of structural planes and water-rock interaction dominate the formation of distinct failure modes, with pore water pressure and seepage force playing pivotal roles in the slope failure process.

Full Text

Preamble

Insight into Failure Mechanisms of Red Bed Landslides Controlled by Structural Planes: Physical Model Tests

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Abstract

The Neogene red beds widely distributed across China's Loess Plateau represent typical strata prone to large-scale landslides due to their complex structural characteristics and pronounced water sensitivity. As the most representative and widely concerned disaster type in this region, red bed landslides have emerged as a frontier scientific issue in engineering geology that urgently requires breakthrough research on their failure mechanisms.

Various types of structural planes are ubiquitously developed within red beds. These geological interfaces, formed through comprehensive processes of original deposition and subsequent modification over long geological history, exhibit diverse origins, scales, and morphologies. The presence of these structural planes not only leads to discontinuity, heterogeneity, and anisotropy of the rock-soil mass, but also constitutes preferential pathways for material and energy exchange between the slope and external environment, thus becoming a controlling factor affecting red bed slope stability.

This study investigates the influence effects and mechanisms of structural planes controlling red bed landslides through physical model tests under three different structural plane combination conditions. The results indicate that under experimental conditions, the hydraulic response and failure modes of red bed slopes show significant variations with different structural plane conditions. Vertical joints, acting as preferential seepage channels, accelerate rainfall infiltration, leading to earlier responses in volumetric water content and pore water pressure within the slope. With the development of vertical joints, the slope failure mode transitions from shallow to deep-seated failure. Bedding-parallel structural planes in red beds exert significant control over landslide kinematic

characteristics. Compared to interlayer contact surfaces, the presence of weak interlayers substantially increases the sliding velocity and travel distance of the sliding mass. Changes in slope failure extent and deformation characteristics caused by structural differences further alter the spatiotemporal distribution patterns of volumetric water content and pore water pressure. The synergistic effects between different types of structural planes and water-rock interactions dominate the formation of different failure modes, with pore water pressure and seepage forces playing critical roles in the slope failure process.

Keywords: red beds; landslide; stiffness; model test; structural plane; mechanism

Note: Figure translations are in progress. See original paper for figures.

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