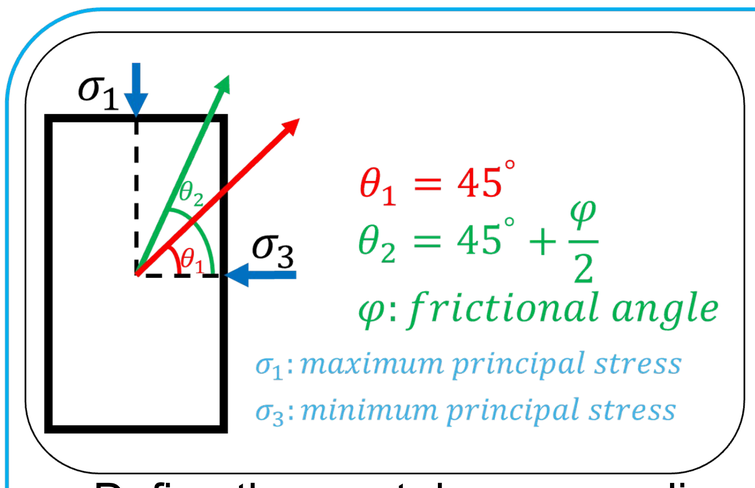
Numerical Investigation of Three-Dimensional Effects in Slope Stability

斜面安定性における三次元効果の数値的検討

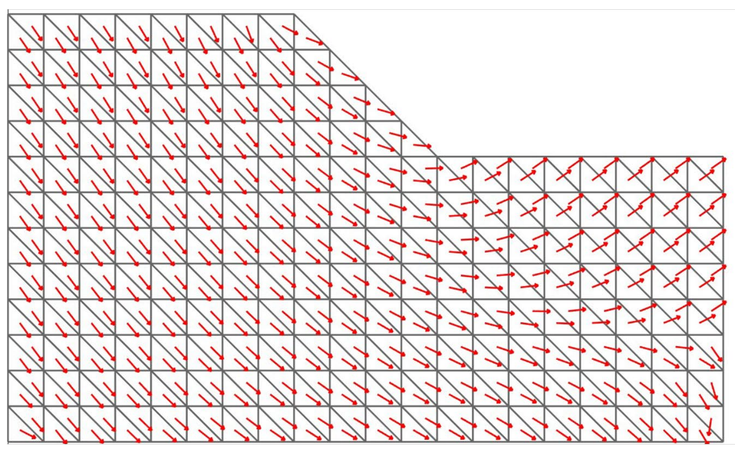
斜面の三次元的特性は、斜面崩壊の一因としてしばしば指摘されている。しかしながら、従来の二次元解析や、破壊面形状を事前に仮定する三次元分析手法では、斜面の三次元効果を適切に評価することは困難である。本研究では、斜面内の土要素が破壊に至る際の「最も危険な滑動方向」に基づき、形状の仮定を要しない破壊面を生成する手法を提案する。さらに、同一の二次元断面を有する複数の三次元斜面モデルに本手法を適用し、斜面の三次元ジオメトリーが破壊面に及ぼす影響を分析した。

The three-dimensional effects of slopes are often regarded as a contributing factor to slope failures. However, conventional 2D analyses and 3D methods that require prior assumptions about the failure surface shape have difficulty capturing such 3D effects. This study proposes a method to generate slope failure surfaces without any shape assumptions, based on the most dangerous slip directions observed at the point of failure in soil elements. The method is applied to various 3D slope models with identical 2D cross-sections to investigate how 3D slope geometry influences the resulting failure surface shape.

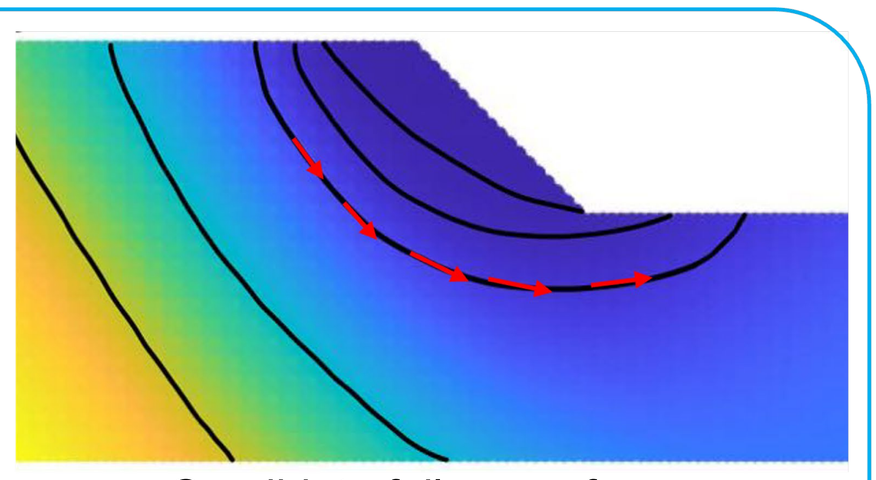
Methodology



Define the most dangerous slip direction vector



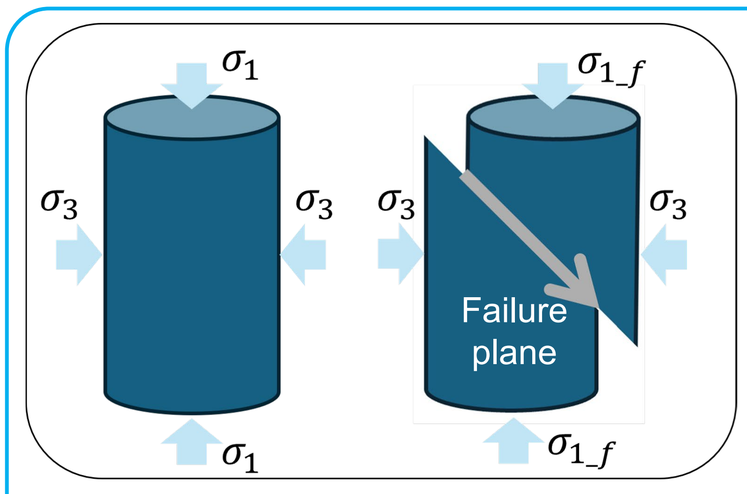
Vector field in the slope



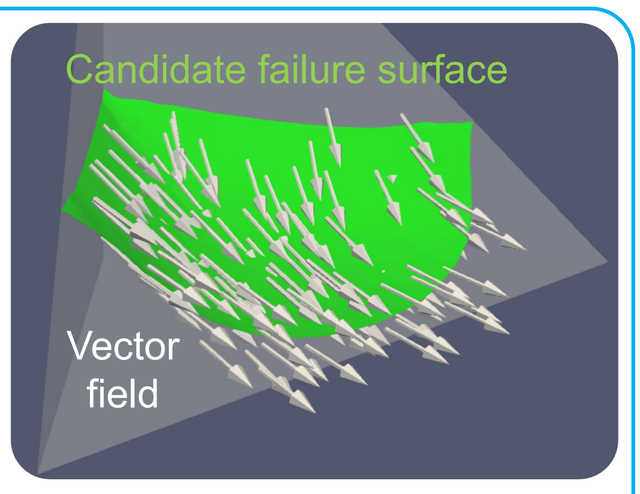
Candidate failure surfaces tangential to the vector field

The most dangerous slip direction is defined based on the related factors like material properties. Based the resulting vector field, surfaces whose tangential directions align with the vector field are generated. This allows for the generation of candidate failure surfaces without assuming their shape in advance.

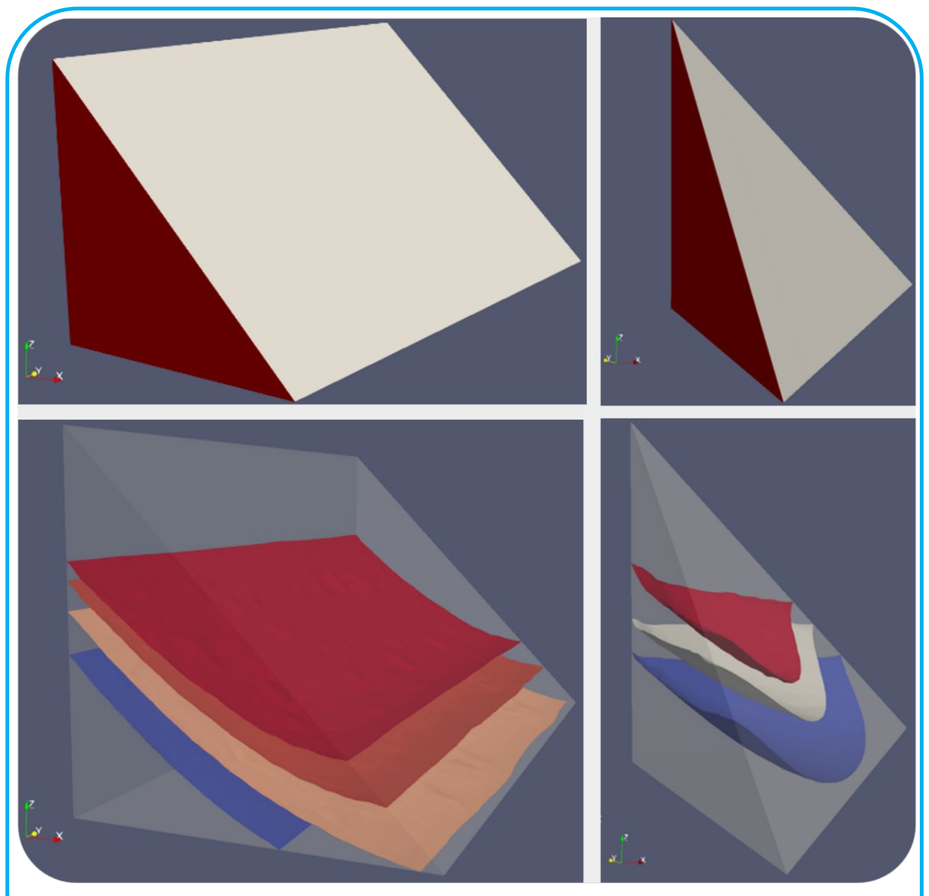
Application and Discussion



Failure plane of triaxial test



Surface tangential to vectors



3D slopes with identical 2D section and their different failure surface shape

The most dangerous slip direction vectors can be determined through geotechnical tests such as triaxial tests, where the orientation of the failure plane provides a basis. Two 3D slopes with identical 2D cross-sections exhibit different candidate failure surface shapes. The left-side slope shows a shape more consistent with traditional 2D analysis results, which validates the proposed method. In contrast, the sharp geometry of the right-side slope leads to a concave failure surface shape from the boundary inward, demonstrating the influence of 3D slope geometry on failure surface shape.

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