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Geometry and pattern of slope failures at a fault scarp in analogue models

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A slope failure, which damages to human lives so much, is a natural phenomenon that a slope instabilized by geological and geomorphological factors is collapsed induced by torrential rain and earthquake motion. Therefore analyzing each factors related to slope instabilization and evaluating the risk of slope failures, are very important for preparing future torrential rains and earthquakes. In our research, we focused on the reverse fault, which is one of geological factors of slope failures, and performed analogue model experiments with dry sand to examine slope topography, development and failure induced by reverse fault activity. In the experiments torrential rain was reproduced, and the experiments were conducted in static condition so that influences such as earthquake motion could be ignored; we could consider only the activity of a reverse fault to evaluate the influences on slope development and failures.

In our experiment, a slope was reproduced that developed on the surface of the sedimentary layer on a basal rock. Wooden rigid blocks cut at the angle of 30 degree were put on the lower part of the experiment apparatus as basal rock, and dry sand is piled on the blocks. Reverse fault displacement was given to these blocks and a slope was induced on the surface of dry sand. During the experiment, slope development and failures are recorded with digital cameras from side and upside of the model at even intervals. The time series deformation process of the model was obtained by analyzing taken digital images using digital image correlation (DIC) technique, and 3D slope topography, patterns of slope failures and fault activity in cross section were related with each other.

The observation of 3D slope topography revealed that a steep area with constant width was at the foot of the slope regardless of slope length, or the level of slope development. On the other hand, fault activity, which is visualized by analyzing images taken from the side of the model, was always localized at the foot of the slope with constant width near surface. These results are very consistency, which suggests that specifying a steep area from slope dip distribution enable us to estimate the position and width of fault under a slope.

The generated slope on the dry sand was not linear but had certain curvature. On the area of the slope convex toward the hanging wall, hanging wall displacement was large and many large slides occurred, which are defined generate at the top of the slope accompanied with large failure areas, and vice versa on the area convex toward the foot wall. As the hanging wall displacement increased and the slope developed, the topography of the top of the slope deformed into one of emphatic initial slope curvature, while the foot of the slope increasingly became flat. Observed phenomena, including large slope failure, seem to be dependent on the initial slope curvature, which suggests the possibility that slope curvature on surface is applicable for quantification of the risk of large slope slide.

Keywords: analogue modeling, reverse fault, slope failure, DIC, 3D topography