The Preliminary Stability Analysis of Su-Hua Highway 115.9k

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Abstract

Su-Ao to Nan-Ao section of Su-Hua highway which causing serious damage in slope of the mountains during the heavy rainfall of typhoon Maggie. In mileage 115.9k, which is the maximum curvature of highway route and the most serious debris slide event by rainfall-induced. The potential instable slope and the landslide hazard area are the key issues for disaster prevention in mountain roads. In this study, the finite element method (Midas/GTS) has been use to establish three-dimensional slope stability model of mileage 115.9k in Su-Hua highway through field investigation and reasonable assumptions. The field survey and simulation results will indicate that the landslide failure mechanism, potential instable slope, and sliding depth. Beside, the results can provide reference for disaster prevention, mapping of geological hazard susceptible areas, and associated renovation project planning.

Keywords: the finite element method, three-dimensional slope stability model, field investigation.

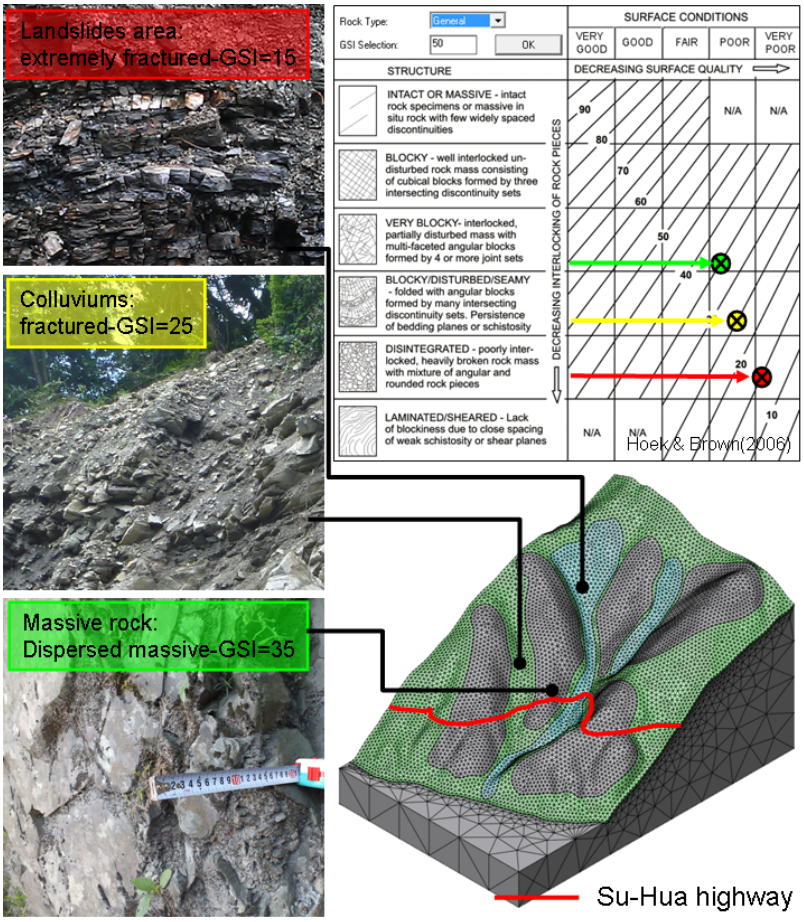
Torrential rain causing serious damage of mountain road near the slope in Su-Ao to Nan-Ao section of Su-Hua highway (also known as highway no. 9) during typhoon Maggie (2010/10/21~24). Base on the results of aerial photo interpretation, the most serious debris slide event in mileage 115.9k, the estimated the collapse area and caving volume about $1\times10^{-1}km^2$ and $2.1\times10^{-3}km^3$ accumulation after mudslide from east southern slope under the impact of roads on the Pacific coastline, forming an area of about $4\times10^{-2}km^2$ alluvial fan. Major material of landslide is colluviums and weathered rock mass, and mainly damage type is debris slide (Chou, 2012; Li, 2010; Central

Weather Bureau, disaster prevention and typhoon database, 2012). In this study, three-dimensional finite element software (Midas/GTS) has been use to establish Su-Hua highway slope near the 115.9k by three-dimensional numerical model, the landslide event simulation in this area through the relevant survey data and assumptions, and to clarify the characteristics of the collapse range and sliding depth.

This research contain three methods include on-site investigation, image interpretation analysis, and full-scale numerical simulation analysis. The concept of geological strength index (GSI, Hoek and Brown, 2006) will use to build simplify numerical model through on-site survey and image interpretation analysis. Verify the old destruction zone to description of the simulation results and to predict the area with scope of the possibility landslide hazard location. The numerical model need collected four main information as follows: (1) geomorphic analysis before Maggie event, (2) colluviums thickness, (3) rock mass parametric assumptions, and (4) stratum setting for full-scale numerical model.

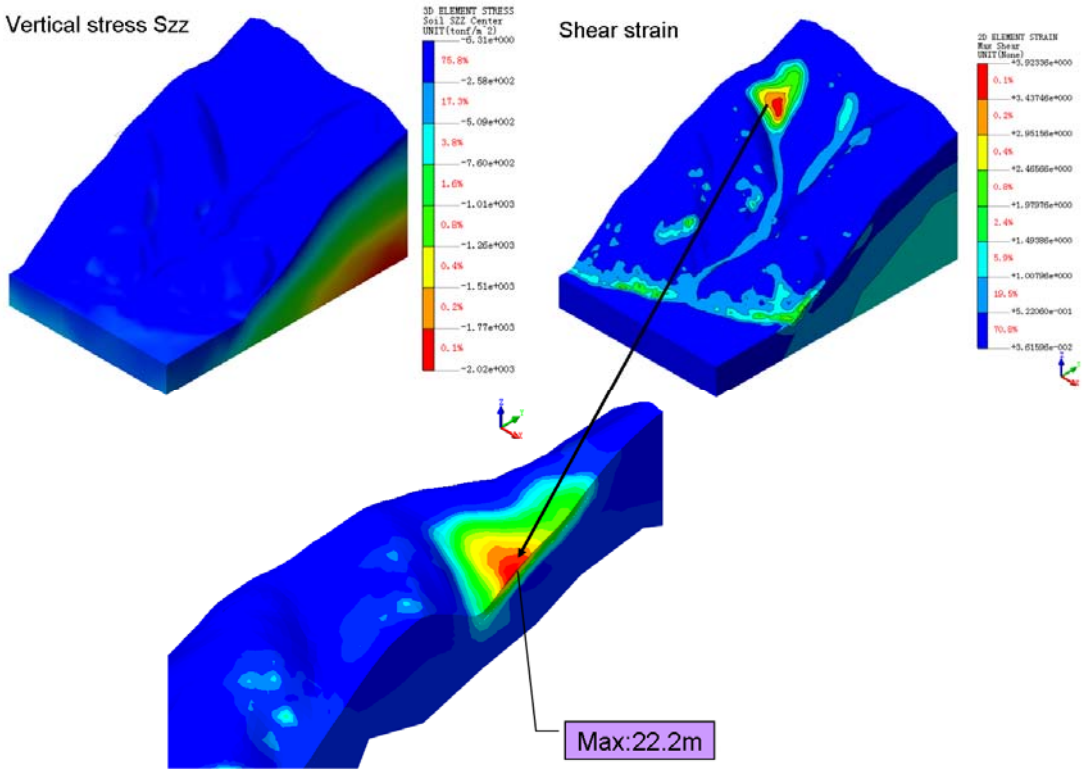
Analysis parameters table

Parameter(unit) \ Stratum	Landslides region	Colluviums	Massive rock
Unit weight(t/m^3)	2.7	2.4	2.7
GSI	15	25	35
Friction angle ($^\circ$)	15	21	25
Cohesion (MPa)	0.180	0.270	0.405
Deformation modulus (MPa)	571	714	1058



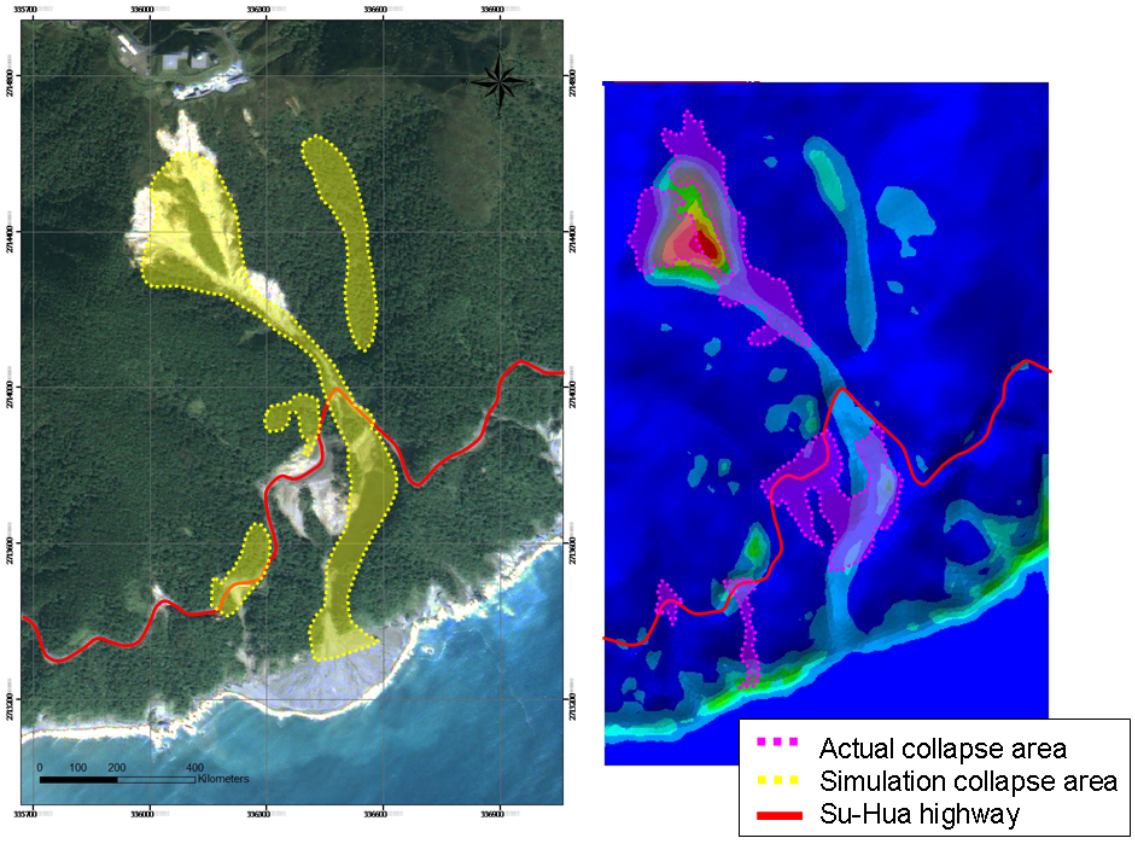
Field investigation representative photos of the rock and the numerical analysis of stratum distribution and grid diagram

Su-Hua Highway on the 115.9k nearly slope stability analysis results reveal that the top left picture shows the slope geo-static of vertical stress state; upper right picture shows the slope safety factor (FS) is equal to 0.9 while the shear strain distribution display slope is a near critical unstable state. Addition to the model edge may be due to boundary restrained, the apparent position of the shear strain can be regarded as the slope instability of the sliding surface. The most serious landslides is on both side of the gullies of 115.9k on the left side of slope, the deepest sliding depth and average sliding depth are 22.2 m and 15.6 m. Sliding surface has been cut through the colluviums to rock. Therefore, the region is a deep rock mass sliding general different from the sliding surface on the soil and rock interface. The results of analysis of mainly slope collapse area and avalanche volume of approximately 1.56×10^{-1} km^2 and 3.56×10^{-3} km^3.



Depth assessment of the numerical analysis results with the sliding surface

The simulate results of compare with post-disaster aerial photographs shown in figure. The slope simulates slide position and the actual landslides position broadly similar. On slope right side investigation found that damage mechanism has been reached in the analysis of simulate destruction, so the overall analysis of the actual situation appears to be conservative. Slope unstable area and the amount of body slightly larger than the actual situation. The intense change of terrain surface with erosion gullies or periphery of road are the mainly distribution location for the destruction area. But the erosion gullies on the sliding edge with lateral erosion failure mechanism are difficult to reflect on this slope stability analysis.



Destruction of aerial images (left) after the typhoon (2011) and Midas / GTS numerical simulation results (right) nearby the road