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Triggering factor evolution and dynamic process simulation of the Formosa Highway dip-slope failure, northern Taiwan

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Taiwan, due to the high seismicity and high annual rainfall, numerous landslides triggered every year and severe impacts affect the island. Accordingly, if the new-built construction does not take into account this threaten, tremendous disasters will occur. On April 25th 2010, Formosa Freeway dip-slope failure caused four deaths, resulted from artificial slope cutting and rock-bot supporting system weakening. This research integrates high resolution Digital Terrain Model (DTM) and numerical simulation to evaluate the triggering mechanism and dynamic process of the landslide. First of all, to access the landslide geometry, the morphology of the event before and after landslide is constructed from high resolution DTM by means of aerial photos. The slid and the deposit volumes of the landslide are thus estimated accordingly. Only part of the surface of separation between slide block and slide slope is exposed. Based on the exposed planar strata/sliding surface, situated on the upper part of the slope, by means of extrapolating part of the plane to mimic the entire slide surface. From DTMs, the slide block is approximately 0.15 million cubic meters. The extrapolated planar surface serves as sliding surface for the numerical models. For numerical model preparation, the particle clusters produced by isotropic stress and the porosity are take into account. To ensure the production range should cover the entire slid mass from the source area, the particle clusters represent the slid block is been rotated, scaled and translated to the source area. Then, part of the particles are been eliminated if it is situated outside the upper and lower surface from the DTM before and after landslide. According to the geological map, the model of the particles to mimic the slide block can be divided into two parts: 1) the underneath interbedded sandstone and shale which may soften by water 2) the supposed upper layer composed of sandstone. Furthermore, set up a layer of particles to simulate ground anchor. The advantages of DTM collocate PFC3d are that real terrain can be represented on the model, and can be simulated the complete landslide process dynamically. Comparing with continuum mechanic analysis that only provides state of instability, but by using discrete element method it can provide the dynamical process of sliding include trajectory, velocity change, sliding distance and also accumulation patterns after landslide and know the affected areas from the disaster event. Results shows: 1) the peak and the residual frictional angle of the sliding surface should be small than 14 and 4 degree, respectively, in the condition of 30% effective resistance of rock-bolt remains. 2)The maximum sliding speed could be as high as 15.34 m/s, caused thus hazard event.