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Rock Mass Classification of Karstic Terrain in the Reservoir Slopes of Tekeze Hydropower Project

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Hydropower reservoirs in deep gorges usually experience slope failures and mass movements. History also showed that some of these projects suffered severe landslides, which left lots of victims and enormous economic loss. Thus, it became vital to make substantial slope stability studies in such reservoirs to ensure safe project development. This study also presents a regional scale instability assessment of the Tekeze Hydropower reservoir slopes.

Tekeze hydropower project is a newly constructed double arch dam that completed in August 2009. It is developed on Tekeze River, tributary of Blue Nile River that runs across the northern highlands of Ethiopia. It cuts a savage gorge 2000m deep, the deepest canyon in Africa. The dam is the highest dam in Ethiopia at 188m, 10 m higher than China's Three Gorges Dam. It is being developed by Chinese company at a cost of US$350M. The reservoir is designed at 1140 m elevation, as retention level to store more than 9000 million m3 volume of water that covers an area of 150 km2, mainly in channel filling form.

In this study, generation of digital elevation model from ASTER satellite imagery and surface field investigation is initially considered for further image processing and terrain parameters' analyses. Digitally processed multi spectral ASTER ortho-images drape over the DEM are used to have different three dimensional perspective views in interpreting lithological, structural and geomorphological features, which are later verified by field mapping. Terrain slopes are also delineated from the relief scene. A GIS database is ultimately developed to facilitate the delineation of geotechnical units for slope rock mass classification. Accordingly, 83 geotechnical units are delineated and, within them, 240 measurement points are established to quantify in-situ geotechnical parameters. Due to geotechnical uncertainties, four classification systems; namely geomorphic rock mass strength classification (RMS), slope mass rating (SMR), rock slope stability probability classification (SSPC) and geological strength index (GSI) are employed to classify the rock mass. The results are further compared with one another to delineate the instability conditions and produce an instability map of the reservoir slopes.

Instability of the reservoir slopes is found to be mainly associated with daylighting discontinuities, thinly bedded/foliated slates, and karstified limestone. It is also noted that these features are mostly located in the regional gliding plane and shear zone, which are related with old slides scars. In general, the instabilities are found relatively far from the dam axis, in relatively less elevated and less steep slopes, which are going to be nearly covered by the impoundment; thus, they are normally expected to have less hazard in relation to the reservoir setting. Some minor failures will be generally expected during the reservoir filling.