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Combined aerial and ground-based Structure-from-Motion modelling for a vertical rock wall face to estimate volume of failure

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A rock wall failure occurred along a major highway in south-eastern Norway, shutting down two lanes of traffic for an extended period of time while the road authority inspected and repaired the wall. It was desired to have a high-resolution digital surface model along a 215-m long section of the 34-m tall vertical rock wall that included the failure zone.

A Structure-from-Motion (SfM)-based methodology was selected to achieve the desired resolution on the rock wall face, as well as below the foot and above the head of the wall. Due to the proximity of the wall face to the remaining open lanes of traffic, it was not possible to survey the face of the wall using a remotely piloted aircraft system (RPAS). Therefore, a combined platform photogrammetric surveying technique was employed to ensure optimal photographic coverage and to generate the best possible model. Ground control points (GCP) were distributed and surveyed along the bottom and top of the wall and an RPAS was flown manually over the head of the wall to capture downward facing (nadir) images. A lift crane was also employed to capture images from elevations varying between 20–30 meters with a standoff distance of 15 meters from the wall. Finally, ground-based images were captured using a camera equipped with real-time GNSS from the top of the opposite rock wall (across the highway) with standoff distance of approximately 65 meters.

In total, over 800 images were ingested into a commercial SfM software package. The bundle adjustments were assisted by the GNSS-equipped camera locations and the surveyed GCP were imported to georeference the resulting model. The dense point cloud product was exported to a separate meshing software package for comparison with a second dense surface model that was derived from pre-existing images of the as-built condition of same rock wall face (prior to failure). By subtracting the post-failure model from the pre-failure model, a volume estimate of the material, that was mobilized during the failure, was determined.

The utility of the multi-platform survey technique was demonstrated. The combination of aerial and ground-based photographic surveying techniques provided optimal photographic coverage of the entire length of the rock wall to successfully derive high-resolution surface models and volume estimates.

Keywords: Structure-from-Motion, photogrammetry, digital surface model, natural hazards, ground control.