Terrestrial and airborne laser scanner techniques applied to rock slope instability analysis: the case of Einser-Cima Una (Sexten Dolomites, Italy)

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Introduction

The characterization of a rock instability phenomenon is a fundamental task in the understanding of its evolution and the forecasting of possible further slope failure. The first step towards a complete study of the unstable slope consists in its detailed geometrical, geomechanical and kinematical characterization in order to generate a high resolution 3D digital model of the investigated area, recognize the main discontinuity sets of the rock mass, evaluate displacements and deformations occurred between subsequent surveys. This kind of study can be carried out by means of remote sensing techniques like terrestrial (TLS) and airborne laser scanner (ALS), which allow detailed investigations of a rock cliff in remote and safe mode. TLS allows the acquisition of sub-vertical cliffs, whereas ALS provides information over wide areas with higher performances in sub-planar surfaces. These remote sensing techniques has been applied to analyze the northern rock wall of Einser-Cima (Fischleintal-Val Fiscalina, Sexten Dolomites, Bozen, Italy).

The 12 October 2007 rockfall event

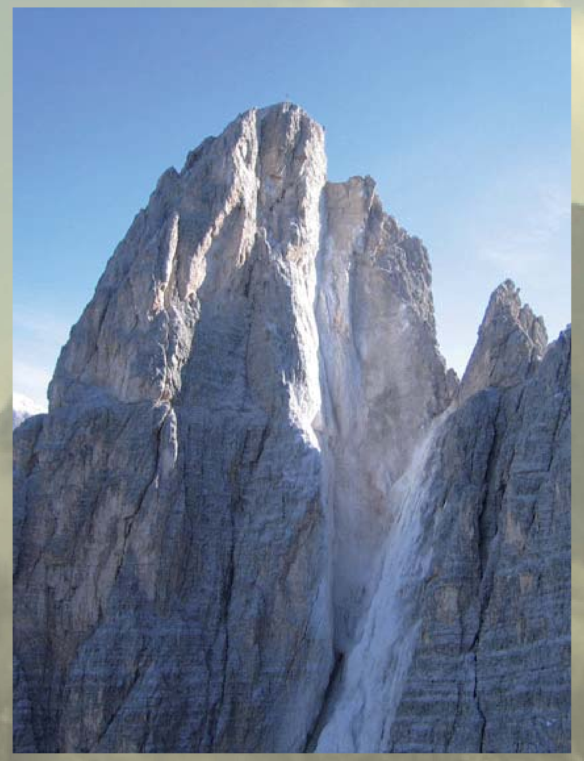
The northern rock wall of Einser-Cima during the 12 October 2007 rockfall event. A dense dust cloud is formed during the material fragmentation.

The dust cloud travels toward the north, up to a few kilometers from the rock wall, deposing a layer several mm thick of fine sand and silty sand.

At 8:40 a.m. October 12, 2007, a large rock wedge detached from the northern wall of Einser-Cima Una (Sesto Pusteria, Bolzano, Italy).
The rock mass fell down from the upper part of the rock wall (top at 2.698 m a.s.l.) to the Fischleintal-Val Fiscalina, nearly 900 m far down from the top.

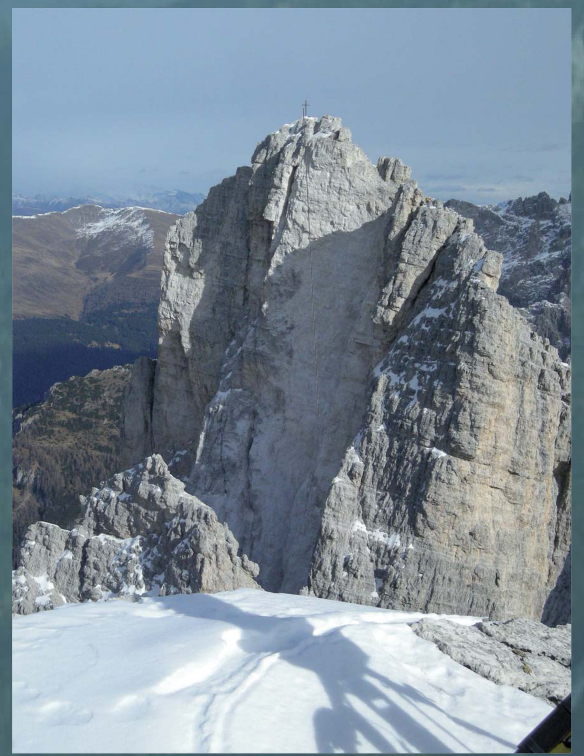
During the fall, the calcareous and dolomitic landslide materials fragmented and generated a dense sandy cloud travelling in the Val Fiscalina up to 4 km far from the base of the rock wall.

The detritic accumulation at the base of the rock wall is composed only by several rock blocks, mainly by fine material.



The northern rock wall of Einser-Cima una after the 12 October rockfall event.

TLS survey of the failure surface



Left: instrumentation used for TLS surveys.
Right: photographic view of the failure surface from the first point of view of TLS surveys.

The TLS surveys of the failure surface were performed using the Riegl LMS Z-420i instrument, coupled with a GPS receiver. A second GPS receiver was used for georferencing purposes.

Two view points was considered, the first one, about 215 m far from the source area, was surveyed in November 2007 and September 2008. The second one, about 115 m far from the rock wall, was surveyed only September 2008.
The obtained point clouds have a sampling rate of 10 cm on the rock wall.

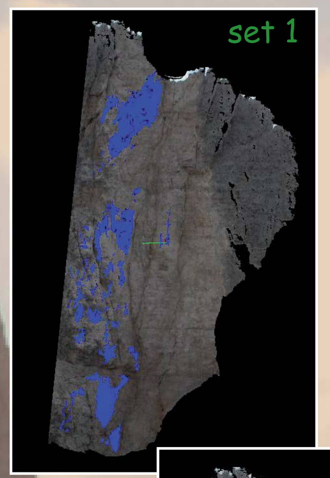
Left: photographic view of the failure surface from the second point of view of TLS surveys.
Right: point cloud coloured with RGB photographic data.

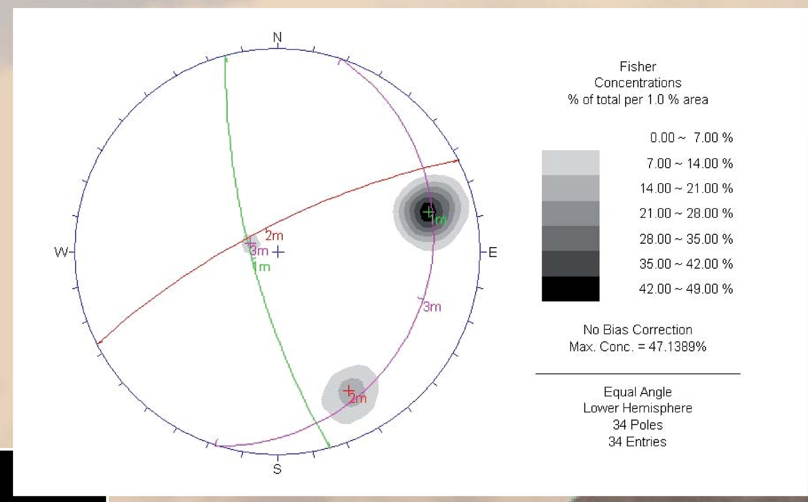
Multimemporal analysis

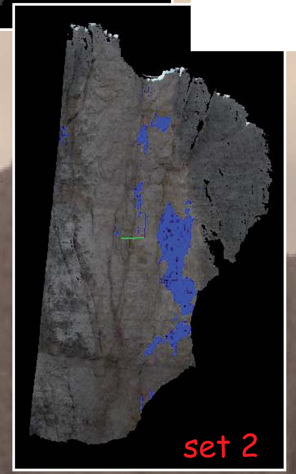
The comparison between the two TLS-based point clouds acquired from the same view point allows the analysis of the displacement field.
This analysis, performed by using the piecewise alignment method on 10-months time scale, do not shows valuable displacements of the rock mass of the failure surface and the surrounding slope sectors.

The failure surface

The point cloud analysis has been performed by using Polyworks and Split-FX softwares.
The failure surface develops vertically from 2.690 to 2.615 m a.s.l. and is formed by to principal high-angle planes with mean orientation 333/75 and 255/75, forming an angle of about 75° between them in the dip direction.







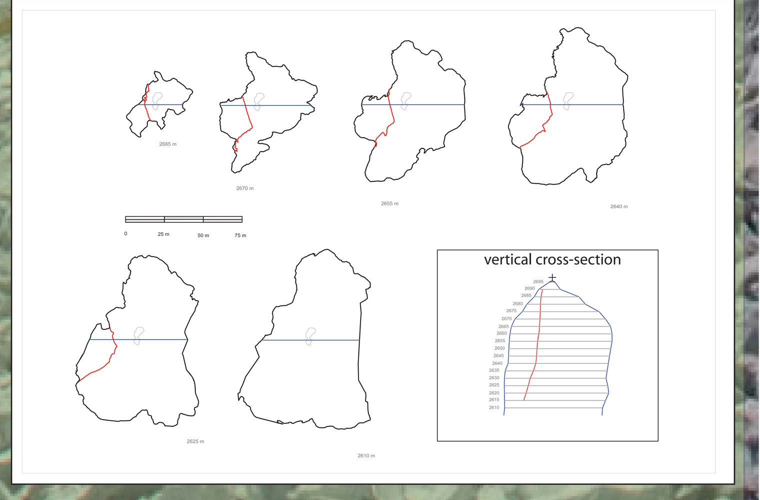
The stratigraphic bedding 110/16, showed in pink in the stereonet, measured on the rock failure surface is consistent with the filed measures taken at the base of the rock wall.

Volume estimation by TLS and ALS

Comparison between the pre-failure ALS (in black) and the post-failure TLS (in red) point clouds. The two point clouds have different sampling rates: 30-50 cm for ALS data, with regional coverage; 10 cm for the ad-hoc acquired TLS data.

Left: horizontal cross-section at 2.650 m a.s.l.
Center: vertical cross-section E-W (thickness of the section in the figure: 10 m).
Right: vertical section with the measure of the thickness of the missing rock mass.

By comparison between the two scans, the volume of the fell mass has been recontructed (using CAD instruments and Polyworks software) and estimated in about 40.000 m^3.



Horizontal cross-sections of Cima Una traced by TLS and ALS data.