Securing the Cliff of Bon Voyage - NICE - A case study of 3D Laser scan contribution in an urban blasting

Tristan BOURDIN (corresponding author)[1], Thierry PARTOUCHE[2], Philippe BOUDON[3]

Keywords: emergency works, laserscanning, rockfalls, blasting, cliff reinforcement, mitigation

Our subject is located in the eastern part of Nice in French Riviera. The site consists in an anthropic cliff made of limestone and dolomites from the Jurassic stemming from a quarry exploited in the first half of the twentieth century. The cliff dominates the Nice-Tende railway line and numerous residential buildings. Because of several collapses, this cliff has been studied since the early 2000s.
From 16th until 19th of January 2014, a very big Mediterranean depression occurred, leading to heavy rainfalls, 270 mm were recorded in this area.
The activity of the cliff increased on January the 30st and it partially collapsed in a 6000 m^3 rockfall.
This manuscript gives a report on mitigation activities in the aftermath of the cliff collapse which pulled the closure of the railway line and evacuation of several housing of this inhabited area.

Directly after the event, an emergency investigation was carried out by GEOLITHE, and showed that the cliff presented in its upper part two large instabilities forming an arc thus preventing any purging. The volume of the instabilities (about 1590 m^3), their degree of fracturing and their high risk of collapse led to the interruption of the railway line and to the evacuation of several families. The geological conditions prevented any reinforcement works in a secure way, thus the remaining solution chosen was to blast the upper part of that cliff.

The preparation phase took 4 months in difficult and challenging conditions. The working zone was protected at first by numerous punctual rock reinforcements and a 90 meters long ETAG like class A rockfall barrier. An instrumentation of the cliff with extensometers was also implemented for surveying. 600 linear meters of boreholes were performed by acrobatic drilling to prepare the blast. The density of fracturation required odex technics to perform the boreholes.

This very special blast occurred at 70 meters high and 70 meters above the nearest buildings. In order to fire with maximum safety, several methodologies were implemented :

- A statement of fracturing was lead for each drilling ;
- An inclinometer measurement was lead for each drilling ;
- A detailed exhaustive 3D laserscan acquisition was carried out from 6 test points. This measurement permitted to lead a structural analysis of the fracturing and give to the miner a 3D model with the geometry of the boreholes;
- 3D loading calculus and 2D flyrock simulations were performed.

This method allowed to supply to the miner the volume of rock covering along each borehole, the lengths which can be loaded and the fracturing network. DCI has chosen to destabilize this arch with a carefully controlled blast, leaving gravity to deal with the rest.

A special protection was designed and implemented with metallic nets doubled by wire nettings and by geotextiles in the cliff to protect the buildings from the projections. On the loading area, protections were placed previously to the loading stage and opening made in the geotextile above the hole to allow loading (cf. Figure1).

As a precautionary measure, a wide security perimeter was deployed around the site. The 1400 concerned residents were asked to leave this area during the day of the mining and to not leave their vehicles in outdoor car parks.

[1] BOURDIN Tristan, GEOLITHE, Mouans-Sartoux, France, tristan.bourdin@geolithe.com
[2] PARTOUCHE Thierry, DYNAMIC CONSULT INTERNATIONAL, Carros, France, thierry.partouche@gmail.com
[3] BOUDON Philippe, DPGR Ville de Nice, Nice, France, philippe.boudon@nicecotedazur.org

The good progress of this operation was made possible by an important campaign of information and preliminary communication of the population with the support of the municipal reserve of civil safety (RCSC) and by the implication of the police forces (360 people were involved in the operation). More than 450 residents were taken care by the city services and bus transported towards one of the three home sites (schools).
The coordination of the operation was led from an operational headquarter situated nearby, with a view of the cliff, under the piloting of the direction of Risks Prevention Service of Nice City Concil and GEOLITHE.
A meteo forecast was assured in connection with a forecaster of Météo-France and radio transmissions allowed the supervision of the operation.

Figure 1: View of the cliff during the preparation of the mining

This blast was done successfully the 25th of June 2014 despite a very bad weather report which delayed the hour of the firing (cf. figure 2). The results were beyond the expectations since no projection was observed in the direction of neighboring structures, or even on the railway. After the blasting, on the basis of detailed diagnostics (cliff diagnostic conducted by GEOLITHE and buildings diagnostic conducted by DPGR and a technical auditor), inhabitants were allowed to come back home in the early evening.

During summer the cliff was temporarily protected by wire nettings. A temporary bund was constructed to protect the railway and the buildings and the families evacuated after the event were reintroduced. Complementary studies are actually underway to design definitive protection structures as well as the monitoring of the cliff face by 9 extensometers. The protection works should begin this year and should last till 2018.

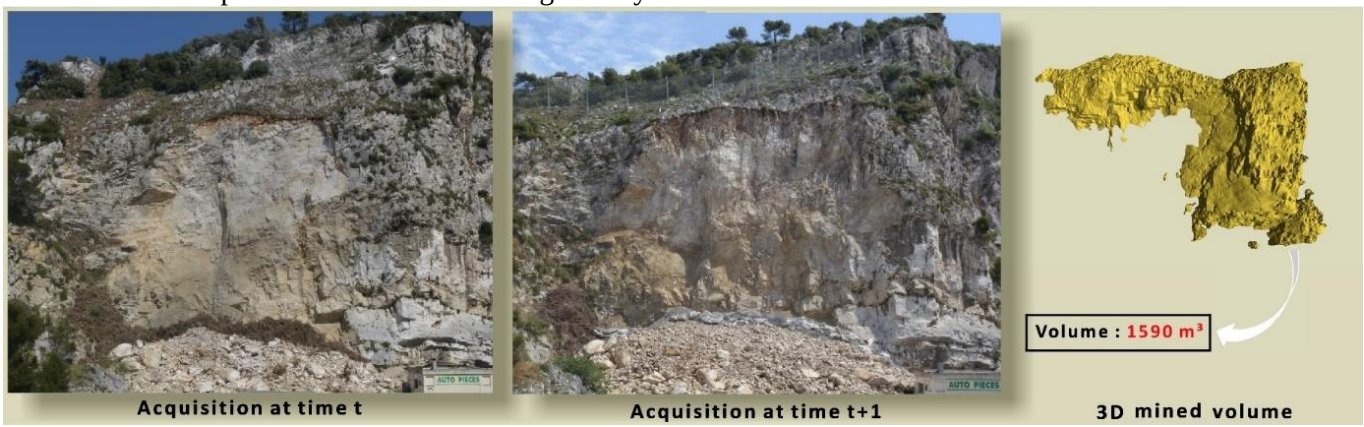

Figure 2 : The cliff before and after the blast + volume of mined rocks resulting from a laserscan of the cliff

The presented methodology allowed to secure temporarily a big cliff in an urban area by blasting using a unique combination of field measurements and advanced technologies. The contribution of 3D laser scan allowed to master the mining and the associated geological hazards.

REFERENCES

Hoek, E & Bray J.W., Rock Slope engineering revised second edition, The Institution of Mining and Metallurgy, London, 1977.