Applications of 3D laser scan data for slope characterization and stability analysis

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In the framework of the RFCS (Research Fund for Coal and Steel) European Project SLOPES (Smarter Lignite Open Pit Engineering Solutions) INERIS used short-range laser scan (FARO Focus3D X330, 0.6-330 m range with ranging error is ± 2 mm) to scan instabilities in a small abandoned French coal mine. One of the main objectives of this project was to evaluate the capacity of terrestrial laser scan (TLS) for slope stability analysis within a lignite mine. The INERIS results of laser scan were also integrated to carry out a 3D numerical modelling. Results of the numerical modelling and laser scan were compared to existing displacement measurements.

1 TEST SITE AND OBJECTIVES

The French coal open-pit mine “Fosse Padène” is one of the latest open pit coal mine located in the city of Graissessac (about 80 km west of Montpellier, Figure 19). This mine was excavated between 1960’s and 1990’s. The open pit is now over the underground mine and is divided into two faces: North and East. The cliffs were not traced and the pit was not backfilled. In addition, the dump of coal materials has a high slope angle. Consequently, this open pit has several types of instability: rock falls at cliff level, deep or superficial slides in the coal deposits and coal deposits erosion. INERIS choses this abandoned mine to evaluate TLS regarding four points of interest: Backfills, East face, North face and one landslide (located in open pit deposits).

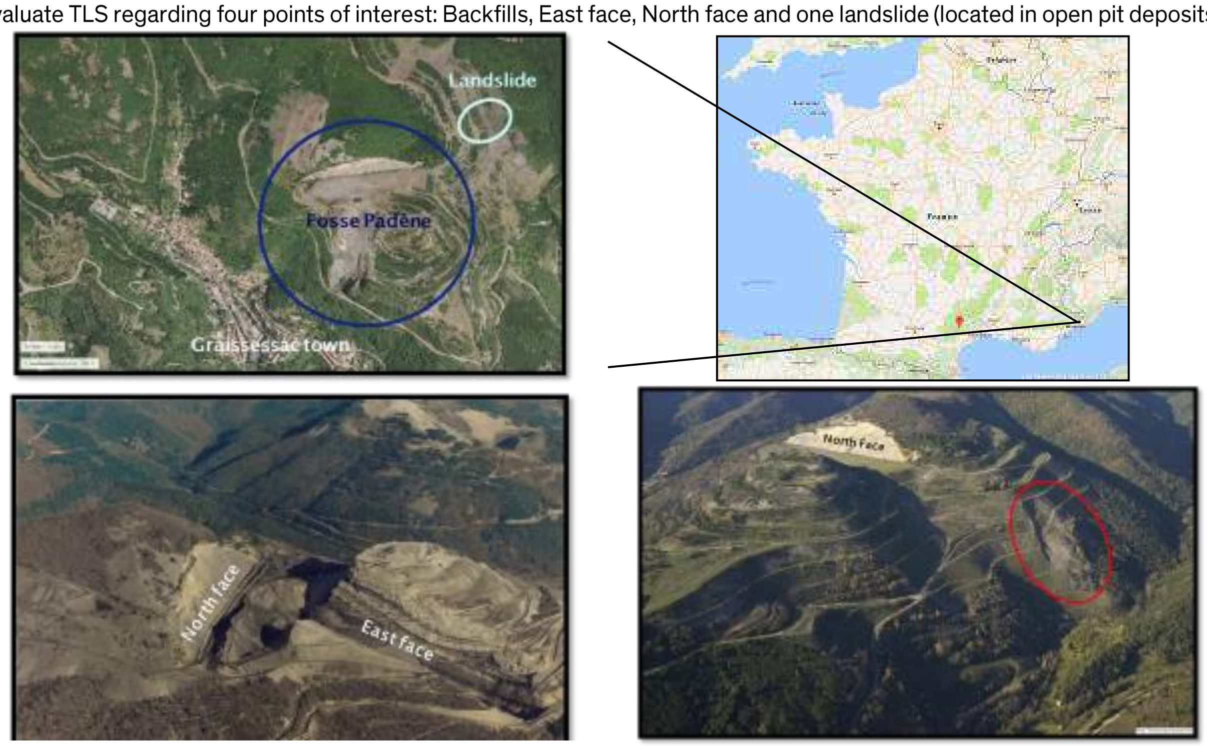

Figure 19 : Location of "Fosse Padène", North-East of Graissessac town

The objectives of using 3D laser scanner technology are to collect geometric and geotechnical data related to the fracturing of rocky slopes and mass displacement for coal mine deposits. 10 measurement stations were positioned into the pit and they were located from 50 m to 200 m from the fronts. Then, dataset was integrated into a numerical model to analyse instabilities.

2 RESULTS

For the 1st point of interest (East face) TLS application: structural geological framework realisation

On the field, this face is the most impressive because each coal layers could be directly observed. For this reason, a geological interpretation was directly performed from the 3D points cloud, and the pseudo-colour interpretation helped to determine geological layers. The result of this data processing was a structural geological framework.

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For the 2nd point of interest (North face) TLS application: discontinuity identification

This face is characterized by several faults analysed thanks to the 3D dataset. Some dip measurements were noted, in a non-man-accessible area, directly form the points cloud. This last data allowed to build a stereogram and to identify discontinuities families. Three families were identified.

For the 3rd point of interest (Dump) TLS application: dip identification

No degradation was observed in the upper part of the dump while, in the lower part, several ravines were observed. Moreover, the Fosse Padène geometry forms a bowl that concentrate all the rainwater. Using the 3D dataset backfills, slopes were analysed to understand the active erosion in the lower part. It appears that the slopes are from 30° to 40° dip at the bottom of the dump, whereas they are about 20° to 30° at the top.

4th point of interest (landslide) TLS application: integration of 3D dataset in a numerical model

The landslide is in the north east of the Fosse Padène (Figure 19). It occurred in the upper part 2 years after the dump building. This landslide is composed of argillite and sandstone and it is built with several 10 m height benches. Its 3D dataset was used to make a numerical model (Figure 20) for stability analysis.

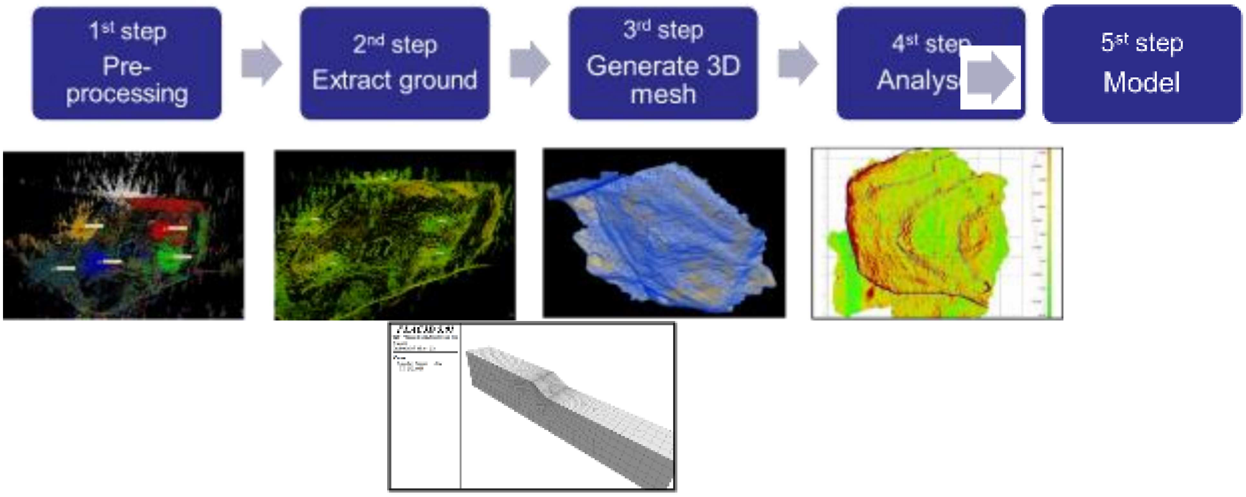

Figure 20 : Slopes analysis methodology based on laser scan and numerical modelling tools

A basic 3D elasto-plastic numerical model using FLAC3D was carried out, the method of strength reduction was employed to determine the safety factor of the slope. The upper layer of the slope is mainly characterized by the friction angle and the cohesion of the soil (phi= 31° and c=8.2 kPa). The deep layer is competent limestone layer, what was considered as elastic layer. Shear and plastic deformation were analysed and compared to the displacement observations. The safety factor after the first instability is equal to 1.2. The local safety factor is smaller. Figure 21 presents the total shear strain. The maximum shear strain is located in the centre of the unstable zone. The thickness of instable zone is about few meters and similar to the in-situ observations and measurements.

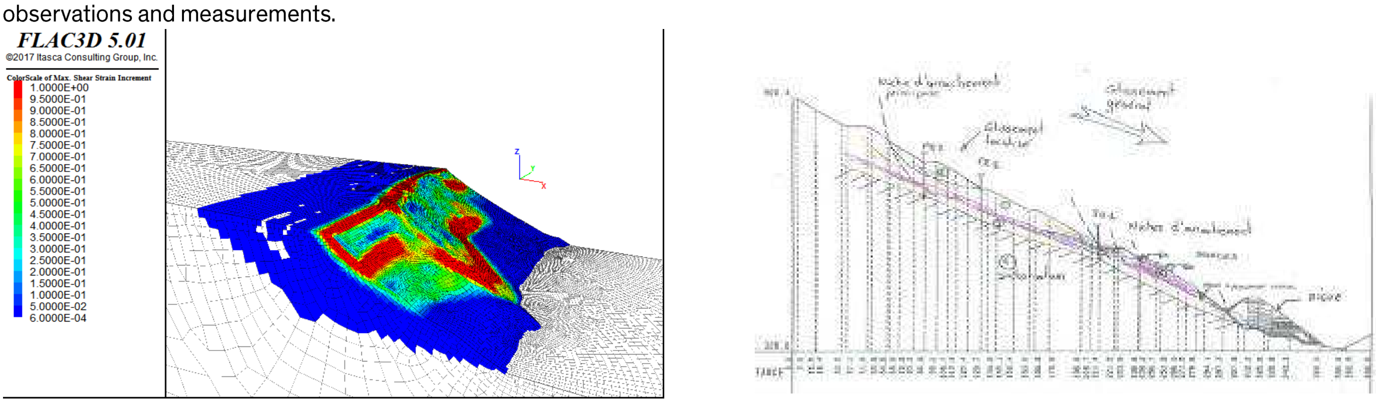

Figure 21: Numerical modelling results (left) of the slope and in-situ observations (right)

3 CONCLUSION

Terrestrial laser scanner technology appears as a very useful tool to characterize and analyse the stability of the inaccessible slopes with very reasonable costs comparing to classical displacement surveys. 3D datasets were also used to carry out a slope assessment and generate a numerical model. This innovative methodology, based on crossing and combination of 3D datasets, numerical modelling and in-situ observation, was successfully used for a real case study.

4 ACKNOWLEDGEMENTS

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