

Multiple landslides in a natural touristic area (Mullerthal, Luxembourg): causes and safety works

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ABSTRACT: The touristic region of Mullerthal (Luxembourg) is an area at particular risk of landslides. In recent years, the combination of complex geology, steep topography, and heavy rainfall, led to numerous landslides, causing extensive damage, and blocking roads. The area is also a nature protection area which limits the options for securing the sites and means that innovative solutions had to be found. The article presents the causes of some landslides, and the solutions implemented to remedy them. The area is characterized by complex geological formations: sandstones, marls, limestones, and clays whose presence strongly influences the risk of landslides by acting as a soap layer. For the first landslide, the water masses resulting from the heavy rains crossed the backfills and mobilized the sliding surface constituted by the clays. About 10,000m³ of materials had slipped. The slope damaged was replaced by a reinforced earth wall constructed with in situ soil. The second landslide, also secured by reinforced earth, was caused by the water seeping into the embankment. At the third place, the embankments and scree have slipped due to the amounts of water that infiltrated them. Piles were used to secure the road. The fourth is an old, backfilled landslide area. The landslide occurred because of water seeping into backfills up to 12m thick, overlying clays. An earth retaining system was proposed. The area of the last landslide is characterized by slope scree overlying sandstone and marls. Multiple stabilizations were used: micropiles at alternating batter angles, reinforced concrete cap wall, steel mesh with soil nails, shotcrete wall with self-drilling anchors and subhorizontal drains to improve slope drainage. Naturalistic engineering measures were provided. These examples demonstrate how landslides can be economically and safely remedied using both conventional and innovative methods while ensuring environmental constraints are respected and future stability is guaranteed.

KEYWORDS: Landslides, touristic region, protected natural area, complex geology, Luxembourg.

1 INTRODUCTION

Situated in the east of the Grand Duchy of Luxembourg, the touristic region of Mullerthal, also known as "Luxembourg's Little Switzerland", is an area at particular risk of landslides. In recent years, the combination of complex geology, steep topography, and heavy rainfall, has led to numerous landslides, causing extensive damage, and blocking roads for months at a time. The area is also designated as a nature protection area (Natura 2000 and drinking water catchment areas), which limits the options for securing the sites and means that innovative solutions had to be found. This article presents the causes of some of these landslides and the solutions being implemented to remedy them. The document offers five instances, four of which are situated on the CR364 route and one on the CR356 route (see Figure 1).



Figure 1. Mullerthal landscape's location

2 GEOLOGICAL SITUATION

In the projects area, complex geological formations from Triassic and Jurassic are found, as shown on Figure 2. Li2, more commonly known as "Luxembourg Sandstone", is composed of

calcareous sandstones of whitish color alternating with sandstones, of which the calcareous cement is less present or totally absent, of yellowish color. Li1 (called "Elvange Marls"), is made up of alternating dark gray marls and partially sandy limestone beds. The ko2 ("Rhaetian: Argile de Levallois – Levallois Clay") are clays and red clayey marls whose presence strongly influences the risk of landslides (by acting as a soap layer). The ko1 ("Rhaetian: Mortinsart Sandstone"), meanwhile, is composed of sandstone, conglomerates and black laminated argilites. Finally, km3 (named "Keuper with compact marnolites") is made up of motley marl with thin dolomitic beds that may contain gypsum.

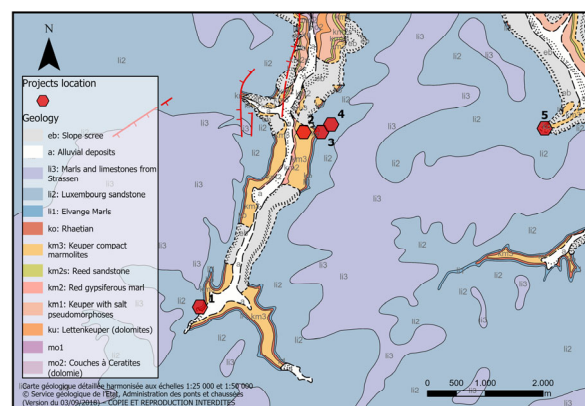


Figure 2. Mullerthal landscape's geology

Due to the topography and the steep slopes, all these geological formations are covered by non-cohesive slope scree, composed of sandstone boulders in a sandy-silty matrix. These scree are the result of the weathering of the sandstone and the placement by gravity of the weathering materials along the slopes.

As the area affected by the landslide is small and surrounded by trees, piles were used to secure the road.

The fourth landslide affected the road between Berdorf and Vugelsmillen. This is an old, backfilled landslide area. The landslide occurred here because of water seeping into backfills to 12 m thick, overlying Rhaetian sandstone or km3 marl, depending on the location. The investigations carried out suggest the presence of a fault bringing the Rhaetian sandstones and the Middle Keuper marls into contact at the same altitude and over a very short distance. This fault undoubtedly affects the movement of underground water. An earth retaining system has also been proposed as a solution.

3.2 CR356

The landslide took place on the downstream side slope of road CR356, between the villages of Mullerthal and Waldbillig. The area is characterized by slope scree of up to 50° mainly overlying Luxembourg sandstone and, in the lower part of the project, the Li1 marl formation. The visual observation of a strike-slip fault and several normal faults clarifies the varying level at which the rock top has been encountered here, as well as the presence of the marl at heights where the overlying sandstone remains in other areas. The entire zone is designated as a protected zone on account of its water sources.

Multiple stabilizations were used in this project. The safety factor of the downstream slopes was calculated using the limit equilibrium method. A series of micropiles were installed at alternating batter angles, along with a reinforced concrete cap wall, to stabilize the CR356. Additionally, a shotcrete wall with self-drilling anchors was implemented to stabilize the bottom of the slope. A substantial amount of 1000 m³ was utilized to stabilize the slope during shotcreting, in accordance with a predetermined work phase. Additionally, sub-horizontal drains were designed to improve slope drainage. To comply with the standards for natural slopes and the existing masonry wall along the road, a steel mesh and soil nail were designed to increase the safety factor. Furthermore, some naturalistic engineering measures (wooden mesh, palisades combined with the planting of local pioneer species) were provided to stabilize the first meter of the steep slopes by improving soil cohesion. Figure 7 shows the different phases of the safety work in progress.

In order to follow the diverse steps of the works, we carried regularly the site supervision, especially for micro-pile works, the realization of access ramps made of crushed aggregate, and the securing of the slope with the steel mesh for example.

During these supervision times with also provide advice on the reuse of excavated sandstone. A transversale fault had been also found during the supervision, which allows us to give additional clues about the global slide, and the presence of marl found higher than expected.



Figure 7. CR356 safety works in progress

4 CONCLUSIONS

The roads and the steep slopes of the embankments present in the Mullerthal require special attention due to their very specific geological and topographical characteristics and the resulting requirements for stability and drainage conditions. Several examples were provided to demonstrate how landslides can be economically and safely remedied using both conventional and innovative methods, such as earth retaining systems and biological engineering, while ensuring environmental constraints are respected and future stability is guaranteed.

5 REFERENCES

- © Service géologique de l'Etat, Administration des ponts et chaussées – Carte géologique détaillée harmonisée aux échelles 1:25000 et 1:50000. Version 03 sept. 2018.
- Gruslin, Steve, & Nola, Domenico. (2021). Slope protection with an earth retaining system: respectful of natural resources and the landscape. *European Geologist*, 51. <http://doi.org/10.5281/zenodo.4954439>
- Gruslin, Steve, & Nola, Domenico. (2021). Slope protection respectful of natural resources and landscape thanks to earth retaining system *Proceedings of the 3rd European Regional Conference of IAEG, Athens, Greece, 6-10 october 2021*