

## Avalanche Protection for Construction Site

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**ABSTRACT:** "Linthal 2015" is a more than 1.5 billion project in the eastern Alps of Switzerland to expand an existing hydro power plant. Several construction sites are located in the area at an altitude between 900 and 2500 m above sea level which are operated in three shifts 24 hours 7 days a week. The winter in this particular region is normally long and snow rich and most of the construction area is exposed to natural hazards. Workers and infrastructure as cable ways, digging machines etc. have to be protected against stone falls and avalanches. The avalanche prevention is a central element for the working site management and the builder company has installed an avalanche service organization which analyses the situation and decide about possible measures like artificial avalanche release or even closing of the site. Different protective structures were established. Since in the past the area was not of interest and deserted during the winter, all experience with snow, weather and avalanches has to be built up new. This paper gives a brief description of the project, its different working areas and the avalanche service organization as well as the artificial avalanche release methods.

**KEYWORDS:** Avalanche, prevention, artificial release, working site, avalanche blasting.

### 1 INTRODUCTION

The Linth valley is located in the eastern Alps of Switzerland approximately one hour away from Zurich. At the deepest end in Linthal exists since the sixties of the last century a hydro power plant with an artificial lake at an altitude of 1900m above sea level – the "Limmernsee". The expansion project "Linthal 2015" involves the construction of a second storage lake at an altitude of 2500 m and the connection of the two lakes to get a so called pumped-storage power plant. All machines will be installed in a huge cave approximately 600 m deep in the mountain. The planned pump and turbine power is about 1000 MW.

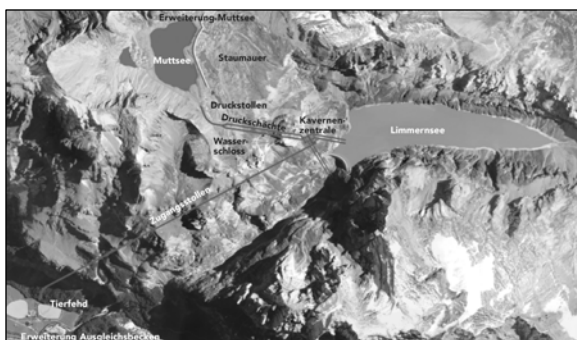


Figure 1. Overview construction site and expansion project.

Several construction sites are located in the area at an altitude between 900 m and 2500 m which are operated in three shifts 365 days a year. Several cable ways and tunnels have to grant the access from the valley to the working areas. At an altitude of 1900 m an installation place on the only existing small level place was established to make accessible the highest working area at "Muttsee". This area is surrounded by steep slopes and is endangered by avalanches.

The avalanche prevention is a central element for the working site management. Several measurements had to be taken by the builder company to make the working areas a safe place during the whole year without having closed the site because of avalanche danger. Since in the past the area was not of interest and deserted in the winter, all experience with snow, weather and avalanches had to be built up from almost zero.

### 2 WORKING AREAS AND ACCESS

There are four main working areas established. Workers have to mount the first level from the valley ground by an existing cable way until the new heavy load cable way will be finished. The top stations of both installations are in an area with avalanche activity.

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Figure 2. Working area Chalchtrittli in autumn 2008.

From Chalchtrittli a 3 km long tunnel is accessing the installation place Ochsenstäfeli. At this small plane near the existing storage lake "Limmernsee" numerous machines, cranes and sheds of the construction companies are stored.



Figure 3. Installation place Ochsenstäfeli with access to Muttsee.

For the digging of the new machine cavern in the mountain there exists access galleries with entrances located underneath steep and long slopes. The mining companies are bringing the excavation through these galleries to the outside. The forth working area is the highest area at the Muttsee where the gravity dam will be constructed after 2010.

To access all the working areas at the highest region workers have to take the first section of the cable way, pass then the tunnel to the installation place and go further with the second cable way. The working site management is responsible to take all measurement to let open the installation as long as possible and to close them if necessary because of avalanche danger.

### 3 CHALLENGES FOR WORKING SITE MANAGEMENT

The builder company is faced with a lot of challenges in regard to the organisation of the plant. Of course the project schedule is tight as it might be nowadays for every project all over the world. The schedule was developed taking in account that all companies can work all time and the site will be closed as few times as possible.

Most of the workers are from regions in Europe which does not have avalanches or even snow and they are not used to behave in such area. While it is more or less understanding for them that there might be danger after a heavy snowfall, it is very difficult for them to believe that there is a rising risk on a sunny spring day in regard to avalanches. To close access ways at noon in good weather conditions sometimes appears as harassment for them.

Since the area was deserted in winter during the last 40 years there was no monitoring of the avalanche activity or the relevant snow data. All this knowledge has to build up new by the responsible persons for natural hazards.

### 5 AVALANCHE AND SNOW CONDITION

The Glarner Alps where the construction site is located is one of the areas in Switzerland with the most snow cover augmentation. Extreme snow falls with tendency for catastrophes has returning interval of about 5 years. There are wind conditions in the higher altitudes which abets windblown snow and a strong south wind can occur which can lead to local reallocation of snow masses.

### 5 ORGANIZATION AND MEASURES

The working site management has established its own organisation to prevent from natural hazards. The department is called the avalanche service department to ensure workers safety also under bad weather circumstances and to keep plant running during winter. In close partnership with the SLF and other partners, an evaluation of all construction areas was made and possible measurements in regard to costs and practicability were drafted. This measurements consists structural, organisational and operational measures.

The most important structural measures are the building of a protection dam and gallery to access the installation place Ochsenstäfeli. The gallery and dam make a save access for workers to their installations. The area behind the dam is filled with the snow that reaches it from the released avalanches and it has to be cleaned out regularly.



Figure 4. Dam against avalanches.

The main point in the organizational measure is that two different groups were formed. The first is the already mentioned avalanche service which is responsible to monitor the weather and snow conditions, to collect all relevant data and to define the danger levels. Based on the European Danger Scale an adapted danger scale with instructions to the workers how to behave was developed. After reviewing the situation and defining the danger level for each working site, the danger level is submitted by SMS to the workers and they have to confirm the receipt of the information also by SMS. The additional level 6 was added to the standard scale to control behaviour of workers in case that avalanche blasting is going on.

Ochsenstäfeli		
Gefahrenstufe	Lawinen-Auslösewahrscheinlichkeit	Massnahmen (Ergänzende Weisungen Lawinendienst sind zu befolgen)
1	Auslösung ist nur bei grosser Zusatzbelastung an sehr wenigen Stellen möglich Spontan sind nur Rutsche und kleine Lawinen zu erwarten	Überwachen auf der Baustelle Verboten! Alle Personen tragen LVS! 10 to Bahn; Zugang über Sicherungsseil! Zugang maschinell räumen möglich!
2	Auslösung ist bei grosser Zusatzbelastung an Stellen möglich Grössere spontane Lawinen sind nicht zu erwarten	Überwachen auf der Baustelle Verboten! Alle Personen tragen LVS! Bei Arbeitschluss sind Krane zu sichern! 10 to Bahn; Zugang über Sicherungsseil und überwacht! Zugang maschinell räumen möglich!
3	Auslösung ist bei geringer Zusatzbelastung möglich Spontane, auch mittelgrosse Lawinen sind möglich!	Überwachen auf der Baustelle Verboten! Alle Personen tragen LVS! Aufenthalt nur in Galerie und hinter Schutzdämmen! Aufenthalt bei Dunkelheit und bei Sprengarbeiten im Freien verboten! Nach Sprengarbeiten Zugang ins Freie erst nach 15 Minuten erlaubt! Krane gesichert! 10 to Bahn; Räumung Zugang nur mit Bewilligung Lawinendienst! Zugang nur über Sicherungsseil und überwacht! Kein Zu- und Abstieg bei Dunkelheit!
4	Auslösung ist bereits bei geringer Zusatzbelastung an zahlreichen Stellen wahrscheinlich Spontane, mittlere und mehrfach grosse Lawinen sind zu erwarten!	Aufenthalt im Freien verboten! Arbeiten im Freien eingestellt! Stollen geschlossen! 10 to Bahn; Betrieb eingestellt! Laufwagen in Bergstation! Maschine im Stollen (ZSB)
5	Spontan sind viele grosse Lawinen auch in massig steilem Gelände zu erwarten!	Baustelle eingestellt (Ober- und Untertal)! Aufenthalt auf der Baustelle verboten!
6	Durch Sprengen werden Lawinen künstlich ausgelöst. Diese können mittlere aber auch grosse Lawinemasse erreichen	Aufenthalt im Freien verboten! Installationen gesichert! 10 to Bahn; Betrieb eingestellt! Laufwagen in Bergstation! Kein Aufenthalt in Bergstation! Massnahmen sind einzuhalten, bis Änderung von Stufe durch Lawinendienst erfolgt!

Figure 5. Example for Avalanche Danger Levels

The avalanche service is formed with the head of the working site management, the chief of the natural hazard department and two external experts which know the area very well. The operational measures such as avalanche blasting are then delegated to the second team, the avalanche blasting team. The two teams are working very close together and they are connected through the chief of the natural hazard department who leads both teams. The splitting is very important and allows the members of the

avalanche blasting team to do their work in calm and uninfluenced area once they have received their mission. Construction companies have to address by the avalanche service department only.

## 6. AVALANCHE BLASTING

Avalanche blasting is the most effective method for the working site management to protect the area from avalanche danger and keep the site open as long as possible. It has to be done very often after snowfall or snow deposition by wind to keep avalanches and its destruction potential as small as possible. Currently there are three different methods in operation:

- blasting by hand
- blasting with helicopter
- blasting with automatic station and remote access

Since all working sites have to be closed when avalanche blasting is going on it has to be done as fast as possible and a good preparation is needed.

### 6.1 Explosive charge storage, transportation and preparation

To transport the explosives, the corresponding regulations and rules (SDR/ADR) has to be followed. In the non public area of the site, a storage depot has installed with an adjacent preparation room. The heliport is just nearby. A slurry type explosive is used for blasting, called with its trade name "Alpinit". The charge is equipped with a blasting cord and a net to avoid that it can slide down the slope when the snow cover is frozen.



Figure 6. Prepared charges for helicopter blasting.

The system "Avalanche Guard" is used as an automatic system for one working site and it can be operated from the office by remote control. For this system, the explosives has to be filled in a carton tube.



All charges are equipped with a Recco plate that they can be found easily if they become a dud.

### 6.2 Avalanche blasting by helicopter

Since the process is known at all mountain regions where avalanche blasting is done it is not described in detail here. All working site areas have its difficulties, mostly in regard to existing infrastructure in the avalanche sliding zone. Figure 7 shows a blasted avalanche at Chalchtrittli. The avalanche release was done at the first possible weather condition after the snowfall in the morning of February 18<sup>th</sup> 2009.

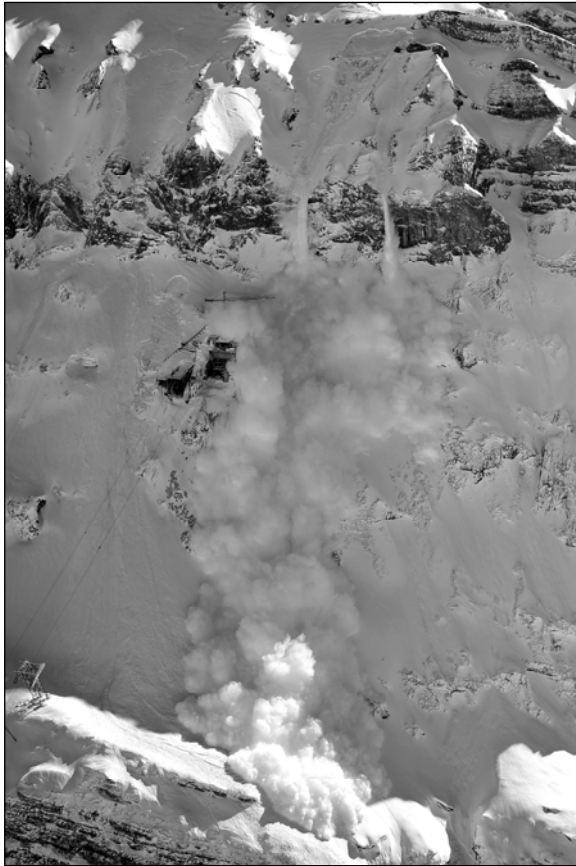


Figure 7. Artificial release of avalanche at the working site Chalchtrittli.

The construction site with the crane is fully covered with the snow. The ropeway pylon at the left lower corner of the picture seems to be well located since the avalanche is guided away from it. The blasting was done in a down to top way which functioned very well in this case. But of course there is no guaranty that the snow can be released sequential in this manner every time.

At the other working site the same method was exercised with the same success. Figure 8 shows the installation place at Ochsenstäfeli.

The avalanche overruns the dam and reaches the plane with all infrastructures.

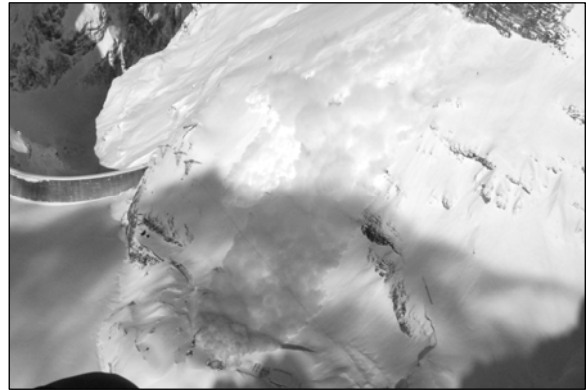


Figure 8. Artificial released avalanche overruns the dam.

There were no damages to the infrastructure in both cases but a lot of shovel work to do ...

### 6.3 Avalanche blasting by Avalanche Guard

The access to the Ochsenstäfeli is very important and should also be secured if there is no flying weather or during the night in case of heavy snow fall. For these situations the automatic system "Avalanche Guard" was installed at three locations. The Avalanche Guard is as system with one to four boxes of which charges are thrown up to 150 m by a propulsive charge. The system can be operated by remote control from the office which makes it possible to blast avalanches during bad weather periods or during the night. Figure 9 shows a location with two boxes and a total of 20 charges for 2 different starting zones.



Figure 9: Avalanche Guard in waiting position.

## 7 CONCLUSION

The avalanche protection for construction site is a combination of structural, organisational and operational measures. It might be not possible or cost effective to protect the site only with structural measures.

For the organizational part, it is important to establish an organization which can act as a team in a timely manner. The partition of the "deciding" responsible persons from the "operational" team shows good results and allows the people to do their work efficient, calmly and un-influenced.

The avalanche blasting is a very important instrument to protect the working sites. Different methods at different locations are needed. Since every winter has its own face and the project just started last winter there will be a lot to learn furthermore.

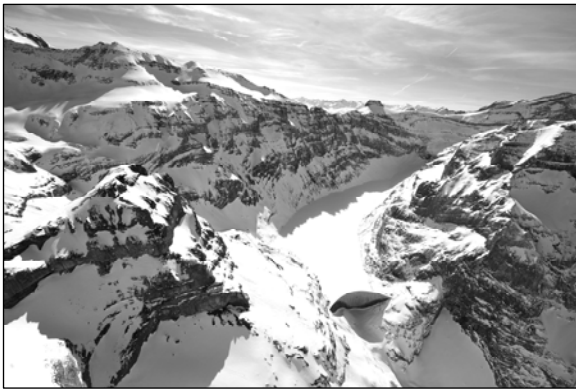


Figure 9. Overview of the Limmernsee

## 8 REFERENCES

- Kraftwerke Linth Limmern AG, 2009. Zukunft Wasserkraft Linthal 2015 Newsletter 1/2009. Fridolin Druck und Medien, 4 pp.
- Margreth S., 2008. Lawinengefährdung der Bauinstallationsplätze KLL, Institut für Schnee und Lawinenforschung, 8 pp.
- Stoffel L., 2001. Künstliche Lawinenauslösung Praxishilfe, Institut für Schnee und Lawinenforschung pp. 21
- Walcher F., 2008-2009. Photographer of Figure 3, 4, 7, 9.