Adaption of Snow Bridges in the Großtal Avalanche in Galtür-Tyrol - Austria, Constructive and Static Problems

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ABSTRACT

The dimensioning of the heights of supporting structures is subject to great uncertainties. For example, uncertain meteorological data, short series of measurements, wind drift or the influence of the wind field on the created construction. The design variable of the "extreme snow height" (H_{ext}) shows an enormous high bandwidth depending on the applied method. The data basis at the beginning of the construction of defense structures in the starting zone was even lower than today. Therefore, the supporting structures of many older construction sites have been dimensioned for too low snow heights and are snowed over and thus overloaded in snowy winters. An alternative to new construction is to raise the existing steel snow bridges. This approach is explained using the case study of the "Großtallawine" (Great Valley Avalanche) (Galtür-Tyrol-Austria). Two building types were developed: the type of construction "Rigid" and the construction type "Flexible". These two variants differ in their different girder connection. The load assumptions and statics are described in detail. The advantages and disadvantages are discussed and the costs are shown. The increase of supporting structures is a practical and economical alternative with regard to labor and costs. The type "Flexible" has proven to be more suitable for practical use. However, the prerequisites for an increase must be met. The special conditions of each construction field must be considered, the described procedure is not transferable one to one to each construction field.

1. INTRODUCTION (BACKGROUND AND AIMS)

1.1 The catchment area and its construction history

The catchment area is located on the orographically left side of the Paznaun valley in the municipality of Galtür, Tyrol, Austria. The area of the avalanche starting area extends from 2,300 - 2,700 m above sea level and covers an area of approx. 8 ha. To date, 11 avalanches have been documented.

In 1967, after a major event that injured 4 people, damaged 5 houses and destroyed 30 cars, a construction project was drawn up. ÖAM supporting structures with effective height of grate of Dk = 3.0, 3.5 and 4.0 m were erected on different foundations. The majority of the supporting structures to be raised were constructed using so-called "rust foundations". This is a buried grate rigidly connected to the girder, the tension and compression forces are dissipated like a "dead man anchor". Fig. 1 shows the erection of a ground plate supporting structure using an excavator. The screes were terraced. In the 80s, individual simple elevations of 0.5 m were already carried out. A U-shaped steel was welded to the beams (see Fig. 2).

The 2010 project led to the extension of the defense structures in the starting area against the SW (towards the valley) with an effective height of grate Dk= 4.5 - 5.0 m and to the new construction of the top row of supporting structures as a replacement for the steel snow bridges, which were largely destroyed by rockfall. Furthermore, it was planned to replace the existing plants with an effective height of Dk= 3.0 m by new ones with Dk= 4.5 m.

	
Figure 1: Installation of a supporting structure with high of 3.5 meters, the foundation will fixed with a will be filling with soil material.	Figure 2: First easy increases of the supporting structures in the begin 80ths of the last century.

1.2 Problems

The dimensioning of the heights of supporting structures is subject to great uncertainties. Reliable meteorological data with sufficient measuring network density and sufficiently long measurement series are not always available. The wind drift or the influence of the wind field on the construction must be considered in advance. The data basis at the beginning of the construction of defense structures in the avalanche starting zone was even lower than today. Apart from the uncertain data basis, the design variable of the "extreme snow depth" (H_{ext}) still represents the greatest uncertainty. Here there is a wide range of methods for determining H_{ext}. The following methods are to be mentioned here: Lauscher (1969), Wakonigg (1975), Fliri (1992), Leichtfried (2010), extreme value statistical evaluations (with height extrapolation), consideration of strong wind influence. The range of H_{ext} for this construction site varies between 240 and 797 cm depending on the chosen method. The latest approach, according to Hölzl, Schellander and Winkler (2017), which has determined snow depth gradients for the whole of Austria, yields values for the construction site of around 400 cm for H_{ext}. Margreth et al. (2011) point out that after completion of the supporting structure, further observations of the snow distribution over several years are necessary before it becomes clear whether the choice of the plant height was actually correct As can be seen from Fig. 3, the snow bridges erected in 1976- 1982 are repeatedly "snowed over", even in "normal" winters. The reason for this is the strong influence of wind on the snow distribution in the construction site. The remediation and supplementary project 2010 now requires the following alternatives to be examined: demolition and new construction of parts of the supporting structures and an increase of the existing ones.

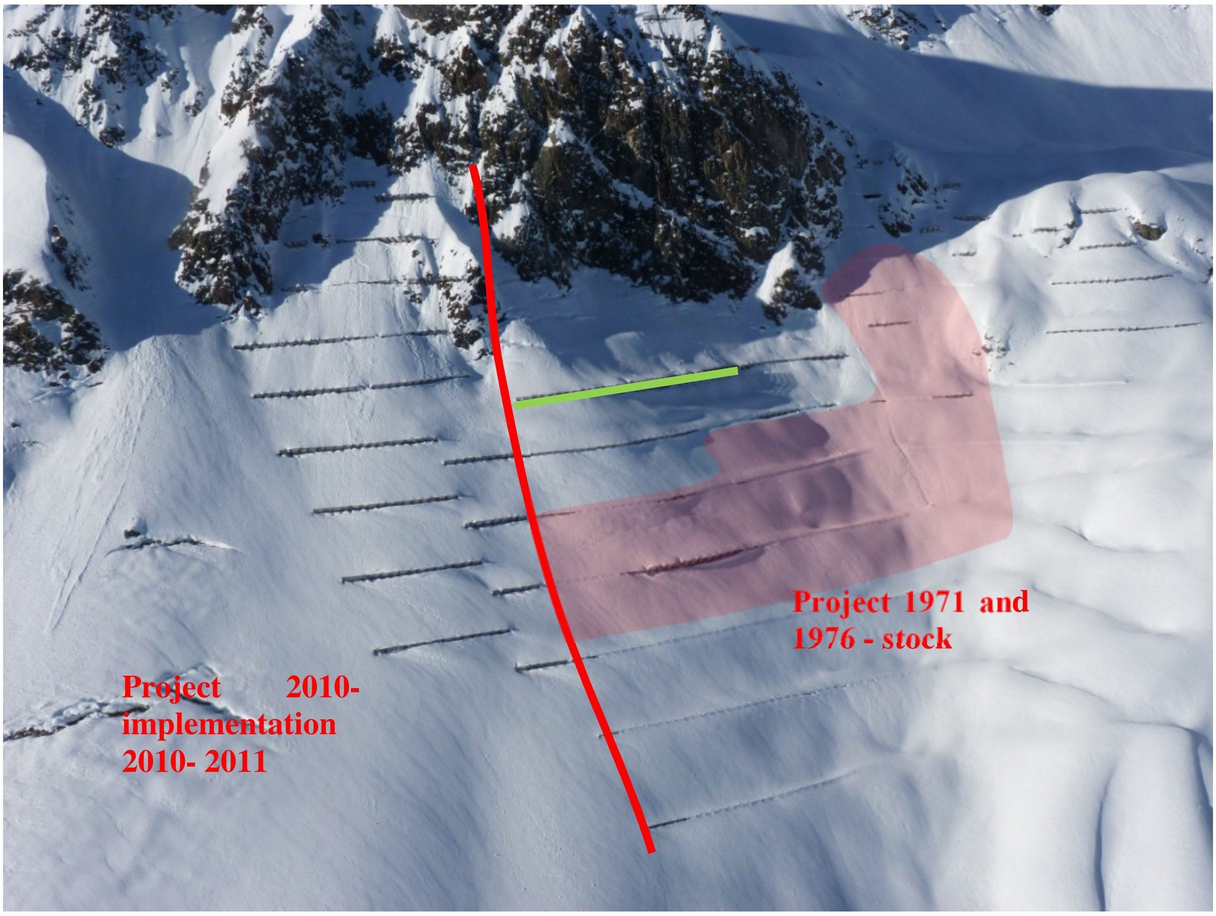

Figure 3: The project field in snowy January 2012. The area with a red background is the one in which the steel snow bridge increasions have taken place in recent years. The green line represents the (local) top row of the supporting structure. This had to be replaced due to severe rockfall damage.

2. METHODS

In order to avoid the costs of the removal and the new construction as well as the associated expenditure, the possibility of increasing the existing steel snow bridges was examined. Two construction types were developed. These differ only in the area of the girder connection: joint "g1" in Fig. 3.

In general, the supporting structure was designed and optimized in such a way that the existing structure only receives a minimal additional load as a result of the supporting structure's increase.

The static calculation of the two-dimensional system was carried out with the help of Dlubal's engineering software. For the structural analysis and design by civil engineer Rainer Zangerle, Kappl. Eurocode 3 and Ö- NORM EN 1993-1-1 were also used. The two variants of increasing and the considerations associated with them are explained below.

2.1 Load assumptions and detailed statics

The load acting on the (elevated) steel snow bridges was determined analogously to the Swiss Guideline for defense structures in the avalanche starting zones (2007). These load assumptions are based on two load models, as shown in Figure 4. (Since the construction field consists of closed support rows, the marginal forces are not taken into account)

Load case 1: Fully snowed-in support system, with evenly distributed snow pressure, the point of application of the resultant is halfway up the supporting structure.

Load case 2: Partially backfilled supporting structure by a set snow cover with a snow height of 77% of the supporting structure height. The resultant impacts on this load model is in the amount of 38.5% of the supporting structure height. The specific snow pressure is increased by a factor of 1.3 due to the snow cover set.

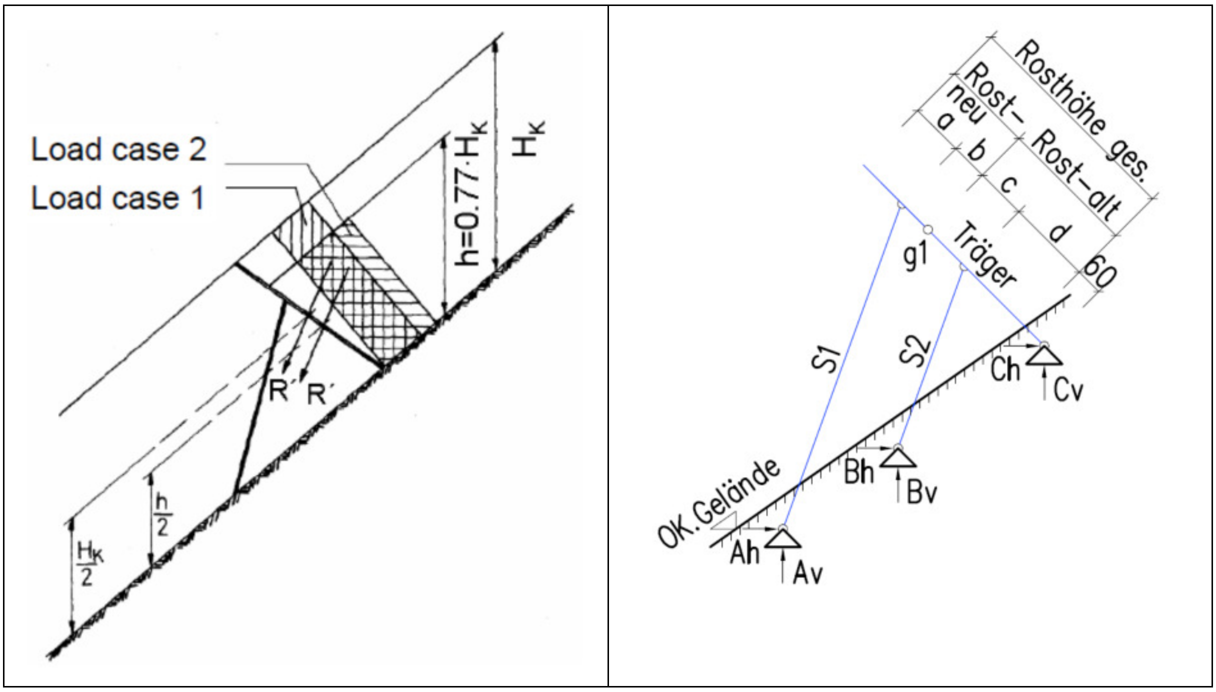

Figure 4: left: Point of attack of the resultant and specific snow pressure distribution in both load models (from Margreth, 2007).
right: Static system of the increasing supporting structure. (*Gelände= surface, Träger = girder, Rosthöhe = height of the crossbeam, Rost = crossbeam, neu = new, alt = old;)*

For the increases, the three new grate heights (1.18, 1.61 and 2.00 m in Figure 3 on the right) were worked out (a and b are variable, depending on the projected increase of the effective height of grate). The higher load, caused by the increase in height, must be absorbed as far as possible by the existing structure. In the course of the calculations, the existing supporting structures and the associated increases were tested with regard to stability and support reactions. Special attention was paid to sufficient static design of the existing girder and supports. Furthermore, the respective maximum support lengths were determined in relation to the greatest load. The load case 2 with a set snow cover was regarded as decisive for the increase. In this case, the resultant force is high due to the higher effective height, but the increase element is not loaded. This assumption was confirmed by the analysis of the support forces. In the old snow bridges the supports are underdesigned. Due to the "special" foundation (rust foundation) with terraces on the mountain side (see Fig. 1) and the associated reduction of the snow pressure parallel to the slope, this dimensioning weakness is not fully bearable.

2.2 Construction types

For the "Rigid" type, the existing girder is raised by means of welding plates on both sides of the girder web (see Fig. 4). For this increase, an IPE 270 (elevation 1.18 m) was welded to an IPE 300 beam on site. The welding plates as a rigid connection provide additional relief for the existing supporting structure, as the pressure is diverted into the ground via two supports. However, the full bending moment cannot be transmitted through the joint. In advance, the moment above the support was regarded as critical, as the new pressure foundation of the "S1" heightening support could settle strongly and the stresses arising as a result would overload the supporting structure. In the course of the construction, however, the subsoil proved to be sufficiently stable. A disadvantage is the more expensive "construction costs". The elevation elements were lifted individually from the access road by crane. A helicopter lift would be another option.

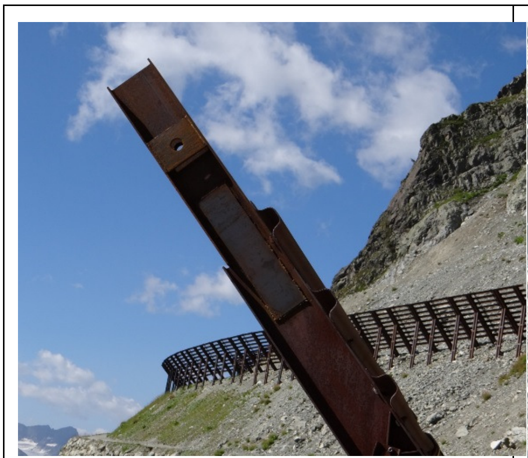

Figure 4: Construction Type rigid

Figure 5: Construction Type flexible

The "Flexible" type is connected by means of fasteners and bolts in the same way as the supporting structures are connected to the micropile. After preliminary work (drilling, welding on the reinforcing straps), the elevation elements can be lifted like works with helicopter (Fig. 5). In this type of construction, the connection is designed as a joint and does not relieve the existing structure. Due to the "play" of the joints, the construction can follow slight settlements of the pressure foundations and stresses or "constraints" in the girder can be avoided. However, the "play" of the joint is limited, the girders have a distance of approx. 1 cm to each other.

2.3 Costs

In the Regional Office Upper Inn Valley (Gebietsbauleitung Oberes Inntal), the new construction of a 4.5 m plant amounts approx. 950 € / running meter. The costs of removal and incurred transport costs are not taken into account here. The increase cost 450 €/running meter in 2012 and was reduced in 2013 by optimizing the workflow to 410 €/running meter.

3. RESULTS

Through the increases described above, it was possible to convert the existing, too low construction relatively inexpensively into such with an effective height that is up-to-date and the state of the art. An increase in supporting structures is profitable in terms of labor input and labor costs. If the prerequisites for an increase exist (sufficient foundation, existing support structure sufficiently dimensioned for increases), the procedure presented here is in any case an expedient, economic and economical alternative.
Of the two increase variants, the type "Flexible" has proven to be more practicable. This is not least because a faster work progress can be achieved here. The increases were already successful in the winter of 2012. Edge forces were not considered in the design, which is why the procedure described here cannot be transferred one to one to another construction site. Particular attention must be paid to the performance of the tension foundation.

4. CONCLUSIO

The determination of the extreme snow height for the dimensioning of snow bridges is still subject to great uncertainty. In particular, the influence of wind on a construction field or its influence by the executed construction can be determined only after implementation of the measures. The described designs show a possibility for the adaptation of existing steel snow bridges. However, an examination of the existing support structure prior to such an adaptation is inevitable. Increasing the effective height of grate will result in higher loads that the base of the structures may not be able to handle. This would increase the probability of failure. However, the shown methods, are an economically way to adapt existing support structures made of steel.

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