AVALANCHE PROTECTION FOR ROSA KHUTOR

Chris Stethem[1] & Roger McCarthy[2]

[1]Chris Stethem & Associates Ltd.
[2] RDM Resort Development and Management Consultants

ABSTRACT: The 2014 Winter Olympics have been awarded to Sochi, Russia. The Alpine skiing venue will be the new ski area now being built at Rosa Khutor, above the village of Krasnaya Polyana. Planning and implementation of the avalanche protection program is an important part of the development given that the area is one of complex alpine terrain and multiple avalanche paths. Snow safety planning includes avalanche risk mapping, structural protection and explosive avalanche control. The explosive control program will include both fixed remote explosive systems and control teams on skis. The paper will be a visual tour of the terrain and the methodology to implement the avalanche protection to open the area.

KEYWORDS: Avalanche, ski area, mitigation, Winter Olympics

1. INTRODUCTION

The objective of this paper is to describe the planning process for avalanche protection for the 2014 Winter Olympic alpine skiing venue at Rosa Khutor, Russia. The Olympics were awarded to Sochi, Russia in 2007.The new Rosa Khutor ski area is being built to stage the alpine events.

2. LOCATION

The Rosa Khutor ski area is located on the Aigba Ridge in the western Caucasus Mountains, 40 km east of Sochi.

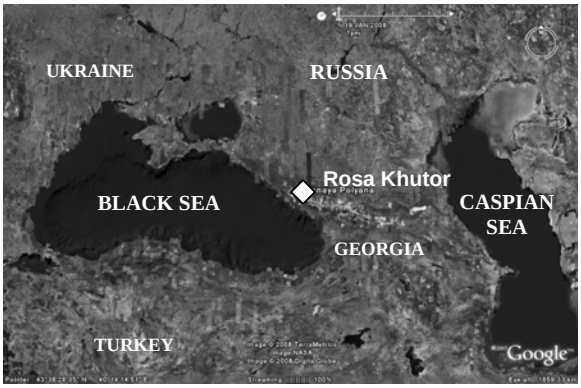

Figure 1. The location of Rosa Khutor in the Western Caucasus Mountains (Google Earth image background).

[*]*Corresponding author address*: Chris Stethem, 409 8th Ave., Canmore, AB, T1W 2E6 Canada; tel: 430 678-2477; fax: 403 678-3486; e-mail: cstethem@snowsafety.ca

The region has become known for alpine skiing since the Alpica Service ski area development began in 1991 above the village of Krasnaya Polyana. The area has also become popular as a helicopter ski destination.

3. CLIMATE AND SNOWPACK

The climate of the Western Caucasus results from a meeting of cold air from the north, and warm, moist air from the west and south from the influence of the Black Sea and Mediterranean Sea (UNEP-WCMC 2003). The climate in the Sochi area is classified as humid subtropical (Koppen Cfa). Precipitation in the southern slopes of the western highlands exceeds 2500 mm per year (Fedyaev 2008).

The result is a heavy snow climate with moderate temperatures in the mountains near Rosa Khutor. Elevation is important, with higher amounts of snowfall being observed as the moist air is lifted and cooled at higher elevations. The snowpack is described as reaching 5 – 8 m in the alpine region of the Krasna Polyana area.

Precipitation in the valley can be observed as rain or snow. In this type of climate, where moist and cool air masses meet, fluctuation of the freezing level can move the snow line up and down the mountain over the winter. This results in the potential for high speed dry snow avalanches, slower wet snow avalanches or glide avalanches.

Fieldwork in 2008 revealed a complex snowpack resulting from low, early season snowfall. A well developed mid-pack facet layer and loading from heavy snowfalls in February 2008 resulted in widespread deep slab avalanche activity throughout the region.

4. TERRAIN

Rosa Khutor extends from the ridge at 2335 m to the river valley at 560 m. The majority of the ski terrain lies on the north aspect between the ridge and 1000 m elevation.

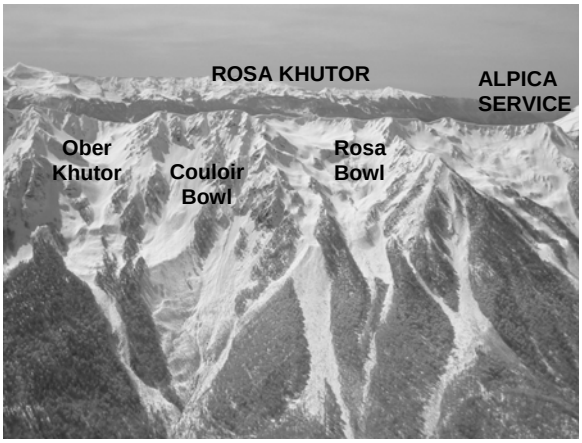

Figure 2: Rosa Khutor overview (N. Polyakov).

The rugged alpine terrain results in avalanche paths starting on a variety of alpine bowls, steep couloirs and fall line ridges. Avalanche paths overrun much of the development terrain and have the potential to affect several of the alpine race courses.

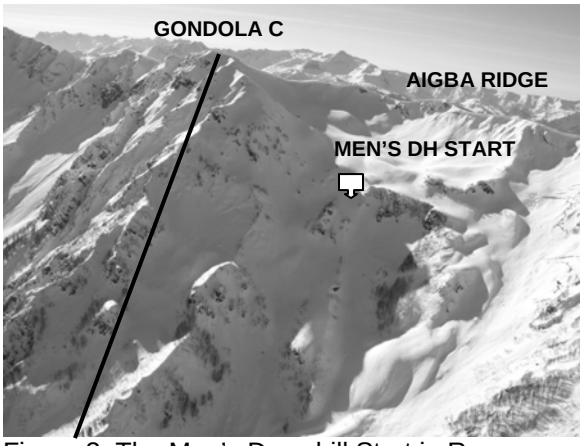

Figure 3: The Men's Downhill Start in Rosa Bowl.

The ground surface in many of the larger alpine starting zones is a combination of rock outcrops, grasses, rhododendron bushes and birch thickets. The resulting low surface roughness leads to a threshold snow depth for avalanches (approx. 1 m) and the potential for glide slab avalanches during some winters.

Mature beech forests below treeline provide excellent tree skiing terrain. With the extensive steep open forests, a potential for small avalanches exists at numerous locations. Skier compaction is expected to be an important influence in both the open alpine terrain and the tree glades.


Figure 4: Ground cover in Rosa Bowl.


Figure 5: Natural glades below tree line.

The Aigba Ridge is well known for free skiing. Skiable steep couloirs and corniced headwalls abound. The Rosa Khutor area is readily accessible hiking about 2 km along the Aigba Ridge from Alpica Service. Skier compaction is already having some effect in stabilizing the snowpack on the more popular lines on Boundary Ridge, which divides Rosa Khutor and Alpica Service.

Figure 6: Free skiing terrain east of the Gondola.

5. AVALANCHE RISK TO FACILITIES

Local knowledge and preliminary broad scale mapping for the master planning process had identified the presence of the snow avalanche hazard. The first step in the snow safety planning process was to complete detailed mapping of the avalanche risk zones. Both occupied structures and ski lifts were of concern in the development of the resort.

Criteria similar to the risk mapping guidelines in Switzerland and Canada were used to identify a red zone of high risk (return periods <30 years and/or impact pressures ≥30 kPa) and a blue zone of moderate risk (return periods 30-300 years and impact pressures <30 kPa).


Figure 7: The runout zone of avalanche path A1. The immature deciduous vegetation has been cleared for skiing.

Uncertainty is a significant factor given a lack of historic avalanche observations or a local database on avalanche runout characteristics.

To identify the risk zones dynamic models of avalanche motion including the Voellmy Salm (Salm et al 1990), PCM (Perla et al 1980 and PLK (Perla et al 1984) were applied. Friction coefficients were determined by fitting the models to the observed maximum damage from past avalanches in the area. Topographic-statistical models of avalanche runout were of limited use here given the lack of a database for the region and the fact that most of the avalanche paths on Rosa Khutor ran out on slopes over 10°.

A significant avalanche risk is present at several ski lift tower locations and nearby some of the lift stations. Return periods for avalanches at these structures were estimated and recommendations for avalanche defence were made based on return period. Where ski lift towers were affected by avalanches with estimated return periods ≤ 30 years, structural defence by splitters or reinforced design was recommended. Acceptance of risk was recommended for lift towers with longer return periods.

Remote explosives systems (such as Gazex) are planned for the key avalanche starting zones. The use of remote explosives systems and the potential for reduction of risk was taken into account in the recommendations for defence of lift tower locations.


Figure 8: A chairlift tower adjacent to the Fin Path (D5) avalanche trimline.

6. SNOW SAFETY PLAN

Preparation of the preliminary snow safety plan followed a similar process to other ski areas including:

- Preparation of an Avalanche atlas;
- Identification of avalanche control zones;

- Identification of personnel requirements;
- Identification of closure locations;
- Description of the avalanche hazard evaluation process;
- Identification of avalanche control methods;
- Layout for remote avalanche control systems;
- Layout of ski and helicopter or handcharge control routes;
- Preliminary sequences of operation for various scenarios;
- Emergency response plan.

Remote avalanche control systems will be essential to complete avalanche control in a timely manner in view of the numerous avalanche paths and the exposure of some of the Olympic race courses. The planned operations include scenarios for remote avalanche control on a 24 hour basis.

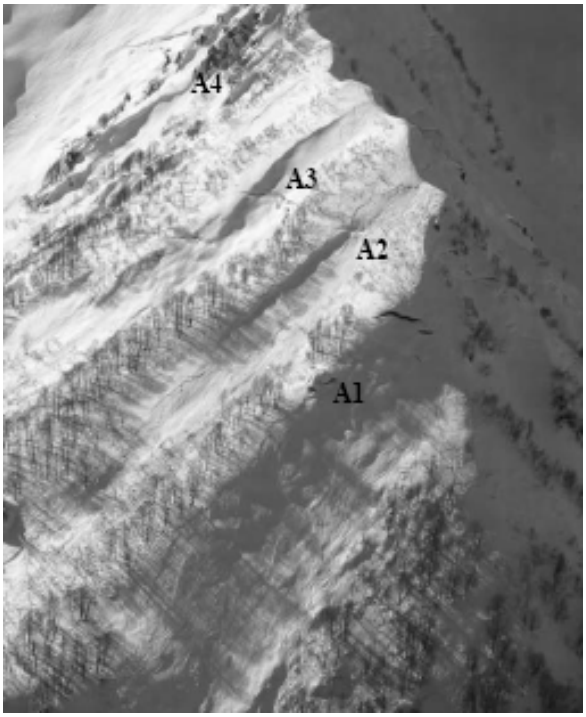

Figure 9: Remote avalanche control targets on the ridge between Rosa Khutor and Alpica Service.

A variety of remote systems including Gazex, Avalanche Guard and the Wyssen Tower could be applicable to Rosa Khutor. Gazex have already been built at the adjacent Alpica Service ski area.

The most likely scenario for daily ski area operations during storms includes a 3.5 hour period for avalanche hazard evaluation, remote avalanche control firing and control routes by helicopter and on skis prior to opening.

Additional scenarios are included for protection of night grooming and snowmaking operations, developing hazard and second day operations following storms.

Some uncertainty remains with respect to the impact of local regulation on the options for active avalanche control. These regulations may ultimately be the most important factor in determining which methods can be applied.

Ski control routes will be critical for clean-up of small avalanches and hang-fire prior to opening.

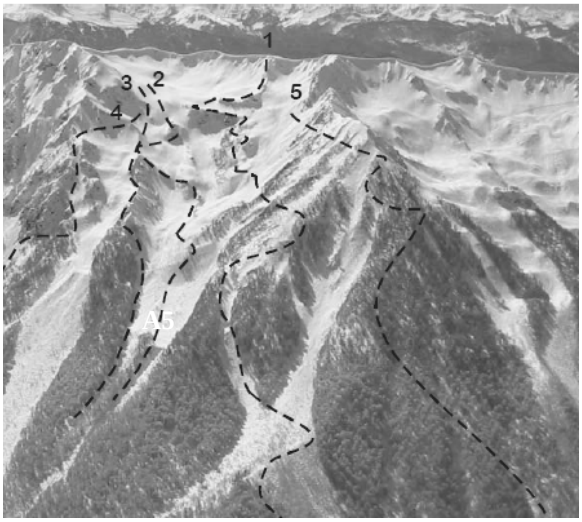

Figure 10: Ski control routes in Rosa Bowl and Boundary Ridge.

7. CONCLUSIONS AND DISCUSSION

Risk assessment and mapping, avalanche atlas preparation and preliminary avalanche control planning are important steps in opening the new alpine resort at Rosa Khutor. Risk assessments include both the natural case and the risk with avalanche control measures in place.

Uncertainty is a factor which must be recognized and articulated in risk assessment. Methods developed in other mountain regions can be applied; however these must be calibrated to fit the local avalanche characteristics

Remote systems for avalanche control will offer important capability for 24 hour avalanche control at Rosa Khutor. The priority

for access and use of terrain during an Olympic event requires all weather avalanche control capability.

Planners should be aware that practical considerations in construction, project schedule, local regulation and economics are important factors. These can determine what passive avalanche control measures actually get built and what methods of active avalanche control are applied.

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