Reinforced fill slopes: Reservoir tsunami protection barrier, Axamer Lizum, Tyrol, Austria

The water storage reservoir 'Dohlennest' was built in the ski resort of Axamer Lizum, close to the Tyrolian capital of Innsbruck. Such reservoirs are located close to ski slopes to store water for artificial snow production prior to the starting of the ski season. The storage reservoir and the pumping station are situated in the Malgruben mountain, a location surrounded by steep slopes and rugged peaks of the Kalkkögel. To secure the storage reservoir against snow avalanche impacts, two avalanche protection barriers were constructed to deflect and/or prevent avalanches from entering the reservoir and creating a tsunami wave.

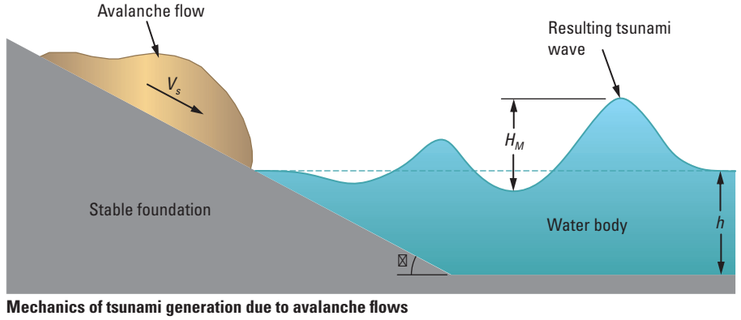
Various areas of avalanche danger were located, and scenarios were investigated and simulated to determine degree of risk. It was concluded that the most critical form of avalanche in the area was the 'snow slab' avalanche. This is where an extended weak layer is located within the snowpack and when this becomes unstable an avalanche can occur.

The slope area Southwest of the storage reservoir is characterised by steep slopes, rocky peaks and steep scree slopes with debris flow channels. The immediate proximity of the reservoir dam crest to the debris cones is the main cause for the prevailing avalanche hazard. The avalanche starting areas are in the upper, steepest part of these debris cones and reach up to the hollows between the rocky peak areas. The fall course is steep and flows directly into the storage reservoir. The fall elevation from the highest point of the cracks to the crown of the reservoir varies between 130 m to 170 m.

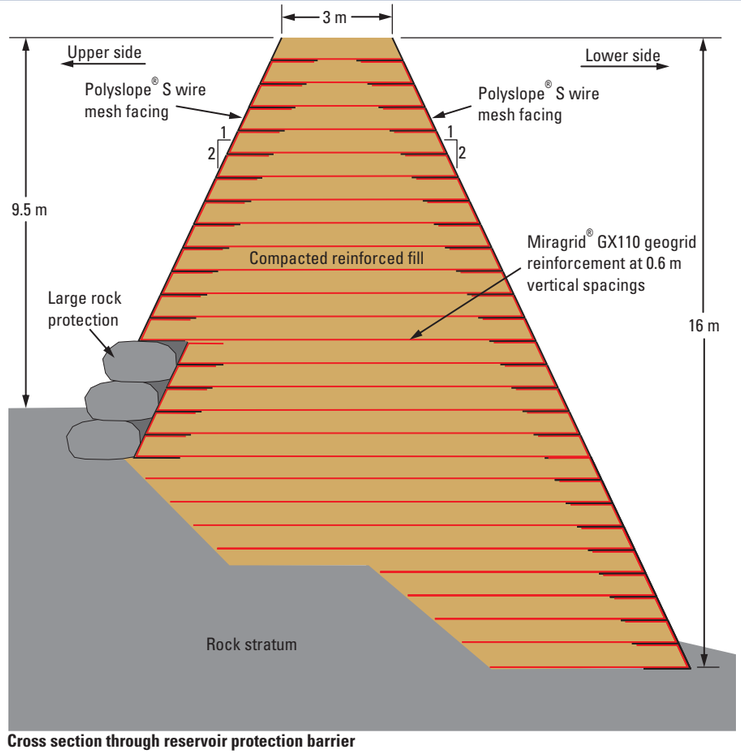
Even without avalanche simulations, it was evident that avalanches can damage the reservoir. Simulations of the design avalanche (using a 150-year return period) show that avalanches from the break-off areas can penetrate the reservoir. For this design return period, the avalanche flow velocity in the area of the reservoir crest is 22 m/s.

Avalanche flows into the storage reservoir cause a resulting tsunami wave to be generated which can spill over the reservoir crest if the freeboard is insufficient. The magnitude of the maximum generated tsunami wave height H_M is related to the depth of the water body h and its shape, and the momentum of the avalanche flow (being its mass and downslope velocity V_s). The resulting water spill causes flooding of the area below the storage reservoir and in the water courses of the streams below.

For the design 150-year return period, avalanches enter the reservoir unhindered. A consequent analysis yielded a maximum generated tsunami wave height of 3.1 m which would have resulted in significant water spill over the reservoir crest with subsequent below-crest flooding and damage.



Mechanics of tsunami generation due to avalanche flows



Cross section through reservoir protection barrier

Polyslope® S facing on protection barrier

Completed protection barrier with vegetated surface

To protect the reservoir from the effects of avalanche flows it was decided to construct two protection barriers, one along the Southwest side of the reservoir and the other along the Southern side. These protection barriers were constructed up to a height of 9.5 m on their upper sides and consisted of a Polyslope® S double-sided reinforced slope system which used Miragrid® GX110 geogrid reinforcement at 0.6 m vertical spacing in the reinforced slope. Miragrid® GX geogrid reinforcement is ideal for long term reinforced soil applications because it has well-defined strength and strain properties over long time periods. The reinforced fill used was local granular material. On the upper sides of the protection barriers large rock was used at the base of the slopes to protect from erosion and other damage.

The avalanche protection barriers were designed to primarily deflect avalanche flows away from the reservoir water surface. The protection barriers can prevent design 150-year return period avalanches from entering the reservoir. This has resulted in the greatest possible safety being achieved.

Reinforced protection barrier during construction

Client: Axamer Lizum Aufschliessungs AG, Tyrol, Austria.

Consultant: Ingenieurbüro Illmer Daniel e.U. and Geoechnik Henzinger, Tyrol, Austria.

Contractor: ALPENBAU GmbH, Terenten, Austria.