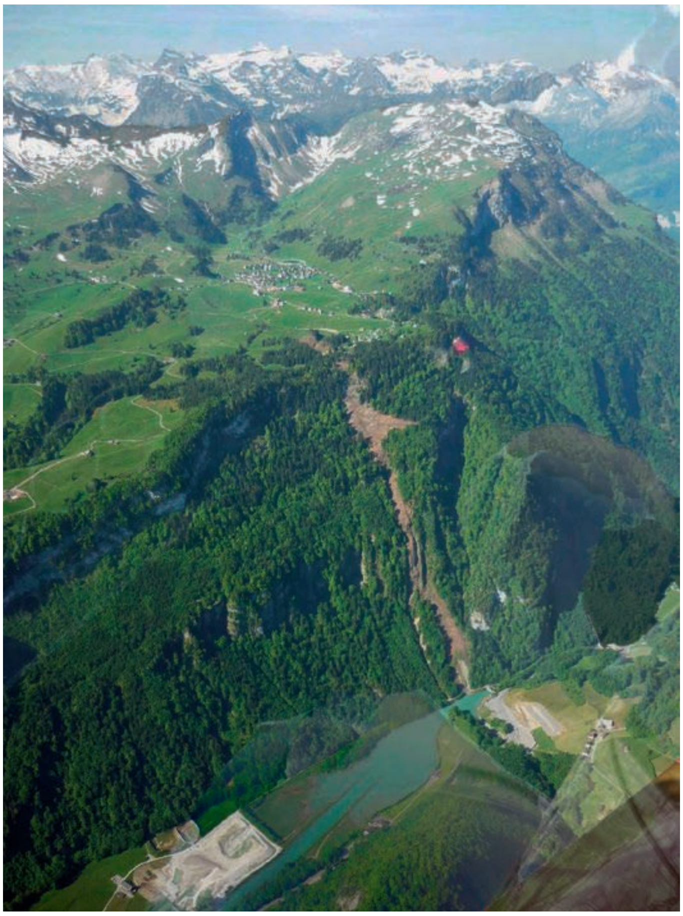


**Pic. above:**
**Future of floating up to Stoos**

**Pic. left: The access to Stoos has to be modernized, the line is already visible**

# The world's steepest funicular railway

**THYSSEN SCHACHTBAU GMBH was awarded the contract for the replacement and modernisation of the funicular railway at the Swiss village of Stoos which has been getting on in years. As well as refurbishing the system the project will also focus on improving the local tourist infrastructure.**

Stoos is a car-free mountain village and a ski resort in the Morschach district of the Swiss canton of Schwyz. The village lies on a high plateau at a height of 1,305 m. It has 106 inhabitants and accommodation for some 2,200 visitors. The ski area reach-es to a height of 1,922 m. Access is via a road from the village of Muotathal and by a funicular railway from Schwyz-Schlattli or by cable car from Morschach.

The existing funicular railway in Stoos can transport 1,000 persons an hour. It was first built in 1933 and takes passengers up to 1,383 m, spanning a height difference of 786 m. At a gradient of 78 % the installation is one of the steepest funicular rail-ways in the world. The current operating approval apply to the end of 2016. As it was considered too expensive to renew the existing funicular railway the Stoos Railway Company now plans to construct a new modern system.

## History of the funicular railway

The history of the funicular railway can be traced back to 1411 when such a device was first described in a military firework book of that year. These earliest funicular railway systems were essentially used for transporting persons and materials to cas-tle buildings on steep hill tops. The world's oldest preserved funicular railway is thought to be the cable system at Hohensalzburg Fortress, which was erected in 1495, while one of the oldest passenger-carrying funicular railways is the water-ballast Prospect Park Incline Railway that first opened in 1845 at Niagara Falls in the USA. The first of the modern funicular railways to be built in Europe was the 1862 installation that operated between Rue Terme and Croix Rousse in the French city of Lyon. This system was shut down in 1967 and re-opened in 1974 as a rack-and-pinion railway.
Some of the earliest funicular railways were built as water-ballast systems, though fixed steam engines were also used. Many of the water-ballast installations were converted to electric drive at the beginning of the twentieth century. Electric powered systems allow lighter cars to be fitted and these require less braking force and can therefore travel faster. This in turn increases the transport capacity of the installation.

Pic. left:
Existing line

Pic. right:
Preperatory operations for raise drilling site

## Development of the new Stoos funicular railway

The Stoos railway has to negotiate a gradient of 110 %. The new installation will fea-ture spacious gondolas with large window areas giving unobstructed views. Each gondola will hold a maximum of 136 passengers. Operating at its maximum speed of 10 m/s the system can transport 1,500 persons an hour. The funicular railway elctri-cal drive is positioned at the top station. The bottom station will have a cable tension-ing system while half way up the track – as with the current system – there will be a passing point for the two cars. [1], [2]

## Terms of reference for the shaft builders: drill two pilot holes using raise boring technology

Constructing the two tunnel sections at a gradient of about 110 % necessitates drill-ing a pilot hole for each tunnel in order to excavate the final cross-section. This means that in order to complete the tunnel faster and more easily the plan is first to drill pilot holes that will later serve as gravity chutes for the removal of the material produced during the final full-section excavation. The excavated material is collected at the bottom of the shaft and taken away without the need for time-consuming transport activities that would impede the tunnel excavation work.

Job-site inspection of a different kind

On 16th July 2013 THYSSEN SCHACHTBAU was awarded the contract to drill the two pilot bores. The holes needed for the two tunnel sections were, respectively, 1.8 m in diameter and about 60 m in depth (length) in the case of the ‚Ober Zingeli‘ sec-tion and 1.4 m in diameter and 245 m in depth for the ‚Zingelifluth‘ section. Both pilot holes are to be completed using the raise boring method. Each operation will involve setting up the raise boring machine at the top end of the excavation and drilling a pilot hole (9 7/8 „) down through a predefined section of the tunnel profile using the directional drilling technique.

When the pilot hole reaches the bottom end the directional drilling tool with its roller bits is dismantled and the reaming bit unit (1.8 m or 1.4 m) is power-tightened to the drill string remaining in the borehole. The assembly is then drawn upwards by the slow rotation of the reamer bits. The cuttings fall to the bottom of the inclined hole under influence of gravity and are then collected and transported away so that the drilling operation can continue uninterrupted.

Construction processPreparations are currently under way on the mobilisation of the raise boring equipment. Work is expected to commence at the site in June 2014.

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**Sources**
[1] http://wikipedia.de
[2] http://seilbahn.net