To Climb A Mountain, A Railroad Needs Gears

Recently, the Addendum team has taken a keen interest in a Swiss mountain. Being the Addendum team, we haven't been interested in this rocky, fissured mountain for its natural majesty.

We've been interested in its geared railway, its very *steep* geared railway.

The mountain is Mount Pilatus, in central Switzerland, near Lake Lucerne. The railway is the Pilatusbahn. It climbs 1,689 vertical meters at an average grade of 42 percent and a maximum grade of 48 percent. At the higher grade, the railway's cars rise almost one meter for every two meters run.

For cars to make the climb, the railway uses a specially designed rack and cogwheel assembly. The design was so special ASME International designated the Pilatusbahn a historic mechanical engineering landmark in September 2001.

The design came from engineer Eduard Locher of Zürich in the late 19th century. His design consisted of a horizontal double rack.

The rack is centered between the rails, with a set of rack teeth facing each rail. Each set is engaged by a cogwheel—a gear. A pair of these wheels is mounted horizontally under each of the railway's cars.

Also, each cogwheel has a flange on its lower side. A horizontal disc, each flange extends under the rack itself, locking it to the rack.

Locher's design was special because it solved problems that had kept a railway from being built on Mount Pilatus. In honoring the Pilatusbahn as a landmark, ASME International researched the history of the railway.

In that history, a railway was proposed in 1873 using a rack and cogwheel design that had proven successful on other mountains. The design also located the rack between the rails, but its cogwheel was mounted vertically under the railway car. Driven by the car's locomotive, the cogwheel rotated, in effect climbing the rack.

The proposed railway wasn't possible. Its track gauge, maximum grade (25 percent), and passenger cars with separate locomotives would've resulted in a railway some 8,000 meters long, with curves too large for Pilatus' terrain and with rolling stock that was too heavy.

Also, Swiss authorities wouldn't permit a steeper grade because they worried high winds on Mount Pilatus would cause the cogwheel to "climb out" of engagement with the rack.

Locher's design solved those problems.

Mounted horizontally, his cogwheels wouldn't climb out of their rack, even on very steep grades. The cogwheel flanges also helped prevent climb out, even in high cross winds.

Other design differences lightened the railway's rolling stock and made the mountain route half as long as the 1873 route.

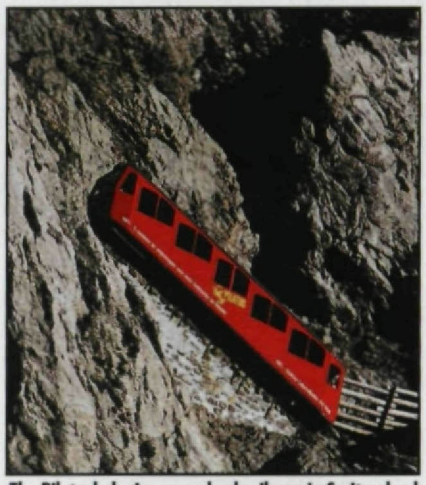
Construction of the railway started in April 1886. Operations started June 4, 1889.

More than 100 years later, the Pilatusbahn is still running. The railway is owned by PILATUS BAHNEN, a Swiss tourism company located in Kriens.

The railway transports an estimated 156,000 people every year up and down Pilatus' south side.

The people visit the top of Mount Pilatus, where two hotels are located, to view art exhibitions, take guided hiking tours, or sunbathe on the hotels' patios in summer and winter. They come to hold conferences and seminars in one of the hotels, the Hotel Kulm.

They also come for the experience of riding the railway.



The Pilatusbahn is a cogwheel railway in Switzerland and climbs 1,689 vertical meters to the top of Mount Pilatus. The steep climb has a maximum grade of 48 percent, or 21.6 degrees.

A segment of the Pilatusbahn's rack and cogwheel assembly is displayed as an outdoor sculpture at Alpnachstad, the railway's station at the foot of Mount Pilatus. (Photo courtesy of ASME International.)

To cover 1,689 vertical meters, the cars actually travel 4,594 meters of railway. The ride up takes 30 minutes; the ride down takes 40. Cars climb at 7–12 kilometers per hour and, for safety reasons, descend at a maximum of 9 kilometers per hour.

Besides the mountain's grade, Locher's design solved the problem of Pilatus' winds. Those winds don't always blow, but when they do: "They can go easily over 100 kilometers an hour," says André Zimmermann, PILATUS BAHNEN's chief executive officer. Even at such speeds, the railway can continue to run—"The system is that safe." ⚙

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