

Station Spotlight

Station construction, expansion and development – June 2014



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Open-heart surgery

Many Swiss railway stations will reach their maximum capacity in the next few years. In densely built-up urban centres, most station upgrades are possible only underground. Construction work in a busy train station is like a surgical operation.

The station of the future is underground

Railway stations are throbbing with life: commuters hurrying past, pupils meeting for school trips, luggage trolleys cutting through crowds. And stations unite many functions: meeting places, conference venues, shopping malls, service centres. But, above all, they are the main transport

hub in the heart of the city. Rail traffic in Switzerland will increase by 60% by 2030. By then, stations in Switzerland's largest cities will have been pushed to their maximum capacity. The time to expand is now. But where in a densely built-up city centre can more room be created for wide platforms, new passages and service areas?

There's only one answer: underground. This development can now be seen everywhere. In Zurich, for example, the second underground through station – the new Löwenstrasse station – commenced operations in 2014. Underground expansions are also in the pipeline in Bern, Lucerne, Basel, Lausanne and Geneva.

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Editorial

Lausanne, Bern, Basel, Geneva, Lucerne – railway station projects are in the pipeline in almost every large city in Switzerland. In densely populated areas in particular, the increase in rail traffic poses certain challenges: how can the capacity of a station be increased in the face of space constraints? Where can space be created for additional services? How can the station be integrated with the city more effectively? Stations and their surroundings have become a hot topic for rail operators and city councils. Basler & Hofmann has been active in this field for decades. One of our largest projects – the new Zurich underground station – commenced operations in mid-June 2014. In our experience, station projects are among the most challenging in terms of design, organisation and structural engineering. No other type of project involves so many participants, requires so many specialist disciplines or presents so many difficult construction stages – all against a backdrop of on-going rail operations, large numbers of people and delicate infrastructure. These are good reasons for a separate series of newsletters on the topic of railway stations. Each issue will present an aspect of the 'station system', from conceptual issues through to construction. The series starts by asking: how is a new underground station built in a busy city centre? As always, the simplest questions are the most difficult to answer.

Ralph Bächli

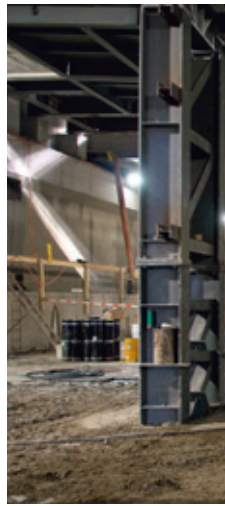
Leading expert station construction
Basler & Hofmann

In the next issues:

construction and operations / integration with the city

Left: Construction in the river Sihl: construction work takes place behind the two closed gates, while the river continues to flow to the left and right. The temporary bridge above the river holds construction containers and materials handling.

Right: How it looks like behind the Sihl gates: The tracks are stored on temporary bridges, while the workmen below concrete the roof of the new station.



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Complex procedure

The underground expansion of a city centre railway station is one of the most complex tasks that an engineering and planning team can face. Construction work in a busy station means intervening in a living system that is already stretched to its limits, while ensuring minimal disruption to normal

operations. The comparison with openheart surgery is therefore very apt. In Switzerland, such an operation has been performed only twice on a large scale: the construction of the two underground stations below Zurich main station – Museumsstrasse station, which opened in 1990, and the new Löwenstrasse station.

Rail traffic has right of way

Zurich main station is the largest railway station in Switzerland. About 400 000 people pass through it each day and a train arrives or departs every 25 seconds on average. The new Löwenstrasse underground station including shopping areas was built between 2007 and 2014 with minimal disruption to operations. When building in a railway station, rail traffic and the safety of passengers take precedence. They shape the entire planning process, from the construction phase to the construction methods. Not a single platform could be closed during this period and the flow of passengers had to be safely diverted around the construction site at all times. But a large construction site has its own requirements: it needs space for machinery and materials as well as deliveries and removals – space that is in short supply in a city centre. The challenge is to reconcile these two incompatible scenarios.

The impossible made possible

Löwenstrasse station lies 16 metres below six overground tracks on which trains run every minute, and crosses under the river Sihl. How could such a major structure be built during ongoing operations? A number of possible approaches are often used in combination.

– Construction in stages: when construction work is below a vital lifeline (a platform, street or river), only one section at a time is closed off. Work then takes

place in this section, while the other areas can be used as normal, avoiding the need for full closure.

- Temporary support structures: platforms, roads, buildings and pedestrian zones are relocated to temporary support bridges or structures, below which existing structures can be demolished and new ones built.
- Cut-and-cover method: this construction method requires space on the surface only for a short period of time. Once a cover has been created, the entire construction process takes place below ground under the protection of the cover, while life goes on as normal on the surface.
- Mining construction methods: mining construction takes place completely underground. It requires 'only' a shaft from which the digging, boring and blasting can be performed. In a station area, the overcover is usually too low for these construction methods, unless the new station is positioned further underground. However, this has an impact on costs, construction schedules, transfer connections and ease of use.

Under the Sihl in stages

A river cannot be 'out of service'. The crossing below the Sihl in Zurich vividly illustrates how the construction methods described above were used under highly challenging conditions. The Sihl flows into five culverts below Zurich main station. As the new station was to be built under the Sihl, two of the culverts had to be closed off gradually. From inside the closed culverts, the side walls of the new station were constructed as diaphragm walls and the station's roof concreted over. The chambers were then freed up again for the river, while the new station concourse was excavated under the protection of the

Current railway station projects at Basler & Hofmann

- Zurich main station, new Löwenstrasse underground station: study, preliminary design, construction project, tender, execution project, site supervision, general project management
- Bern railway station, RBS underground station: feasibility study, preliminary design, general planning contract from construction project to operation
- Bern railway station, expansion of underground passages: study, preliminary design, general planning contract from construction project to operation
- Lausanne railway station, platform extension with three new underground passages and service areas: preliminary project, construction project
- Lucerne railway station, new underground station: feasibility study, preliminary design
- Geneva-Cornavin railway station, new underground station: expertise with project development, including access routes

The projects were and will be handled by various engineering consortia.



new roof. The same approach was used to cross underneath roads and tram lines.

With the overall system in mind

The 'right' construction method depends on various factors. What are the geological conditions underground? Is there any groundwater? How intensively and for how long can work be performed on the surface? How does the construction method affect costs, schedules and future maintenance? Are any sensitive activities performed in the vicinity? During expansion of the RBS underground station in Bern, the initial plan was to blow out the caverns using explosives. However, the Physics Institute at the University of Bern, where experiments are conducted with highly sensitive measuring devices, is in close proximity to the station. The plan now is to use a road header for future excavation work. During a station expansion, the welfare of the whole system has to be considered.

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Logistics schedule

The flow of materials is the blood supply of a construction site. Without the delivery and removal of materials to and from the site, construction would grind to a halt. But when faced with the space constraints of a city centre and an already overburdened road network, logistics becomes a real challenge – and a critical factor in meeting tight schedules.

All construction sites entail enormous mass transport. This is particularly true of a structure built completely underground, since the entire building volume must be excavated from the site. As an example, during work for Löwenstrasse station in Zurich, 300 000 cubic metres of rock material were excavated, the equivalent of a 90 metre high pyramid with a base length of 100 metres. While excavation work is taking place in one area, building work is already underway in another. Tens of thousands of tonnes of construction machinery, steel and concrete must be delivered at the same time as removal of excavated material. Logistics requires space – precisely what is lacking in a city centre.

Creating space where there is none

On any station construction site, every square metre of installation space is a struggle. During the construction of the cross-city line between 2007 and 2014, Zurich main station was surrounded by temporary platforms that created storage space for containers and materials above the flow of traffic. But such platforms can't just be placed anywhere, since the heavy loads they bear are transferred underground. If garages or other structures already exist below the surface, this isn't

always possible. Each installation area must have a transport connection to the construction site – such as a crane, a special logistics route, a supply tunnel or conveyor belt. At Zurich main station, pipes with a diameter of 125 mm were used to pump concrete to the construction site up to 400 metres from the installation site. To save on storage space, materials can also be requested 'just in time'. This requires waiting areas for lorries at convenient points outside the city.

Logistics determines advance rate

Rail is the preferred method of transporting bulk material to and from the installation site – for environmental reasons, to avoid stress on the local road network and to protect local residents. But in railway stations in particular, the infrastructure is already stretched. During construction of the Weinberg tunnel in Zurich, the advance rate and times had to be coordinated with the train timetable. The construction site had seven time slots a day in which to remove the excavated material. The freight trains had to be loaded up and depart within these timeframes. Based on the experiences of other construction sites, a system was designed that could load a train with up to 1000 tonnes of excavation material within 30 minutes. The system was enclosed and sound-proofed, as it was in the middle of a residential area.

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Zurich main station during the construction of the new underground station: the station was surrounded by temporary platforms for storing material.



When the tunnel meets an underground car park

An underground station by itself is not enough – access routes need to be built through the city zone. This poses a number of challenges for the tunnel constructors, such as low cover, densely populated areas, sensitive activities on the surface and existing underground structures.

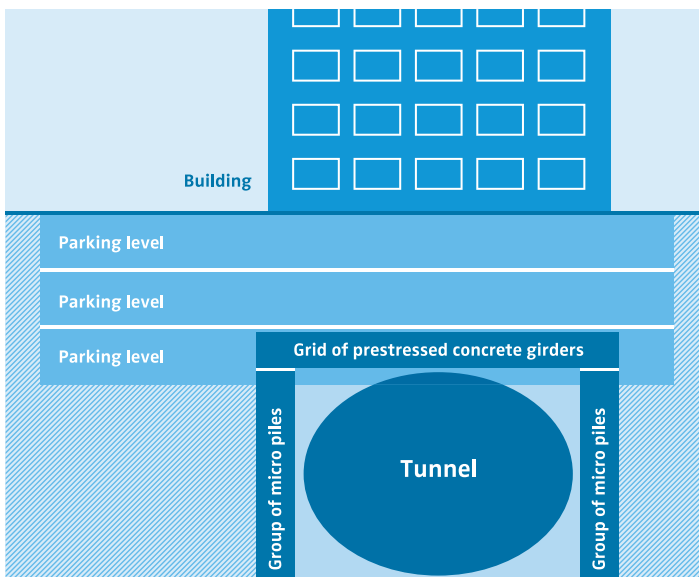
Two of the most challenging inner-city rail tunnel projects in Switzerland were the Zimmerberg base tunnel and the Weinberg tunnel. The Zimmerberg base tunnel, which opened in 2003, connects Zurich and Thalwil. The Weinberg tunnel leads from Zurich's new Löwenstrasse underground station to the Oerlikon district and commenced operations in June 2014. Sections of both tunnels are situated in loose rock with groundwater and pass below busy streets and sensitive buildings with just a few metres of cover.

Strict safety requirements in the city centre

For the Weinberg tunnel, the final 300 metres were the most challenging, as the tunnel runs below the Limmat river and Bahnhofplatz – one of the most important traffic hubs in Zurich – before ending in the shaft in front of Zurich main station. Strict safety requirements were specified for this section. Numerous construction support measures were needed to ensure that the tunnel-boring machine could excavate safely through the water-bearing loose rock. Below Bahnhofplatz and the Limmat, a 140 metre-long pipe umbrella was created, from which the ground below the surface was reinforced by grouting. Under the protection of this umbrella just below the Limmat, the tunnel bore machine worked through to the target shaft in November 2010.

Parking level in the tunnel cross-section

In inner-city areas, deep building foundations or basements can often get in the way of a planned tunnel. This was the case with the Zimmerberg base tunnel, where the lowest parking level of a six-storey office block protruded into the intended trackbed. This called for a highly challenging construction method: while work was taking place on the upper storeys, the construction machinery demolished the parking level below ground. The 120000 tonne building then had to be lifted on to new foundations during ongoing operations, without causing any deformation. Massive support girders made of prestressed, reinforced concrete had to be constructed inside the building to support its weight and transfer it to new 18 metre micro pile foundations alongside the tunnel. Hydraulic presses braced the building on to the new foundations. With completion of the tunnel, now just 20 cm separates its roof from the building's main support girders. As the tunnel tracks are laid on a mass-spring system, users of the building do not feel the heavy rail traffic beneath them.



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Schematic view of the new micro pile foundations of an office building undercrossed by the Zimmerberg base tunnel.

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