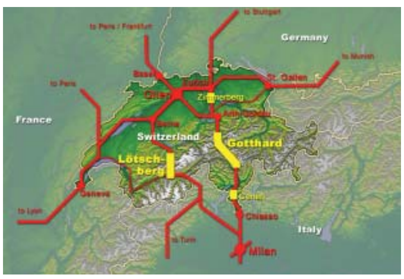
Leica Geosystems TruStory

Railway Bridge Monitoring
Kirchtobel – Switzerland

100 year old railway bridge "Kirchtobel" and the monitoring system setup

The extension of the railway line between St. Gallen – Arth-Goldau is part of the integration of Eastern Switzerland with the New Railway Link through the Alps (NRLA). There are several engineering projects associated with this enlargment, such as the building of the new railway bridge close to St. Gallen. As the new bridge will be built close to the existing one hundred year old brigde, the project is complex as the old bridge is made of natural stone and the foundation of its pillars are not accurately defined. This means that construction work can affect the old bridge in the forms of settlement and torsion. A permanent monitoring system is required to monitor these movements and inform the key people in the railway service "SOB Südostbahn" in any case of emergency.



Important swiss railway connections

Monitoring Object

The railway bridge crosses a steep forested ravine and has a length of 150 m and the maximum height is about 30 m. The overpass consists of four minor and six main arcs, and there are trains crossing the ravine every 15 minutes in both directions.

During the building process of the new bridge, the structure of the old bridge and the overlying tracks has to be monitored. Due to a geological report, the people in charge concluded that the existing bridge foundations will be influenced by the construction work around the old bridge, especially during the building of a temporary road through the ravine, which could lead to subsidence and rotation of the piers. Movements in the foundation of a railway bridge can be disastrous for the railway service and distortions in the railroad

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Challenge
Monitor and display the movements of a railway bridge during the construction of a second parallel bridge

Date
November 2011 to May 2012

Location

Project Summary

Instruments
Leica TCA2003, Leica TCA1800
Leica Prisms
Leica Nivel220 Bus System
W&T Meteo Sensor
Webcam

Software
GeoMoS Monitor and Analyzer
GeoMoS Web

Communication
Leica ComBox20
Leica TCPS27 Radio Modem
GSM/UMTS, Ethernet, RS232/485

Power
Fuel Cells

Alarming
SMS and E-Mail

Distributed monitoring prisms

tracks are the most critical factor in the rail geometry. Therefore, in addition to monitoring the various foundations, focus is also placed on the bridge head where the tracks lay. The expected movement at the foot of the bridge could be in the millimetre to centimetre range. In addition to these conditions, the location of the object, the different weather conditions and the progress of construction of the new bridge must be also considered during the design process of the monitoring system.

Monitoring System

For this monitoring project primarily tachometric measuring equipment (Leica TCA2003, TCA1800) was selected. The required measurement accuracy is ± 2-3 mm. The total stations have been placed on each side of the bridge in the ravine. With the choice of these instrument stand points, the piers of the arcs can be monitored from each side, leading to redundant. A total of 81 prisms are mounted in a uniform pattern on the bridge. For setting up and orienting the total stations, there are twelve stable fixed points available around the viaducts that are mounted on concrete pedestals.

Special pillars are created to ensure the stability of the total station locations. These pillars are made of a solid foundation, where the frost depth is considered, a stable outer shell serves to protect against temperature and mechanical damage. The measuring device is installed on the core of these pillars.

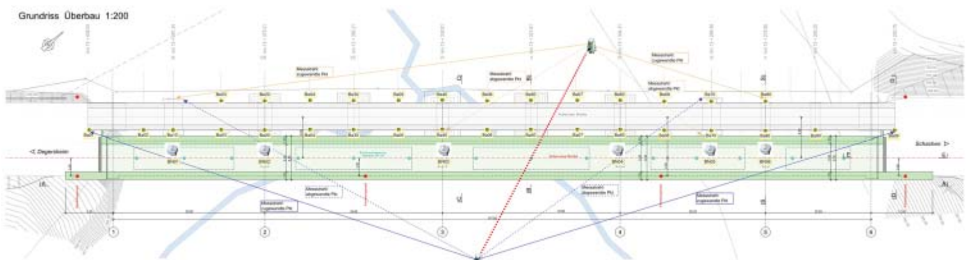
To use optical measuring instruments as total stations, a clear view of the monitoring object must be ensured. For that reason several problems need to be taken into account for this project. Firstly, because this gorge is heavily wooded, certain shrubs and trees have to be felled. Secondly, the new bridge will obscure a face of the old bridge during its construction progress, which cannot be prevented. Thirdly, in winter months, fog often covers this region, which impedes geodetic measurements. Due to these problems, six inclination sensors (Leica Nivel220 bus system) are installed at the bridge head. These high-resolution sensors monitor the longitudinal and transverse tilt of the bridge. They form redundant measurements and a fall-back for the monitoring system, if optical measurement techniques fail.

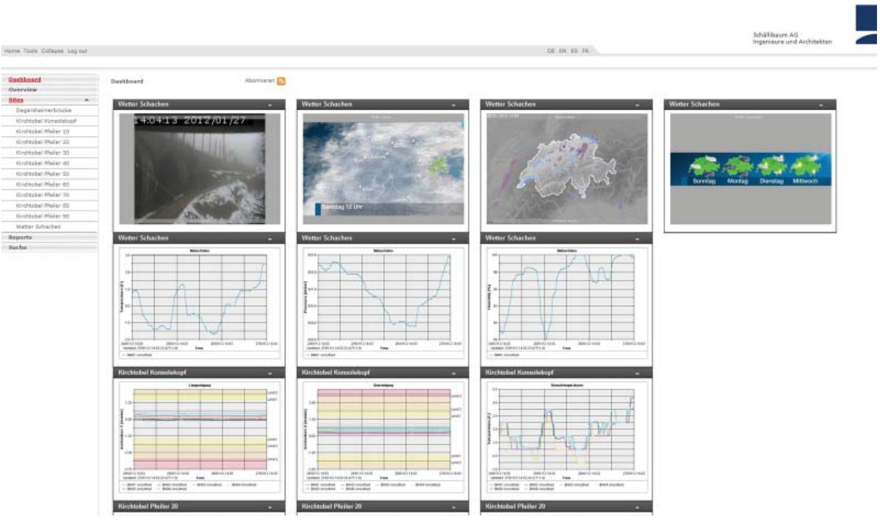
Benefit

- Redundant measurements of monitoring points from different TPS locations
- Nivel220 Bus System as a fallback system for bad weather conditions
- Data access anytime and anywhere over Leica GeoMoS Web
- Efficient messaging via SMS and E-Mail
- Flexible and secure communication setup
- Fuel cell technology provides a secure and self-sufficient power supply in the outback
- Automatic versus manual monitoring systems reduces costs
- Leica Geosystems Support

The automatic monitoring system also determines the atmospheric corrections for geodetic measurements with meteo data (temperature, pressure and humidity) from a meteorological sensor. Furthermore, these weather data are helpful for the concreting phases of the new bridge elements.

Beside all these measuring sensors, a rotating webcam is





Graphical visualisation of the monitoring data in Leica GeoMoS Web: web cam image, weather forecast, rain radar, meteo data, inclinations with shown limit levels, etc.

also used to monitor the surveying process and the measurement equipment. The measured data of the individual sensors (Leica total stations and Nivel220) are collected in a master station (Leica ComBox20) and are transferred, on the mobile internet (GSM/UMTS), to the control centre (Leica GeoMoS) where the whole system is supervised. The connection from the master station to the different sensors is done via cable and/or wireless connec-tions and the data transfer interfaces are serial RS232/485 and TCP/IP protocols.

Via the SMS service, the connetion status (e.g. UMTS signal strength) of the master station can be queried and in addition, the station may also be rebooted in the event of various faults in the communication. Since the project is in rural areas, the power of the monitoring system is somewhat more complicated. Before the construction of the new bridge, mains electricity is not available at the site and must therefore be supplied by fuel cells. The development of power-boxes in combination with fuel cells and batteries generates emission-free electricity and runs the system self-sufficiently for several days or weeks.

By using Leica GeoMoS in the control centre, the data is vali-dated on the basis of filter criteria, processed and stored in a database. If any measure-ment results exceeds set limits and satisfies the filter conditions, the messaging system notifies the appropriate people in charge.

These messages are sent via e-mail and SMS service. After the messages are sent, further action will be taken based on set regulations. This begins with a consultation of the monitoring data through the Leica web portal GeoMoS Web, then a site visit if necessary, which can lead to immediate closure of the railway operation.

Monitoring System Calibration
Before a system is set to active, a proper null measurement of the monitoring object is necessary. During this phase, the measurement data of the stationary bridge, and thus the intrinsic behaviour of the bridge are studied. It is also an opportunity to fine tune the moni-toring system.

Conclusion
By using such an automated monitoring system through the construction, the companies involved get an image of the health status of the constantly monitored object. With high-resolution and independent measuring techniques and the deployment of modern means of communication, the reliability and quality of measurement results can be increased. These are essential prerequi-sites for monitoring tasks. Such a monitoring system increases the efficiency and flexibility of the construction and therefore allows costs to be saved (e.g. insurance premiums for con-structions, manual monitoring costs, etc.).

Power-Box (fuel cell) and ComBox

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