

Tunnel expertise in the mountains, underwater and in the jungle

With the official opening of the world's longest railway tunnel, the 57-kilometer Gotthard base tunnel in Switzerland on June 1 2016, another major infrastructure project can be added to the numerous tunnel construction projects in which LafargeHolcim has played a role around the world.

The new railway link through the Alps, including the Gotthard and the Ceneri Base Tunnels, is a Swiss centennial project and one of the largest environmental protection projects in Europe. Moving some of the passenger and freight transport from road to rail is expected to save environmental costs of CHF 130 million each year and the time it takes to travel between Zurich and Milan, and many other destinations north and south of the Alps, will be reduced by an hour. LafargeHolcim is the partner for construction materials and logistics for both tunnel projects.

Environmental concerns were a priority right from the start of the project. The excavated material was transported in an environmentally friendly manner via conveyor belts for 70 km. The total amount of excavated material weighed 28.2 million tonnes and LafargeHolcim was able to recycle a more than one third of this amount into aggregates for use in the manufacture of concrete. The remaining material was reused for many different purposes, including the natural landscaping of the access routes leading to the tunnel.

Concrete – the end product of mixing cement, crushed stone, water and concrete additives together – has to be durable, robust and above all resistant to frost and potential chemical reactions. Involved in the project right from the start, Holcim Switzerland, began its research to find the right cement mix and application methods in 1996 with numerous cement formulae and applications being tested in a test gallery to take into account the characteristics of the rock to which it would be applied.

Logistics were also a factor. Owing to the long journey to reach the tunnel, the ready-mix concrete needed to remain in a liquid state, i.e. unset, for twelve hours. A specially developed concrete train with a mobile concrete mixing unit and a tailor-made ready-mix concrete unit within the tunnel both played a critical role in ensuring the concrete was delivered in perfect condition. The Group also invested in building the most modern cement plant in Switzerland and connecting it to the railway cargo infrastructure, as well as the operation of 400 cargo rail cars. These investments guaranteed that the Group would be able to create up to 2,300 cubic meters of concrete every day when working around the clock, without interruption, at peak construction times.

Once the Ceneri base tunnel is complete, the Group will have supplied 2.3 million cubic meters of ready-mix concrete and 1 million tonnes of cement to this unique project.

Global demand for expertise

Projects such as the Gotthard Tunnel often extend over many years and feature special challenges from the building site to the temperature and geological conditions. In the case of metro stations and

cross-city lines, limited accessibility in heavily populated inner city areas poses a further challenge. Tailored solutions with smoothly functioning logistics, substantial production capacity and reliable delivery times, together with specialist advice on concrete and global expertise working on major project, are among the most important criteria for the awarding of a contract.

LafargeHolcim has many years of experience in tunnel construction, and its expertise is in demand throughout the world. Building tunnels for metro stations located in heavily populated urban areas can be a particularly challenging task for engineers and partners. This was the case for the Metro Line B in Lyon, France which, at its deepest point, is 15 meters below the bed of the Rhone River. Likewise for the metro system in Milan which has added a fully automatic line in the last four years. Working in a heavily populated area is a challenge on a much larger scale, in the project being carried out in Cairo, where LafargeHolcim is currently helping to construct a third metro line. Of the 15.5 million people who live in the largest city in the Middle East, 3.5 million commuters travel to work using the metro. The new line will be opened in 2019 and will accommodate a further 1.8 million passengers.

A crucial factor for each of these projects has been the development of an individual solution featuring special products and integrated logistics, which is one of the strengths of LafargeHolcim when working on major infrastructure projects.

Production capacity as a competitive factor

The availability of large production capacity and guaranteed delivery times were two key factors in LafargeHolcim winning the contract for the construction of Australia's longest highway tunnel in Brisbane, Australia. When concreting the roof of a section of the tunnel, the work had to be carried out without interruption. In one night, LafargeHolcim delivered a total of 2,800 cubic meters of concrete involving 48 trucks supplying concrete in two-minute cycles. Four concrete pumps ensured that 300 cubic meters of concrete per hour were poured throughout the entire night.

Logistics were also important in India, where they were the core component of the cement delivery contract for the Qazigund-Banihal railway and road tunnels being built in the state of Jammu and Kashmir. These major projects span a distance of 8 and 11 km respectively and will cut the time it takes to travel through the Himalayas by over three hours. In order to ensure the cement was delivered safely and on schedule, the Group had to draw up a meticulous plan. The cement first had to be transported downhill by road from the factory for 85 kilometers before it was transported 400 kilometers to Jammu by train. On arrival, it then had to travel a further 225 kilometers by road to the construction sites which sit at over 3,000 meters above sea level. Since construction began in 2012, approximately 62,000 tonnes of cement have been delivered to the sites.

Combined expertise and a cooperative partnership

The tunnel construction expertise of LafargeHolcim is also in demand in the jungles of Ecuador, the Coca Codo Sinclair hydroelectric facility. The Coca Codo facility, which will provide half of the country's future energy needs, is the largest hydropower project in the country's history and one of the largest infrastructure projects in Latin America. During this project, LafargeHolcim not only had to deal with the logistical challenge of making deliveries to a remote jungle region, but it also had to ensure that the cement quality met the special requirements demanded by the project. Local aggregates contained silica, so the cement had to be resistant to the alkali-silica reaction which can result in

dangerous cracks forming in concrete. The entire project comprises a 25-km tunnel which transports the water to the facility, a dam wall and water intake facilities on the River Coca.

LafargeHolcim formed a dedicated expert team to deal with all business, technical and financial issues and work closely together with the authorities, planners and the Chinese construction company in carrying out an extensive project appraisal. This successful collaboration has resulted in LafargeHolcim carrying out follow-up work in Ecuador and being involved in four more dam projects within the country.

About LafargeHolcim

With a well-balanced presence in 90 countries and a focus on cement, aggregates and concrete, LafargeHolcim (SIX Swiss Exchange, Euronext Paris: LHN) is the world leader in the building materials industry. The Group has 100,000 employees around the world and combined net sales of CHF 29.5 billion in 2015. LafargeHolcim is the industry benchmark in R&D and serves from the individual homebuilder to the largest and most complex project with the widest range of value-adding products, innovative services and comprehensive building solutions. With a commitment to drive sustainable solutions for better building and infrastructure and to contribute to a higher quality of life, the Group is best positioned to meet the challenges of increasing urbanization.

More information is available on www.lafargeholcim.com