Valuable Consulting Experience for ITC Advisory Services

Feasibility Study on Ukrainian Railw

The International Institute for Geo-Information Science and Earth Observation (ITC) and Witteveen + Bos Consultants have recently executed a feasibility study on upgrading the Beskyd railway tunnel in the Ukraine (Photo 1). This tunnel is located in the western region of the Ukraine, and forms part of the important railway line between East and West Europe (Figure 1). Four years ago, Ukrainian Railways received a loan from the European Bank for Reconstruction and Development (EBRD) to upgrade this railway connection. Obviously, little interest in East-West connections existed in the days of the Iron Curtain, but since the changes in the early 1990s economic cooperation between East and West has been booming and as a consequence traffic between East and West has also been increasing.

By: Robert Hack and Siefko Slob

Photo1. Entrance Beskyd tunnel

Beskyd Tunnel

A series of railway connections exist between Eastern and Western Europe. One of the main lines is from Moscow via Kiev and Lviv to Budapest, Prague and Vienna. This line crosses the Carpathian Mountains in the west of the Ukraine, and at one of the highest passes a series of tunnels cut through the mountains. Trains pass about every 10 minutes and are very long: passenger trains generally have 30 to 40 carriages, while freight trains consist of a hundred or more wagons. Three or four large locomotives pulling and two pushing are necessary to get the trains through the mountains. The 1.7 km Beskyd tunnel, located close to a village of the same name, is one of the longest tunnels on the line. It is a single-track tunnel that was built in the late 1800's when the area was part of the Austrian-Hungarian empire. The tunnel has been upgraded and repaired a couple of times, but is presently in poor condition. Trains passing through can reach a maximum speed of only 20 km an hour. Furthermore, the tunnel is the only single-track stretch of the whole line. In winter, the continuous influx of water in the tunnel freezes, and the ice has to be removed daily to keep the line open. Because of the poor condition and the fact that the tunnel has only one track, the tunnel forms a serious bottleneck in the railway link between Eastern and Western Europe. To remove this bottleneck, it is necessary to either improve the existing tunnel by widening it or create a new double-track tunnel parallel to the old one. An engineering geological study was vital before embarking on construction.

Beauty Contest

Ukraine Railways and the ERBD organised a so-called "beauty" contest tender for the engineering geological study and invited European consulting companies to tender. A beauty contest tender means that the proposals are evaluated primarily on quality and only secondly on price. ITC, in a joint venture with Witteveen + Bos Consultants, beat off all rivals, including large consulting and railway companies from Austria, Germany and the United Kingdom.

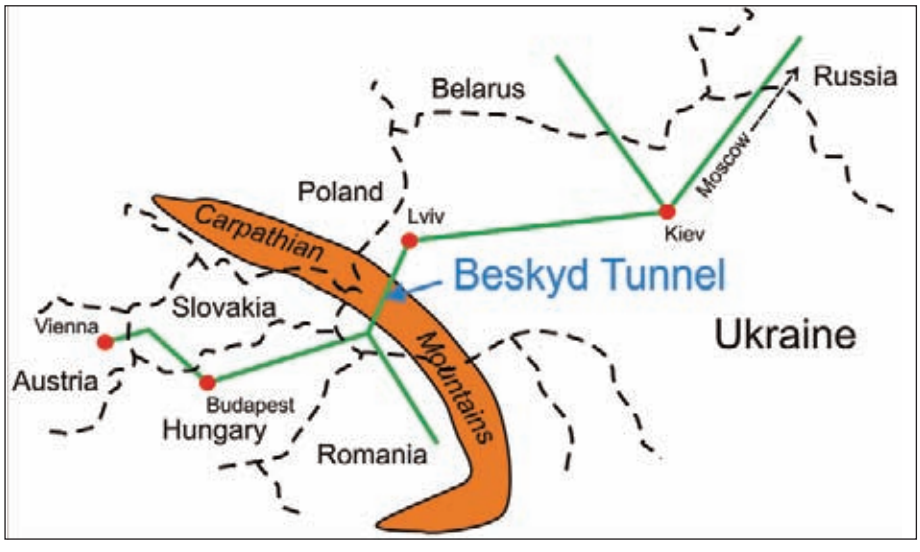

Figure 1. Location of Beskyd tunnel

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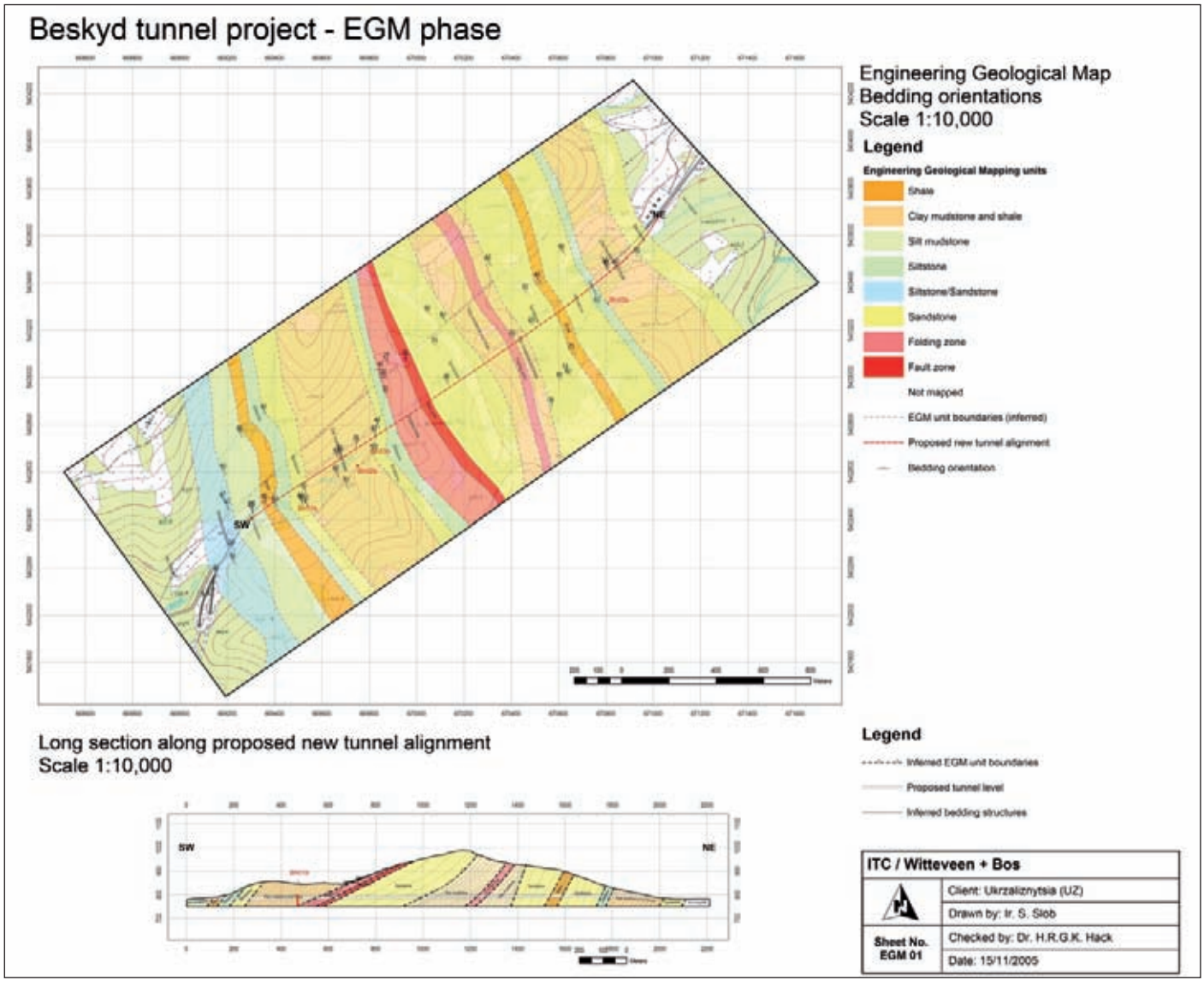

Figure 2. Engineering geological map and section

Engineering Geological and Geotechnical Survey

The first stage of the work consisted of engineering geological mapping of the area and an inspection of the existing tunnel. All exposures of rock and soil were investigated in a two-week campaign by staff from ITC/W+B and the Ukrainian railway company UZ. Each exposure was characterised according to type of rock or soil, discontinuity patterns, compressive and shear strength properties, and all other features that are relevant when designing a new or enlarged tunnel. Based on this survey, a detailed (1:10,000 scale) engineering geological map and cross sections were made. Also the locations were selected for the subsequent site investigations for the second stage of the project. This second stage consisted of an underground campaign of four boreholes drilled to a maximum depth of 250 m and an electrical resistivity survey. The cores of the boreholes were described in detail, and pumping tests in the boreholes established groundwater levels and the permeability of the rocks. Laboratory tests were carried out on selected samples from the boreholes.

Results

The rocks in the tunnel area consist of so-called flysch deposits, which are strongly deformed and folded and include some important faults (see Figure 2). Flysch deposits are repeating sequences of material, starting with coarse sandstone, becoming finer sandstone and then siltstone, and ending with shale. One sequence has an approximate thickness of 1 to 20 m. This repeating sequence is expected to be a major problem in designing a new tunnel (Photo 2 and Figure 3). The sandstones are strong and highly permeable, while the shale is weak and impermeable. Hence, a tunnel will have to go through water-bearing permeable sandstones, with a water head up to the surface to a maximum of 250 m. The weak shale will squeeze when excavated, allowing the release of stress on the sandstone and making it possible that

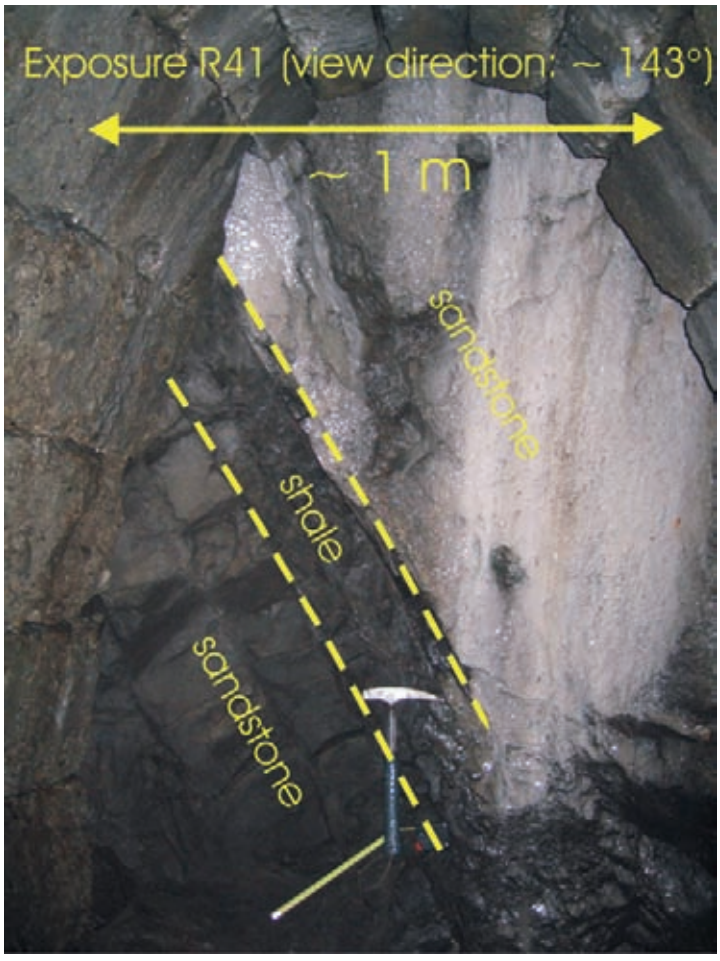

Photo 2. Exposure of rock in the existing Beskyd tunnel

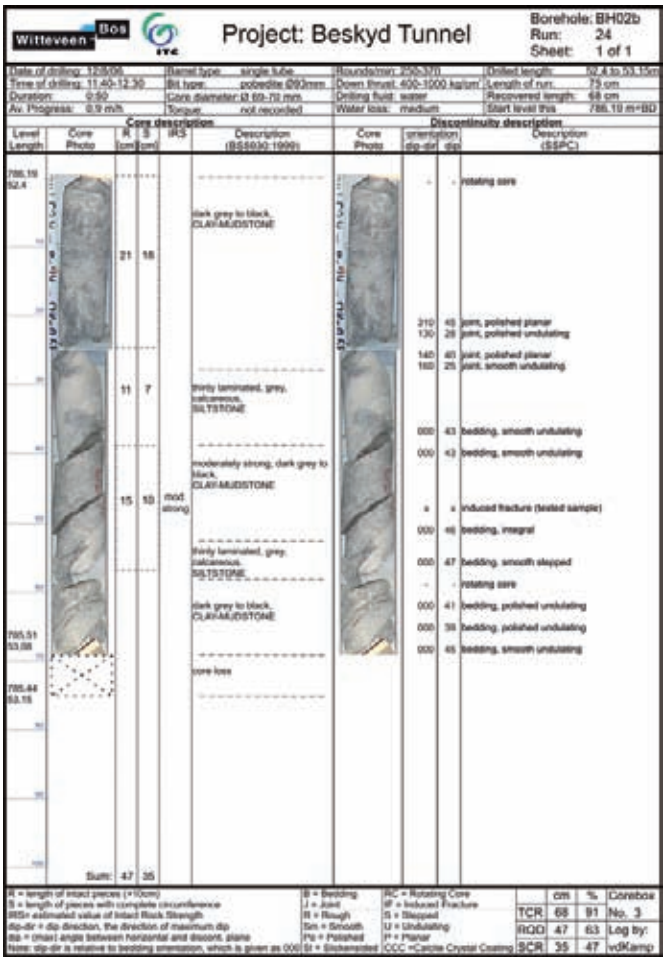

Figure 3. Example of borehole log

sandstone blocks will fall from the roof and walls in the newly excavated tunnel. Excavation methods and the design of a new tunnel or the widening of the existing tunnel will have to take this into account. Suitable excavation methods will have to use a shield, sophisticated forepoling techniques, or a tunnel-boring machine.

As a result of the survey, different design scenarios can be drafted for the new tunnel or for upgrading the existing Beskyd tunnel. It will depend on the contractors as to which option is going to be the most economical. This is going to be decided in the following phase of the project. Ukraine Railways were very satisfied with the work done and awarded the ITC and W+B project leaders the Order of Merit as a token of appreciation for the work of the whole project crew (see Photo 3).

Photo 3. The Order of Merit of the Ukraine Railways as a token of appreciation for the excellent work performed by the whole project crew

Tunnels in Developing Countries

Although this was not a typical ITC project, it was very beneficial for the Institute. Obviously, the staff involved gained valuable consulting experience that will help in attracting additional advisory and research projects. Indirectly, it will also increase the quality of the education, since the experience can be transferred to the students.

Transport routes such as roads and railways in tunnels are an environmentally friendly way of arranging transport. In addition, sustainability is very high. Anyone who has visited developing countries knows of roads in mountainous areas that are flushed away each rainy season. Apart from a devastating effect on the environment, the disruption of transport is also very bad for economic development. Initially, transport in a tunnel requires high investment, but in the long run it is far more beneficial for a developing country because it ensures long-term uninterrupted functioning without much maintenance.

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