

School of Rock Mechanics and Geomechanics from *Bosnia and Herzegovina*

Development of Rock Mechanics in Bosnia and Herzegovina



The development of rock mechanics in Bosnia and Herzegovina is related to development of mining, and, in more recent times, with the construction of hydro-technical structures, roads and railways. Underground mining has been practiced for several thousands of years. Its significant development occurred 2000 years ago, during the Roman Empire, at the beginning of the new millennium. As the Romans arrived they already found existing mines. They intensified production of metals for their needs. Iron, lead, zinc, copper, gold, silver, manganese, chromium and coal were the most valuable ores mined in Bosnia and Herzegovina. Along with the development of mining, the first well-known Roman roads were built of limestone. Bosnia is known for tombstones (“stećak”), the medieval monolithic stone monuments built of limestone.

In the Middle Ages, along with the increased demand for metals in Europe, the German miners, known as Sassi (Saxons), arrived to the area of Bosnia and Herzegovina and brought the new mining skills. In particular, the miners had improved tools they used for mining, as well the technology for roof support in the underground mines.



Figure 1. Bosnian „Stećak“ tombstone, X – XV century, heritage of UNESCO.

The development of mining was intensified upon Bosnia's annexation by Austria-Hungary, after the collapse of the Turkish Empire, in 1878. The Austrians opened the underground mines at greater depths, started rock demolition by explosive, modernized roof supports, transport and safety in mines. At the same time, the Austrians built railways throughout Bosnia including the first tunnels and slopes in the rock mass for railway which were considered to be a serious engineering operation.

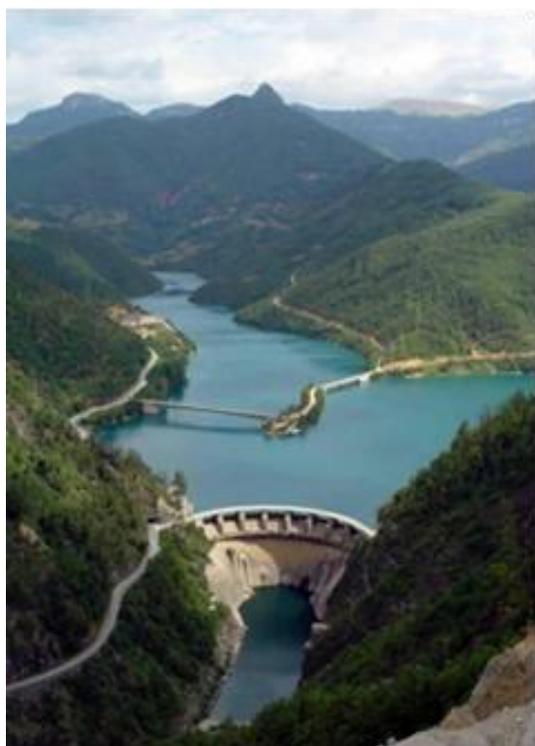


Figure 2. The Hydro Power Plant „Jablanica“, constructed in 1955.

After the World War I, Bosnia and Herzegovina's territory was a part of the Kingdom of Yugoslavia, and after World War II, it became one of the federal republics of the Socialist Federal Republic of Yugoslavia. The intensive industrialization of the country had begun. Modern hydroelectric power plants, roads, large bridges and tunnels were constructed. The mining became prosperous in particular when the large open pits were constructed and the underground mines descended to the depths of over 500 meters. It may be regarded that rock mechanics, as scientific and engineering discipline, emerged after the Second World War, as a result of

significant need for investigation of rock mass behavior and characteristics.

Yugoslav Society for Rock Mechanics and Underground Works was founded in 1965. Based on its significant involvement in ISRM activities, the Yugoslav Society hosted the ISRM congress in Belgrade, in 1970. Bosnia and Herzegovina, as a part of Yugoslavia, was involved in activities of Yugoslav Society for Rock Mechanics and Underground Works.

The first hydro-technical structure in Bosnia and Herzegovina, for which the “in-situ” measuring was performed, was the hydro power plant – HPP „Jablanica“ and it was constructed in 1955. Pre-stress injection was applied for the first time during tunnel construction for HPP “Rama”, completed in 1966. The Third Yugoslav Symposium for Rock Mechanics and Underground Works was held in Tuzla in 1972. With the application of the freezing rock massif technology the 500 meters deep vertical shaft was constructed in the Tušanj mine in 1967. At that time, the construction of the 7864 meters long Karavanke tunnel began which was the largest tunnel in Yugoslavia. The development of rock mechanics was based on the intensive development of mining and hydro-construction, as well as on the road and hydro tunnels’ construction. The Mining Faculty, equipped with modern laboratory for rock mechanics, was founded in Tuzla in 1960. The Faculty of Civil Engineering, founded in Sarajevo in 1949, commenced the rock mechanics investigation for hydro power plants. Afterwards, two faculties of civil engineering, in Mostar and Banja Luka, were engaged in rock mechanics in relation to hydro power plants, rock slopes and seismic engineering.

Professor Maks Štrajher, at the Faculty of Mining and Geology in Tuzla, was one of the founders of the rock mechanics’ development in Bosnia and Herzegovina. Significant contributions were made by Dževad Sarač, Mustafa Selimović, Milan Cvetković, Ibrahim Jašarević, Zlatko Langof, Enver Mandžić, Milan Stević, Mehmed Suljkanović, Ivan Vrkljan, Murat Redžepagić, Hamid Dolarević, Dušan Krsmanović and others. Professor Mevludin Avdić initiated application of numerical methods in rock mechanics in the eighties.

Rock mechanics had been dealing with significant technical issues in the seventies. Some of those are: dynamic testing of rock mass, the effect of discontinuity on stability, capacity and secondary stress state, rock mass stability on arch dam supports, measuring of secondary stress and pressure on roof support in mines, dimensioning of supporting pillars and chambers in underground mines, deformation characteristics of rock, stress in hydro-technical tunnels, in-situ test for shear strength of rocks, stability of working and final slopes on open pits, stability on high tailings. The subsidence in Tuzla city is one of the major challenges in rock mechanics in Bosnia and Herzegovina.

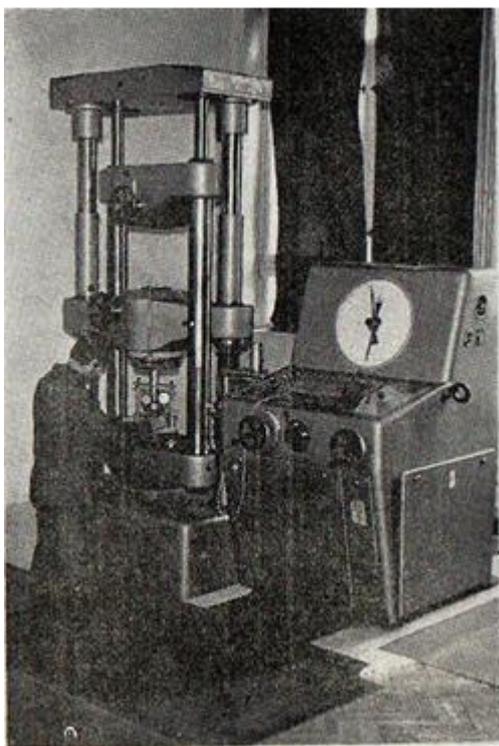


Figure 3. Laboratory equipment for rock testing, Faculty of Mining in Tuzla, 1965.

The ground subsidence monitoring has started in 1956. To date, the vertical subsidence in

Tuzla is approximately 18 meters. The largest project in the last twenty years is the construction of the Corridor Vc „Budapest – Ploče” highway, which goes through Bosnia and Herzegovina. Rock mechanics was required in realization of this project for tunnels construction and rock mass stability at cuts.

Now days, geomechanics is studied at four university centers in Bosnia and Herzegovina: Tuzla, Sarajevo, Banja Luka and Mostar. There are differences in number of hours of lectures in studding programs. In general, lectures in soil and rock mechanics are delivered in one semester, while other disciplines of geotechnics are involved in other lectures, for example: foundation, tunnels, roof supports, slope stability, numerical methods, retaining structures, landslides, engineering geology, landfills and similar. Mining, geology and civil engineering are studied at faculty in Tuzla, while civil engineering at Sarajevo, Mostar and Banja Luka's faculties.

Now days, The Geotechnical Society of Bosnia and Herzegovina gathers engineers involved in rock mechanics. The Society organizes scientific and expert conferece GEO-EXPO every year. Geotechnical Society of Bosnia and Herzegovina is the member of ISRM.

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