Extreme Deformation and Damage during the Construction of Large Tunnels

D. Brox and H. Hagedorn

Abstract:
Extreme deformations occurred during the construction both prior to and through a significant fault zone along the 16-m-wide, three-lane, twin tubes of the Bolu Mountain Tunnel of the 114 km Anatolian Motorway in north-central Turkey. Semi-concurrent excavation of the full top benches of both large tunnels was carried out through the fault zone with a final design deformation tolerance of 500mm in accordance with a NATM design philosophy. During excavation maximum deformations in the left and right tube reached 580 mm and 350 mm, respectively. With continued semi-concurrent excavation through the fault zone an additional 140 mm of deformation occurred in the left tube thus, greatly exceeding the design tolerance. Extensive damage of the installed tunnel supports in the form of cracked shotcrete and distorted steel arches was observed in both tubes. An investigation was carried out on behalf of re-insurers to assess the causes of the additional deformation that exceeded the design tolerance. The main cause of the additional deformation above the design tolerance has been attributed to the re-start of excavation of the large lower benches of both tubes and the significant stress re-distribution that occurs with this excavation stage for large tunnels sited in weak geological conditions. This paper presents the summary findings of the review of the investigation that was carried out for re-insurers of the project as to the causes of the additional deformation that exceeded the design tolerance.

Keywords: seismically active faults; extent of damage; intermixed sandstones, siltstones, and limestones at the fault zone; NATM tunnel design; tunnel support performance; assessment of tunnel stability prior to additional deformation; tunnel design assessment; construction practice assessment; causes of additional movement.