Brenner Base Tunnel, Italian Side, Lot Mules 2-3: risk management procedures

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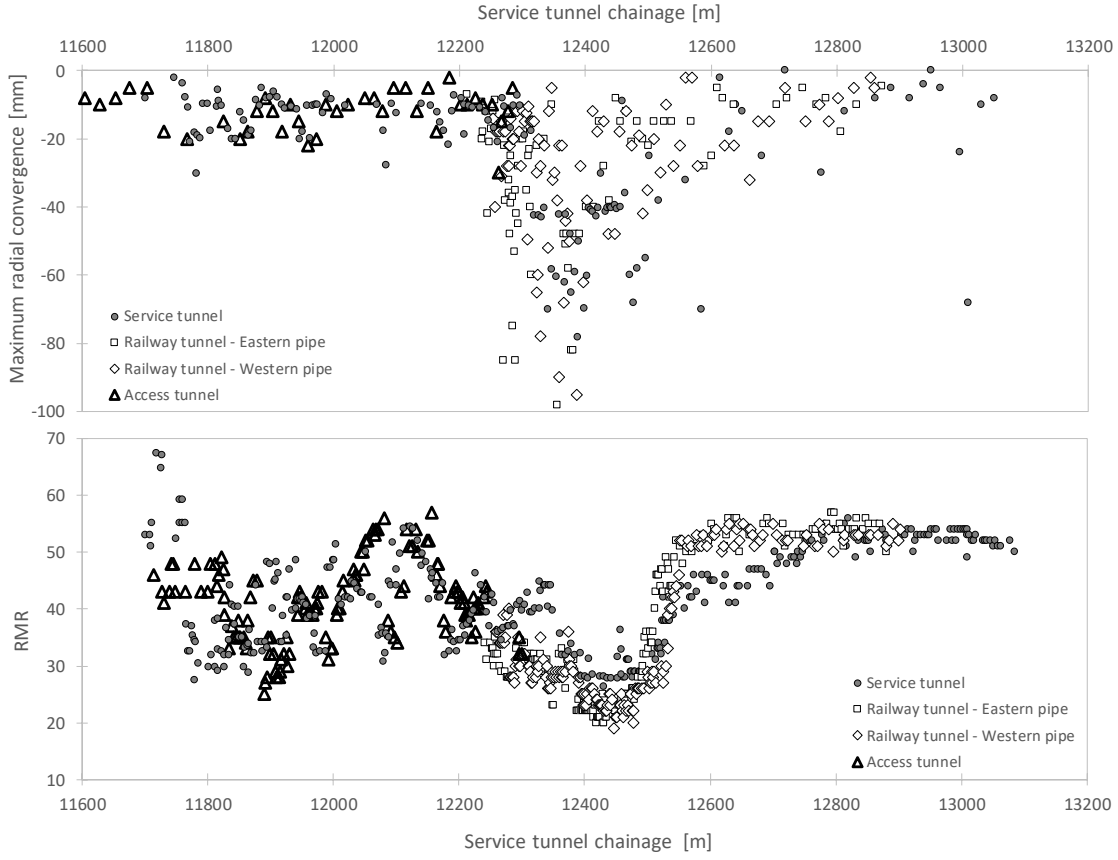
ABSTRACT: The Brenner Base Tunnel is mainly composed of two single-track Railway Tunnels and an Exploratory Tunnel; Lot Mules 2-3 concerns a 22 km long stretch on the Italian side. It crosses the South part of mountainous dorsal between Austria and Italy, under overburdens up to 1850 m, consisting of rocks both of the Southalpine and Australpine domains, separated by the major Periadriatic Fault. The tunnels have to be carried out both with Mining and Mechanized (TBM) Methods, with average dimension ranging from 7 m (Exploratory Tunnel) to 20 m (Logistics Caverns). The forecasted rock mass behavior varies from rock burst to squeezing phenomenon. The paper illustrates the risk management procedures planned at the design stage and the first experiences of their application: monitoring, surveys, and tests during the advancement, guidelines for the application of excavation sections, design and operational risk identification, assessment & analysis, ownership, mitigation & control phases.



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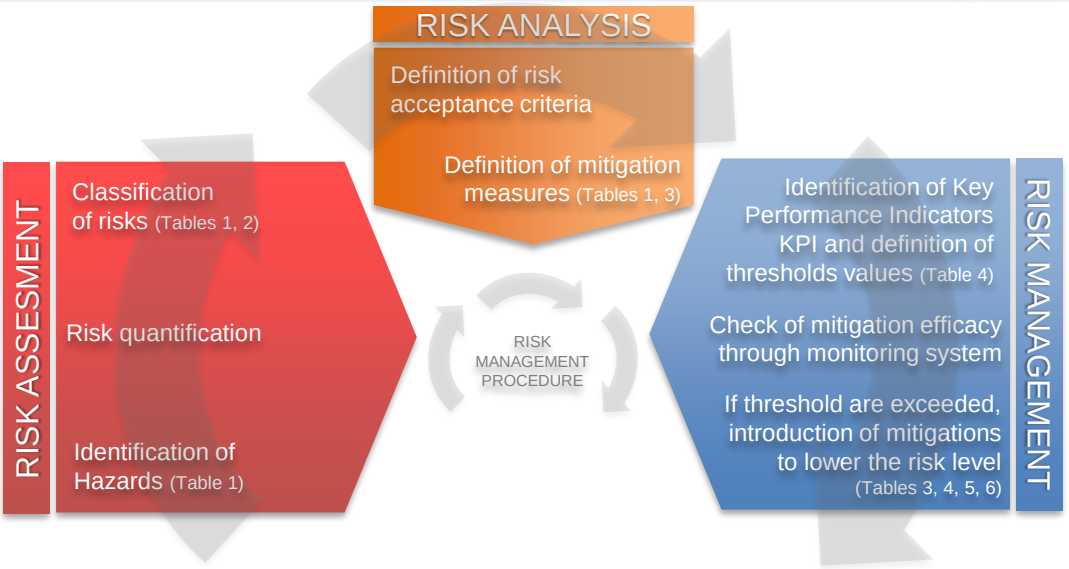

TABLE 1

HAZARD	RISK CAT.	MITIGATION MEASURES
FACE INSTABILITY	A	1, 2, 3, 6
SQUEEZING	A, B	1, 2, 3, 5, 6
ASYMM. STRESSES AND STRAINS	B	1, 2, 3, 5, 6
CAVE IN	A, C	1, 2, 3, 5, 6
SPALLING / CRUMBLING	B	1, 2, 3, 5, 6
FAULTS	A, B	1, 2, 3, 5, 6, 7
WATER INFLOW / PRESSURE	A	1, 2, 3, 7
DISSOLUTION / TRANSPORT	B	1, 2, 3, 7
GAS	A	8
MIXED FACE LITHOLOGY	B	1, 2, 3, 6
SWELLING	A, B	1, 2, 3, 9, 6
ROCK BLOCKS INSTABILITY	A, B	1, 2, 3, 6
ROCK BURST	A	1, 2, 3, 10
INTERF. WITH OTHER CAVITIES	B	11
INSTAB. IN MULTI STAGE EXCAV.	A	12
RADIOACTIVE MINERALS	A	13
CLOGGING	A	14
HIGH TEMPERATURES	A	15
IMPACT ON WATER RESOURCES	C	2, 4

TABLE 2

RISK CATEGORIES	
A	BLOCK OF REGULAR EXCAVATION PROCESS
B	COLLAPSE OR SIGNIFICANT DAMAGE TO LINING
C	IMPACTS ON ENVIRONMENT OR OTHER STRUCTURES

TABLE 3

MITIGATION MEASURES	
1	TBM: DRAINAGES + GROUTED FIBERGLASS BARS
2	TBM: DRAINAGES + MPSP CEMENT MIX INJECTION FROM FIBERGLASS BARS
3	TBM: BY-PASS TO REACH THE DAMAGED AREA + MPSP CEMENT MIX INJECTION FROM FIBERGLASS BARS
4	TBM: RADIAL RESIN INJECTIONS
5	(HYDRO)GEOLOGICAL / GEOMECH. INVESTIGATION
6	MOVING TO AN HEAVIER TYPICAL SECTION / INCREASING OF SUPPORT
7	INCREASING OF DRAINAGE
8	STRENGTHENING OF VENTILATION SYSTEM
9	REDUCTION OF WATER USE
10	MOVING TO Rb TYPICAL SECTION
11	REINFORCEMENT OF ROCK MASS BETWEEN CAVITIES
12	APPROPRIATE CONNECTION BETWEEN STRUCTURES
13	ADOPTION OF SPECIFIC PROTECTION FOR STAFF MEMBERS; REDUCTION OF EXPOSITION TIME
14	APPLICATION OF SOIL CONDITIONING AGENTS; REDUCTION OF WATER USE
15	STRENGTHENING OF COOLING SYSTEM

TABLE 4

KPI	ATTENTION THRESHOLD	ALARM THRESHOLD
SURVEYS, TBM SPOIL ANALYSIS	SMALL AMOUNT OF ATYPICAL MATERIAL WITH RESPECT TO GEOLOGICAL MODEL	GREAT AMOUNT OF ATYPICAL MATERIAL WITH RESPECT TO GEOLOGICAL MODEL
GEOMECH. CLASSIFICATION OF FRONT	TRACES OF ASYMMETRY, ANISOTROPY, DISHOMOGENEITY, RMR NEAR ATTENTION THRESHOLD	CLEAR ASYMMETRY, ANISOTROPY, DISHOMOGENEITY, RMR NEAR ALARM THRESHOLD
WATER FLOW RATE / PROPERTIES	NOT IN PRESSURE WATER INFLOW, TEMPERATURE COHERENT WITH PREVIOUS RESULTS	IN PRESSURE WATER INFLOW, TEMPERATURE NOT COHERENT WITH PREVIOUS RESULTS
CONVERGENCE / EXTRUSION	1 % OF EXCAVATION RADIUS	2 % OF EXCAVATION RADIUS
TBM PARAMETERS	SIGN OF ANOMALIES, LIGHT REDUCTION OF SPECIFIC ENERGY	CLEAR ANOMALIES, DRASTIC REDUCTION OF SPECIFIC ENERGY
STRESS IN LININGS	77 % OF MATERIAL DESIGN STRENGTH	100 % OF MATERIAL DESIGN STRENGTH
ACOUSTIC EMISSIONS	NOT RELATED TO INCIPIENT FRACTURE PHENOMENA	RELATED TO INCIPIENT FRACTURE PHENOMENA

TABLE 5

KPI	CONSEQUENT ACTIONS	MITIGATION MEASURES (MINING METHODS)
ALL UNDER ATTENTION THRESHOLD	ONLY SYSTEMATIC MONITORING	NONE
AT LEAST ONE OVER ATTENTION THRESHOLD	SYSTEMATIC AND NON-SYSTEMATIC MONITORING	PREPARATION TO 6
AT LEAST ONE OVER ALARM THRESHOLD	SYSTEMATIC AND NON-SYSTEMATIC MONITORING	6

TABLE 6

KPI	CONSEQUENT ACTIONS	MITIGATION MEASURES (TBM)
ALL UNDER ATTENTION THRESHOLD	ONLY SYSTEMATIC MONITORING	NONE
AT LEAST ONE OVER ATTENTION THRESHOLD	SYSTEMATIC AND NON-SYSTEMATIC MONITORING	NONE
AT LEAST ONE OVER ALARM THRESHOLD	SYSTEMATIC AND NON-SYSTEMATIC MONITORING	1, 2, 3, 5 OR DEFINITION OF OTHER MITIGATION MEASURES