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INFLUENCE OF GEOLOGICAL AND GEOTECHNICAL CHARACTERISTICS DURING THE REDACTION OF TUNNEL PROJECTS

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INTRODUCTION

The construction of tunnels is a complicated task that requires a rigorous knowledge of the materials along the entire route. In recent times, there have been many accidents in tunnels around the world that show the importance of geological and geotechnical knowledge before the construction of any tunnel. The geomechanical classifications are fundamental to obtain a correct vision of the behavior of the materials presented in the rock mass and how they interact with each other. The rock mass can be defined as the non-homogeneous material formed by rock fragments and blocks of different sizes, intact or altered, with their defects, separated by series of discontinuities, such as joints, faults, stratification planes, etc. Its composition varies in space and time. The rock mass classifications emerge at the beginning of the 20th century. They are based on an empirical approach and are developed as a systematic design tool in civil and mining engineering. The aim to organize and systematize the procedures of field investigations. However, they should not be used as substitutes for analytical studies, observations and measurements in the field, nor contributions from experts. They should be used in conjunction with other techniques.

CLASSIFICATION SYSTEM	AUTHOR, YEAR	COUNTRY OF ORIGIN	APPLICATION
Protodyakonov	*Protodyakonov, 1907*	*Eastern Countries*	*Tunnels*
Load on rocks	*Terzaghi, 1946*	*EEUU*	*Tunnel with steel support*
Self-stability time	*Lauffer, 1958*	*Austria*	*Tunnels*
Rock Quality Designation	*Deere et al., 1967 and Deere, 1968*	*EEUU*	*Tunnels*
Rock Structure Rating	*Wickham et al., 1972*	*EEUU*	*Tunnels*
Rock Mass Rating	*Bieniawski, 1973 and 1989*	*South Africa*	*Tunnels, mines, slopes and foundations*
System Q	*Barton et al., 1974*	*Norway*	*Tunnels, caverns.*
Geological Strength Index	*Hoek et al., 1995*	*Canada*	*Not applicable to support calculations. Characterization of rock masses*
Rock Mass index	*Palmström, 1995*	*Norway*	*Rock engineering*
Rock Condition Rating	*Sheorey, 1993 Goel et al. 1996 Kumar et al., 2004*	*India*	*RMR variant*
Qmod Index	*Sheorey, 1993 Goel et al. 1996 Kumar et al., 2004*	*India*	*Q system variant with SFR = 1*
Rock Mass Fabric Index	*Tzamos and Sofianos, 2007*	*Greece*	*Diagrams to obtain so simplified the parameters of the RMR, Q, GSI and RMi systems*
Rock Mass Quality Index	*Aydan et al., 2014*	*Japan Turkey*	*Estimation of the properties of the rock mass*

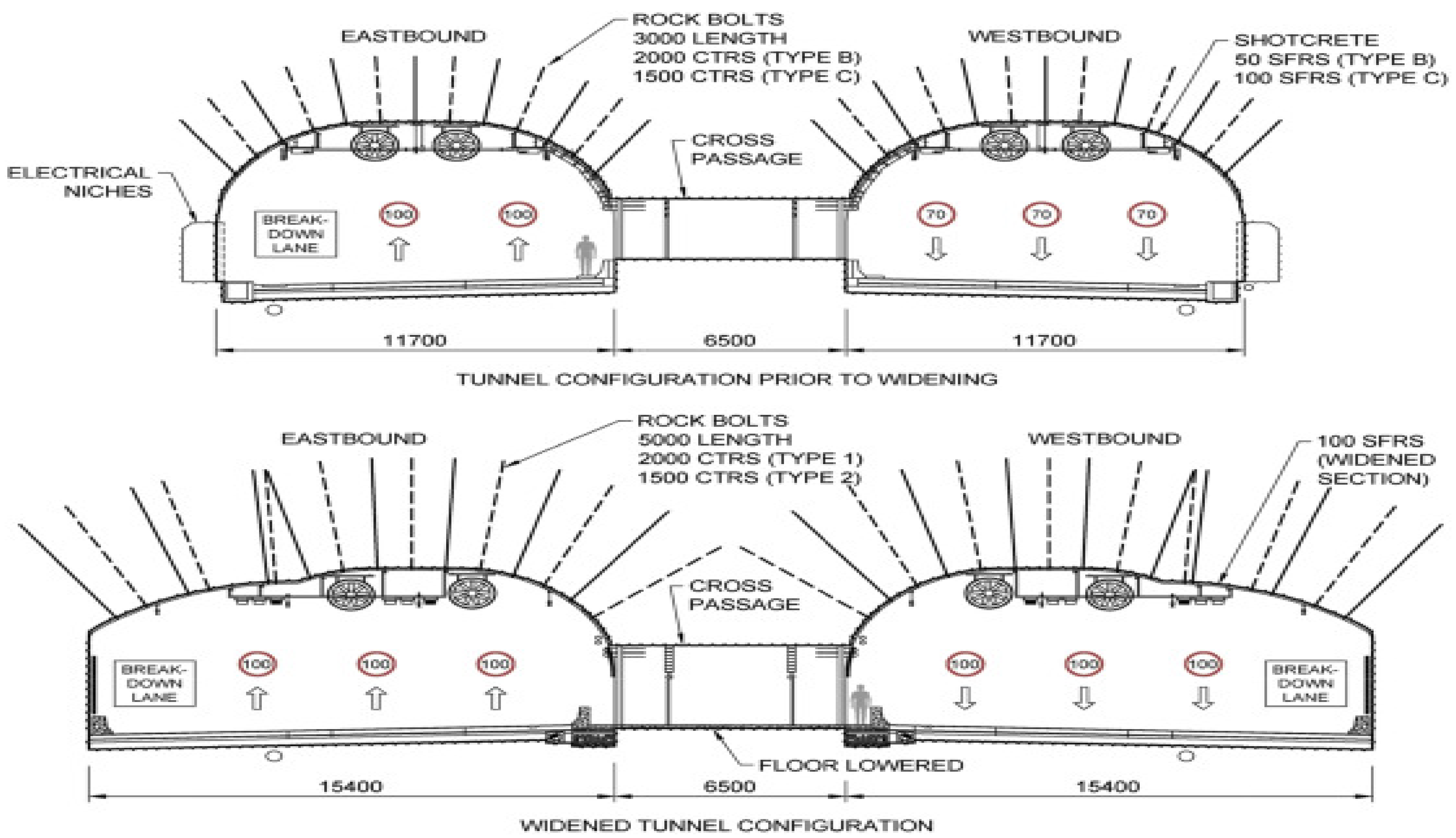
Table 1.- *Summary of the systems most used throughout the world, indicating the author, when it was developed and the field of application of the proposed system.*

PARAMETERS AND GEOMECHANICAL AND CLASSIFICATIONS TO USE IN TUNNELS

The RMR system, developed by the South African Council of Scientifical and Industrial Research, and the Q system, developed by the Norwegian Geotechnical Institute, have established themselves as the most used rock mass classification methods in the world. Since both classification systems divide the rock mass in different classes of similar characteristics that can be easily evaluated by visual or simple observations, a correlation between can be expected. Since the first correlation presented by Bieniawski in 1976, numerous authors have presented different correlations based on regression analysis of RMR and Q data obtained from tunnel and mine projects in different parts of the world. The value of the Q allows us to get an idea of both the quality of the mass, as well as the influence of the tensional state, the block size, the resistance to cut between the blocks and the support measures to be used. To avoid misuse of the described classifications, the authors themselves, Bieniawski and Barton, have published some recommendations for their correct application. Currently, there are numerous correlations between both classifications that allow to obtain reciprocal values of system Q or RMR.

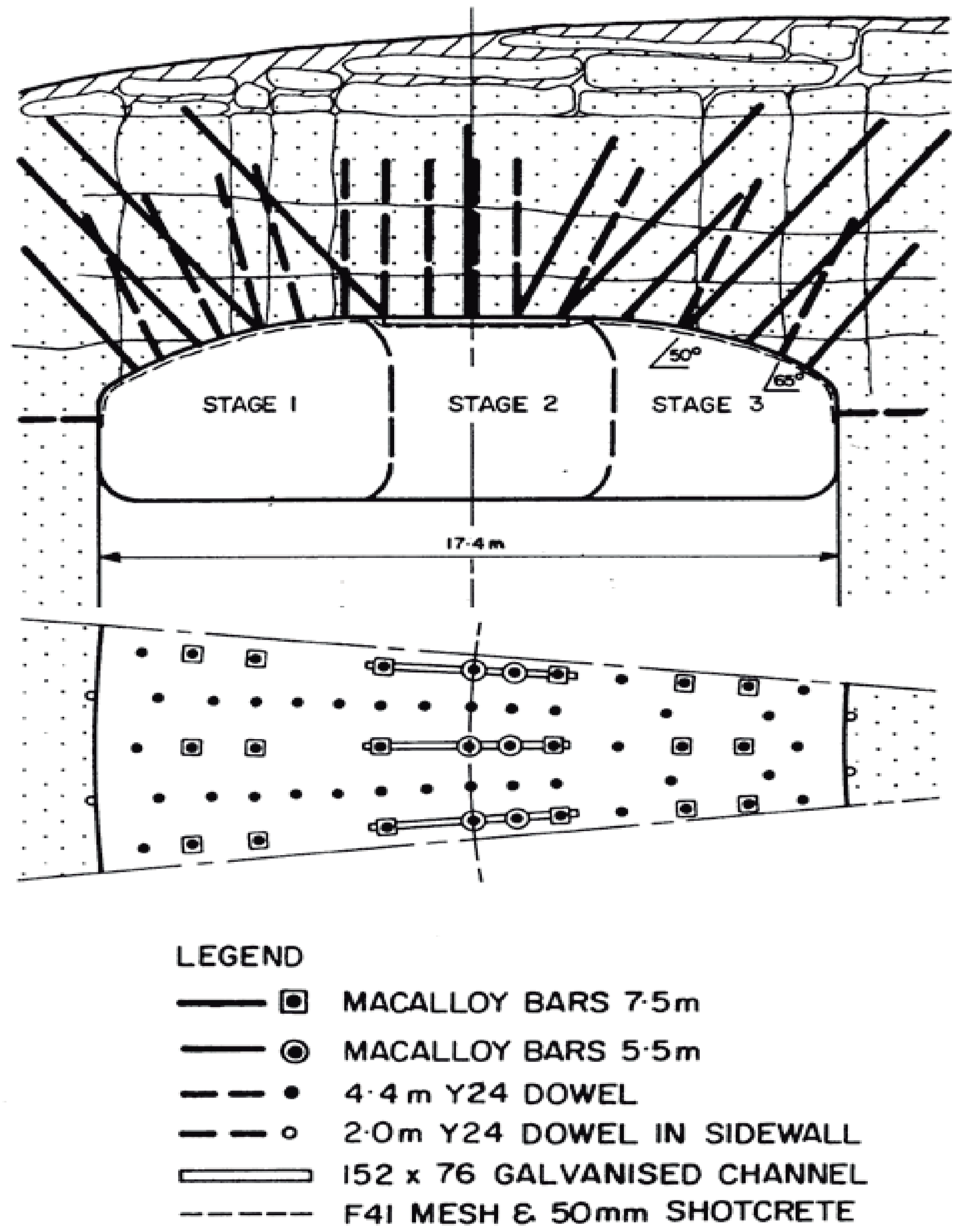
GEOMECHANICAL CLASSIFICATION AND APPLICATION INTO TUNNEL EXECUTED

<u>THE M2 TOLLWAY TUNNEL (NORFOLK TUNNEL)</u>



The design of this tunnel consisted of two tunnels of 11.7 meters wide separated by a pillar of 6.5 meters. The cover has a thickness between 16 and 22 meters consisting of sandstones of good quality. The values of the Q system in the crown ranged from 20 to 45 points and the RMR values from 55 to 75 points. For these RMR values the support indicated consisted of bolts 3 to 4 meters long, separated from 1.5 to 2 meters with shotcrete of 50 to 100 millimeters. However, the support recommendation consisted in bolts of 4 meters in length separated by 2.5 meters and in some cases use of bolts of 4 meters without shotcrete. At the present time the support of the tunnel consists in bolts of 5 meters in length with separations of 1.7 meters with 110 millimeters of shotcreate, and 2.4 meters with 50 millimeters of shotcreate.

<u>SYDNEY OPERA HOUSE PARKING CAVERN</u>



The design and construction of the cavern took place in the parking lot of the Sydney Opera House, but was described in detail in Pells, Best and Poulos . The ceiling of the cavern composed of 6 to 8 meters of sandstone obtained a score of 65 points in the RMR classification, and occasionally what corresponds to a support for every 2.5 meters of 3-meter-long bolts with mesh and 50 mm shotcrete where required. There are differences in the support between the project and the built part, because of the structural analysis that is based on bolts of 3.6 meters and 7.5 meters in length spaced in 1.3 meters, with an electrowelded mesh and 150 milimeters of shotcreate.

CONCLUSIONS

The classification systems of the rock mass emerged as a transmission mode of acquired knowledge by the design engineers and geologists in different parts of the world and with different geologies. These serve as a systematic method for characterization of the rock mass and allow as to know a recommended support to be used. However, they should not be a substitute for analytical calculations, field observations or expert knowledge. Any classification has been imposed over the others. It is recommended using more than one classification in the same project. The two most commonly used systems in the world are the RMR system proposed by Bieniawski and the Q system proposed by Barton et al. The design correlations published in the various articles on the Q and RMR systems, should be used with great caution in geological settings, significantly different from those in the original case studies. Numerical modeling is a very useful tool in the design and calculation of tunnels, since it allows us to obtain specific support needs for specific cases.

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