SAVEZ GRAĐEVINSKIH INŽENJERA SRBIJE
UNION OF ENGINEERS AND TECHNICIANS OF SERBIA

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MEĐUNARODNO NAUČNO-STRUČNOG SAVETOVANJA

PROCEEDINGS
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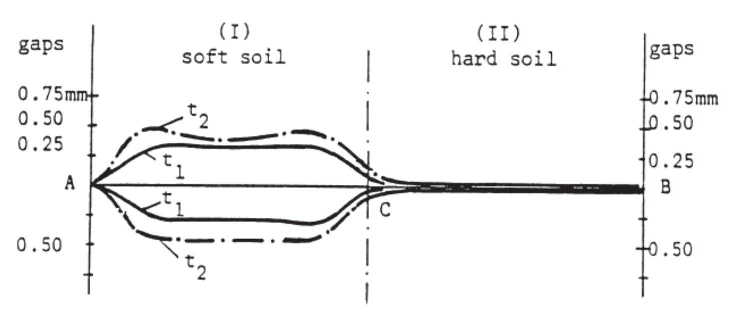
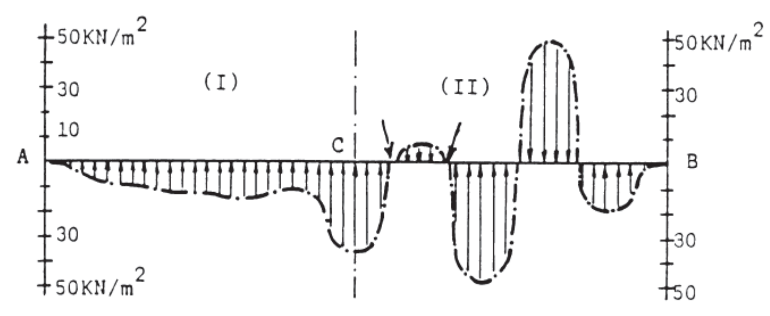
ZEMLJOTRESNO INŽENJERSTVO I GEOTEHNIČKI ASPEKTI GRAĐEVINARSTVA

EARTHQUAKE ENGINEERING AND GEOTECHNICAL ASPECTS OF CIVIL ENGINEERING

Editor: Prof. emeritus dr Radomir Folić



Gaps mean values along the pipeline at times t1 = 0.6 sec and t2 = 2.1 sec



Soil-pressure distribution mean values along the pipeline at the time t1 = 0.6 sec

Vrnjačka Banja, 03. - 05. novembar 2021.

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DRUŠTVO ZA ZEMLJOTRESNO INŽENJERSTVO SRBIJE
I
SRPSKO DRUŠTVO ZA MEHANIKU TLA I GEOTEHNIČKO INŽENJERSTVO

U SARADNJI SA INŽENJERSKOM KOMOROM SRBIJE

ZBORNIK RADOVA

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PRODOR STENA U EVROKODU 7

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REZIME
Već 2023/4 god. planira se objavljivanje nove generacije Evrokoda 7. Jedan od motiva je da se obuhvate principi razvijeni u mehanici stena. U radu su istaknute najznačajnije tačke primene Evrokoda 7 u inženjerstvu stenskih masa, vezano za njihov diskontinualni karakter, modeli loma, čvrstoće stenskog masiva itd. Dat je i osvrt na karakteristične vrednosti i parcijalne faktore parametara stenske mase. Odgovarajuća pažnja posvećena je mogućnosti primene propisanih mera u procesu projektovanja zasnovanog na principu uporednog iskustva. Najznačajniji aspekti vezani za kategorizaciju Geološke složenosti terena i Geotehničkih kategorija su takođe analizirani, kao deo koji se može poboljšati.

KLJUČNE REČI: Evrokod 7, mehanika stena, standardi za projektovanje, propisane mere

BREAKTHROUGH OF ROCKS IN EUROCODE 7

ABSTRACT
The second generation of Eurocode 7 is planned for publishing in 2023/4, where the principles of rock mechanics are to be implemented. Some of the most important points concerning their application are discussed, as the implications of the discontinuity of rock masses, failure modes, strength etc. An overview is done to the characteristic values and partial factors for rock mass parameters. An attention is given to the use of classification systems in definition of prescriptive measures during design. Some key issues related with combination of Geological Complexity and Geotechnical Category are noted as a field for possible improvement.

KEY WORDS: Eurocode 7, rock mechanics, design standards, prescriptive measures

INTRODUCTION

The roots for European design and construction standards (Eurocodes) can be followed from 1957, connected with overall concept for European integration stipulated with a Treaty of Rome. Eurocode development started in 1975, while in 2010, the Eurocode for Geotechnical Design, EN-1997-1: 2004 (informally known as Eurocode 7 or EC7), became the Reference Design Code (RDC) for geotechnical design (Harrison et al., 2015). The main idea in EC7 is to adopt limit state design (LSD) philosophy, also known as reliability-based design (RBD). In the beginning EC7 was related mainly to design of common buildings and civil engineering works on/in/of soil, while special structures, such as dams, tunnels etc. dominantly constructed in or on rock masses were not analysed adequately.

During the phases of development and implementation, it became evident that principles of rock mechanics and rock engineering problems were not incorporated in EC7 in a satisfactory manner (Lamas et al., 2014). Therefore, in 2014, the Commission of the European Communities (CEC) and the International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE), asked the Board of International Society for Rock Mechanics and Rock Engineering (ISRM) to establish Commission on the Evolution of EC7 in Rock Mechanics. The development schedule until 2020 has been agreed (Table 1).

Tabela 1. Planirana dinamika rada na Evrokodu 7 (Harison i sar., 2015)
Table 1. Eurocode 7 work schedule, 2015-2020 (Harrison et al., 2015)

Phase 1, commencing early 2015		
Task 1: Harmonization and ease-of-use reorganized framework for EC 7	Task 2: General rules Revised Eurocode 7 Part 1, concentrating on principles and similar in form to the other structural EC	
Phase 2, commencing early 2016		
Task 3: Revised EC 7 Part 2 focused on more practical information for a wider range of tests	Task 4: Foundations, slopes and ground improvement The first half of the new EC 7 Part 3, devoted to practical rules for design of these structures	Task 5: Retaining structures, anchors and reinforced ground The second half of the new EC7, Part 3
Phase 3, commencing early 2017		
Task 6: Rock Mechanics and Dynamic design Adding to and enhancing existing text throughout all parts of EC 7 with regard to any aspects of these subjects that may inadvertently have been neglected		
Final draft, issued early 2018 Adoption vote, early 2020 New generation of Eurocodes issued mid 2020		

During the recent period, specific scientific events were organised by the ISRM community, but beside all efforts, it is evident that initial expectations about adoption of new generation of EC are not fulfilled. Having in mind this situation, in a frame of this article some key aspects regarding EC7 and rock engineering, using some own ideas and examples from the practice will be underlined.

SOME KEY ISSUES IN EC7 WITH REGARD TO ROCK ENGINEERING

Ideas for possible improvements of EC7 in regard to rock engineering came from the key problems pointed from several authors. E.g., Lamas et al. (2014) noted the following:

- The assumption of the aleatory nature of the rock mass parameters may not apply to rock masses.
- Non-linear strength criteria are currently used in rock mechanics. Guidance on determination of characteristic values is not available.
- Limit states and failure modes applicable to fractured rock masses need more attention.
- Partial factors (PF) either do not exist or are not calibrated for rock masses and for discontinuities.
- Rock matrix and rock mass anisotropy need to be addressed in EC7.
- Rock mass characterization needs improvement in EC7 as regards discontinuities, as well as lab and field tests.
- Incorporation of the widely used rock mass classifications for design of rock mass structures in the scope of EC7 needs to be clarified.

Beside these, the following weak points of EC7 can be added:

- EC7 does not take into account special slope protective measures as rockfall barriers.
- Suggested method for estimation of bearing capacity of rock masses gives only a simple approach which differs a lot from known methods for analytical calculations.
- PF are mainly related to linear dependence between normal and shear stress, while rock mass strength criteria are mainly non-linear.
- Fixed PF may not correspond to the same structural reliability for all design situations.
- Present three geotechnical categories in EC7 need to be connected with some additional criteria, in order to obtain possible risks during construction.
- Prescriptive measures, very important for rock mechanics, are not explained in adequate way for rock masses.
- Not all testing methods from Suggested ISRM methods are accepted as EU standards.

From the other side, there are a lot of improvements in the past period in all specific areas of interest. This means that principles of EC7 are already applied for rock mechanics problems, in different ways, in some National Codes, as NS 348 (Norwegian Council for Building Standardization, 1988), Canadian Highway Bridge Design Code (Canadian Standards Association, 2014), Swedish national guidelines for design of the main structural support system in road and railway rock tunnels etc.

Lot of authors contribute to solving of open questions. For example, some aspects of rock slope stability analysis and comparison of the results obtained with deterministic, probabilistic and EC7 approaches are explained by (Nilsen, 2000) and (Mathe and Ferentinou, 2021). In that direction, also the newest versions of Rocscience© for stability analyses (RocPlane, Swedge) have the EC7 approach already incorporated.

Palmström and Stille, (2015), underline that the EC7 application rules give very short and weak guideline for using prescriptive measures as one of the four design methods that can be applied when no calculation models are available or necessary. They also give some recommendations about appropriate description for selection of the Geotechnical Category (GC) in EC7.

Problems with PF concept introduced in EC7 in protection from rockfalls or debris flows are analyzed by Vagnon et al. (2020). Some interesting analyses in using of LSD of weak rock slopes and proposals for partial factors are presented by Mahmoud and Mansour (2017). Their analyses highlight the significance of introducing a new PF with respect to the geological strength index (GSI). The idea is to achieve the expected matching between the LSD of weak rock slopes using Mohr Coulomb (MC) or Hoek-Brown (HB) shear strength parameters. The use of design charts for preliminary support design based on known RMR system, using partial factors and in a form of design charts is presented by Lowson and Bieniawski (2013).

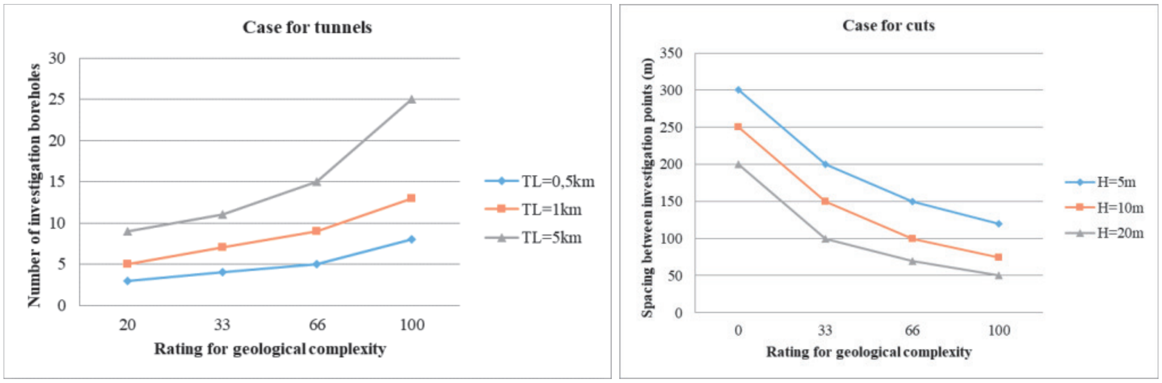
Miranda et al. (2012) noted that the EC7 method for estimation of bearing capacity of spread foundations in rock masses doesn't take into account important factors that influence the bearing capacity. High dispersion was found in the results calculating with EC7 compared to other analytical methods, which indicates that EC7 method should be used with caution even for very simple cases.

SUGGESTIONS FOR IMPROVEMENT REGARDING ROCK ENGINEERING

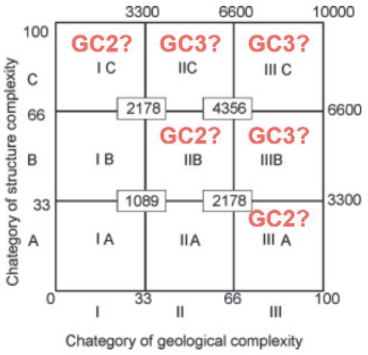
Based on existing studies and own analyses some possibilities for linking the geological and structure complexities, uncertainty, consequences and risks in EC7 are discussed.

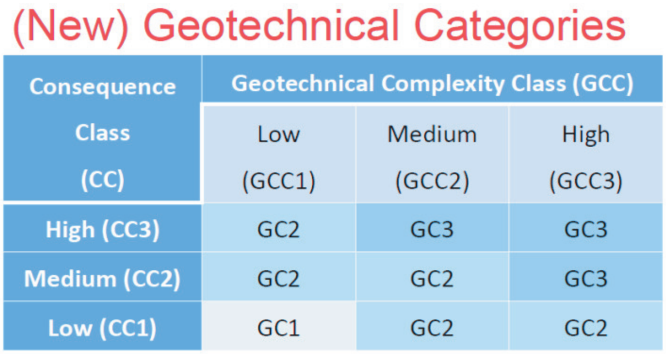
METHOD FOR IMPROVEMENT OF GEOTECHNICAL CATEGORIES DEFINITION

Improvement in the new generation of EC7 is possible in the initial concept of geotechnical investigations planning. Without going into details, the concept is explained in Figure 1, based on earlier works by Lokin i Ostojić (1992), Jovanovski (2001) and Jovanovski et al. (2016, 2020). There, in definition of geological complexity of the rock mass (ground) media and structure complexity, rating methodology of several parameters is developed. Final idea is to connect these "independent" parts in one system, because EC7, so far, does not give an appropriate description for selection of the GC. Now, in the second generation, there is an intention to introduce new GC, where Consequence Classes (CC) and Geotechnical Complexity Classes (GCC) are combined, which gives certain GC. The idea is presented in Figure 2 (see also approach by Walter, 2017).



Slika 1. Prognoza rastojanja između istražnih radova u zavisnosti od geološke složenosti i karakteristike objekta za tunele (dužina TL) i useke (visina H), (Jovanovski i sar., 2016, 2020)
Figure 1. Estimation of distance between investigation points depending upon geological complexity and structure's properties for tunnels (length TL) and cuts (height H), (Jovanovski et al., 2016, 2020)



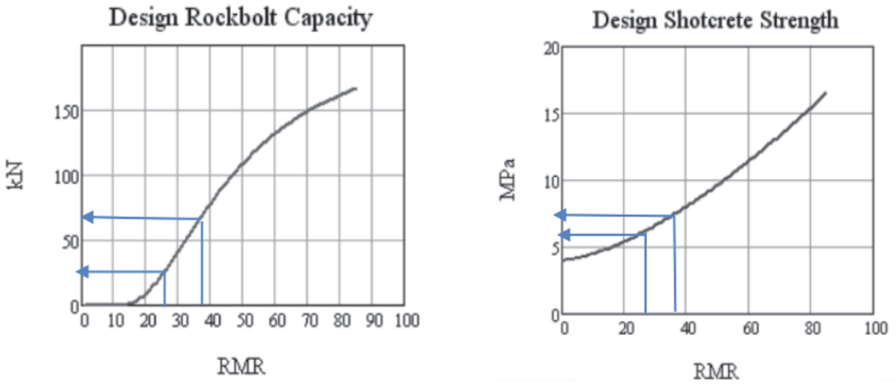

(New) Geotechnical Categories

Consequence Class (CC)	Geotechnical Complexity Class (GCC)		
	Low (GCC1)	Medium (GCC2)	High (GCC3)
High (CC3)	GC2	GC3	GC3
Medium (CC2)	GC2	GC2	GC3
Low (CC1)	GC1	GC2	GC2

Slika 2. Kombinacije kategorija geološke složenosti i složenosti konstrukcije upotrebom rejtinga (Jovanovski i sar., 2016) (levo); Sličan pristup predložen od Walter (2017) (desno)
Figure 2. Combination of ratings for geological complexity and structure complexity using rating (Jovanovski et al., 2016) (left); Similar approach suggested by Walter (2017) (right)

DISSUSION ON PRESCRIPTIVE MEASURES IN EC7

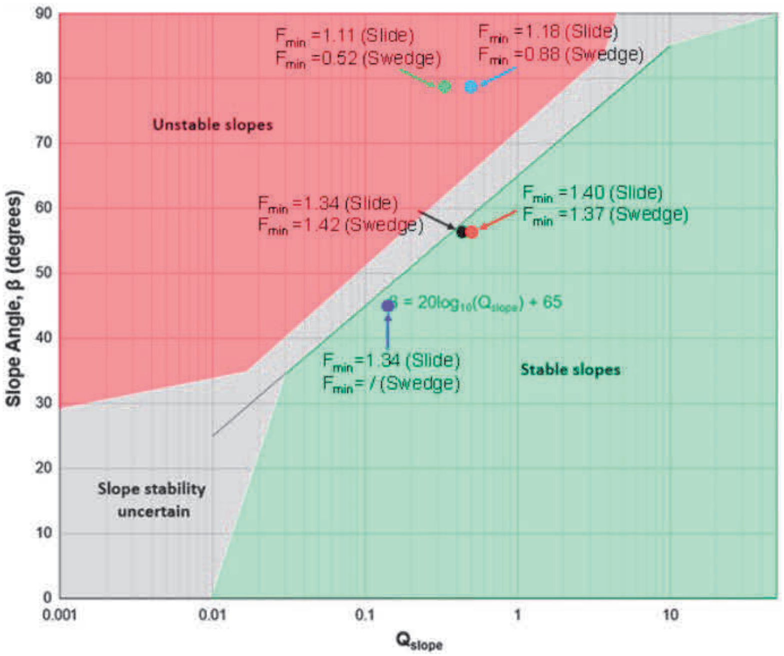
One of the four offered design methods in EC7 are prescriptive measures, but, at the moment, the application rules give weak guideline for using them. From the other side, in rock engineering, most rock mass classification systems have important role in design of complex underground and surface structures. Systematic documentation of earlier experiences is, in fact, basis for application of prescriptive measures. The paper shows some possibilities in use of well-known RMR and Q systems in different structures. In Figure 3, the application of RMR system is presented, for a case of estimation of support for a tunnel "Vrsnik" in Serbia, based on Lowson and Bienawski charts (2013).



$$F_{bd} = \frac{F_b}{\gamma_b} \cdot \left(\frac{RMR}{85}\right)^{\frac{40}{RMR}} \qquad f_{cd} = \frac{f_{ck}}{\gamma_s} \cdot \left[0.2 + 0.8 \cdot \left(\frac{RMR}{100}\right)^{\frac{3}{2}}\right]$$

Slika 3. Projektovanje nosivosti sidra upotrebom vrednosti RMR za slučaj F_b=250 kN i PF γ_b=1.5 (levo); projektovanje nosivosti prskanog betona za čvrstoću f_{ck}=30 MPa i PF γ_s=1.5 (strelice ukazuju na dijapazon vrednosti za RMR duž trase tunela "Vrsnik") (desno) (Marinković i sar. 2021)
Figure 3. Design Rockbolt Capacity using RMR for case F_b=250 kN and PF γ_b=1.5 (left); Design Shotcrete Strength versus RMR for shotcrete strength f_{ck}=30 MPa and PF γ_s=1.5 (arrows indicate range of value for RMR defined along tunnel "Vrsnik" in Serbia) (right) (Marinković et al., 2021)

Application of so-called Q-slope method, in design of high cuts in weathered schists formations for a motorway from Kičevo to Ohrid in Macedonia is presented in Figure 4 (Janevski and Jovanovski, 2021). In the frame of the article, results for different possible failure mechanisms in complex geological media are presented, using the traditional limit equilibrium method and the relatively new empirical approach Q-slope. It is relatively fast and intuitive empirical method for stability assessment of excavated reinforced-free slopes, whose main advantage over the other empirical methods is that it helps estimate the long-term stable slope angles without reinforcement. The coloured dots in Figure 4 represent the Q-slope value. The factors of safety in the software Slide refer to the global stability and the factors of safety obtained with the software Swedge refer to the stability of surface wedges. This is an example of possible combination of results from analytical and prescriptive methods. Having in mind that the principles of EC7 analyses are incorporated in newer versions of these softwares, that can be one area for future improvement in EC7.



Slika 4. Q-slope dijagram za useke sa odgovarajućim vrednostima faktora sigurnosti upotrebom softvera Slide i Swedge (Janevski i Jovanovski, 2021)
Figure 4. Q-slope stability chart for the cut slopes and their corresponding factors of safety obtained with Slide and Swedge softwares (Janevski and Jovanovski, 2021).

USE OF PARTIAL FACTORS IN STABILITY ANALYSES USING EC7

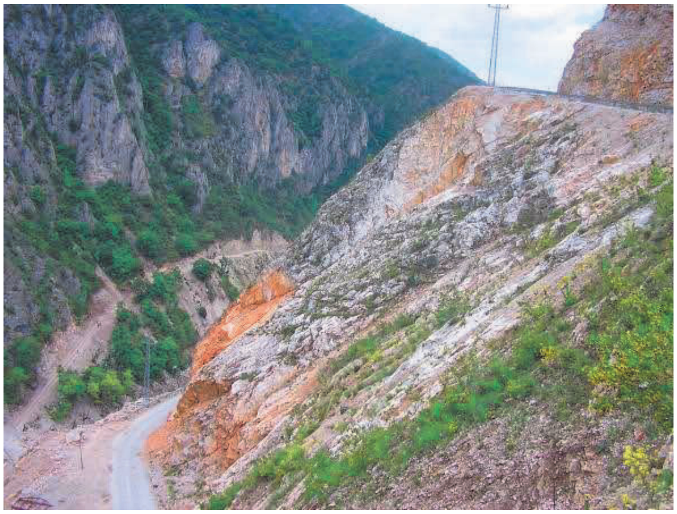
A case representative for a common stability problem with cut for access road to Sv. Petka dam nearby Skopje is also given in the paper. This example, beside approaches on LEM and LSD, serves also as a case to open some dilemmas of PF use in definition of shear strength along joints in rock mass. The geometry of the problem and input parameters are presented in Figure 5, while the results are shown in Table 2 and Table 3: they are obtained through use of a APF PlaneFailure software.

Tabela 2. PF i nalazi iz analize stabilnosti primenom proračunskog postupka 1, kombinacija 2, u EC7
Table 2. PF and results for stability analyses using Design Approach 1, Combination 2 in EC 7

Partial factors (Limit State Design)	Static conditions	Seismic conditions
$\gamma_{G,unfav}$	1,00	1.0
γ_c	1,25	1,25
γ_φ	1,25	1,25
$\gamma_{R;e}$	1,00	1,00
Results from deterministic analysis	Weight [kN]	3571.77
	Groundwater (S) [kN]	215.83
	Groundwater (T) [kN]	8.42
	Earthquake [kN]	357.18
	Driving force [kN]	2575.95
	Resisting force [kN]	3040.51
	Factor of safety	1,18

Tabela 3. Uporedna analiza, sa parcijalnim koeficijentim za granično stanje
Table 3. Comparative analysis, with partial factors for Limit State Design

Parameter	Results	W (groundwater)
Driving force [kN]	2295.89	2302.34
Resisting force [kN]	3322.28	3184.00
Factor of safety	1,45	1,38
Results - seismic		W
Driving force [kN]	2569.50	2575.95
Resisting force [kN]	3178.78	3040.51
Factor of safety	1,24	1,18



Slope

Slope height [cm]	H	1400.0
Slope face angle [°]	ψ_f	65.0
Upper surface angle [°]	ψ_s	28.0
Sliding plane angle [°]	ψ_p	40.0
Tension crack inclination [°]	ψ_c	90.0
Tension crack distance [cm]	b	1920.0

Material

Cohesion [MPa]	c	0.06
Friction angle [°]	φ	38.0
Unit weight [kN/m^3]	γ	26.50

Ground water

Percent filled	**%**	50
Unit weight [kN/m^3]	γ	9.81

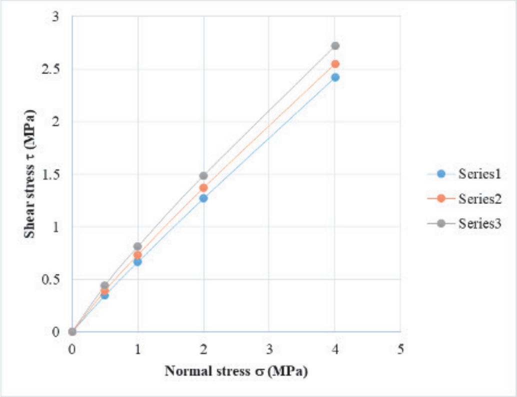
Slika 5. Izgled analizirane kosine sa kinematskim uslovima za planarni lom (levo); Ulazni parametri za proračun stabilnosti (desno)
Figure 5. Picture of analyzed slope with kinematic preconditions for planar failure (left); Input parameters for stability analyses (right)

What is important in the application of PF is that they are related to linear shear strength envelope; in rock mechanics, non-linear shear strength criteria are usually used (ISRM, 2007). However, Papić et al. (2012) have shown that it is also possible to include EC7 partial factors in the non-linear failure envelopes for slope stability analyses (by reducing the shearing strength in, e.g., user-defined models) as well as to adapt, i.e. vary PF for the needs of design and verification at different load cases (Papić et al., 2014).

For the cut at Fig.5, the Barton-Bandis failure criteria is used. The values of respective JRC and JCS parameters are reduced to the range of rock mass (JRC_m and JCS_m) based on field observations and laboratory tests (Jovanovski, 2001). Parametric analysis is used, so min, average and max values for some normal stresses are given in Table 4 and Figures 6 and 7.

Tabela 4. Raspon iznosa ugla unutrašnjeg trenja za lom u ravni za pojedine nivoe normalnog napona
Table 4. Range of values for angle of friction for planar joints for some level of normal stresses

Normal stress σ [MPa]	Min.values for angle of friction along failure plane [°]	Average values [°]	Max values [°]
0,5	34,76	38,02	41,47
1	33,58	36,2	39,04
2	32,37	34,36	36,5
4	31,17	32,49	34,21

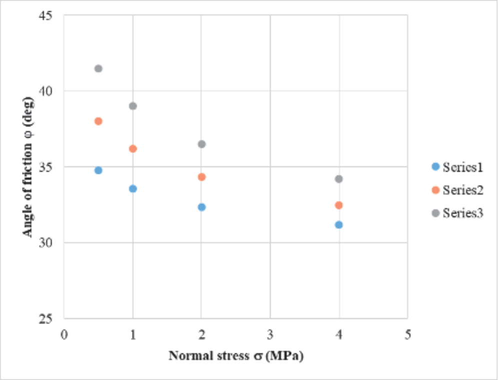


$$\tau = \sigma_n tg\left[JRC \cdot log\left(\frac{JCS}{\sigma_n}\right) + \varphi_r\right]$$

$$\varphi_r = (\varphi_b - 20) + 20(r/R)$$

JRC - joint roughness coefficient
JCS - joint compressive strength
φ_r - residual angle of friction
φ_b - basic angle of friction
r - Schmidt Hammer Rebound Value for altered surfaces
R - Schmidt Hammer Rebound Value for fresh surfaces

Slika 6. Dijagram normalni napon - tangencijalni napon za pukotinsku površinu za planarni lom sa variranjem vrednosti za ulazne parametre i definisanje različitih anvelopa loma
Figure 6. Diagram normal vs shear stress of planar failure plane for different range of values of the input parameters and defining different failure envelopes



$$JRCm = JRCo(Lm/Lo)^{-0.02\,JRCo}$$

$$JCSm = JCSo(Lm/Lo)^{-0.03\,JRCo}$$

JRCo (sample range)	8 – 10
JCSo [MPa] (sample range)	29 – 32
JRCm (rock mass range)	5 – 6
JCSm [MPa] (rock mass range)	14 – 18
φ_r [°]	29

Slika 7. Varijacije ugla trenja duž površine loma za različite nivoe normalnog napona i varijacije ulaznih parametara
Figure 7. Variation of angle of friction for different values of normal stress and range of values for input parameters

In definition of design value from characteristic ones, analysing values for angle of internal friction from table 4, several solutions are possible. For normal stress σ=0,5 MPa, the design value is 38/1,25=30,4°. Totally different situation is if the normal stress is 1 MPa, when design value becomes 33,58/1,25=26,86°. This indicates that the use of PF can be realistic only for some level of normal stress along failure plane, which can be another approach to modified use of non-linear envelopes in analyses: apply PF to different values of angles along failure plane which are defined for range of normal stresses.

CONCLUSION

The discussions regarding the applicability of rock mechanics principles in EC7 are still intensive in scientific community. Many opinions exists, some of them are similar like the earlier dilemmas from soil mechanics aspect, although there are some new! Main concern is how to incorporate discontinuous nature of rock masses in EC7, the greater application of prescriptive measures used in rock design, adequate definition of partial factors, etc. These should be considered as stimulating and can lead to the best possible solution at this moment. Beside all difficulties, it seems that the main idea of EC7 – to discuss with a same engineering language and philosophy in Europe and wider – is prevailing, and rock mechanic community is focused to give effective contributions to EC7 in the revised code.

REFERENCES:

Harrison J.P., Alejano L., Bedi A., Ferrero A.M., Lamas L., Mathier J.F., Migliazza R., Olsson R., Perucho A., Sofianos A., Stille H., Virely D., Wittke M.: Rock engineering design and the evolution of Eurocode 7: The critical six years to 2020. Proceedings of the 13th ISRM International Congress of Rock Mechanics. Montreal. 2015

ISRM: Suggested Methods for Quantitative Description of Discontinuities in Rock Masses. In R. Ulusay & J.A. Hudson. (eds), *The Complete ISRM Suggested Methods for Rock Characterization, Testing and Monitoring: 1974–2006*. Ankara. 2007

Janevski B., Jovanovski M.: Comparative assessment of slope stability in weathered schists using Q-slope and LEM. Eurock. IOP Conf. Series Earth and Env. Science 833(1):012173. 2021

Jovanovski M.: A Contribution on the Methodology of Investigation of the Rock Masses as a working media. Doctoral thesis, University "Ss. Cyril and Methodius", Civil Engineering Faculty – Skopje. 2001

Jovanovski M., Papic J.Br., Pesevski I.: Synchronizing of geotechnical investigations with ground's and structures complexities. National / EU Ground Engineering Registration, Workshop Meeting. Leuven. 2016

Jovanovski M., Peshevski I., Papic J. Br.: An approach for adapting geotechnical investigations to the cases of Rock Mass Structure Interaction – Applicability to Eurocode 7. Recent Trends in Rock Mechanics, Workshop meeting. Ljubljana. 2020

Lamas L., Perucho A., Alejano L.R.: Some Key Issues Regarding Application of Eurocode 7 to Rock Engineering Design. ISRM Regional Symposium - EUROCK 2014. Vigo. 2014. Doi:10.1201/b16955-254

Lokin P., Ostojić S.: Uputstvo za projektovanje i izvođenje geoloških istraživanja za potrebe projektovanja hidrotehničkih objekata. Studija: Energoprojekat-Hidroinženjering MDD. Beograd. 1992

Lowson A.R., Bieniawski Z.T.: Critical Assessment of RMR based Tunnel Design Practices: a Practical Engineer's Approach. Rapid excavation & tunneling conference. Washington. 2013

Mahmoud M.H, Mansour F.M.: Limit States Design of Weak Rock Slopes: Proposal for Eurocode Partial Factors. Engineering 191, pp.1161-1168. 2017. doi: 10.1016/j.proeng.2017.05.291

Marinković N., Jovanovski M., Zlatanović E., Bonić Z., Romić N., Geotechnical conditions for construction of the Vrsnik tunnel on the Nis-Pristina highway. 8th International Conference, Contemporary achievements in Civil Engineering. Novi Sad. 2021. ISBN: 978-86-80297-86-6

Mathe L., Ferentinou, M.: Rock slope stability analysis adopting Eurocode 7, a limit state design approach for an open pit. IOP Conference Series: Earth and Environmental Science, Volume 833, Mechanics and Rock Engineering, from Theory to Practice. Turin. 2021

Miranda T., Martins F., Araujo N.: Design of spread foundations on rock masses according to Eurocode 7. Harmonising Rock Engineering and the Environment. 12th International Congress on Rock Mechanics. Beijing. 2012. ISBN 978-0-415-80444-8, doi: 10.1201/b11646-373

Nilsen B. New trends in rock slope stability analyses. Bull Eng Geol Env 58, 173–178 (2000). Doi:10.1007/s100640050072

Palmström A., Stille H.: Rock Engineering, second edition. Book published by ICE. Publishing (Thomas Telford), 444p. London. 2015

Papić J., Dimitrievski Lj., Prolović V.: Value of partial factors for EC7 slope stability analysis: solved "mystery"?", 3rd International Conference on New Developments in Soil Mechanics and Geotechnical Engineering, pp193-198. Nicosia. 2012.

Papić J. Br., Ristov R., Ognjenović Sl., Peševski I.: Possible impact of Eurocode 7 on slope design for roads and railways. 3rd CETRA, pp.567-572. Split. 2014.

Vagnon F., Bonetto S., Ferrero A. M., Harrison J. P., Umili G.: Eurocode 7 and Rock Engineering Design: The Case of Rockfall Protection Barriers. Geosciences, 10(8), 305. 2020. doi:10.3390/geosciences10080305

Walter H.: Consideration of Rock Engineering in Eurocode 7 (EN 1997), Current state of the amendment. Workshop: Rock Mechanics in EC7, 66th Geomechanics Colloquium of Austrian Society for Geomechanics. Salzburg. 2017