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ENGINEERING REQUIRED TO HAVE SAFE STRUCTURES IN/ON THE EARTH CRUST AND EUROCODE 7

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Highlights

- Ground engineers' responsibilities have not been changed at all. They have to supply evaluations for stable spaces and structures for urban life in/on earth crust as they have always been required.
- Engineers dealing with earth for its properties, features, stabilities for different engineered structures like; dam, bridge, tunnel, mine gallery & stopes, pits, foundations of buildings etc. have their tough decisions under various uncertainties.
- Some European countries have gradually provided specifications to define ground engineering under EUR-ING qualifications.
- Rock engineering contributions to ground engineering have been assessed here by pointing Eurocode 7 progresses in time.
- In general, legal procedures may be started to check engineering standards, engineers' responsibilities and their professions, material qualities and documentations, structural designs, laboratory test results, official design approval procedures, foundation tests and their stability analyses etc., for detailed research.
- Therefore, engineers should certainly define their professions, expertise and responsibilities according to supplied standards. Thus, they should restrict themselves from getting loaded responsibilities and uncover their certificated professions and expertise.
- Engineering applications related to earth crust require excavations in soil and rock formations.
- Different types of surface and underground excavations could possibly be realised through diverse engineering designs due to their specific requirements.
- Engineering branches which have concentrated different aspects of works in/on earth crust have wide ranges of knowledge and experiences for ground engineering including in Eurocode 7 applications.
- Combination efforts of ground engineers have increasingly provided new dimensions and research areas for the stability concerns of engineered structures in/on earth crust (rock/soil masses).

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ABSTRACT: While engineering has recently been presented in medias by computers and laboratory outfits, responsibilities of ground engineers who perform works in/on earth crust have not been changed at all. They have to supply stable spaces and structures for urban life in/on earth as they have been always required. Engineers dealing with earth for its properties, features, stabilities for different civil work circumstances like; dam, bridge, tunnel, mine gallery & stopes, pits, foundations of buildings etc. have their tough decisions under various uncertainties. They have recently been categorised as ground engineers including, soil and rock engineers, geotechnics, geomechanics, geologist, civil and mining engineers etc. subjects. Some European countries have gradually provided specifications to define ground engineering under EUR-ING qualifications. Engineers who have been controlling product qualities, organising works for employees, testing in laboratories have their work places which have not been changed regularly, as it is the case for ground engineers. Rock engineering, (concepts based mainly on rock mechanics in geology, mining and civil engineering) contributions to ground engineering have been worked here under Eurocode 7 applications and evaluations performed by engineers.

Keywords: Eurocode 7, Ground Engineering, Rock Mechanics, Soil Mechanics, Geotechnics, Geomechanics, Eur-Ing

1. INTRODUCTION

Earth crust contents vary in different parts of the globe and supply requirements for humans and their civilisations. Engineers dealing with geology and geophysics have their works on formation and structures of rocks and soils layers shaped in geological eras. Civil engineers in soil mechanics subjects and rock engineers have works to understand soil & rock materials and their behaviours. Beside the usage of rocks and soils as construction materials in different human related activities, especially excavation and construction works for safe & stable spaces in/on earth crust for different usage purposes have been evaluated here to present rock engineering contribution in ground engineering concept.

Different types of open spaces, volumes, in/on rock masses have been designed & engineered for their shapes, dimensions, stabilities, ventilation (air quality and temperature suitability) properties etc. to comfort human requirements. These spaces have been supplied by mining and civil engineering construction works in/on the crust through history. It has been already known that, caves, sinkholes, underground city spaces, houses, buildings, skyscrapers and other types of structures have their unceasingly changing stability conditions which are partly depended on earth crust properties and their structural features. The earth mass has various types of soil and rock formations. Their behaviours under different stress conditions together with variable water & gas contents have been researched for several engineering purposes. For these purposes, the first task is often the discontinuity analysis to reveal the deterministic features of discontinuities such as cracks, joints, faults in different rock masses. Rock masses; massive, dry, saturated, fissured, fractured, swelling types etc. have been diversely researched to define more comprehensive explanations for their stability cases in engineering activities. Discontinuities supply weakness surfaces in fractured rock masses which should be evaluated for their positive and negative influences on engineered projects. These projects can be designed to realise in/on rock masses. Material

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properties of rock and soil masses and their structural features have common bases in some limits to be tested. Decisions, on the other hand, which should be supplied by ground engineering evaluations have supposed to cover whole aspects of earth crust (soil & rock masses). Understanding behaviours of soil and rock masses have gradually released the decision burdens over ground engineers in last decades. Supplying decisions for suitability of designs related with rock & soil masses have their own risks which are related with uncertain rock & soil features, (due to their natural characteristics). Experiences gained for certain earth localities and regions have played important roles in design decisions supplied for foundations, tunnel excavations & supports, slope reinforcement etc.

Eurocode 7 has recently started to be applied for ground engineering cases as a standard, (including risk evaluations as well). Engineers who work on soil and rock engineering fields have supplied their experiences and research results to point their evaluations related with Eurocode 7 applications. This study realised here have focused mainly on rock engineering evaluation of those researchers to present importance of joint works for the cases of Eurocode 7 allegations. At this point, it is required to mention statements of Alejano et al. [1] reported by Vagnon et al. [2] that, engineers had considered and followed standard code EN1997-1, [3], (called as Eurocode 7, EC7), as a reference design code for their geotechnical design circumstances in ground engineering cases in the CEN, (European Committee for Standardization), member countries. Their designs have possibly included rock engineering related subjects whenever necessary. Thus, Eurocode 7 has gradually become comprehensive standard application due to its new concerns & attitudes in ground engineering considerations in CEN countries. Actually, there are several other states which are not members of CEN are also aimed to follow Eurocode 7 procedures as well [4]. Understanding the background features of Eurocode 7 and related rock engineering impacts have progressively revealed more realistic engineering strategies in ground engineering projects.

2. GROUND ENGINEERING CONSIDERATION IN CONTENT OF EUROCODE 7

European countries have followed several engineering standards in national bases but, they have gradually enforced to follow common European standards. They are commonly called as Eurocodes and one of them is EC7 and it is related with ground engineering, geotechnical, geomechanical features of earth crust. In the cases of urban areas, foundations of any buildings & constructions and tunnels & infrastructure excavations etc. in Eurozone countries have to be engineered gradually according to EC7. Engineering projects related with earth crust including dam & bridge constructions, metro tunnels & stations, underground passageways, underground storage spaces, underground cities, protection works for caves, sinkholes rehabilitations, mine related excavations and support designs etc. have progressively been planned also according to EC7 for European countries. Usage of Eurocodes can likewise be a manner in engineering mobility for companies and engineers throughout the Eurozone countries. Efforts to develop Eurocodes have their difficulties mentioned in literatures but also have opportunities to reconsider national engineering standards. New approaches and technological developments could also be introduced into standards under developing stages. Engineering efforts supplied in underground excavations, tunnels and all types of space designs as working places in mining operations have to follow strict work & workplace safety and health related legislative rules including environmental and social concerns. These safety rules have gained throughout the mining histories of related nations. Underground metro tunnel excavations, bridge & dam constructions, big scale buildings & industrial plants and other works for modern urban life have also their success and failure stories in their stabilities. Similarly, geomechanical and geotechnical experiences gained for certain regions have collected after performing different works & tests and observing behaviours of foundations for examples through their usages. Civil, mining, geological and geophysical engineers who have extra professions on geotechnics, geomechanics, rock engineering, soil mechanics, foundations, excavation methods etc. have their contract works, project, performed in/on earth crust through different soil and rock masses for years. Each of this profession has its own good practices. Thus, experiences gained in their performances & projects are very valuable assets for our civilisation in this modern world. Engineering standardizations in these areas (related with earth crust) have therefore their own specifications and difficulties under discussions.

Governing authorities in the world on the other hand have their own experiences accumulated through successes and failures of the ground engineering projects. Disasters and aftermaths of them have always their traumas on societies. Coal mining explosions, water inrushes into mines and tunnels, collapse of mine galleries and tunnels, collapses or damages occurred at houses & constructions due to their structure and/or foundation problems, damages occurred at cities and towns partly due to earthquakes, slope failures, landslides, collapsing of the dams and resultant flood disasters etc. have caused many casualties which societies sometimes have difficulties to bear their traumatic scales.

Uncertainties in earth related engineering data have common facts and designing structures in/on earth crust have their approaches & criteria for those uncertain parameters in design stages. The questions have always aroused after those disasters if the casualties and/or collapsing of the urban structures could be prevented by applying different engineering methodologies. Legislative court procedures started after those disasters have their own methodologies which may or may not consider risks related with uncertainties in earth crust related engineering parameters. Engineering standardization in ground engineering efforts therefore, have gradually brought relief to ground engineers, earth crust related projects owners & employers and governing bodies of societies. Engineering standards describe basic rules to follow in engineering applications. Eurocode 7 includes also risk considerations controversially in analyses to cope with unpredicted design factors and uncertainty characteristics of earth crust related data sets. It is basic knowledge that stresses and strains, for example, could not be measured in full scale in surrounding rock masses around tunnels or beneath large scale concrete foundation slaps. That means there are always uncertainties in test measurements, eventually input parameters of engineering designs which should be predicted and modelled by test results but also with experiences of engineers (empirical and observational analyses, numerical approaches etc.).

New approaches and technologies might decrease the number of uncertain parameters in time. But, there are still many of them for current project conditions. Positive aspects of earlier socio-economic, environmental and ground engineering related projects which had been furnished with available theoretical, analytical, observational and numerical solutions have progressively forced governing bodies to pursue their procedures as flagship operations. However, new approaches in earth related projects have their own conditions to be considered. Therefore, there should be methodologies described in engineering standards covering most of the hesitations supplied by related engineers, contractors, project owners, governing bodies, societies etc. Thus, in order to discuss positive and negative influences of engineering standards in ground engineering works, remarks forwarded in the literature should also be taken into considerations. For instance; sentences written by Bolton [5] who stressed on influences of standards on engineering skills put some limitations forward arose due to application of the new standards (EC7 in this content) into words as follows; *"It is therefore possible to imagine optimistically that a new generation of codes might free the engineer from unnecessary constraints by emphasising proper objectives and acceptable methodology while eliminating references to specific guidelines which lawyers might interpret as "rules". It is equally possible, however, that new codes might become even more detailed and specific, offering less scope to the skilful designer, and possibly even forcing him into avenues which his professional judgement warns him are erroneous".* Similar remarks and their contents are helpful to re-evaluate forwarded EC7 contents to maximise its outcomes to the societies.

3. "ADEQUATE ENGINEER" PHENOMENA IN EUROCODE 7

Eurocode preparations have enlightened one case also, that is requirements of adequate engineers, technicians and workers. Defining "common bases" for different branches of engineers educated and graduated in different European countries has a deal to be resolved. Thus, European engineering definition, EUR-ING in short abbreviation, has emerged to describe engineers who obtain extra certification to play their engineering activities in any European country. At this point it is necessary to mention "*The fédération Européenne d'associations nationales d'ingénieurs*", FEANI, which was founded in Europe in 1951 to bring together 25 European countries` national engineering associations. Number of members in/out of Europe is currently 34 countries, *(including: Austria, Belgium, Bulgaria, Croatia, Cyprus,* *Czech Republic, Denmark, Estonia France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Kazakhstan, Malta, Netherlands, North Macedonia, Norway, Poland, Portugal, Romania, Russia, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom, Affiliated member Angola).* Purpose of this organisation was defined as *"To secure the recognition of European engineering titles and to protect those titles, in order to facilitate the freedom of engineers to move and practise within and outside Europe"*, [6]. Thus, defining the engineering education, training, experiences in accepted manners described in FEANI has vitally important for the certification. National education differences in engineering education and their recognition and registration systems (if any) in national engineering associations have stayed as diversity of applications. In FEANI system, engineering types and required education backgrounds have been defined to follow for candidates to be called as a "European engineers", [6]. In order to perform engineering works, projects or procedures in different European countries, graduates of engineering faculties (or any other types of education systems) should be fulfilled the requirements of the application steps of EUR-ING.

Engineers in "ground engineering" common subject title who work in their projects by following EC7 procedures cover; geotechnical, geomechanical, geological, engineering geology, rock engineering, mining engineering, civil engineering, foundations engineering etc. graduates. Thus, next generations in faculties who would like to be "engineer" and have EUR-ING certificate, must understand the limits and descriptions in FEANI system. In this aspect; descriptions related with certification of EUR-ING engineer in ground engineering is also be documented [7]. European countries such as, Germany, Macedonia, Austria etc. have already started EUR-ING certifications. Moreover, this certification procedure has already started new understanding in engineering and engineering educations in Eurozone countries. Non-European countries which follow European engineering standards for their common economic relations might also accept EUR-ING certifications gradually in time. Discussion and debates have been continued about Eurocodes and EUR-ING applications but, the codes have already accepted together with several years of adaptation periods. In this respect, universities offering engineering educations in Europe should evaluate their programs and courses together with their ECTS credits to follow requirements of Eurocodes and European engineering, EUR-ING, certification procedures. Logically they would like to graduate engineers who have legitimate to apply EUR-ING certifications directly. Requirements of adequate engineering acts in Eurocodes have reshaped, modelled, the future of engineering in different industries in Europe and other countries which have close economical connections & relations.

For the cases of ground engineering Jovanovski et al. [8] mentioned EC7 and requirement of experts in engineering activity covering "ground engineering" subjects. They wrote that *"Eurocode 7 (EN 1997, EC7), beside other important aspects, introduces the necessity of qualified and experienced personnel needed for adequate design and safe construction of geotechnical structures".* They pointed out also the works which should be performed by educated & trained experts listed in EN 1997-1, [3], Paragraph 1.3 as; *"Data required for design are collected, recorded and interpreted by appropriately qualified personnel; Structures are designed by appropriately qualified and experienced personnel; Execution is carried out according to the relevant standards and specifications by personnel having the appropriate skill and experience".* Engineers, technicians, workers and employers of companies (consulting, design, measuring, excavating, construction, supporting, maintaining etc.) who have works related with earth crust should realise that, their projects in Europe have to be started & finished by following standard rules supplied in EC7. European countries have education and diploma procedures for their educated human resources in engineering in different manners. ECTS credit system has been offered to supply common platform for European university educations. However, Jovanovski et al. [8] pointed that *"The question is how to insure "common platform" for necessary requirements and qualifications for engineers and to find a legal definition consistent with the European Directive 2005/36/EC on Recognition of Professional Qualifications in engineering disciplines".* According to these authors *"This question is maybe most complex for professionals involved in ground engineering, because geotechnics deals with variety of problems, covered by engineering geology, soil mechanics, rock mechanics, foundation engineering, risks, environment etc.".* Description of engineers who should perform required works and analyses to supply reports and decisions as they are required in EC7 has complicated and several branches of engineering associations had been asked earlier to resolve meaningful procedures. On this subject, Bock et al. [9] and then Buggy et al. [10] reported about, a Joint European Working Group, JEWG. They wrote that JEWG was established in July 2002, and this group had included joint efforts of International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE), International Association for Engineering Geology and Environment (IAEG), and International Society for Rock Mechanics (ISRM) to provide common understanding in required engineering activities in EC7. Jovanovski et al. [8] pointed also that; *"JEWG intensively works on the problem of qualification requirements in EC7. Moreover, it held three workshops: in Leuven (2016), Oslo (2017) and Reykjavik (2019)".* These authors pointed also that, the JEWG early report in 2008 presented that *"An idea for professional competencies of all three primary disciplines (soil and rock mechanics and engineering geology) in terms of key and general competences, as well as specialized fields for work in ground engineering"*. Bock et al. [11] wrote on "qualification" description also for ground engineering. These authors mentioned on the German Geotechnical Society, (DGGT) procedures and pointed that *"Neither EN 1997 nor the various national annexes and/or Building Codes specify precisely what these ''appropriate'' qualification and experience requirements might be*". They wrote that unclear description of qualified people performing EC7 reports and documentations will "*opens the door for all sorts of self-declared ''experts'' to carry out ground investigations and to submit Ground Investigation and Geotechnical Design Reports*". According to them this situation is "*The detriment of safety*". The German Geotechnical Society (DGGT) had previously worked also on the subject and presented a document titled; *''Geotechnical Professionals Requirements on qualification and experience''*, [12]. Approaches to define ground engineering considerations in EC7 subjects have still under considerations through joint efforts. Engineering societies in European countries like the other countries have members graduated from predetermined departments of universities. They supply engineering decisions through reports in different subjects of earth crust for example according to their engineering education background. Logically, societies which have high enrolments (as official members) in a country, have focused more about their engineering branches during categorising subjects of interest related with "ground engineering". Truly, engineering works, applications in/on earth crust have gradually been complicated while the urban populations and their necessities are also increased. Almost carbon-free energy harvesting through geothermal projects, urban spaces in underground, deeper open pit and underground mines, foundation designs for high-rise buildings etc. have pushed scale of ground engineering dealing with earth crust further away from the regular considerations. Lamas et al. [13] evaluated EC7 facts by considering involved engineering subjects under discussions. They critically pointed that; *"Introduction of EC7, bringing structural safety concepts in geotechnical design, was an important step forward in many European countries. It is interesting to note that several European countries, with well-established codes for structural design of buildings and bridges, had no code for geotechnical design before EC7".* Engineers reporting currently about soil properties for construction companies can be different in different countries. They can be graduated different branches of engineering and earth sciences, such as; civil engineering, foundation engineering, engineering geology, geology, geotechnics, geomechanics, etc. Defining safety of engineering projects in/on earth crust (weak soil, soil, hard soil, hard soil-soft rock, weak rock, rock, hard rock etc. masses) needs adequate engineering considerations including risk of failure decisions as well.

Availability of detail building codes related with construction bodies (concrete types, properties of applicants etc.) but less concentration on buildings' foundations (properties of soils and rocks masses) might be the results of different considerations in earlier times. However, modern urban life enforcements to have higher & heavier buildings; deeper infrastructures (including metro lines and underground living spaces and depositories); bigger ports & industrial plants; deeper mine activities etc. have progressively transformed design efforts and considerations in last decades. Discussions on earth crust properties and behaviours may continue among the earth mass related engineering professions but, currently engineers (or groups of engineers in consulting companies) might have been in a position to supply ground related decisions for their planned projects. Those decisions should be taken with the requirements related with official ground engineering evaluations on the bases of EC7 if the rules are applicable in that country.

Therefore, any discussions, *"Regarding applicability of the design principles of the Eurocodes to geotechnical structures, and also regarding its application in practice to geotechnical construction works"*, should be resolved, [13]. These researchers pointed in 2014 also that rock engineering subjects are missing in EC7. According to them, the reason of this gap has been originated due to soil related subjects & problems dominations in EC7. Design and other efforts supplied for engineered structures, such as; dams, bridges, tunnels, mine, buildings, constructions, etc. in/on the rock masses should also be included in EC7 coverage.

Rock engineers and related researchers have mainly mining, petroleum and geological engineering backgrounds. EC7 have soil engineering background in early version, so rock mechanics issues had not included to the code as far as required. However, as already point before, designing for soil and rock masses differs due to nature of the engineered masses. Soil can be somehow considered continuum material but, rock masses have discontinuities and they cannot be issued as massive or continuum media. Underground spaces opened in rock masses have required special design considerations supplied in rock and soil mechanic texts. Each underground space has its own local design conditions originated through the earth crust parts surrounding. Moreover, even the same engineered volume design in underground can possibly have different surrounding rock formations. Therefore, different engineering procedures for example have suggested in rock engineering for different rock behaviours. Thus, defining standard procedures for rock and soil engineering assets have application difficulties. In addition, these earth crust masses have their uncertainties in their property tests and behavioural analyses & considerations. Decisions given through earth crust properties & behaviours for designed spaces in/on the crust have their responsibilities related with engineering, social and environmental considerations. Therefore, engineers and related consultant and engineering companies have full load of their decisions and works. Legal and moral responsibilities of these decisions in ground engineering have reasonably forced these engineers to deal with more secure sections of the projects. Actually, defining responsibilities of a project without mentioning uncertainties in input data (mostly related with properties and behaviours of earth crust) is not fair. Experiences have played important roles here to handle those data to produce reasonable conclusive decisions. Risks of misjudgement encountered here also possible to predict actual facts (full scale behaviours, stresses, strains, properties etc.) related with rock and soil masses. Descriptions, (coverage), of methods in excavation design or similar activities are not directly supplied, because earth crust conditions for each project are different. Similar considerations stated by Koc [14] as; *"It is not clearly stated that in the Eurocode how the tunnels should be designed"*. Feeling engineering responsibilities of contracted projects in/on earth crust have forced the engineers in creative but stressed work environments. Due to numerous design factors; uncertainties related with collected input data; results of analyses based on criteria, (approaches, numerical iterations etc.), it should be logical that ground engineers would like to supply their decisions with associated risks of coverage.

Quality of engineering works, analyses, designs, and adequate engineering on related subjects (together with reliable collected inputs, data) make the differences among the offered or realised projects in/on earth crust. Olsson & Palmström [15] wrote that *"The Eurocodes were initiated for bridge construction, and have then been applied in more and more applications, such as in soil mechanics and finally in rock engineering"*. That means the official standards are not fully descriptive at their early versions, they are getting reliable as the reviews have been recognised and performed.

4. RESPONSIBILITY OF ENGINEERS: PROFESSIONS, DECISIONS AND LIABILITY

Engineers deal with soils and rock masses to provide engineered structures & spaces for urban requirements have pressured to define their subjects and responsibilities in more detail in social disputes when there are legislative sessions after failure of any urban structure or space with fatalities. Casualties (if there is any) especially are main engineering concerns. When social and governing bodies' efforts related with the failures (or disasters) turn into official investigations to determine the failure causes, all the design and operational documents can be asked for re-evaluation. In addition, failure of urban structures can also be occurred due to earthquakes, slope failures, landslides, sinkholes, caving etc.

Researches have also been performed to analyse main causes of collapses and damages. In similar cases, (i.e. exemplified hypothetically here), engineers worked for such a project have to define their duties, positions and responsibilities through their field of professions and professional applications according to national and international standards and rules. In general, legal procedures may be started to check engineering standards, engineers' responsibilities and their professions, material qualities and documentations, structural designs, laboratory test results, official design approval procedures, foundation tests and their stability analyses etc., for detail researches. Therefore, engineers should certainly define their professions, expertise and responsibilities according to supplied standards. Thus, they should restrict themselves for getting loaded responsibilities uncover their certificated professions and expertise. Buggy and Franzén [16] wrote about their evaluation about "ground engineering" concept. They concluded that, *"Given the critical role of ground engineering professionals in the planning, design and construction of major infrastructure, industrial, mining, commercial and residential development in the modern world, it is readily apparent that the interests of both public safety and the minimisation of economic losses from failure are served by having qualified and competent persons perform these services".* These researchers analysed also the registration of engineers for the cases of EC7 in different European countries. These countries have different procedures followed already and they concluded that, "*a common platform fully compliant with EU Directive 2005/36/EC is a much more distant aspiration which requires many more countries to participate and is unlikely to be achieved in the short term".*

5. ROCK ENGINEERING CONSIDERATIONS AND EC7

Usages of underground spaces and facilities have common practices gradually. Accessibility supplied by underground metro tunnels and additional underground spaces designed for shopping centres, car parks, sport centres, passageways have already under practices. Engineering activities related with them cover rock and soil mass considerations. Harrison et al. [4] wrote that; in 2010, EC7 became the Reference Design Code for geotechnical design within the European Union. These authors reported also that, applications of EC7 rules in "ground engineering" projects which include rock engineering subjects have difficulties. Therefore, reviewing of EC7 procedures had progressed starting from 2011 to finish in 2020, [4]. Researching to understand ground behaviours around underground spaces have supplied suggestions for related engineers to evaluate their decision. For example, Rahimi, et al. [17] wrote that deep mining operations had special attention required for their stability. They said that *"The main challenges at great depth are high rock stress levels, seismic events, large-scale deformation, sudden failures and high temperatures that may cause abrupt and unpredictable instability and collapse over a large scale".* Therefore, they presented support design through "strategic, tactical, and operational" design stages. Similar research on the bases of different evaluations (conceptual, analytical, theoretical, observational, etc.) can be followed for shallow and deep underground space stabilities.

Earth crust can be different in characters around or under the engineered spaces. It can be deposited sediments (soil types) or rock formations. Dimensions and shapes of engineered spaces in earth crust or foundations on ground surfaces could be different according to offered projects' purposes. However, the "primary" objectives of the projects certainly cannot be changed; they should be stable, safe, socially and environmentally approved. In this subject, paper presented by Uotinen et al. [18] can be forwarded here. They wrote that, *"In Finland (and Sweden and Norway), there is no formal procedure on how to design rock spaces. The design is based on a designer's expertise, experience, views, and specific procedures".* They also mentioned their concerns about differential design outcomes for *"identical initial data".* According to them; "*The Eurocodes do not explicitly state how to design rock spaces, but they define the minimum requirements on how to design structures*". These researchers evaluated that; description of tunnels in FISE, *"Qualification of Professionals in Building, HVAC and Real Estate Sector in Finland"*, has more practical interpretation compared to EC7 covers. Therefore, they preferred to suggest FISE tunnel classification. According to them *"The clarifying note given in EC7 is unreasonably restrictive for geotechnical classification purposes*".

Similarly, Buyukkagnici and Isik, [19], compared the outcomes of Turkish Standard-TS8853; British Standard-BS8006 and EC7 by considering slope stability conditions. They worked by handling limit equilibrium and finite element methods. Their works presented that outcomes could have diversity among the applications of different standards. Applications and real-world experiences in rock engineering field have gradually produced additional experiences as well. Thus, revisions of EC7 have seemed to be on going procedure to keep good practices applicable.

6. CONCLUSIONS

Engineering applications related with earth crust require excavations in soil and rock formations. Different types of surface and underground excavations could possibly be realised through diverse engineering designs due to their specific requirements. Primary targets in these engineering plans is always obtaining safe and stabile structures, constructions. Therefore, workers, foreman, engineers, experts dealing different concepts of earth crust in case of data collecting, evaluating, analysing, modelling, designing, back testing and analysing, rock blasting, excavating, supporting etc. have to be adequate in their professions. Required education levels (definitions) for engineers have stated in FEANI for EUR-ING titles for its members. Works and projects required for modern urban life have gradually located in deeper in earth crust. New underground space requirements have been accelerated with new metro lines, rock caverns, underground storages, roads, parks, shopping & sport centres, and other urban facilities. Therefore, engineers adequate to handle risk based design procedures should also be experienced in surface and underground engineering activities in different rock and soil mass conditions. Engineering decisions have been taken through ground engineering projects influence stabilities of engineered structures in/on earth crust. Standardisation efforts progressed in European Union include ground engineering subjects in EC7 procedures. EC7 has brought modified new attitudes for engineers to deal with their projected works' stabilities in/on earth crust. Engineers with rock engineering experiences (certificated) in rock cutting, mining, tunnelling, rock slope excavation, rock supports etc. might also be in service in EC7 applications. Lamas et al. [13] presented deliberate features of EC7, for example, in rock engineering designs in their study and, they pointed that, rock mass related; discontinuities, classes, matrixes, anisotropies, failure modes, strength considerations are the ones in several other factors to be considered carefully to supply related ground engineering decisions cases. As the results have gradually supplied through research studies which have been performed to observe suitability and effectiveness of EC7, its comparisons with national standards will also be involved progressively like given by Buyukkagnici & Isik [19] and Uotinen et al. [18]. Thus, revision steps which will be expected, in future, in EC7 should then include improvements according to on-going engineering researches and experiences. Engineering branches which have concentrated different aspects of works in/on earth crust have wide ranges of knowledge and experiences for ground engineering including in EC7 applications. Combination efforts of them have increasingly provided new dimensions and research areas for the stability concerns of engineered structures in/on earth crust.

Declaration of Ethical Standards

In this paper, all ethical guidelines including authorship, citation, data reporting, and publishing original research are followed by the author.

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Data Availability

In this paper, no research data available in a data repository were used.

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