14th International Symposium

WATER MANAGEMENT AND HYDRAULIC ENGINEERING 2015

September 8th to 10th 2015, Brno, Czech Republic

Editors: Jaromír Říha, Tomáš Julínek, Karel Adam

Organized by:

Brno University of Technology
Faculty of Civil Engineering

In collaboration with:

University of Zagreb
Faculty of Civil Engineering, Zagreb, Croatia

Gdansk University of Technology
Faculty of Civil and Environmental Engineering, Gdansk, Poland

Slovak University of Technology in Bratislava
Faculty of Civil Engineering, Bratislava, Slovak Republic

BOKU University of Natural Resources and Applied Life Sciences
Institute of Water Management, Hydrology and Hydraulic Engineering

Vienna, Austria

Ss. Cyril and Methodius University in Skopje
Faculty of Civil Engineering, Skopje

14th International Symposium
WATER MANAGEMENT AND HYDRAULIC ENGINEERING 2015
Editors: Jaromír Říha, Tomáš Julínek, Karel Adam

Papers have been double-blind peer reviewed before final submission to the conference. Initially, paper abstracts were read and selected by the conference Scientific Committee as possible papers for the conference.

WMHE2015's Publication Ethics and Publication Malpractice Statement is based, on the guidelines and standards developed by the Committee on Publication Ethics (COPE). Publication Ethics and Publication Malpractice Statement defines responsibilities of authors, reviewers, members of Scientific Committee and editors.

Reviewers:
Aleš Dráb, Petr Hlavínek, Jan Jandora, Andrej Šoltész, Miroslav Špano, Ladislav Tuhovčák

Many thanks to the reviewers who helped ensure the quality of the published manuscripts.

Published in 2015
First edition

Front cover photos by Institute of Water Structures, FCE, BUT

Print version with full text papers **ISBN**: **978-80-214-5230-5**

Print version with full text papers **ISSN**: **2410-5910**

Conference web page: wmhe.fce.vutbr.cz

SYMPOSIUM CHAIRMEN

CHAIRMAN

Jaromír Říha (*BUT, Faculty of Civil Engineering, Brno, Czech Republic)*

Co-CHAIRMEN

Romuald Szymkiewicz (*Gdansk University of Technology, Faculty of Civil and Environmental Engineering, Gdansk, Poland)*

Davor Malus (*University of Zagreb, Faculty of Civil Engineering, Zagreb, Croatia)*

Andrej Šoltész (*SUT, Faculty of Civil Engineering, Bratislava, Slovak Republic)*

Christine Sindelar (*BOKU, Vienna, Austria)*

Cvetanka Popovska (*Ss. Cyril and Methodius University, FCE, Skopje, Macedonia)*

SCIENTIFIC ADVISORY COMMITTEE

Jan Jandora, **Aleš Dráb**
(BUT, Faculty of Civil Engineering, Brno, Czech Republic)

Ján Szolgay, **Peter Dušička**, **Štefan Stanko**
(SUT, Faculty of Civil Engineering, Bratislava, Slovakia)

Neven Kuspilić, **Živko Vuković**, **Goran Lončar**
University of Zagreb, FCE, Zagreb, Croatia

Michał Szydłowski, **Hanna Obarska-Pempkowiak**, **Jerzy Sawicki**
Gdansk University of Technology, FCEE, Gdansk, Poland

Helmut Habersack, Willibald Loiskandl, **Johannes Hübl**
BOKU, Vienna, Austria

Milorad Jovanovski, **Petko Pelivanoski**, **Violeta Gešovska**
Ss. Cyril and Methodius University , FCE, Skopje, Macedonia

ORGANIZING COMMITTEE

Tomáš Julínek, Karel Adam, Jan Vrubel, David Duchan, Pavla Kozlová

(BUT, FCE, Brno, Czech Republic)

Content

Preface.. 7

Keynote lectures

240 Years Dresden Gauge – 1000 Years Floods of the Elbe (Labe) River (*R. Pohl*)….. 9
Seepage Problems at Areas Protected against Floods (*T. Julínek, J. Říha*).................... 20
Development of Automated Approaches for Hydropower Potential Estimations and Prospective Hydropower Plants Siting (*N. Badenko, T. Ivanov, O. Nikonova, V. Oleshko*).. 32
Braided river gravel reach hydrodynamics: a field example *(A. Radecki-Pawlik, J. Bencal, M. Kowalski, B. Radecki-Pawlik)*.. 46

Hydraulics and hydromechanics

Parameters of wind driven waves on Nove Mlyny water reservoir (*P. Pelikán, M. Šlezingr*).. 55
Physical and Mathematical Modelling for Canoe Slalom Whitewater and the 2016 Olympic Games in Rio de Janeiro (*J. Pollert jun., J. Pollert sen., J. Procházka, P. Chmátal, B. Campbell, J. Felton, D Dungworth*).. 65
Calculating erosion rates of river bank sediment by combining field measurements of erodibility parameters and small-scale topographic features – A case study at the Danube River (*M. Pfemeter, M. Klösch, E. J. Langendoen, H. Habersack*)………… 77
Modelling of open channel flow with FLOW-3D (*D. Duchan, T. Julinek*) 87
Quantification of hydrodynamic load on the bridge deck using numerical simulations (*M. Špano, A. Dráb*) …………... 95
Water hammer analysis-impact of the pipe material in water supply system (*G. Taseski, C. Popovska*)... 103
Numerical analysis of the impact of breakwater culvert to the sea exchange in the Adriatic marinas (*G. Loncar, H. Mostecak, T. Polak*).. 111
The CFD analyses of the lateral spillway using different turbulence models (*M. Orfánus, A. Šoltész*)... 121

Hydrology and river basin management

Analysis and visualization of irrigation distribution systems (*M. Čistý, Z. Bajtek, L. Celar*).. 131
Stormwater and snowmelt runoff storage control and flash flood hazard forecasting in the urbanized coastal basin (*M. Szydłowski, P. Zima, K. Weinerowska-Bords, P. Mikos- Studnicka, J. Hakiel, D. Szawurska*)... 141
Determining Czech Republic’s minimum residual discharges (*P. Balvín, A. Vizina, M. Nesládková, L. Kašpárek*)... 151
Predicting output flood wave on the section of the Drava River (*M. Šperac, T. Mijušković-Svetinović, A Rabi*)... 162
Climate and land use changes impacts on small catchment areas (*T. Dadić, L. Tadić*) 171
The influence of the synthetic rainfall hyetograph on runoff from urban catchment (*K. Mazurkiewicz, M. Sowiński*).. 181

Evaluation of reservoir degradation state by Autonomous Underwater Vehicle (*V. Sočuvka, Y. Velísková*).. 191

Sanitary and environmental engineering

Reasons why Onsite Wastewater Treatment Systems are not Systematically Used in the Republic of Croatia (*D. Malus*).. 199
Membrane Technology in Surface Water Treatment for Drinking Purposes (*D. Barloková, J. Ilavský, M. Kunštek, J. Buchlovičová*).. 209
Possibilities for recycling of sewage sludge (*D. Vouk, D. Nakić, N. Štirmer, D. Malus*).. 219
The Greenhouse Gas Emissions for Several Water Utility Companies in Croatia (*I. Halkijević, Z. Vuković, D. Vouk*)... 229
The Comparison of Green and Conventional Stormwater Management – Zagreb Case Study (*I. Halkijević, M. Kuspilić, Z. Vuković*).. 235
Technical Audit of Water Supply Systems (*L. Tuhovčák, T. Kučera, M. Tauš*)... 245
Defining the time of closing the valve at small hydro power plant on the main pipeline of the water supply system *(G. Taseski, C. Popovska, P. Pelivanoski)*...................... 254
Runoff quality from green roofs (*M. Sokáč*).. 264
Efficacy of sorption materials for metals removal from water (*R. Biela, T. Kučera*) 271

Sustainable water use, water resources, flood risks

Flood Warning System for Valašsko – Horní Vsacko (*V. Kolečkář, J. Kubík, R. Říhová*) 280
The Adriatic Sea Wave Energy Analysis (*E. Ocvirk*, *K. Duvnjak*, *M. Kaciga*).............. 289
Dispersion tracking experiments in different streams types (*M. Sokáč*)........................ 298
Cross border water resources and water supply management – DRINKADRIA project (*B. Karleuša, P. Banovec, I. Radman, J. Rubinić*).. 307
The operational water consumption of energy production: Czech Republic case study (*L. Ansorge, M. Zeman*).. 317
Concept of Restoration and Preservation of River Odra's Biodiversity and Eco-system Services (BIO -ODRA) (*D. Kunštek*).. 329
Environmental damage due to floods assessment *(M. Zeleňáková, L. Gaňová)*………. 339
Multicriteria analysis method for flood risk assessment (*J. Kozubík, A. Dráb*)............. 348
Overview of water resource based human carrying capacity assessment models (*M. Kuspilić, Z. Vuković, I. Halkijević*) 357
Considering Uncertainties in Design of Stormwater Infiltration Facility (*D. Duchan, J. Říha*) ……………………………………………………………………… 365
Hydraulic assessment of flood protection measures in Small Carpathians (*A. Janík, A. Šoltész*) ……………………………………………………………………… 379

Geotechnical engineering, groundwater hydraulics, erosion control

Effect of soil erosion on filters behavior in hydraulic structures (*S. Azirou, A. Benamar, A. Tahakourt*).. 391
Investigations and Analysis of Levee Failures during recent Floods in Saxony and Saxony-Anhalt (Germany) (*T. Heyer, J. Stamm*).. 401

Methodology for determination of rock mass characteristics for hydrotechnical tunnels (*Z. Zafirovski, I. Peshevski, M. Jovanovski*).. 411
Effect of designed material pits on filtration stability of the subsoil of polder Borša (*D. Grambličková, E. Bednárová, M. Minárik, E. Kolesárová, M. Bakeš*)................. 419
Changes in groundwater level regime along channel due to surface water level fluctuations (*P. Dušek*)... 428
Experiences on the use of polymer coated steel net for the protection of dykes against the intrusion of beavers (*P. Di Pietro, J. Adamec*) ………………………………… 439
Modelling of the impact on groundwater regime due to construction of the proposed hydraulic structure on the Danube River (*M. Nahálkova, D. Baroková, A. Šoltész*) 449

Hydraulic structures, monitoring

Arch dam behaviour evaluation by comparison of numerical model and monitoring data (*S. Mitovski, L. Petkovski, G Kokalanov*) 457
Flood zone modelling and flood losses estimation using GIS and numerical hydrodynamic models (*N. V. Badenko, T. S. Ivanov, S. P. Kotlyar, K. A. Osmolovsky, M. V. Petroshenko, V. A. Prokofyev*) 467
Analysis of SHPP Brodraci influence on production of HPP Ozalj (*E. Ocvirk, G. Gilja, J. Berbić*) 479
Temperature measurement methods on the water structures (*O. Černý, J. Hodák*)…... 487
Using high-precision total station operating in ATR mode and robust adjustment of geodetic networks for safety supervision over waterworks (*T. Macháček, V. Krnáč*) 498
The effect of flow regime on navigation near the Water Structure (*A. Palkovičová*).... 509
Kolárovo Water Structure - selected results of the hydraulic research (*L. Možiešik, M. Orfánus, J. Rumann, P. Šulek, P. Dušička*) …………………………………….. 518
Monitoring of the embankment dam and effectiveness of remedial measures by EIS method (*J. Pařílková, I. Pavlík, M. Novák, J. Veselý*).. 530
Classification of dam failures for adopting limit states (*K. Adam, J. Vrubel*).............. 540
Restoration of the stilling basin of the Drtijščica dam (*N. Humar, A. Kryžanowski*).... 550
Use of gabion structures as flood mitigation in hydraulic works (*J. Adamec, L. Luboš*) 560
Influence of Genetic Algorithms Parameters on the Optimization of Hydrothermal Coordination Problem (*P. Šulek, T. Kinczer, P. Dušička*) 570
Application of artificial intelligence methods in solving problems of hydrotechnics (*S. Kelčík, R. Květon*) 580
Modeling of long-term sedimentation in the Osijek port basin (*G. Gilja, N. Kuspilić*) 590

Water Management and Hydraulic Engineering 2015
© Litera Brno, ISBN 978-80-214-5230-5, ISSN 2410-5910

Methodology for determination of rock mass characteristics for hydrotechnical tunnels

Z. Zafirovski, I. Peshevski, M. Jovanovski

(University Ss. Cyril and Methodius, Faculty of Civil Engineering Skopje, Partizanski Odredi 24, Skopje, Republic of Macedonia, e-mail: zafirovski@gf.ukim.edu.mk, pesevski@gf.ukim.edu.mk, jovanovski@gf.ukim.edu.mk)

Abstract

The analysis of stress-strain conditions is based on a large number of influential parameters of a rock mass that are very difficult to determine.

This paper includes analysis of a large amount of data derived from static and dynamic methods for ground investigation, drill holes and on site measurements. The methods used for investigation are particularly important since we tried to exceed the deterministic approach to analysis, because it does not always allow reliable information for adequate determination of input parameters; thus, the paper advocates the probabilistic approach to analysis.

The subject and methodology used in the paper are also mainly related to practical aspects, because final conclusions of investigations are obtained from analysis of a large amount of field and laboratory data, with experiences gained during the design process of hydrotechnical tunnels.

Keywords

rock mass, ground investigation, probabilistic approach, practical aspects, hydrotechnical tunnels.

1. INTRODUCTION

Geotechnical investigations present a very important part in the design of hydrotechnical tunnels. They are being performed from preliminary design phase, trough basic design and even in the phase of finalized constructions (Barton n., Lien , Lunde 1974). Some of the most important tests performed for rock mass characterisation include in situ tests as permeability (packer tests) and seismic wave velocity, laboratory tests as compressive strength, shear strength along joints, tensile strength, point load testing etc. (Hoek, E., Brown E.T. 1997). Since rock mass in most cases is anisotropic and discontinuous, it is usually very hard to adopt representative values for all geotechnical parameters and perform precise categorisation (Marinos, P; Hoek, E. & Marinos, V. 2006). Therefore we present statistical approach for adaptation of reliable parameters (Hoek, E. 2000). All results are from investigations performed for hydrotechnical tunnels in R.Macedonia in recent times.

2. RESULTS OF THE ANALYSIS

Results are statistically analyzed using computer program Statistica. For each analysis appropriate histogram is prepared, from where classes of parameter values can be deduced and their distribution. For example, presented are statistical analyses from compressive strength, point load index for rock masses from dam Sveta Petka, for phases before and during construction.

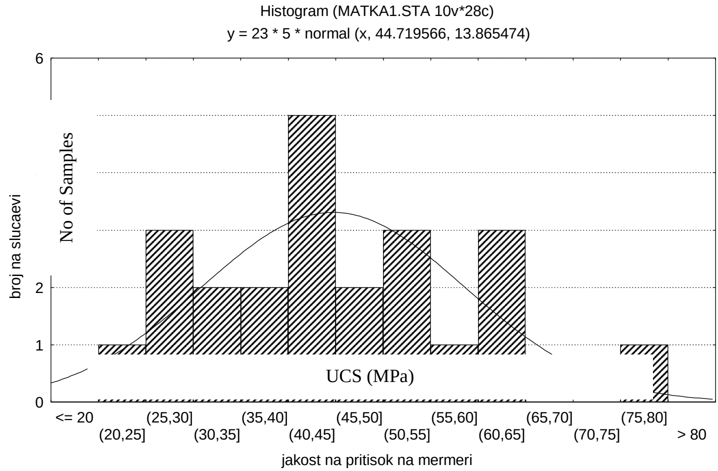

Fig. 1 Histogram of compressive strength values, results from investigation phase (Jovanovski et al. 2010)

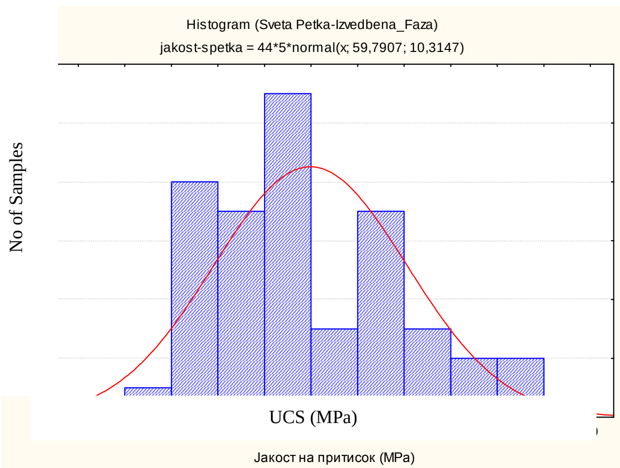

Fig. 2 Histogram of compressive strength values, results from construction phase (Jovanovski et al. 2010)

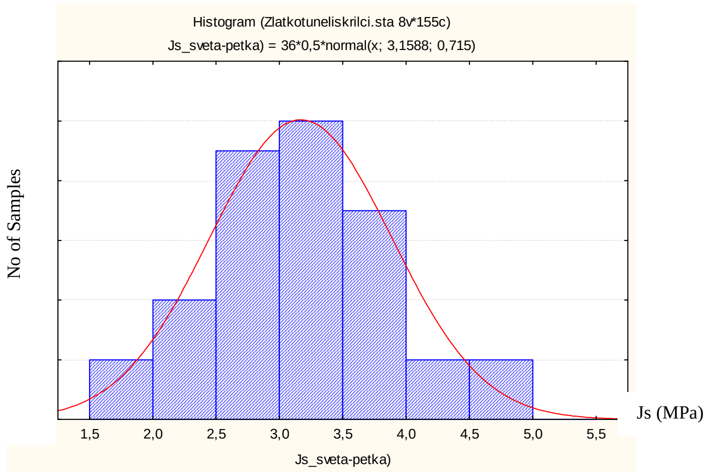

Fig. 3 Histogram of point load index values, results from investigation phase (Jovanovski et al. 2010)

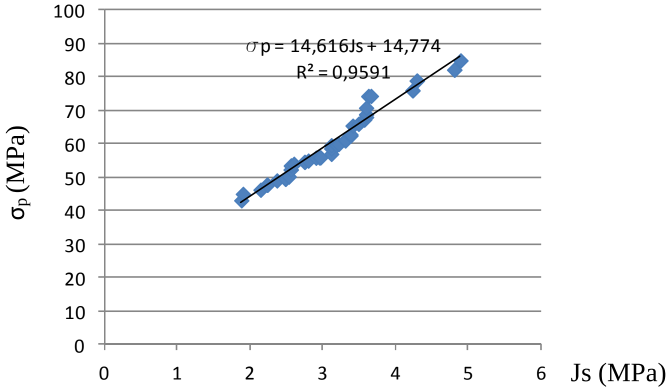

Fig. 4 Correlation between point load index and compressive strength, results from construction phase (Jovanovski et al. 2010)

Following figures show statistical analysis of results related to degree of fracturing and rock quality designation (RQD parameter).

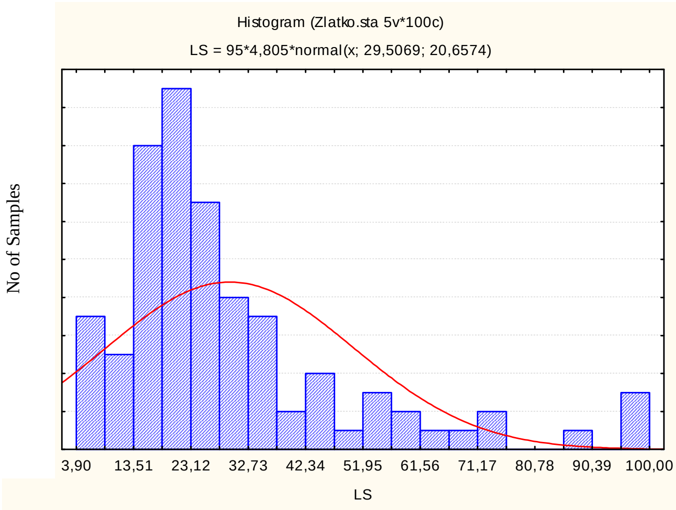

Fig. 5 Histogram of distribution of fracture density from drill hole data for dam Sveta Petka (Zafirovski et al. 2014)

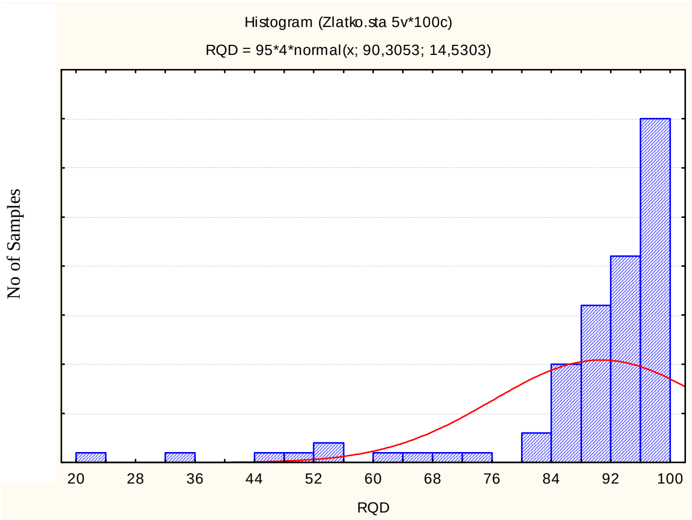

Fig. 6 Histogram of distribution of RQD parameter from drill hole data for dam Sveta Petka (Zafirovski et al. 2014)

From these histograms we can make better adaptation of most frequent values of parameters and interval of variation. Then decision can be made with which parameters we enter into the advanced designing which relies on these data.

It is obvious that the assessment of the class of rock mass for areas where we do not offer direct observations, it is necessary to establish a correlation relationship between the values obtained for the quality of the rock mass (eg RMR), with speeds of longitudinal elastic waves Vp (m/s). Some examples are shown on these pictures.

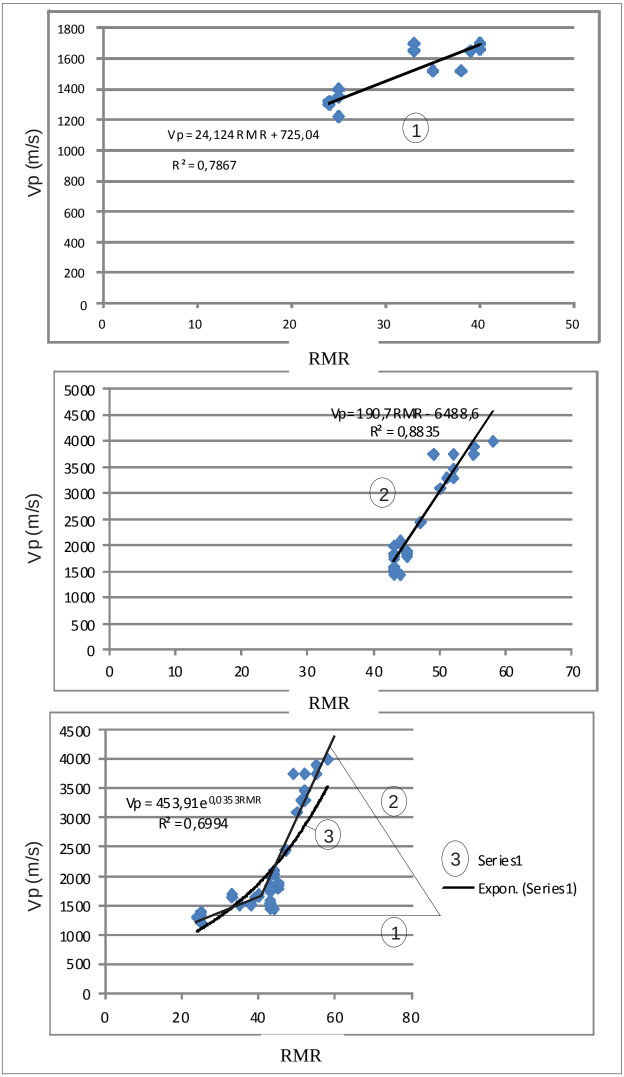

Fig. 7 Correlation between RMR and speed of elastic waves V_P→ RMR=f(V_P) (Zafirovski et al. 2014)

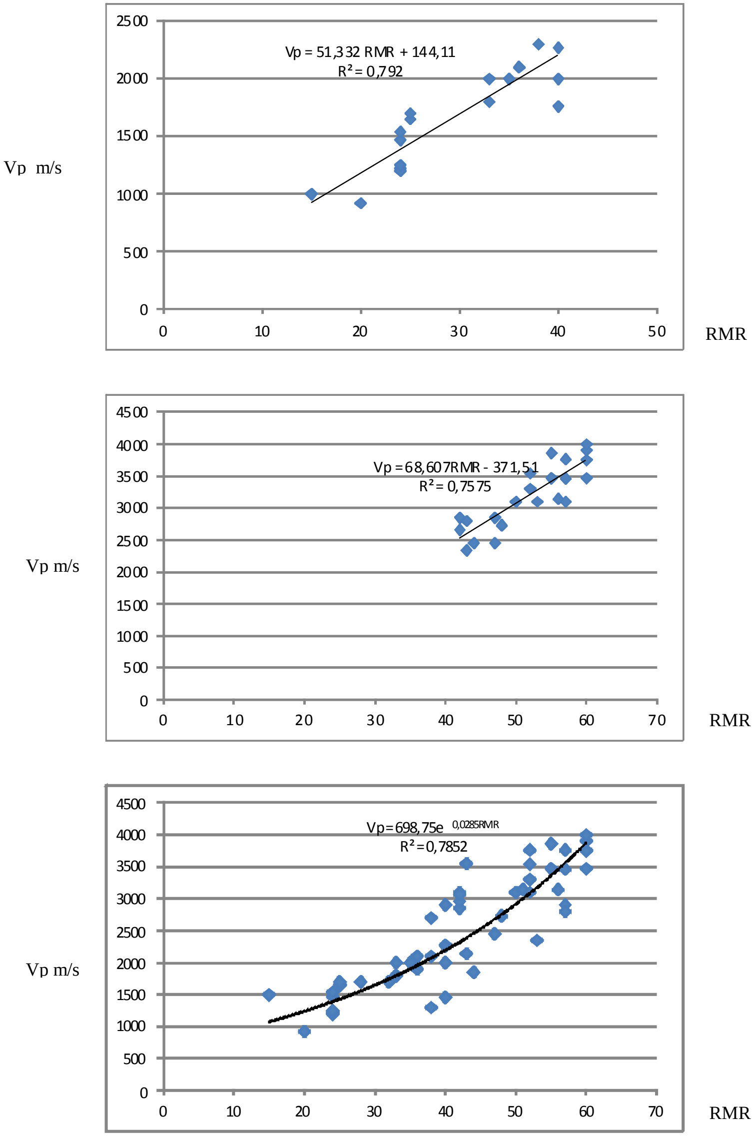

Fig. 8 Indirect correlation between the speed of elastic waves and modulus of deformation estimated by quality rocks D→ D=f(V_p) (Zafirovski et al. 2014)

When there are direct measurements, they should also be used in appropriate analyzes, shown in figure 9.

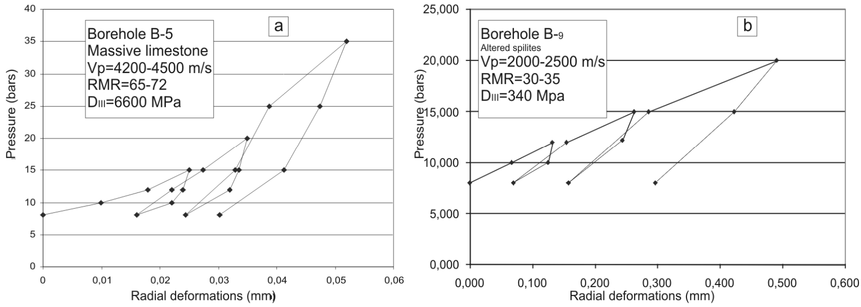

Fig. 9 Typical diagram of dilatometric tests (Zafirovski et al. 2012)

3. CONCLUSION

Statistical analysis of geotechnical data and correlations between analysed parameters are very important steps in any tunnel engineering project. Results from preliminary investigations can be considered as starting point, but their number should be increased in more advanced stages of design, and even checked in the phase of construction. With such approach we can calibrate correlations between geotechnical parameters and improve design.

The presented empirical–static–dynamic method for data extrapolation can be very useful tool in preparation of geotechnical models for further analyses in tunneling. Because of its verification, the suggested methodology must be critically re-examined meanwhile in terms of possibilities to apply it on other locations and other facilities in different geological media.

However, it will open doors and possibilities for further researches, considering that it is practically impossible to exhaust this scientific theme with only one paper. Analytical models for prognosis of possible intervals of deformation modulus *D* are useful as input data in numerical analysis for relatively shallow tunnels.

Also, the process of modelling must be harmonized with research and design phases. It is common to use simpler approaches in initial phases, which meet current quality and quantity of available data. Results of such kind of initial models for complex facilities can indicate the need for new data and they enable re-interpretation of existing data, what, in the other hand, influences the improvement of models or leads to new ideas for new model types.

Based on the aforementioned, we can conclude that there are many unlimited possibilities for further researches in this area. The purpose is to improve and confirm the methodologies suggested in this article, yet not only when it comes to tunnelling but also for other types of structures.

4. REFERENCES

AFTES. 1993. Description of Rock Masses useful for examining the stability, Tunnels et ouvrages souterains.

BARTON, N., LIEN, R., LUNDE, J. 1974. Engineering classification of Rock masses for design in Tunnel support , Rock Mechanics Vol.6, No 4.

HOEK, E., (2000): Rock engineering, Course notes by Evert Hoek. http: //www.rocksciennce.com.

HOEK, E., BROWN, E.T. 1997. Practical estimates of rock mass strenght. Intnl. J. Rock Mech□Mining Sci.□Geomechanics Abstracts. 34(8), pp 1165-1186.

HUDSON, J. A. 1993. Rock Properties, Testing methods and site Characterisation, Comprehensive rock Engineering.

JOVANOVSKI, M., KRVAVAC-SPAGO, A., PESHEVSKI, I. 2010. Range of Engineering-geological properties for some carbonate rock complexes from Balkan Peninsula, Geologica Macedonica, Vol.24, No.1, pp.23-30, ISSN 0352-1206.

MARINOS, P; HOEK, E., MARINOS, V. 2006. Variability of the engineering properties of rock masses quantified by the geological strength index. the case of ophiolites with special emphasis on tunnelling. Bull Eng Geol Environ (2006) 65, pp 129-142.

VISSER, P. J. 1995. Application of Sediment Transport Formulae to Sand-dike Breach Erosion. Communication on Hydraulic and Geotechnical Engineering. Report No. 94-7, FCE, Delft University of Technology, 78 p.

ZAFIROVSKI, Z., PEŠEVSKI, I., PAPIĆ, J. 2012. Methodology for extrapolation of rock mass deformability parameters in tunneling, FACTA UNIVERSITATIS - Scientific Journal Series Architecture and Civil Engineering, ISSN 0354 – 4605, Vol.10, No 3.

ZAFIROVSKI, Z. 2014. Probabilistic approach for defining rock mass properties in stress – strain analysis in tunneling, DOCTORAL DISSERTATION.