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IF (2009) – 0,160
<http://scientific.thomsonreuters.com/cgi-bin/jrnlst/jlresults.cgi?PC=D&ISSN=0562-1887>
6. Todić, A., Nedeljković B., Cikara D., Ristović I. **Particulate basalt-polymer composites characteristics investigation**. Materials and Design 32 (2011) 1677-1683, Elsevier Ltd. doi: 10.1016/j.matdes.2010.09.023, ISSN: 0261-3069.
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RECOLTIVATION AND SUSTAINABLE DEVELOPMENT OF COAL MINING IN KOLUBARA BASIN

by

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Coal plays a fundamental role in global development, but the coal mining industry exerts impact on the environment, society, and economy. Kolubara Coal Company produces about 30 million tonnes of coal, and digs about 70 million m³ of overburden per year. The main result of surface coal is certainly taking agricultural land, so that surface mines, which affect large areas in Kolubara, about 100 hectares a year, causing a number of problems related to the recultivation of degraded area after coal extraction.

The lignite extraction through the method of opencast mining in Kolubara is about 60 years old. The previous exploitation usage is characterised by the fact that the disposal of overburden is made non-selectively, whereas the top soil layer is not being preserved. The recultivation is carried out in parallel with overburden excavation. It is necessary to preserve the fertile soil layer through selective excavation in order to bring the soil back to its previous purpose – agricultural production.

The objective of this paper is mainly to point out the need for the further expansion of the utilisation of fossil fuels, which in turn reduces the emission of CO₂, and thus reduces or prevents global climate changes on Earth. In addition to that, bringing back deteriorated terrains to their previous purpose – agricultural production, or the afforestation – contributes to the maintenance of ecological balance in nature, which then makes coal mining sustainable.

Key words: mining, recultivation, sustainable development, economic development, environment, social responsibility

Introduction

A widely accepted definition of sustainable development is development that meets the needs of the present generation without undermining the capacity to meet future generations' needs. Sustainable development is a synthesis of three fields of our activity: economic development, environment protection, and social responsibility.

The open-pit mining of lignite is distinctive through the fact that it requires large terrain surfaces. Lignite is a type of coal which is relatively poor in quality and therefore mostly

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- [23] ***, University of Belgrade, Faculty of Mining and Geology, Analysis of the Impact of Surface Mine Tamnava East Field on the Environment (in Serbian), Belgrade, 2004, pp. 1-110
- [24] ***, HPC Harress Pickel Consult AG, LDK Consultants SA, EAR, Assessing the Environmental Impact the Mine Expansion Tamnava West Field (in Serbian), 2002, pp. 1-150
- [25] Ristović, I., Soil Protection Against the Influence of Mining Activities, *Proceedings*, 1st International Conference Environment Protection in Industrial Areas (in Serbian), Kosovska Mitrovica, Serbia, 2007, pp. 131-138
- [26] ***, Coal Industry Advisory Board, International Energy Agency, Case Studies in Sustainable Development in the Coal Industry, Case Studies: People, IEA Publications, Paris, 2006
- [27] ***, The Aluminium Industry's Sustainable Development Report, International Aluminium Institute, London, Associations and Int. Org/UNEP Report dated 20.11.01 CPC and EE&LCI/LCA, London, 2001
- [28] Singh, G., Environmental Issues with Best Management Practice of Coal Mining in India, Responsible Mining – a Multi-Stakeholder Perspective, TERI, New Delhi, 2006, pp. 189-198
- [29] Wellmer, F. W., Becker-Platen, J. D., Sustainable Development and the Exploitation of Mineral and Energy Resources: a Review, *International Journal of Earth Sciences*, 91 (2002), 5, pp. 723-745
- [30] Suwala, W., Modelling Adaptation of the Coal Industry to Sustainability Conditions, *Energy*, 33 (2008), 7, pp. 1015-1026

Parametric adjustment of a junction triangle in terms of the precise construction of haulage drives in underground mines

Nivelamento indireito do triângulo de conexão em função de escolha de vias ótimas de transporte em minas subterrâneas

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Resumo

Nos custos totais de exploração de matérias-primas minerais, o transporte participa com 30-60%, o número total de empregados no transporte excede 35%, enquanto o consumo total de energia para o transporte na mina é acima de 40%. Todos esses valores mostram que o transporte representa um dos processos tecnológicos mais importantes na exploração subterrânea de matérias-primas minerais e que a questão de transporte é muito importante, como na escolha do tipo de sistema de transportação, como também na sua projeção, exploração e manutenção. A eficiência do transporte, além de muitos parâmetros técnicos e tecnológicos de exploração, como também de condições mineiro-geológicas, depende, também, da escolha de vias de transporte ótimas, que, se conseguem através de conexão exata de locais subterrâneos de minas com pontos da rede mineira na superfície do terreno. A escolha de vias ótimas de transporte mineiro representa uma das tarefas mais importantes nas medições mineiras. Essa obra mostra a maneira de nivelamento indireito do triângulo de conexão em fossa através de método de nivelamento indireito.

Palavras-chave: Medições mineiras, transporte, conexão, triângulo de conexão, nivelamento indireito.

Abstract

In total costs of ore mining, haulage participates with 30-60%; the total number of workers engaged in the transportation exceeds 35%, while the participation of transportation in the total power consumption amounts to over 40%. All these values indicate that transportation is one of the most significant challenges in the underground mining of ore deposits and that haulage analysis is very important both in selecting the haulage type and its design, utilization and maintenance. In addition to various technical mining parameters, together with mining and geological conditions, haulage efficiency depends on the selection of optimal haulage drives, which can be achieved by accurately connecting the underground mine workings with mine network points on the surface of a site. The selection of the best mine haulage routes is one the most critical tasks in mine surveying. This paper shows how to adjust a junction triangle on a working level using the parametric adjustment method.

Keywords: Mine surveying, underground mine haulage, junction triangle, parametric adjustment.

are also applied in underground mines in performing different tasks. The fact is that all softwares will give the same final results, if they are based on adjustment according to the least-squares method. However, end users are not familiar with the algorithm according to which the software is realized, that is, the unknown is the applied adjustment method according to which calculations are made.

The procedure shown in the paper enables a simple, but efficient verification method for commercial softwares and their determining method, if the calculations were made according to the least-squares method and if the obtained results are the most probable values of unknown variables. The verification of the procedure was made by comparing results obtained by the conditional adjustment method, on the example of the haulage drive connection in the coal mine Soko.

Thus the experts can, in practice, organize a measurement program in a

simpler and better way; that is, they can achieve better results and a more efficient work, and thereby ensure lower operating costs for the company.

6. Bibliographic references

- ALEKSIC, I. *Geodezija 3 (Geodesy 3)*. Belgrade: Naucna knjiga, 1990. 245p.
- BLAHA, G. Tensor structure applied to the least-squares method, revisited. *Journal of Geodesy*, v.58, n.1, p.1-30, 1984
- BORSHCH-KOMPONIETS, V. et alli. *Mine Surveying*. Moscow: Mir Publishers, 1989. 365p.
- FAN, J. AND YAO, Q. *Nonlinear time series: nonparametric and parametric methods*. Springer Netherlands, p.551, 2005.
- GANIC, A. AND DJORDJEVIC, D. *Izravnanje prikljucnih trouglova izduzenog oblika (Adjustment of Connected Triangles Elongated in Shape)*. Underground Mining Engineering, v.8, n.10, p.95-98, 1999.
- GOLUB, G. AND VAN LOAN, C. *Matrix Computations*. Baltimor and London: The Johns Hopkins University Press, 1996. 694p.
- HU, W.C. AND TANG, W.H. Automated least-squares adjustment of triangulation-trilateration figures. *Journal of Surveying Engineering*, v.127, i.4, p.133-142, 2001.
- RISTOVIC I. *Optimization of parameters of continuous haulage systems for underground mining of metallic and non-metallic mineral raw materials*. Belgrade: Faculty of Mining and Geology, 2006. 190p. (Doctors Thesis).
- STRANG, G. AND BORRE, K. *Linear Algebra, Geodesy and GPS*. Wellesley: Wellesley College, 1997. 624p.
- VIŽINTIN, G. et alli. Development of environmental criteria for estimation of land development using GIS. *RMZ - Materials and Geo-environment*, v.55, n.2, p.237-258, 2008.

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MEASUREMENT OF COMPRESSIVE FORCES ON THE ROLLS OF A PIPE CONVEYOR BY ACTION VARIOUS TENSILE FORCES IN A CONVEYOR BELT

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Original scientific paper

The paper deals with measuring of compressive force on rolls of a pipe conveyor by acting of various tensile forces in a conveyor belt.

Key words: pipe conveyor, rubber belt, roller

INTRODUCTION

Number of pipe conveyors in use during their only 30th year existence confirmed necessity of substitution for classic belt conveyors with trough leading of a conveyor belt. Pipe conveyors found their application in all industrial branches – mining, energy, building chemical and we can not omit food and agricultural branch. A conveyor belt remains to fulfil the function of bearing and pulling element, but against classic belt conveyor it has a shape of closed pipe (Fig. 1). This shape is reached by forming rollers behind feeding station of a pipe conveyor and the shape of closed pipe with circular cross-

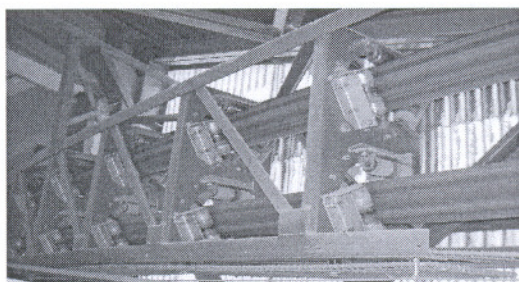


Figure 1. Upper and lower branch of a pipe conveyor

section of a conveyor belt is maintained during all the pipe conveyor line by using of six rollers alternately attached on a roller mill. The main reason of substitution of classic belt conveyors by pipe conveyors in spite of higher number of moving elements and more expensive conveyor belt is

reduction and complete prevention of effect of transported material for environment and vice-versa. The structure of a pipe conveyor allows negotiation of transport lines with higher incline as well as allows creation of transport line arches in horizontal and vertical plane.

Pipe diameter can be 110 - 850 mm and conveyor length is from 40 m - 10 km. The most frequently used length of a pipe conveyor is about 100 m.

THE IDEA

Concerning short period of pipe conveyor existence there were discovered various structural malfunctions that are specific for individual operations. On the basis of them could be then realised necessary structural modifications. The modifications relate to the most used elements of a pipe conveyor like conveyor belt and transport rollers so we put our attention to interaction of conveyor belt to the rollers in laboratory conditions. The value of compressive forces we read by using resistance strain-gauges on testing facility with conveyor belt.

THE STRUCTURE OF TESTING FACILITY

For discovering interaction of conveyor belt and the rollers in roller mill at rest we designed and created the testing facility (Fig. 2), which represents a part of a pipe conveyor. Its technical data are in (Tab.1).

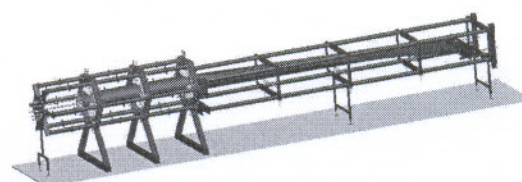


Figure 2. Testing facility for conveyor belts of a pipe conveyor

P. Michalik, V. Molnár, G. Fedorko, Faculty of Mining, Ecology, Process Control and Geotechnology, Technical University of Košice, Košice, Slovakia, I. Ristović, Faculty of Mining and Geology, University of Belgrade, Belgrade, Serbia

- [5] Marasová, D., Taraba, J.: Pásová doprava, F BERG, Košice 2006, s. 85,86, ISBN 80-8073-628-6.
- [6] Marasová, D. - Fedorko, G. - Molnár, V.: Hadicový dopravník a výpočet jeho základných parametrov. *Acta Montanistica Slovaca* 2/2002, s.101-107, ISSN 1335-1788.
- [7] Ragan, Emil - Kollárová, Marta: Štúdium parametrických veličín v dutine formy. In: TSO - Technology Systems Operation '2007 : 8th international scientific conference : Proceedings : 21st-23rd November 2007, Prešov. Prešov : FVT TU, 2007. 2 s.
- [8] Ristović I., Hamović J., 2002: The latest development tendencies in combined conveyance at opencast metal mines, *Transport and Logistic*, No 3/02, ISSN 1451-107X, p.p. 69-79, FMG, Belgrade, BERG Faculty TU, Košice.
- [9] Senderská, K. - Mareš, A. - Fabian, M.: Praktická aplikace ergonomických modulů CATIE při analýze ručního montážního pracoviště. In: IT CAD : Dvuměsíčník o CAD, počítačové grafice a CA.. technologiích. vol. 18, no. 2 (2008), p. 18-19. ISSN 1802-0011.
- [10] Stehlíková, B., Horovčák, P.: Vybrané výsledky dotazníkového prieskumu kvality testu. In: DidInfo 2008 : Medzinárodná konferencia, Banská Bystrica, 3. 4. apríl 2008. Banská Bystrica : UMB, 2008. 5 s. ISBN 978-80-8083-556-9.
- [11] Husáková, N. - Koniarik, A. : Aplikácia reverznej logistiky pri zhodnocovaní opotrebovaných dopravných pásov. In: Výrobné inžinierstvo. roč. 6, č. 4 (2007), s. 59-61. ISSN 1335-7972.
- [12] Stanová, E. : New kinds of the epicycloid. Cycloid motions. In: Micro CAD-System '93 5.Special Sections of the Faculty of Mechanical Engineering the Technical University / Proceeding of the International Scientific Conference. Košice. Košice : SZVTS, 1993.
- [13] Dečmanová, J.: The conveying capacity of belt conveyor. In: Zaštita životne sredine u industrijskim područjima : Zbornik radova : Drugi međunarodni simpozijum : Kosovska Mitrovica, 28.-29. April 2009. Vrnjačka Banja : Novograf, 2009. p. 580-582. ISBN 86-80893-23-5.

**TESTS OF PERSONAL CABLE LIFT WITH THE POSSIBILITY OF SOLUTION
COMPARISON IN SIMULATION PROGRAM**Received: 2009-7-20
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The article describes the testing of personal cable lift „fall” before its first starting up. Technical tests are conducted by building societies normative with the participation of Technical inspection of SR where is important the nominal speed of cage. After this speed exceeding the other mechanisms are setting into operation, by the help of them the lift is off. Effects of these mechanisms are verified in agreement with valid standards and in the case of fulfillment of demands, the lift can be put into operation.

Key words: test, velocity, safety

INTRODUCTION

After lift mounting every manufacturer has to perform so called „primary” safety test, test of accuracy and test of utility. Authorized person (for example Technical inspection, TÜV Slovakia et al.) performs, regulates and evaluates the test because the activity of the lift complex is conditional on strict safety regulation. Every safety device on the lift has to fulfil these criteria. The task of these devices is to limit and prevent to the next operation in case of state identification which is not in accord with some categorial specified safety parameters.

The article is centred on the safety gear action in test performance and the consequence of these facts is the generation of stress to the axis x,y in the guides. Calculated values and input parameters of the safety gears are the basis of dynamic calculation of the lift cage free fall in suitable simulation program. The test of safety gear was realized by procedure which results from valid standard STN EN 81-1+AC part 1: Electric lifts and Regulation of government 571/2001 Collection of laws, as amended by Regulation of government 327/2003 Collection of laws.

DESCRIPTION OF TEST COMPONENTS

The test of safety gear efficiency and their impingement on guides was realized at the personal freight traction lift of type marking ONTV 2000. The lift was

made and delivered by firm LIFTEX, Ltd. Košice to the company VSH, Inc. Turňa nad Bodvou. There is a basic characteristics of the lift in the Table 1.

Table 1. Basic technical data of the lift

Loading capacity	2000 kg
Travel	33,4 m
Rated speed	0,63 m/s
Number of stations/platforms	6/6
Drive	electric traction
Feed array	3/PE AC 400/230V 50Hz, TN-S
Control	button

The producer in lift supply used self locking safety gear as a element of protective device against the excessive speed of the lift cage above and deorsum. The Fig. 1,2,3 illustrate behaviour of jaw safety gears which clasp guides in the moment of nominal speed excess.

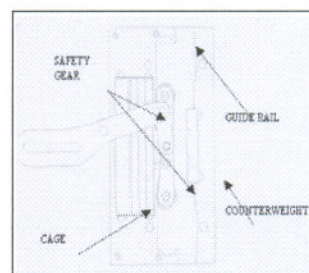


Figure 1. Rest position

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CONCLUSION

The test of safety gears was realized by driving of centric led and suspended cage deorsum with uniformly distributed loading along, in running of lift machine up to impact of safety gear and stopping (stoppage) of cage on the guide inder the proviso that:

- ⇒ The cage had to lead in rated load and it had to move deorsum with rated speed.

Braking distance of the lift cage is negligible by using of these safety gears. Sliding safety gear is more suitable type of safety gear for simulation model creation, thereby the stopping of cage on the guides does not cause by feeling of „tearing“ but „sliding“ and it has an impact on passengers security, too.

In this case the cage has to be loaded by 125% rated load and it has to move by rated speed or by lower speed. We are able to determine total fall, braking distance on the guides and slipping line of the rope on the speed limiter from the results of measuring.

Simulation of running safety gears action to the cage guide by free fall and comparison of static calculation to dynamic calculation are the subjects of the next solution of the grant project.

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REFERENCES

- [1] Janovský, L.: Systémy a strojní zařízení pro vertikální dopravu. Praha, ČVUT. 1991. 139s. ISBN 80-01-00493-7.
- [2] Janovský, L.: Výtahy a eskalátory 2. Praha, ČVUT. 1974. 170s.
- [3] Puškáš, H.- Kufka, J.- Kopas, M.: Výťahy z pohľadu prevádzky. In: AT&P Journal. 2007, č.1. [on-line]. [cit. 2009-07-03]. Dostupné na internete: http://www.atpjournal.sk/atpplus/archiv/2007_1/PDF/plus150_152.pdf.
- [4] STN EN 81-1+AC. Časť 1: Elektrické výťahy.
- [5] TECHNICKÁ DOKUMENTÁCIA VÝŤAHU LX 711. In: LIFTEX, s.r.o. Košice. Interný materiál.
- [6] Boroška, J. - Fedorko, G. : Safety and reliability of the steel ropes operation. In: Zeszyty naukowo-techniczne. no. 33 (2004), p. 154-161. ISSN 1640-4351.
- [7] Fedorko, G. : Simulation of the transport systems in extend. In: Development of new technologies and equipment for mine and hoisting : 5th international symposium on Mine Haulage and Hoisting : Beograd-Vrdnik, 25.-27. september 2002. Belgrade : Faculty of mining and geology, 2002. s. 245-249. ISBN 86-7352-096-7.
- [8] Molnár, V. - Stanová, E. : The computer possibilities of the steel rope mathematical modelling. In: Podzemni radovi. vol. 11, no. 13 (2004), p. 119-124. ISSN 0354-2904.
- [9] Boroška, J. - Molnár, V. - Fedorko, G. : Vplyv priemeru drôtu oceľového lana na jeho skutočné napätie. In: Doprava a logistika : Transport & Logistics. č. 8 (2005), s. 5-15. ISSN 1451-107X.
- [10] Stanová, E. : Some possibilities of solution for structure geometry of steel ropes. In: Selected Scientific Papers : Journal of Civil Engineering. roč. 3, č. 1 (2008), s. 125-134. ISSN 1336-9024.

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Applicability of Continuous Real-Time Monitoring Systems in Safety Assurance of Significant Structures

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In recent years, there has been significant advancement in monitoring sciences, especially due to the continued development of measuring equipment. Consequently, continuous real-time monitoring of integrity of significant structures, like buildings, bridges, dams, as well as the movement of slopes, landslides and volcanoes has become possible. This paper presents the usefulness of continuous real-time monitoring system that is able to combine geodetic, geotechnical and meteorological sensors to match the needs of the monitoring project. At the experimental polygon, we have installed four points; one reference and three observation points, all based on global navigation satellite system (GNSS) sensors. For every point, we acquire location in sense of coordinate Y, X and H in the local coordinate system, which allows observing any movements and deformations on observation points. Moreover, the characteristics of experimental polygon correspond to observing structures and also any changes on the Earth's surface. The real-time visualization of acquired data enables us to decide on further measures in the shortest possible time, which reflects in major safety, as well as in the avoidance of severe damage. On the basis of 20 minutes of measurements, executed every 24 hours, we have calculated that it is possible to detect, with a 99.73% probability, all displacements larger than 1.2 mm and relative movements larger than 3 mm. The monitoring results and regression lines indicate that displacements for two points are no more than 1 mm, while on one we have obtained displacement of approximately 7 mm in a time period of only three months. The results obtained are significant and confirm the necessity of continuous real-time monitoring systems.

Primjenjivost kontinuiranog monitoring sustava u realnom vremenu za održavanje sigurnosti važnih objekata

Izvornoznanstveni članak

U posljednjih nekoliko godina, došlo je do velikog napretka u znanosti o nadzoru (monitoringu), posebice zbog kontinuiranog razvoja mjerne opreme. Prema tome, kontinuirani real-time nadzor integriteta značajnih objekata, kao što su zgrade, mostovi, brane, pomicanje padina, klizišta i vulkana, postao je moguć. Ovaj rad opisuje korist kontinuiranog monitoring sustava u realnom vremenu koji omogućava kombiniranje geodetskih, geotehničkih i meteoroloških senzora kako bi se odgovorilo potrebama monitoringa. Na eksperimentalnom poligonu su instalirana četiri mjerna mjesta; jedna referentna i tri promatrane točke, a sve se zasniva na globalnom navigacijskom satelitskom sustavu (GNSS). Za svaku točku može se odrediti položaj u lokalnom koordinatnom (Y, X, H) sustavu koji omogućuje praćenje pomicanja i deformacija na mjernim mjestima. Štoviše, karakteristike eksperimentalnog poligona odgovaraju opažanim strukturama kao i bilo kakvim promjenama na površini Zemlje. Real-time vizualizaciju prikupljenih podataka omogućuje odlučivanje o daljnjim mjerama u najkraćem mogućem roku, što se odražava boljom zaštitom radi sigurnosti, kao i izbjegavanjem ozbiljnih šteta. Na temelju 20 minutnih mjerenja, koje se vrši 24 sata na dan, izračunato je da je moguće s 99,73 % vjerojatnosti otkriti sva pomicanja veća od 1,2 mm, a relativna pomicanja veća od 3 mm. Rezultati monitoringa i regresijska analiza pokazuju da pomicanja dvaju mjernih mjesta nisu veća od 1 mm, a za jedno mjesto je dobiven pomak od oko 7 mm u vremenskom periodu od samo tri mjeseca. Dobiveni rezultati su značajni i potvrđuju nužnost kontinuiranih real-time monitoring sustava.

- [7] GE, L.; RIZOS, C.; HAN, S.; ZEBKER, H.: *Mining subsidence monitoring using the combined INSAR and GPS approach*, The 10th FIG International Symposium on Deformation Measurements - Proceedings, Orange 2001.
- [8] KIM, D.; LANGLEY, R.B.; BOND, J.; CHRZANOWSKI, A.: *Local deformation monitoring using GPS in an open pit mine: initial study*, GPS Solutions (2003) Vol. 7, 176-185.
- [9] ROŠER, J.; KOS, A.; KORTNIK, J.; LAMOT, A.; VULIĆ, M.: *Monitoring – spremljanje pomikov in deformacij v realnem času*, Zbornik Strokovnega posvetovanja rudarjev in geotehnologov ob 41. Skoku čez kožo, Ljubljana 2009.
- [10] RUTLEDGE, D.; GNIPP, J.; KRAMER, J.: *Advances in real-time GPS deformation monitoring for landslides, volcanoes, and structures*, The 10th FIG International Symposium on Deformation Measurements - Proceedings, Orange 2001.
- [11] BERTACCHINI, E.; CAPITANI, A.; CAPRA, A.; CASTAGNETTI, C.; CORSINI, A.; DUBBINI, M.; RONCHETTI, F.: *Integrated Surveying System for Landslide Monitoring*, Valoria Landslide (Appennines of Modena, Italy), FIG Working Week 2009, Surveyors Key Role in Accelerated Development - Proceedings, Eilat 2009.
- [12] ČELEBI, M.: *GPS in dynamic monitoring of long-period structures*, Soil Dynamics and Earthquake Engineering (2000) Vol. 20, 477-483.
- [13] BARŠIĆ, Z.; BARŠIĆ, G.: *Uncertainties of Out of Form and Position Measurements Results Obtained by Co-ordinate Measuring Machine*, Strojarstvo, 48 (2006) Number 1- 6, pp. 251-261, Zagreb, Croatia.
- [14] WOLF, P. R.; GHILANI, C. D.: *Elementary Surveying, An Introduction to Geomatics*, 9th Edition, Pearson Prentice Hall, New Jersey 2002.
- [15] STRANG, G.; BORE, K.: *Linear Algebra, Geodesy, and GPS*, Wellesley - Cambridge Press, Wellesley 1997.
- [16] GODEC, Z.: *Zaokruživanje mjernog rezultata*, Strojarstvo, 37(1995), pp. 213-217, Zagreb, Croatia
- [17] Leica Geosystems, GPS Newsletter – Sensor, A One Page Newsletter On System 500 GPS. Vol. 00, No. 17.
- [18] Leica Geosystems, GPS Newsletter – SKI-Pro, A one page weekly newsletter on System 500 GPS, 00/16, August 28, 2000.
- [19] KUANG, S.: *Geodetic Network Analysis and Optimal Design: Concepts and Applications*, Ann Arbor Press, Inc., Chelsea, Michigan 1996.
- [20] MIHAILOVIĆ, K.: *Regresiona analiza, objektivni pristup određivanju parametara funkcija*, Građevinski fakultet Univerziteta u Beogradu, Beograd 2002.
- [21] WEISBERG, S.: *Applied Linear Regression*, 3rd Edition, John Wiley & Sons, Inc., Hoboken, New Jersey 2005.
- [22] BROWN, N.; KALOUSTIAN, S.; ROECKLE, M.: *Monitoring of Open Pit Mines using Combined GNSS Satellite Receivers and Robotic Total Stations*. http://www.leica-geosystems.com/en/page_catalog.htm?cid=5311. Accessed 25 Oct 2009.
- [23] Leica Geosystems: Leica GNSS Spider, Advanced GNSS Monitoring; Leica's internal material (provided upon request by manufacturer technical support in 2008).



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Technical Report

Particulate basalt–polymer composites characteristics investigation

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ABSTRACT

Basalt has remarkable physical and mechanical characteristics. However, its use and further processing is limited due to mechanical characteristics, e.g., density, hardness, fraying resistance, etc. The basalt–polymer composite enable maintains of physical and mechanical characteristics, further processing, and broader basalt application in various industries. Consequently, composites characterization, and production process technological parameters influence on the composites properties need to be appraised.

Basalt from locality Vrelo, on the eastern hillsides of the Kopaonik Mountain in Serbia was used for evaluation with 18 samples applied for each test. Samples of basalt–polymer composite with various ratios of basalts, polymeric matrixes and additives, and with different basalt particles composite grain size are synthesized to be tested. The results elucidate the composite mechanical properties dependence on the before mentioned parameters. Thus, it is possible to ascertain the most suitable composite with respect to basalt/polymer proportion.

Results demonstrate the practicability of the technological procedure development that would result in basalt–polymer composite, an inexpensive material with outstanding characteristics. This composite might be used in the first period for construction, and later for use in industry – especially machine and car industry. Presented data can be of importance for the development of new composite materials (composite basalt stones) which certainly will have significant application in the future.

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1. Introduction

As a construction material, basalt has exceptionally good physical and mechanical properties, specifically high hardness, high strength, good wear resistance, color and shine. Properties of jointed basaltic rock masses and its limits on strength and deformation were evaluated by Schultz [1]. However, its shaping and processing is very difficult due to before mentioned mechanical characteristics, and its extensive application is limited. Basalt processing into more complex forms while retaining its mechanical and physical characteristics is feasible only if the basalt particles are mixed with polymeric resins. As a result, particulate composite, suitable for cold casting process manufacturing of different geometric forms is generated.

1.1. Literature review

Divers studies have investigated various basalt composite combinations. Several authors in their studies evaluated a series of commercial-grade polypropylenes (PP) filled with different short basalt fibers quantity. Storage modulus increase with expand of the fiber content, based on dynamic mechanical thermal analysis accomplished by Botev et al. [2]. Matkó et al. [3] in their study discovered the improvement in mechanical properties as a result of the interface modification with low concentration of additives. Further, Kadykova et al. [4] evaluated comparative characteristics of polymer composites based on carbon, glass, and basalt fibers. The analyses indicate that the strength and physicochemical characteristics of polycondensation-filled composites generated by modification exceeds the corresponding properties of unmodified specimens. Thus, the method is justified given the associated cost reduction, working characteristics improvement, and the production time decrease. Basalt-based glass–ceramic coatings structural characterization is explored by Yilmaz et al. [5]. Their main conclusion is that crystalline phases enlarge as a result of the crystallization temperature increase; while lower temperature and longer treatment time generate harder coating layer. Other authors have based their research on the effect of fiber arrangement in 3D

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clutch and brake pedals, etc. generates results from 0.010 to 0.0350 g for wear resistance. It is clear that basalt composite have exceptional wear resistance characteristics.

Generally, all samples have a small amount of loss of mass, which indicates that samples have a high wear resistance regardless of the amount of basalt powder in the composite and granulometric composition of basalt.

4. Conclusions

The obtained samples from this research have a compact, non-porous structure although discharging and solidification of the prepared were conducted without combination of vibrating, pressing and vacuuming. Technological solutions described above and measured values show that:

- Maximum compressive strength 157 N/mm² on a sample with 30% of basalt, 150 + 50 µm granulation (Mark 2).
- Maximum bending strength $\sigma_s = 66.14$ N/mm² on a sample with 60% of basalt and –1000 + 500 µm granulation (Mark 17).
- Maximum toughness $\rho = 0.0069$ Nmm/mm² on a sample with 50% basalt and –150 + 50 µm granulation (Mark 6).
- Maximum wear resistance 0.00099 g/mm² (Marks 10, 12, 16 and 18).

The findings are valuable and usable, and on their basis it is possible to develop a technological procedure and to establish the production of composite stone of basalt–polyester type. Based on the generated mechanical characteristics, this particle composite is applicable in a wide range of industries. In the construction industry basalt is used for a wide variety of purposes, specifically for the production of the exterior and interior facing panels, construction of the different columns and pillars, and for floor tiles, building veneer, etc. Additionally, basalt composite is applicable in the mechanical industry for the fabrication of the friction elements given its high resistance to the fraying. Finally, it is appropriate for the use in both automotive and agriculture industry, for the production of the brake covering and other elements, and for the crusher components, respectively. Although the mechanical characteristics for basalt are not the same as these of steel and metal components, the mass of basalt compost, its price, energy saving, simpler production and equipment that is used for basalt components makes its wide application economically efficient.

Considering all good properties of basalt, especially the properties to be milled to Micronics (nano) values, it is very suitable for the preparation of particle composites with polymer matrices. Polymer masses mixed with micronized basalt particles enable creation of various forms of plates and other regular and irregular geometric shapes. Explorations which were conducted have shown that basalt could be used for obtaining a new, attractive product, composite rock, the price of which on the market is 50 times higher than the price of crushed and screened basalt aggregate.

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References

- [1] Schultz RA. Limits on strength and deformation properties of jointed basaltic rock masses. *J Rock Mech Rock Eng* 1995;28(1):1–15.
- [2] Botev M, Betchev H, Bikiaris D, Panayiotou C. Mechanical properties and viscoelastic behavior of basalt fiber-reinforced polypropylene. *J Appl Polym Sci* 1999;74(3):523–31.
- [3] Matkó Sz, Anna P, Marosi Gy, Szép A, Keszei S, Czigány T, et al. Use of reactive surfactants in basalt fiber reinforced polypropylene composites. *J Macromol Symp* 2003;202(1):255–68.
- [4] Kadykova YuA, Vasil'eva OG, Artemenko SE, Leont'ev AN. Comparative characteristics of basalt, glass, and carbon fibre reinforced plastic formed by polycondensation filling. *J Int Polym Sci Technol* 2004;31(1):60–2.
- [5] Yilmaz S, Bayrak G, Sen S, Sen U. Structural characterization of basalt-based glass–ceramic coatings. *J Mater Des* 2006;27(10):1092–6.
- [6] Wang X, Hu B, Feng Y, Liang F, Mo J, Xiong J, et al. Low velocity impact properties of 3D woven basalt/aramid hybrid composites. *J Compos Sci Technol* 2008;68(2):444–50.
- [7] Keszei S, Matkó Sz, Bertalan Gy, Anna P, Marosi Gy, Tóth A. Progress in interface modifications: from compatibilization to adaptive and smart interphases. *J Eur Polym J* 2005;41(4):697–705.
- [8] Czigány T. Basalt fiber reinforced hybrid polymer composites. *J Mater Sci Forum* 2005;473–474:59–66.
- [9] Liu Q, Shaw MT, Parnas RS, McDonnell AM. Investigation of basalt fiber composite mechanical properties for applications in transportation. *J Polym Compos* 2006;27(1):41–8.
- [10] Akinci A. Mechanical and morphological properties of basalt filled polymer matrix composites. *J Arch Mater Sci Eng* 2009;35(1):29–32.
- [11] Czigány T. Special manufacturing and characteristics of basalt fiber reinforced hybrid polypropylene composites: Mechanical properties and acoustic emission study. *J Compos Sci Technol* 2006;66(16):3210–20.
- [12] Zhang X, Pei X, Wang Q. Friction and wear properties of basalt fiber reinforced/solid lubricants filled polyimide composites under different sliding conditions. *J Appl Polym Sci* 2009;114(3):1746–52.
- [13] Belyea MO, Beckman BW. Advanced polymer composites: an international perspective. *J Mater Des* 1988;9(2):78–84.
- [14] Aceves MC, Skordos AA, Sutcliffe MPF. Design selection methodology for composite structures. *J Mater Des* 2008;29(2):418–26.
- [15] Cikara D, Cikara D. Possibilities of production of wear resistant construction elements by processing of domestic basalt. In: *Proceedings of the Yucomat, Herceg Novi, Montenegro*; 2003.
- [16] Cikara D, Kalaba D, Nedeljkovic B, Savic Lj. Preparation of basalt glass and basalt – base castings. In: *Proceedings of the Yucomat, Herceg Novi, Montenegro*; 2006.
- [17] Study of reserves and quality of basalt as a raw material for building stone and technical petralurgy. *Geozavod – Nemetali, Belgrade*; 1999.
- [18] Producer (Boytek – Turkey) Catalogue for Product characteristics and technical information, Distributor for Serbia “GI-NI”, Belgrade; 2008.
- [19] http://en.zhermack.com/Clinical/Clinical/Condensation_Silicones/Zetaplus_System/C100610.kl.
- [20] Koleva M, Boyiadjiyski Gr. Polymer composite material with abrasive features containing abrasive waste. *J Univ Chem Technol Metall* 2008;43(3):303–8.
- [21] Bozadgiev L, Popova E. Perlite based ceramic tiles. *J Int Res Publ* 2000;1 (2000/01).
- [22] <http://www.matweb.com/reference/compressivestrength.aspx>.
- [23] Hosford WF. *Mechanical behavior of materials*. Cambridge University press; 2005.
- [24] Ryall MJ, Parke GAR, Harding JE. *The manual of bridge engineering*. Inst Civil Eng; 2003 (1–982).
- [25] Dobrzański LA, Tański T, Čížek L, Domagała J. Mechanical properties and wear resistance of magnesium casting alloys. *J Achievements Mater Manufact Eng* 2008;31(1):83–90.