

Loading and haulage in quarries: criteria for the selection of excavator - dumper system

Original

Loading and haulage in quarries: criteria for the selection of excavator - dumper system / Cardu, Marilena; Lovera, E.; Patrucco, Mario. - ELETTRONICO. - (2005), pp. 1594-1606. (Intervento presentato al convegno MPES 2005 - Int. Cong. Mine Planning and Equipment Selection tenutosi a BANFF, ALBERTA, CANADA nel 31 ottobre - 3 novembre 2005).

Availability:

This version is available at: 11583/1416605 since:

Publisher:

The Reading Matrix Inc

Published

DOI:

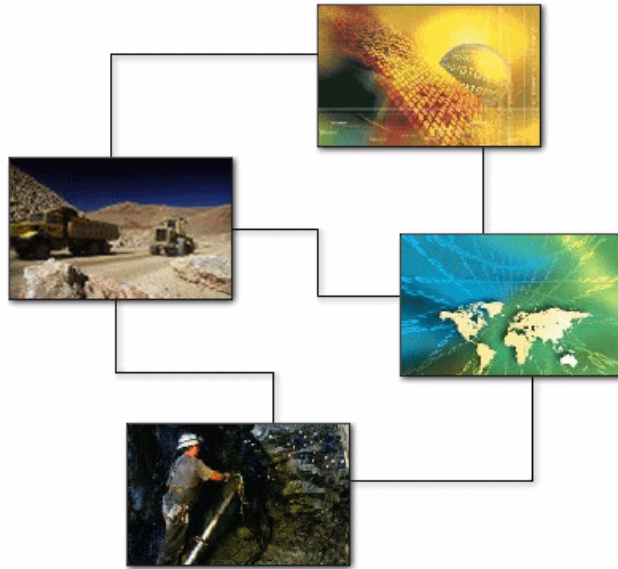
Terms of use:

This article is made available under terms and conditions as specified in the corresponding bibliographic description in the repository

Publisher copyright

(Article begins on next page)

PROCEEDINGS OF THE FOURTEENTH INTERNATIONAL SYMPOSIUM ON
MINE PLANNING AND EQUIPMENT SELECTION (MPES 2005) AND THE
FIFTH INTERNATIONAL CONFERENCE ON COMPUTER APPLICATIONS IN
THE MINERALS INDUSTRIES (CAMI 2005)



MINE PLANNING AND
EQUIPMENT SELECTION
AND
COMPUTER APPLICATIONS IN
THE MINERALS INDUSTRIES

HELD JOINTLY IN
BANFF, ALBERTA, CANADA
OCTOBER 31-NOVEMBER 3, 2005

Edited by
SINGHAL / FYTAS / CHIWETELU

ORGANIZING COMMITTEE

Honorary Chair

Ms. Martina Shehata, P.Eng.

International Chair

Dr. Raj K. Singhal

Co-Chairs

Professor Raimondo Ciccu
Professor Kostas Fytas
Prof. John Sturgul
Dan Hack
Professor Monika Hardygóra
Dr. Vera Muzgina
Professor Sukumar Bandopadhyay

Plenary Session

Paul Clark, Canada
Professor Joan Osborne, Australia
Professor Uday Kumar, Sweden
Professor Michael Karmis, United States
Dr. Andrew Robertson, Canada

Luncheon Speakers

Peter Lighthall
Dr. Jonathan Peck
Dr. Vera Muzgina

Banquet Speaker

Bill Fleming

Session Chairs

Alan Fair, Syncrude Canada
Professor Nick Vayenas, Canada
Dr. Vladislav Kecojevic, United States
Matt Meyer, Canada
Professor Morteza Osanloo, Iran
Professor S. Frimpong, United States
Professor Kikuo Matsui, Japan
Raymond Bergeron, Canada
Dr. Marilena Cardu, Italy
Sibabrata Patnayak, Canada
Professor Doug Stead, Canada
Dr. Antonio Nieto, United States
Professor Masuyuki Ujihira, Japan
Daniel R. Hack, United States
Professor A. Ivanov, Ukraine
Doug Kennedy, Suncor, Canada
Professor Zhenqi Hu, China
Wes Funk, Canada
Professor Lindolfo Soares, Brazil
Dr. Chris Chiwetelu, Canada
Professor Vladimir Kebo, Czech Republic
Professor Bibhu Mohanty, Canada
Professor Roman Y. Poderni, Russia
Dr. Meena Singhal, United States
Dr. Eugene Wusaty, Canada

Professor Dwayne D. Tannant, Canada
Professor Carsten Drebenstedt, Germany
Professor E. De Souza, Canada
Professor Tony Szwilski, United States
Dr. John Unrau, Canada
Professor Roger Thompson, South Africa
Dr. Arun Basu, Canada
Professor Irwandy Arif, Indonesia
Professor Branko Salopek, Croatia
Dr. Emile Pecharova, Czech Republic
Dr. Jan Gottfried, Japan
Dr. A.A. Salama, Canada
Professor Richard McNearney, United States
Professor S. P. Singh, Canada
Mr. Sven-Erik Osterlund, Sweden
Dr. Dragan Komljenovic, Canada
Mr. Hais Martin, Czech Republic
Professor Gento Mogi, Japan
Tim Skinner, Canada
Professor Mircea Georgescu, Romania
Professor Wildor Hennies, Brazil
Ms. Gail Pauley, Canada
Professor Yoginder Chugh, United States
Dr. Jyri-Rivaldo Pastarus, Estonia
Ivan Montenegro de Menzies, Brazil

MINE PLANNING AND EQUIPMENT SELECTION AND COMPUTER APPLICATIONS IN THE MINERALS INDUSTRIES

Edited by

Raj K. Singhal

*Federal Government of Canada and Universite Laval, Quebec, Canada
International Journal of Surface Mining, Reclamation and Environment*

Kostas Fytas

Universite Laval, Quebec, Canada

Chris Chiwetelu

Federal Government of Canada, Calgary

*CD ROM published by The Reading Matrix Inc, Irvine, CA USA
ISSN 1712-3208*



IJSM

Foreword



Raj K. Singhal

The basic aim of this conference is to contribute to the development of high-tech methods and technologies for the various segments of the mining and processing industries. A wide range of high quality papers from North and South America, Europe, Australia, Africa and Asia have been attracted. Major topics to be covered at MPES 2005 and CAMI 2005 are: Coal Mining Technologies: Processing Equipment and Quality Control; Open Pit Mine Planning, Design, and Productivity Gains; Underground Mine Planning and Design; Drilling, Blasting and Excavation Engineering; Mining Equipment Selection, Automation and Information Technology; Mine Maintenance and Production Management; e-Maintenance, e-Diagnostics, and Prognostics; Road Headers, Tunneling and Other Excavation Equipment; Case Histories From Coal Mining, Industrial Minerals and Metalliferous Mining; Cost Effective Methods of Mine Reclamation, Mine Closure and Waste Disposal; Rock Mechanics and Geotechnical Applications; Advances in Mine Design, Mine Optimization and Reclamation Planning Technologies; Mine Equipment: Design, Selection, and Real-Time Health and Performance Monitoring; Mine and Machine Automation; GIS, GPS, Telecommunications, Artificial Intelligence, and Internet Application; Rock Mechanics and Geotechnical Applications: Underground and Surface Mine Stability, Groundwater, Tailings and Waste Disposal; Computer Simulation; Real-Time Mine Management Systems; and Computer Applications in Mining Education.

MPES 2005 and CAMI 2005 are supported by a number of organizations. To be noted are: Department of Mining, Metallurgical and Materials Engineering, Universite Laval; Department of Mining and Mineral Process Engineering, University of British Columbia; Department of Mining, Metals and Materials, McGill University; Department of Energy and Geo-Environmental Engineering, The Pennsylvania State University; Laurentian University; Western Australian School of Mines, Curtin University of Technology, Australia; Department of Earth Resources and Mining Engineering, Kyushu University, Japan; Department of Civil and Environmental Engineering, University of Alberta; University of Alaska, Fairbanks; Henry Krumb School of Mines, Columbia University; Department of Earth Sciences, Simon Fraser University; International Journal of Surface Mining, Reclamation and Environment; Faculty of Geoengineering, Mining and Geology, Wroclaw University of Technology; Atilim University, Ankara, Turkey; Rock Engineering, Helsinki University of Technology, Finland; Department of Mining and Nuclear Engineering, University of Missouri-Rolla; The National Technical University of Athens, Greece (NTUA); Dipartimento di Geoingegneria e Tecnologie Ambientali, Universita degli Studi di Cagliari, Italy; National Mining University of Ukraine, Dnipropetrovsk; CENTEK-International Training and Development Centre, Lulea University, Sweden; Faculty of Mining and Geology, VSB - Technical University, Ostrava, Czech Republic; and Hokkaido University, Mineral Resources Engineering Department, Japan.

The organization and success of such a symposium is due mainly to the tireless efforts of many individuals, authors included. All members of the Organizing Committee and conference chairpersons have contributed greatly. The support of our plenary session and invited speakers and co-chairs is gratefully acknowledged. My greatest appreciation goes to my daughter Dr. Meena Singhal who has worked tirelessly to ensure that proceedings appear on time and who has single-handedly developed the technical program. In addition, particular recognition is accorded to our sponsors, without whose support this conference might not have taken place, Margaret-Anne Stroh for managing administrative functions for CAMI/MPES, Merlene Sparks from Elk Valley Coal Corporation who compiled this CD and Walid Sabbagh of The Reading Matrix Inc. for technical support on the MPES and CAMI website.

This conference is designed to provide a forum for the presentation, discussion and debate of state-of-the-art and emerging technologies in the field of mining and computer applications in the minerals industries. Authors from over 15 countries with backgrounds in computer sciences, mining engineering, research, technology and management representing government, industry and academia concerned with mining and mineral production have contributed to these proceedings. The contents of this volume of proceedings will be of interest to engineers, scientists, consultants and government personnel who are responsible for dealing with the development and application of innovative technologies to the minerals industries. Papers on this CD are available in PDF format and are saved under the authors' last names (Adobe Acrobat is also provided).

LIST OF ARTICLES ON CD PROCEEDINGS

SPECTRAL ANALYSIS TECHNIQUES APPLIED TO BLASTING VIBRATION
GULSEV UYAR ALDAŞ

PREPARATION AND BURNING OF WATER-FUEL (WATER IN OIL TYPE) EMULSION IN
BOILERS OF HEAT GENERATING INSTALLATIONS
A.M. BALABYSHKO, V.G. MERZLYAKOV AND R.Y. PODERNI

MAXIMIZE PRODUCTION EFFICIENCY THROUGH DOWNTIME AND PRODUCTION
REPORTING SOLUTION
MICHAEL BROWN AND WARREN RIGELSFORD

DYNAMIC MODELING OF ARCHING EFFECTS IN SILLMAT SUPPORT STRUCTURES
EULER DE SOUZA & ALDRICH P.E. DIRIGE

MODERN TRENDS IN DRILL RIG NAVIGATION AND SYSTEM INTEGRATION CASES STUDIES
FROM BOLIDEN AND KEMI UNDERGROUND MINES
ROLF ELSRUD

SOLUTION OF DANGEROUS GASES LEAKAGE FROM THE UNDERGROUND WITH THE HELP
OF MODELING
JAN GOTTFRIED, HIDEKI SHIMADA, KIKUO MATSUI AND VLADIMÍR STRAKOŠ

DIAGNOSTIC MEASUREMENTS ON THE GREAT MACHINES CONDITIONS OF LIGNITE
SURFACE MINES
FRANTISEK HELEBRANT, JOSEF JURMAN, JIŘÍ FRIES

DEM SIMULATION OF COLLAPSE IN CUTTING OF SLOPES
YOUHEI KAWAMURA, KEN ITO, TATSUO SAKAKIBARA, MASAYUKI UJIHIRA, AND
NOBUHARU AOSHIMA

ACHIEVEMENTS IN INDUSTRIAL AUTOMATION AND THEIR POSSIBLE APPLICATIONS FOR
UNDERGROUND MINING
V. KONYUKH

MODELLING COUPLED SEDIMENTATION AND CONSOLIDATION WITH SECO SOFTWARE
SRBOLJUB MASALA

APPLICATION OF A MODEL BASED METHOD OF COMPUTER TO INCREASE EFFICIENCY
FLOTATION CONTROL
V. MOROZOV, V. AVDOKHIN, V. STOLYAROV, AND V. MITIN

CAN DAVID COMPETE WITH GOLIATH? – A QUESTION OF SHEARER LOADER CUTTING
METHODS
KARL NIENHAUS, ULRICH LANGE AND ARNE KRISTOFFER BAYER

LARGER SHOVELS – THE REALITY
LEE B. PATERSON AND ANDREW J. WILLIAMS

SELECTED ENGINEERING SOLUTIONS FOR DYNAMIC LOAD SUPPRESSION FOR BWE
WORKING ORGAN WHILE DIGGING
R.Y. PODERNI AND A. I. SHENDEROV

ON THE APPLICATION OF HEAT INTEGRATION IN OIL SANDS PROCESSING
AHMED I. A. SALAMA

EVALUATION OF THE TAILING DAM STABILITY
SOUZA JR., G. R.; SOARES L; FUJIMURA F. & HENNIES, W.T.

INTEGRATING REAL-TIME MINE HAUL ROAD MAINTENANCE MANAGEMENT WITH MINE-
WIDE ASSET LOCATION AND COMMUNICATION SYSTEMS
R.J. THOMPSON, A.T. VISSER AND P.S. HEYNS

THE STABILITY OF FOOTWALL AND DUMPWALL IN OPEN CUT COAL MINES
TAKESHI UEDA, KIKUO MATSUI AND HIDEKI SHIMADA

STUDY ON THE IMPROVEMENT OF THE CREDIBILITY OF ROCKFALL SIMULATION -DIRECT
MEASUREMENT OF ACCELERATION APPLIED TO ROCKFALLS-
SATOSHI YAMACHIKA, YOUHEI KAWAMURA, MASUYUKI UJIHIRA AND NOBUHARU AOSHIMA

MODELLING OPEN PIT DYNAMICS USING MONTE CARLO SIMULATION
HOOMAN ASKARI-NASAB AND JOZEF SZYMANSKI

WASTE WATER TREATMENT IN QUARRIES OF TECHNICAL STONE
BEDEKOVIĆ G., SALOPEK B., AND SOBOTA I

THE USE OF QUARRY FINES FOR MORTAR: A PROPOSAL OF METHODOLOGICAL STUDIES
L.Z.D' AGOSTINO; L.SOARES; HENNIES, W.T. & FUJIMURA, F.

TRAINING FOR NEW UNDERGROUND ROCK BOLTERS USING VIRTUAL REALITY
V. DEZELIC, D.B. APEL, D.B. DENNEY, A.J. SCHNEIDER, M.G. HILGERS, R.L. GRAYSON

THE APPLICATION OF MULTI-DIMENSION SPATIAL-AND-TEMPORAL MODELS OF WEBGIS
FOR LAND RECLAMATION
IN MINING AREA
JIANZHONG FENG, ZHENQI HU, AND LINYAN BAI

EVALUATION OF STRESS-STRAINED STATE OF ROCK MASSIF WITH BOREHOLE MINING
TECHNOLOGY
A. M. GRIGORIEV, V. I. KOLESNIKOV, AND V. I. STRELCOV

SILVER GRANITE BLOCK MINING IN SÃO PAULO, BRAZIL
W.T. HENNIES, A. STELLIN JUNIOR, L. SOARES, F. FUJIMURA C.T. LAUAND, & G.R. MARTÍN
CORTÉS

STUDY OF IMPROVING THE ULTRASONIC MEASUREMENT SYSTEM TO DETECT
PENETRATION OF BOULDERS USING THE CEPSTRUM ANALYSIS
YOUHEI KAWAMURA, YU ITO, MAMORU TSURUSHIMA, NOBUHARU AOSHIMA, KOICHI
MIZUTANI, SENRO KURAOKA,
AND MASUYUKI UJIHIRA

GEOTECHNICAL PROBLEMS ENCOUNTERED BY HARD ROCK TUNNEL BORING MACHINES
CHRISTOPHER LAUGHTON

OPERATING EXCELLENCE – THE KEY FOR IMPROVING CAPACITY IN CVRD MINES
IVAN M. MENEZES, RICARDO NORONHA, AND SÉRGIO V. MENEZES

GEOINFORMATION TECHNOLOGIES IN DESIGNING AND PLANNING AT OPEN CASTS
D.M. MUKANOV, B.ZH. BEKMURZAYEV

PLANNING OF SUSTAINABLE LAND REHABILITATION
CANDRA NUGRAHA, KIKUO MATSUI

PERFORMANCE MONITORING OF ELECTRIC SHOVELS DIGGING OIL SANDS
SIBABRATA PATNAYAK, DWAYNE D. TANNANT, IAN PARSONS AND VICTOR DEL VALLE

OPTIMIZATION OF BLOCKS CUTTING ON AT PART OF ORE FIELD
SARMANTAY M. RAKHIMBEKOV, SALTANAT Z.UISIMBAYEVA
KAZAKH NATIONAL UNIVERSITY, KAZAKHSTAN

CONTROL OF SLAKING BEHAVIOR WHEN FLYASH CEMENT IS INJECTED INTO SLAKE-
PRONE ROCK
HIDEKI SHIMADA, KIKUO MATSUI, MASATOMO ICHINOSE, JAN GOTTFRIED, SHUICHI
FUJITA, IMAM A. SADISUN AND YASUHIRO YOSHIDA

AREA RECOVERY PROJECT OF DIMENSION STONE QUARRY CLOSURE
STELLIN JR., A.;HENNIES, W. T.;SOARES L.;FUJIMURA F.;STELLIN M. R. M.; & LAUAND V. H.

CYBER SECURITY IN MINING
DONOVAN TINDILL AND RICK KAUN

CONTROL OF WATER EROSION AND SEDIMENT IN OPEN CUT COAL MINES IN TROPICAL
AREAS
TAKESHI UEDA, CANDRA NUGRAHA, KIKUO MATSUI, HIDEKI SHIMADA, MASATOMO
ICHINOSE AND JAN GOTTFRIED

TWO SOFTWARE TO ASSIST MACHINE MAINTENANCE STUDIES
GREG YURIY AND NICK VAYENAS

DYNAMIC SIMULATION OF CABLE SHOVEL SPECIFIC ENERGY IN OIL SANDS EXCAVATION
K. AWUAH-OFFEI, S. FRIMPONG AND H. ASKARI-NASAB

SELECTION OF A MECHANICAL MINING SYSTEM FOR AN UNDERGROUND CHROMITE MINE
N. BILGIN, H. COPUR, C. BALCI, H. TUNCDEMIR, D. TUMAC, AND C. FERIDUNOGLU

BENEFITS OF HIGH ACCURACY GPS APPLICATIONS TO THE MINERALS INDUSTRY
P. DAILEY, A. SZWILSKI, AND R. BEGLEY

OPTIMIZATION OF SCHEMES AND PARAMETERS OF OPEN CAST'S FREIGHT TRAFFICS BY
MEANS OF GRAPHS AND IMITATIVE SIMULATION
U.A. DZHARLKAGANOV, D.G. BUKEIKHANOV, K.E. CHUPRIN

SCHEDULING OPEN PIT MINES WITH MICROSOFT® EXCEL.
RAYMOND G. T. GARNSEY

THE EFFECT OF CEMENT AND FINE PARTICLES ON YIELD STRESS OF PASTE BACKFILL
F. HASSANI , A. S. MOGHADDAM , AND S. M. RAZAVI

THE APPLICATION OF MULTI-DIMENSION SPATIAL-AND-TEMPORAL MODELS OF WEBGIS FOR LAND RECLAMATION IN MINING AREA
JIANZHONG FENG, ZHENQI HU, AND LINYAN BAI

THE ECONOMIC AND TECHNICAL ASPECTS OF MINE CLOSURE IN POLAND
J. KICKI, J.JAROSZ, A.DY CZKO, H. PASZCZA

INFLUENCE OF INTERMEDIATE PRINCIPAL STRESS ON ROCK MASS STABILITY
G. LI, S. VONGPAISAL, R. PAKALNIS AND T. BRADY
CLOSURE OF URANIUM MINES IN THE CZECH REPUBLIC
BEDŘICH MICHÁLEK, ANTONÍN HÁJEK AND ARNOŠT GRMELA

A STUDY ON THE DETECTION OF MISFIRING CYLINDER OF THE DIESEL ENGINE IN EXCAVATION MACHINERY USING IMPROVED ALM ANALYSIS
MAKOTO NAGAYAMA, YOUHEI KAWAMURA, MASUYUKI UJIHIRA, DAUREN F. AKHMETOV, FUMITO ITO, NOBUHARU AOSHIMA

FUZZY RELATIONS AMONG MECHANICAL PROPERTIES OF ROCKS
C. A. OZTURK AND E. NASUF

ENERGY CHARACTERISTICS OF ROCKS UNDER DYNAMIC LOADING
VLADIMÍR PETROŠ AND PETR MICHALČÍK

THE USE OF SOLUBLE SILICATE IN WASTE TREATMENT, CEMENT AND CONSTRUCTION MATERIALS /THE STATE OF THE ART
S.M. RAZAVI I F. HASSANI I, AND A. S. MOGHADDAM I

DEVELOPMENT OF A TIRE-REPLACEMENT HANDLER FOR LARGE SCALED DUMP TRUCKS
HIROSHI SHIMAUCHI AND MASUYUKI UJIHIRA

EVALUATION TECHNIQUES AND BLAST CONTROL
S. TANGCHAWAL

RELATIONSHIP BETWEEN THE GEOLOGICAL AND WORKING PARAMETERS IN HIGH PRODUCTIVITY LONGWALLS IN UNDERGROUND COMPETITIVE COAL MINING OF VERY THICK SEAMS
JAVIER TORAÑO, J.M. RIVAS, R.RODRIGUEZ, I.DIEGO, AND A.PELEGRY

ROCK PROPERTIES ASSESSING WHEN BOOM TUNNELLING MACHINES ARE TO BE USED
J. VASEK

TECHNOLOGICAL AND ECOLOGICAL ASPECTS OF COMPLEX USING OF MINERAL RAW MATERIALS OF KAZAKHSTAN
ZHARMENOV A.A., MUZGINA V.S., TERLIK BAYEVA A.ZH.

DEMOLITION AND RUBBLE RECYCLING AS A NEW SOURCE OF BUILDING MATERIALS
BADINO V., BLENGINI G.A., ZAVAGLIA K.

AN APPLICATION OF REGRESSION MODEL FOR EVALUATION OF BLAST VIBRATION IN AN OPENCAST COAL MINE - A CASE ANALYSIS
K.C. BRAHMA, B.K.PAL, AND C. DAS

THE ENGINEERING PERFORMANCE OF GLASS BASED BINDERS IN MINE BACKFILL
EULER DE SOUZA AND JAMIE F. ARCHIBALD

PLANNING OF WINNING OPERATIONS AT OPEN CASTS WITH DUE ACCOUNT
OF INDEXES OF ORE MINING AND PREPARATION
U.A. DZHARLKAGANOV AND D.G. BUKEIKHANOV

OPTIMUM ORIENTATION OF SIAHBISHE HYDRO-ELECTRIC PUMPING STORAGE POWER
CAVERN
A.GHAZVINIAN AND N.SHAFIEZADEH

CRAWLER SIMULATIONS - A CHALLENGE FOR THE MULTIBODY SIMULATION (MBS)
H. HAUT, M. DIETRICH AND K. NIENHAUS

USE OF SURFACE HEIGHT MEASUREMENTS FOR THE EVALUATION OF UNDERMINED
FIRM ROOF FAILURE
EVA JIRÁNKOVÁ, VLADIMÍR PETROŠ, KAREL KONESZ, PETR KUBICA

POSSIBILITIES FOR OPTIMIZATION OF RELIABILITY AND MAINTENANCE IN MINING
OPERATIONS BASED ON EXPERIENCE IN NUCLEAR INDUSTRY
DRAGAN KOMLJENOVIC, JACEK PARASZCZAK AND VLADISLAV KECOJEVIC

DEVELOPMENTS IN UNDERGROUND MINING
P. N. MARTENS, L. RATTMANN AND T. STRAETEN

COMPUTER APPLICATIONS IN MINING EDUCATION –CURRENT PRACTICES AT UBC
MARIO A. MORIN

SOCIAL LICENSE TO OPERATE MINES: ISSUES OF SITUATIONAL ANALYSIS AND PROCESS
JACQUELINE NELSEN AND MALCOLM SCOBLE

MINING BLOCK LIFE-TIME PREDICTION METHOD BY ROOF-TO-FLOOR CONVERGENCE
JYRI-RIVALDO PASTARUS

SYSTEM OF AUTOMATIC LOAD STABILIZATION OF MINING BELT-CONVEYORS
L. PEVZNER V. DMITRIEVA

ACCURACY OF LEAST-SQUARES MONTE CARLO IN VALUING MINERAL PROPERTIES
SABRY A. ABDEL SABOUR AND RICHARD POULIN

THE EFFECT OF BLASTED MUCK ON THE LOADER'S PRODUCTIVITY
S.P.SINGH AND R.NARENDRULA

CONTROLLING EFFICIENCY AND PRODUCTION GOALS IN AN UNDERGROUND MINE
VICTOR O. TENORIO AND SUKUMAR BANDOPADHYAY

USE OF FEM, FUZZY LOGIC AND VIRTUAL REALITY IN THE UNDERGROUND ACTIVITIES.
APPLICATION TO THE LONGWALL MINING WORKS.
JAVIER TORAÑO, J.M. RIVAS, R.RODRIGUEZ, I.DIEGO, AND A.PELEGRY

COMPREHENSIVE MINE DATA INTEGRATION AND IMMERSIVE 3D DATA VISUALIZATION AT
GOLDCORP INC. RED LAKE MINE

WANG, J., HINTON, E., MICHAEL P., TWOMEY, T.

IMPROVEMENT OF DISK CUTTERS PERFORMANCE IN THE EXCAVATION OF SMALL
TUNNELS

A.BORTOLUSSI, R. CICCUCI, B. GROSSO, C. LODDO, S. PISTIS AND J. VAŠEK

ENERGY BALANCE OF THE AREA INFLUENCED BY BROWN COAL MINING IN THREE
PHASES

M. HAIŠ, M. PECHAROVÁ, I. SVOBODA

AN OEM SYSTEM APPROACH TO EXCAVATOR MONITORING

JACK RUPERT

TREATMENT OF WET NICKEL LATERITE ORE STOCKPILE EMBANKMENT FAILURE

IRWANDY ARIF, SLAMET PRABUDI, DAVID NOLAN, RIVADINO RIZA, HARRY ASMAR, KELLY
BINDLE, AGUS SUPERIADI

LANDSCAPE EVALUATION OF QUARRY USING VIRTUAL REALITY SIMULATION

TAKAHIKO HOKAZONO, NAOHIRO OTSUKA, YUTAKA SHIDA AND MITSUGU SAITO

WAYS OF INCREASING THE OUTPUT OF BUCKET CHAIN EXCAVATORS BY USING DIRECT
DRIVES

C. DREBENSTEDT AND S. PAESSLER

PRODUCTION MANAGEMENT IN THE DIAMOND INDUSTRY

S. WONG AND R. TONEGUZZI

INTEGRATED MINE ENGINEERING SOLUTION: IMPLEMENTATION OF CAMP AT RAGLAN,
FALCONBRIDGE LTD

BERNIE SMITH, BRUNO LEMELIN, TERRY GINGRAS AND CLIFF DUSICK

DISTRIBUTED INTELLIGENCE AND INTEGRATED NETWORKING: COST EFFICIENT WAYS
TOWARDS MINE PROCESS OPTIMIZATION

CHRISTOPH MUELLER

OFF-ROAD TRUCK BODY OPTIMIZATION

M. D. KAIZER, N. BARBIERI, AND R. BARBIERI

THE CURRENT SITUATION OF IMPACT OF COAL MINE DEVELOPING ON ENVIRONMENT IN
CHINA AND GOVERNMENT PROPOSAL

LU YANG

THE APPLICATION OF MULTI-DIMENSION SPATIAL-AND-TEMPORAL MODELS OF WEBGIS
FOR LAND RECLAMATION

IN MINING AREA

JIANZHONG FENG, ZHENQI HU, AND LINYAN BAI

MONITOR OF HEAVY METAL POLLUTED SOIL BY HYPERSPECTRAL REMOTE SENSING

GAO YONGGUANG, HU ZHENQI, GAO AILIN, AND WANG JIAN

RISK ASSESSMENT OF REUSING MINE LAND AFTER MINE CLOSURE
YAN BAO, ZHENQI HU, JIANFENG WANG, XIA ZHAO

WATER CONTENT SENSITIVITY OF GPR DETECTING RECLAMATION SOIL
ZHENQI HU, XINGTONG CHEN, AND BAOZHEN CHEN

THE STUDY ABOUT THE OPTIMIZATION OF THE USE STRUCTURE OF RECLAIMED LAND IN
THE HILLS MINING AREA OF EASTERN CHINA
ZHAO SHU-QIN

STUDY ON THE THEORY AND METHODS ABOUT THE POLLUTION CHARGE ON THE WASTE
ROCK IN THE STRIP MINE
ZHAO FANG

ANALYSIS OF BLASTING TREMOR IMPACT ON ROADWAY STABILITY IN COAL MINING
YIXIN ZHAO AND YAODONG JIANG

NEW DEVELOPMENTS IN THE ANALYSIS OF SURFACE MINE SLOPES
DOUG STEAD, MING YAN, JOHN COGGAN AND ERIK EBERHARDT

FIELD MONITORING OF RECLAMATION TREATMENT SUCCESS IN THE HELENA NATIONAL
FOREST, MONTANA
R. L.MCNEARNY AND K. GAUER

COMDRAG – A DRAGLINE SIMULATOR FOR STRIP MINES
E. Y. BAAFI AND H. KERR

A LIFELONG LEARNING APPROACH TO TRAINING AND DEVELOPMENT IN MINING
MALCOLM SCOBLE

BENEFITS OF A DOWNTIME ACCOUNTING SYSTEM
CHRISTINE LESHER AND GREG BUNTING

ANALYSIS OF CUTTING RESISTANCES FOR BUCKET WHEEL EXCAVATORS IN HARD
CLAYS
C. DREBENSTEDT AND S. PAESSLER

INTEGRATION OF PRE-CONCENTRATION UNDERGROUND: REDUCING MINING COSTS
A.S. BAMBER, B. KLEIN, M. MORIN, M.J. SCOBLE

EVALUATION OF A RESOURCES DEVELOPMENT PROJECT USING REAL OPTION ANALYSIS
G. MOGI, F. CHEN AND T. ADACHI

EXPERIENCES WITH ONLINE CONTINUING EDUCATION FOR MINING
SIMON W. HOULDING

VALUING MINE 2 AT RAGLAN USING REAL OPTIONS: A LEAST-SQUARES MONTE CARLO
APPROACH
BRUNO LEMELIN, SABRY A. ABDEL SABOUR AND RICHARD POULIN

PREDICTION OF ROCK FRAGMENTATION IN OPEN PIT MINES, USING NEURAL NETWORK ANALYSIS

K. ORAEE AND B. ASI

WAYS OF MINE LOCOMOTIVE TRACTION MOTOR COMMUTATION IMPROVEMENT

B. IVANOV

EXPLOITATION PROJECT FOR ROSARIO BODY USING SUBLEVEL STOPING AND IN-MINERAL RAMP AT UCHUCCHACUA MINE

J.C.SOTOMAYOR, M.FARFAN AND C.FANO

PRODUCT SUPPORT ISSUES FOR MINING EQUIPMENT AND SYSTEMS: OPPORTUNITIES AND CHALLENGES

UDAY KUMAR

RISK ANALYSIS OF TAILING DAMS COLLAPSE

A.BORTOLUSSI, B. GROSSO, P.P. MANCA

HAULAGE ALTERNATIVES IN A DOLOMITIC LIMESTONE QUARRY FOR AGGREGATES: A TECHNICAL-ECONOMICAL AND ENVIRONMENTAL COMPARISON

M. CARDU , E. LOVERA , R. MANCINI AND M. PREVE

DEVELOPMENT OF SIMPLE PRODUCTION MODELING SOFTWARE FOR CONTINUOUS MINER PRODUCTION SYSTEMS

YOGINDER P. CHUGH, A. MOHARANA AND A. PATWARDHAN

A MODEL OF FAULT SHEAR RUPTURE VALIDATED USING MICRO-SEISMIC MEASUREMENTS

BATTISTA GROSSO, PIER PAOLO MANCA AND ROBERTO SARRITZU

SUBLEVEL STOPING AT A LARGE UNDERGROUND QUARRY: STUDIES FOR THE IMPROVEMENT OF THE PRODUCTION BLASTING

M. CARDU , R. FOLCHI , E. LOVERA R. MANICINI , L. ZAMMARIAN AND N. BERRETTA

ADVANCEMENT OF 2D AND 3D ELECTRICAL RESISTIVITY TECHNIQUES FOR UNDERGROUND APPLICATIONS IN A POTASH MINE

MICHAEL MAXWELL, JOHN UNRAU, ROB ESO, DOUG OLDENBURG, AND LIN-PIN SONG

EXPERIMENTAL RESEARCH ON THE "GEO-TUBES" TECHNOLOGY

M. CARDU, O. DEL GRECO, M. PARRINELLO

LOADING AND HAULAGE IN QUARRIES: CRITERIA FOR THE SELECTION OF EXCAVATOR-DUMPER SYSTEM

M. CARDU, E. LOVERA AND M. PATRUCCO

OPTIMIZING CONTINUOUS MINER COAL PRODUCTION SYSTEMS BASED ON PRODUCTION AND PRODUCTION COST

YOGINDER P. CHUGH, A. PATWARDHAN AND A. MOHARANA

SUBLEVEL STOPING AT A LARGE UNDERGROUND QUARRY: THE IMPROVEMENT OF THE DEVELOPMENT AND EXPLOITATION DESIGN

R. MANCINI, M. CARDU, V. PIOVANO AND L. ZAMMARIAN

DEMOLITION AND RUBBLE RECYCLING AS NEW OPERATION FIELDS FOR MINING
TECHNOLOGIES AND MACHINERY
R. MANCINI, E. GARBARINO AND E. MICHELOTTI

NOISE AND DUST EMISSIONS FROM MINING ACTIVITIES: A SOFTWARE FOR A FIRST
APPROACH TO THE MEASUREMENT MANAGEMENT AND SELECTION OF SUITABLE
REDUCTION TECHNIQUES
C. CIGNA, E. LOVERA AND M. PATRUCCO

DESTINATION SCHEDULING WITH MIXED TRUCK FLEETS AT OCEANAGOLDS' MACRAES
MINE
PIETER DOELMAN AND ALUN PHILLIPS

WEB-BASED 3D GIS GEOLOGICAL DATABASE INFORMATION SYSTEM FOR BAIYUNEBO
IRON MINE
HAIFENG DUAN, YANHUI WANG

POSITIVE RESEARCH OF VALUE ASSESSMENT OF THE MINING RIGHT OF SOME GOLD
MINE IN SHANDONG OF CHINA
ZHANG ZHEN KAI

SIMULATION OF A CONTINUOUS LIGNITE EXCAVATION SYSTEM
T.N. MICHALAKOPOULOS S.E. ARVANITI, AND G.N. PANAGIOTOU

Loading and haulage in quarries: criteria for the selection of excavator-dumper system

M. CARDU ¹, E. LOVERA ² and M. PATRUCCO ²

¹ Politecnico di Torino - DITAG, Italy; IGAG - CNR, Torino Italy

² Politecnico di Torino - DITAG, Italy

The optimisation of loading and haulage is one of the most important issues for the yield of quarrying activities. Many external factors may affect loading and haulage system selection: amongst them a very important role is played by local topography, stability conditions, size of the excavated material and capacity of the crusher. Of course, loading and haulage equipments affect one another and should be matched in order to get an efficient system, considering both production and economical aspects; selection criteria should be mainly based on:

- optimisation of loading system (sometimes working as excavation equipment too);
- optimisation of haulage system (in terms of both single equipment and fleet);
- optimisation of maintenance programs and organisation (in terms of availability of the system).

In particular, the paper deals with the hydraulic excavator – dumper (or truck) system, focusing on the relations between the technical characteristics of the equipments. Many loading and haulage operations have been analysed in different Italian open cast mines and quarries, in order to identify the best working relations and to derive a simple procedure for a proper selection.

Keywords: optimisation of mining operations; loading and haulage; excavators; dumpers

1. Foreword

The selection of the loading and haulage system is strongly affected by the global economy of the extraction unit, and should be based on a series of analysis bearing on, among others, the following subjects:

- optimisation of the loading machine, which can be used either to excavate directly from the face, or to muck blasted material;
- optimisation of the haulage stage, concerning the features of the individual machines and the composition of the fleet;
- optimisation of the organisation-maintenance choices, aimed to increase the availability of the system.

Loading and haulage are interconnected with the other steps of the production process, hence the selection of the best suited equipment is conditioned by a number of external factors. First, the morphological and topographic features of the site can impose absolute limits to the size of the machinery, independent from economy and production considerations. The same applies to the limits posed by the stability of the benches and of the face (Cvetkovic *et al.* 1999). Moreover, when the run of mine has to be subjected to primary crushing, the size of the bucket should be smaller than the maximum block size accepted by the crusher, to avoid the need of secondary blasting or mechanical breakage at the crushing plant feeding point.

Within the general limits posed by the above quoted restrictions, the paper, on the basis of a number of field surveys and literature data, tries to define optimal ratios between the most significant technical features of the loading and haulage machines in selected production sites.

2. Data acquisition




In the quarries analysed hydraulic shovels (front and backhoe) are used for loading and excavation, and dumper trucks for haulage.

Five sites, in Piemonte region (NW Italy), have been retained as “sample sites”, and several “standard” loading and haulage operations have been monitored. Data were recorded in purposely prepared forms, to be treated with data processing programs. The following have been carefully determined:

- the mean volume loaded in a cycle by the excavation bucket, with an approximate evaluation of the size distribution of the material;
- the actual bucket filling, rotation, unloading, bucket return times and displacement of the shovel;
- the number of dump trucks engaged at any time in the operation;
- the mean volume actually loaded on the dump truck;
- the mean waiting time of the dump trucks, when more than one is used.

The information on the technical features of the machines has been obtained from manufacturers technical literature: bucket capacity; installed power of the shovel; ideal cycle time; dumper capacity; dumper installed power. The ranges of the most important features of the machines engaged in the sample sites are shown in table 1. Figure 1 shows the ranges of the characteristic ratios (power/capacity and power/ weight) of the machinery involved: it can be seen that the ranges of the machines employed in the sample sites are well within the general range.

Table 1. Ranges of the most important features of the machines engaged in the sample sites.

	Equipment	Power kW	Weight t	Capacity m³
	Hydraulic excavator	80 - 230	19 - 50	1 - 3
	Front shovel excavator	306 - 728	75 - 200	4.5 - 9
	Dump truck	166 - 447	20 - 38	10 - 34

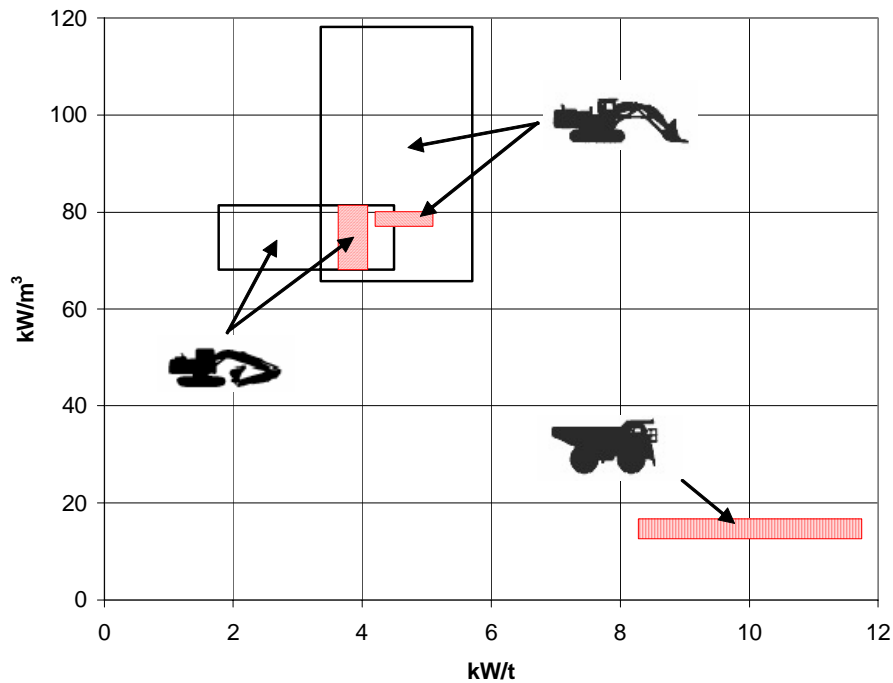


Figure 1. Ranges of the power/capacity and power/weight of the machines engaged: contoured area refers to the whole family of machines, coloured area to the sample sites machinery.

We can conclude that the sample sites are quite typical, as far as the fleet engaged is concerned.

3. Analysis of the data collected

Field collected data and information on machinery have been used to define generalizable correlations (assuming that the sample sites are a representative sample of the whole population of crushed stone quarries in our district), linking the technical features of the machinery to the production obtained.

3.1. Bucket capacity/dumper truck capacity correlation

The observed data are plotted in figure 2, showing a correlation coefficient quite high (0,78).

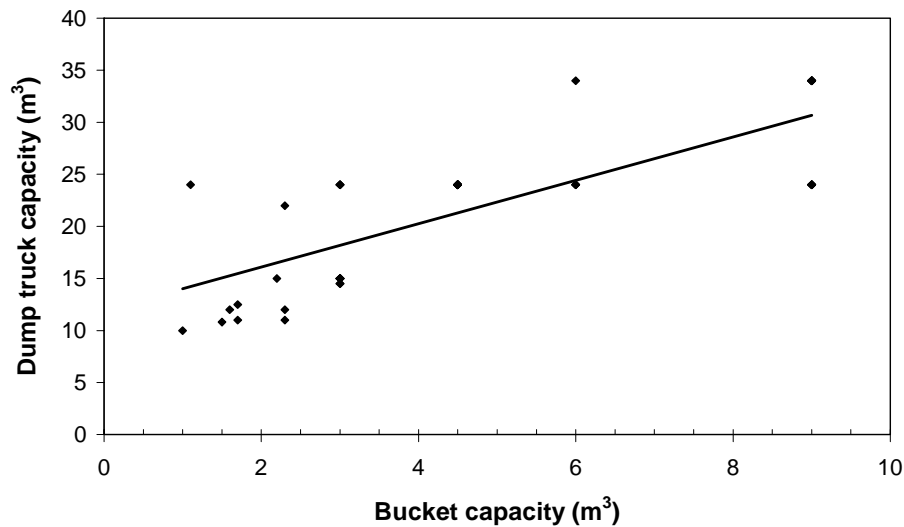


Figure 2. Correlation linking the bucket capacity to the truck capacity, in the sample sites.

The ratio truck capacity/bucket capacity varies in the 2.6 to 10 range (excluding one anomalous case), which qualitatively agrees with literature data (for example Rzhnevsky, 1987, indicates a 4.7-10 range, for a comparable range of bucket capacities).

The average number of buckets required to fill a truck has been calculated: the mean value is 5.5, in agreement with literature data.

The degree of utilisation of the loading capacity (K) can be calculated as:

$$K = \frac{N_b \cdot V_E \cdot K_{BF} \cdot K_{RC}}{V_D} \quad (1)$$

where:

N_b = number of buckets to fill the truck

V_E = bucket capacity (m^3)

K_{BF} = bucket filling coefficient (0.85-1.05)

K_{RC} = broken rock compaction coefficient (0.87-0.94)

V_D = truck capacity (m^3)

Calculated values for K (from all the data collected in the sample sites) are 0.8-0.9, slightly lower than optimal values quoted in literature (1-1.07).

The productivity of the whole shovel-truck system, hence bucket/truck capacity ratio, depends on the mutual position of the two machines, say on the availability of space and on the geometrical features of the site, that can make possible one side or both sides loading, as shown in figure 3.

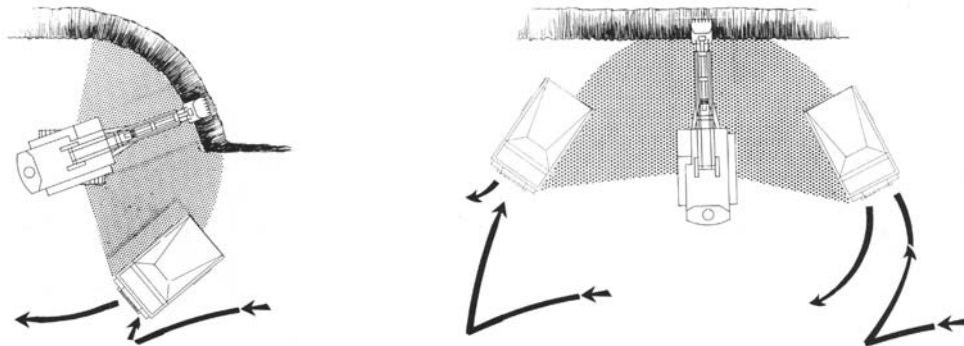


Figure 3. Schemes of one side (left) and both sides (right) loading of the trucks (Martin *et al.* 1982).

When applicable, both sides loading is preferred, making possible continuous loading, avoiding the shovel idle time due to the dump truck manoeuvre to get to the loading position.

If the haulage distance does not introduce further idle times, the relationship ideally linking the bucket capacity to the truck capacity and to the hourly production is:

$$V_E = \frac{V_D \cdot t_c}{\left(\frac{3600 \cdot V_D}{Q} - t_{wD}\right) \cdot K_{BF}} \quad (2)$$

where:

V_E = bucket capacity (m^3)

V_D = truck capacity (m^3)

t_c = shovel cycle time (s)

Q = hourly production (m^3/h)

t_{wD} = waiting time due to truck positioning

K_{BF} = bucket filling coefficient

Field data from the sample sites agree with equation (2), to within 10%.

By assuming the average value of 30 s, for average dump truck wait and shovel cycle time (from the measured data at the sample sites), the correlation linking bucket capacity, truck capacity and hourly production is represented by the nomogram of figure 4, which can be confidently used for practical purposes (in the case $t_{wD} = 0$, the production depends only on bucket capacity).

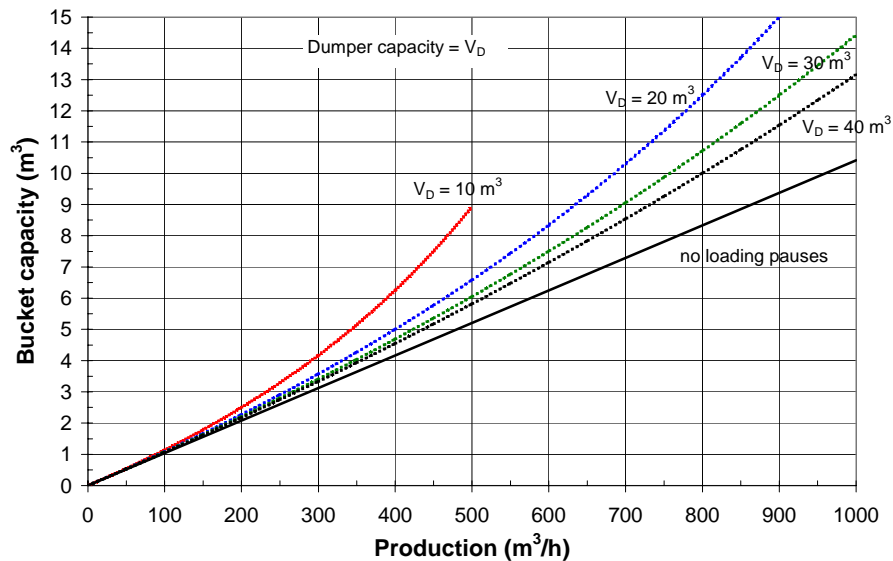


Figure 4. Nomogram linking bucket capacity to truck capacity and production.

3.2. Correlation linking cycle time to shovel features

At the sample sites, for all monitored loading operations, the components of the cycle time (say: bucket filling time, relation to the truck time, bucket emptying time, return time) have been measured.

As a general observation, the shortest cycle time are recorded where the shovel stays on the upper bench, with a bench height compatible with the reach of the shovel arm, as shown in figure 5.



Figure 5. Example of optimal placement of the shovel and truck.

Productivity depends also from the rotation angle, and is critically reduced when rotation angle is over 90° .

The average cycle time has been found to be 22 s for the backhoe shovel and 32 s for the heavier and larger front shovels. A rather poor correlation has been found linking the cycle time to the bucket capacity and to the installed power of the shovel (see figures 6 and 7).

Apparently the cycle time is affected mainly by the volume moved in the cycle, hence by the filling and unloading times.

The features of the truck do not affect significantly the cycle time.

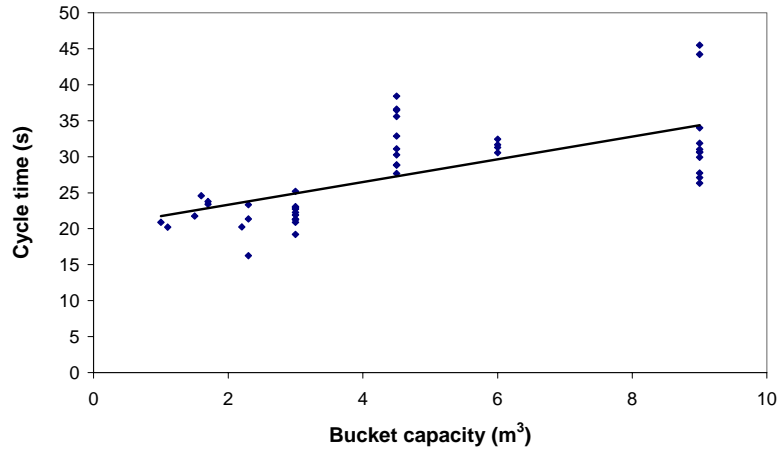


Figure 6.

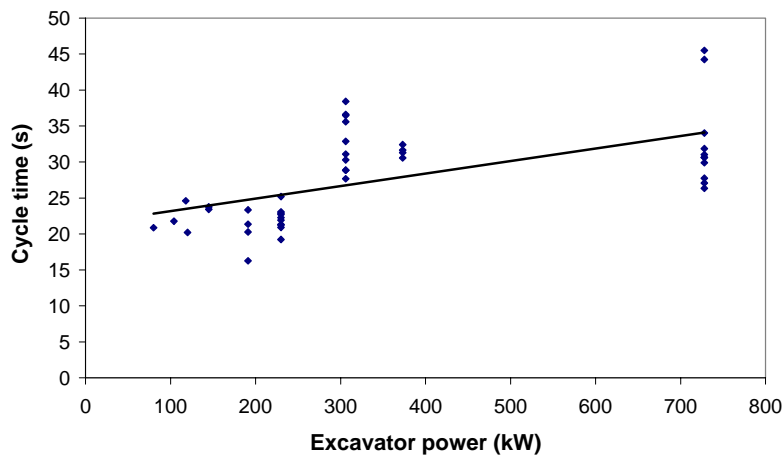


Figure 7.

3.3 Correlation linking the installed power to the bucket and truck volumes

For the shovel-truck system, correlation has been found linking the installed power of the two machines, which could represent a criterion for a preliminary check of the good match of the machinery selected (see figure 8).

The same applies to the correlations found between bucket capacity and truck capacity and truck installed power, and between truck capacity and shovel installed power (see figures 9 and 10).

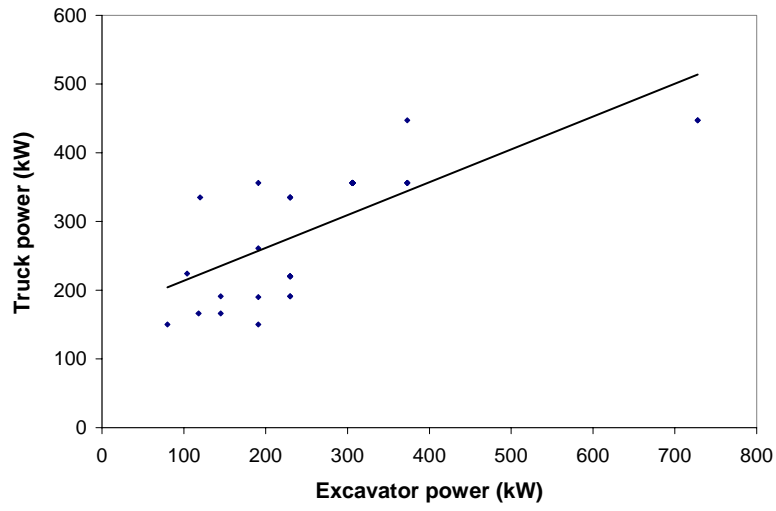


Figure 8.

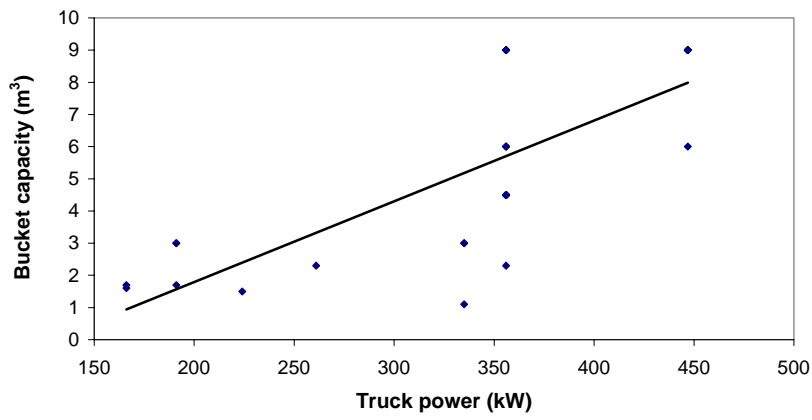


Figure 9.

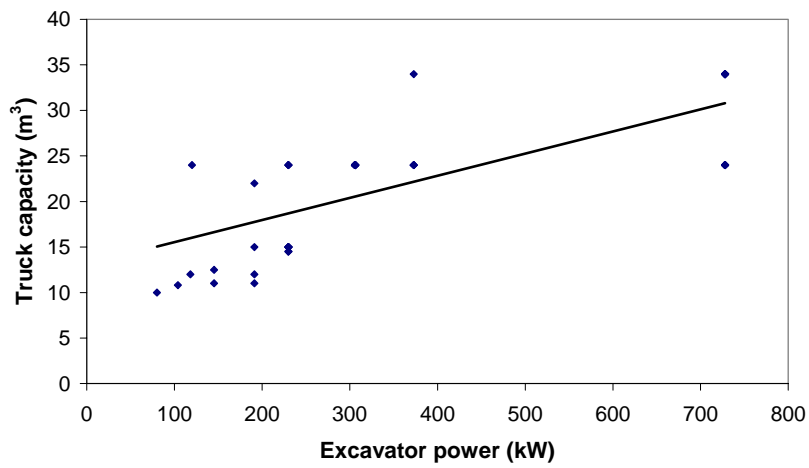


Figure 10.

Indeed, this is an outcome of the power-capacity correlations existing for the two families of machines (see figure 11 and 12).

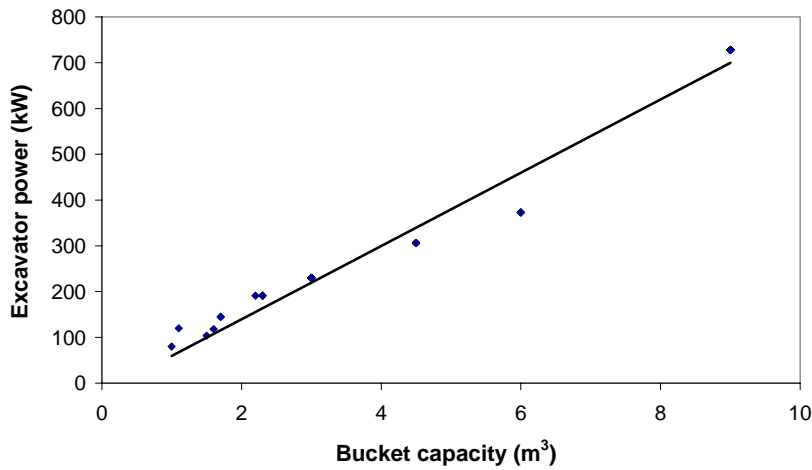


Figure 11.

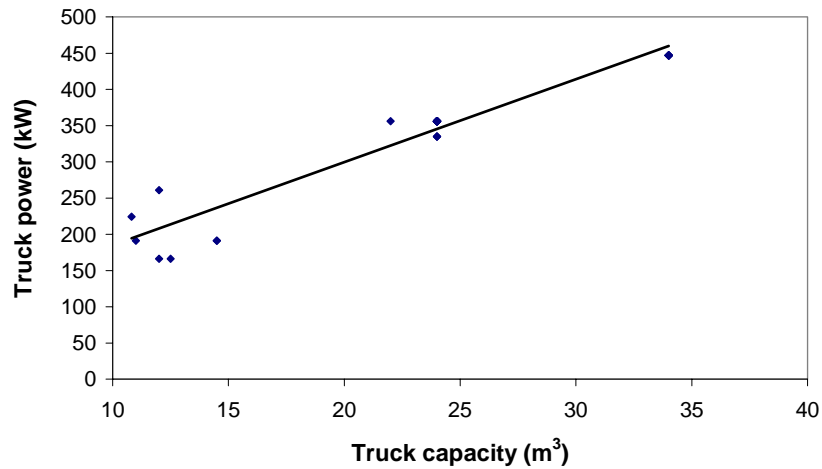


Figure 12.

Confirming literature data (W.J. Martin *et al.* 1982) the backhoe shovels, for the same bucket capacity, are heavier and install more power.

The trend seems to point out that, when front shovels are used, larger bucket capacity are preferred, within the limits posed by machine stability restrictions.

3.4. Hourly productivity v/ bucket capacity correlation

The analysis of the test site data provided a quite good correlation, shown in figure 12, which can be confidently used for a preliminary selection of bucket size for a given productivity.

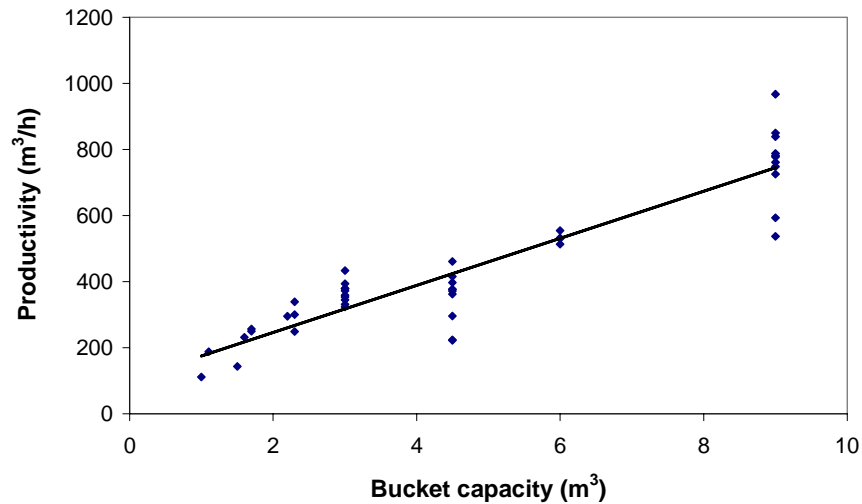


Figure 13.

4. Conclusions

A conspicuous collection of data from test sites made possible an analysis of the main features of the shovel-truck system adopted by mining and quarrying activities in Italy.

A logical sequence to be followed when checking for the optimal match of the shovel-truck system is suggested by the observed correlations:

- on the basis of the required hourly productivity, the bucket capacity is selected and the average cycle time is estimated, according to the suggestions of figure 13 and figure 6;
- the truck capacity is selected on the basis of the bucket capacity, according to the suggestion of figure 2;

- the installed power of the machines are estimated from the bucket and truck capacities, according to figure 11 and figure 12.

References

CAT. *Caterpillar Performance Handbook*, Caterpillar Inc., USA, 2003.

Church, H.K., *Excavation handbook*, McGraw-Hill, USA, 1981.

Cvetkovic, M., *The effect of working machines on rock stability*. Journal of Mining and Geological Sciences, Vol. 37. Belgrade, Yugoslavia. 1999, pp. 157-165.

Flachsenberg, P., *Loading and Haulage in Quarries. Opencast mining, quarrying and alluvial mining*, 1964, pp. 299-323.

Herbert, L.N., *Moving the heart*, North Castle Books, USA, 1976.

Martin, W.J. et al., *Surface mining equipment*, Martin Consultants Inc., USA, 1982.

Rzhevsky, V.V., *Open cast mining. Technology and integrated mechanization*, Mir Publishers, Moscow, 1987.