

# FRAGBLAST9

[ 9<sup>th</sup> International Symposium  
on Rock Fragmentation  
by Blasting ]

13-17 September 2009

Granada, SPAIN

ACCEPTED PAPERS

---

## Keynote addresses

Fragmentation characterization; the Swebrec function and its use in blast engineering

*F. Ouchterlony*

Intra-hole and inter-hole effects in typical blast designs and their implications on explosives energy release and detonator delay time – A critical review

*B. Mohanty*

## 1 Rock characterization

Mechanical characterization of rocks at high strain rate by the JRC modified Hopkinson bar: a tool in blast and impact assessment

*E. Cadoni, M. Dotta, D. Forni, P. Giorgetti, G. Riganti & C. Albertini*

Rate dependence of tensile/flexural strengths of Laurentian granite

*F. Dai & K. Xia*

Determination of dynamic fracture parameters of rocks using a semi-circular bend technique

*R. Chen & K. Xia*

Dynamic caustics experiment of blast-induced crack propagation in material containing plane of weakness

*R. Yang, Z. Yue, J. Dong, J. Zhang & X. Niu*

3-Dimensional visualization of granitic rocks subjected to impact loading using Micro-focus X-ray CT scanner

*S.H. Cho, S.K. Kim, B. Mohanty, K. Xia & K. Katsuhiko*

An application of fuzzy sets to the blastability assessment of rock mass

*Y. Azimi, M. Osanloo, M. Akbarpour-Shirazi & A. Aghajani-Bazzazi*

Hydrothermal alteration impact on drilling and blasting management, planning and fragmentation results

*C. Muñoz & N. Guerra*

How 3D images support bench face profiling, blast planning and rock mass characterisation

*A. Gaich, M. Pötsch, P. Moser & W. Schubert*

Referenced 3D images from inside cavities and behind rings in sublevel caving

*M. Wimmer, F. Ouchterlony, P. Moser, A. Nordqvist & G. Lenz*

## 2 Explosives and Initiation systems

Study of the effect of particle size distribution on the detonation velocity of modified ANFO

*L.S. Liu, C.P. Wu & X.G. Wang*

Application of Heavy ANFO explosives in quarries nearby Istanbul

*T. Hüdaverdi, E. Guclu & C. Kuzu*

Development of low density reactive agents

*G. Silva & C. Scherpenisse*

Evaluation of salt-ANFO mixture in back break reduction by data envelopment analysis

*I. Enayatollahi & A. Aghajani-Bazzazi*

Properties of alternatively fueled ammonium nitrate explosives

*C. Hurley, V. Petr, S. Liu & J. Banker*

Use of furnace oil as liquid fuel in site mixed slurry explosive system – A case study

*G.K. Pradhan, M. Pradhan & N.R. Thote*

A long-hole open stope blast in hot ground

*S. Roberge, M. Verreault & D. Roy*

A new principal formula for the determination of explosive strength in combination with the rock mass strength

*P.A. Rustan*

Study and application of an elliptical bipolar linear shaped charge

*J.F. Qin, R.X. Qin & H.H. Li*

Limitations of electronic delays for the control of blast vibration and fragmentation

*D.P. Blair*

Pre-programmed electronic detonators for underground blasting

*G. Teowee & D. Lansburg*

The key technique of highly precise and safe delay detonator without primary explosive

*Z.W. Shen & H.H. Ma*

## 3 Blast design, monitoring and fragmentation assessment

A common form for fragment size distributions from blasting and a derivation of a generalized Kuznetsov's x50-equation

*F. Ouchterlony*

Formulae and techniques for assessing features of blast-induced fragmentation distributions

*A.T. Spathis*

Evaluating a calibration method for the estimation of fragmented rock 3D-size-distribution out of 2D images

*S. Outal, J. Schleifer & E. Pirard*

Fragmentation size measurement using 3D surface imaging

*M. J. Thurley*

Evaluation of some distribution functions for describing rock fragmentation data

*J.A. Sanchidrián, P. Segarra, L.M. López, F. Ouchterlony & P. Moser*

Influence of rock mass blastability on explosive energy distribution

*S.S. Mitrović, L.M. Kričak, M.N. Negovanović, I.V. Janković & D.I. Zeković*

A practical method of bench blasting design for desired fragmentation based on digital image processing technique and Kuz-Ram model

*I.C. Engin*

Kuznetsov model's efficiency in estimation of mean fragment size at the Sungun copper mine

*S. Gheibie, H. Aghababaei, S.H. Hoseinie & Y. Pourrahimian*

Determination of the practicable burden in Sungun open-pit mine, Iran

*H. Khoshrou, M. Badroddin & E. Bakhtavar*

Control of rock fragmentation and muck pile geometry during production blasts (environmentally friendly blasting technique)

*B. Müller, J. Hausmann & H. Niedzwiedz*

The application of electronic monitors to understand blast movement dynamics and improve blast designs

*D.M. Thornton*

New methodology for the quality control of long-hole drilling in underground hard rock mines

*K.Q. Liu*

Causes, implications and control of oversize during blasting

*S.P. Singh & R. Narendrula*

Tunnel blast pattern design using short holes

*H. Mansouri, H. Shiva, M.A. Ebrahimi-Farsangi & H. Darbani*

#### 4 Modelling of rock blasting

Simulation of real detonations as an energy source term for the Hybrid Stress Blasting Model

*M. Braithwaite, G.J. Sharpe & G.P. Chitombo*

Developments in numerical modeling of blast induced rock fragmentation: Updates from the HSBM project

*J.K. Furtney, P.A. Cundall & G.D. Chitombo*

Towards a complete validation of the lattice scheme in the Hybrid Stress Blasting Model (HSBM)

*I. Onederra, G. Chitombo, P. Cundall & J. Furtney*

Modelling the impact of sublevel caving blast design and performance on material recovery

*I.D. Brunton*

A numerical investigation of the effect of blasthole delay in rock fragmentation

*A. Mortazavi & E.F. Salmi*

Use of a modified particle-based method in simulating blast-induced rock fracture

*J. Yoon & S. Jeon*

A new 3D simulation framework to model blast induced rock mass displacement using physics engines

*A. Tordoir, D. Weatherley, I. Onederra & A. Bye*

Large scale concrete cube blasts for the HSBM model

*E.J. Sellers, M. Kotz, L. Dipenaar & M. Ruest*

Analysis of single particle fragmentation curves after drop weight impact of blast induced fragments

*P.D. Katsabanis*

Waves, fractures and boundary effects associated with blast experiments conducted in cylindrical and block type specimens

*H.P. Rossmannith, K. Uenishi & V. Hochholdinger-Arsic*

Seismic radiation patterns from cylindrical explosive charges by analytical and combined finite-discrete element methods

*L.F. Triviño, B. Mohanty & A. Munjiza*

Borehole excitation by oscillating/moving pressure band

*K.R.Y. Simha & M. Ramesh*

## 5 Rock damage and wall control

The size of the damage zone in relation to the linear charge concentration

*M. Kilebrant, T. Norrgård & M. Jern*

The extent of blast damage from a fully coupled explosive charge

*S.R. Iverson, W. Hustrulid, J.C. Johnson, D. Tesarik & Y. Akbarzadeh*

Crack lengths or blast damage from string emulsion and electronic detonators

*F. Ouchterlony, M. Olsson & J. Svård*

Controlled blasting (pre-splitting) at an open-pit mine in India

*P.K. Singh, M.P. Roy, A. Joshi & V.P. Joshi*

Carving-like blasting technique and its application in rock anchor beam excavation

*C. Xu*

Evaluation of Kiruna mine drifting data using the NIOSH design approach

*W.A. Hustrulid & S.R. Iverson*

A study on the estimation of the Tunnel Contour Quality Index in a drill and blast tunnel

*Y. Kim & A. Bruland*

Blasting in a large scale opening gallery – case study: Feter 6 gallery, Faryab chromate mine

*J. Salari, M.A. Ebrahimi-Farsangi & H. Mansouri*

Effect of joint orientations on rock mass damage at a penstock tunnel subjected to repeated blast vibrations – a case study

*M. Ramulu, P.B. Choudhury, A.K. Raina, A. Sinha & T.G. Sitharam*

New perspectives for blast damage evaluation in crystalline solid materials

*C. Muñoz, N. Guerra & P. Mancilla*

## 6 Vibrations

The impact of geological features on level of ground vibrations

*T. Lewandowski, L. Richards, L. Hamson, M. Merchant & A. Spargo*

Determination of 'safe' infrastructure vibration levels using alternative approaches

*A.J. Moore & E. Gad*

Assessment of the error of blast vibration measurements

*P. Segarra, J.A. Sanchidrián, L.M. López, E. Querol & J. Gutiérrez*

Seismic wave monitoring and ground vibration analysis for bench blasting in Sungun open pit copper mine

*Y. Azimi, S.H. Khoshrou, M. Osanloo & A. Sadeghee*

Impact assessment of surface mine blasting on adjacent underground mine structures using field measurements and numerical techniques

*A.K. Jha, D. Deb & N.C. Jha*

Comparison of traditional near-field vibration prediction models with three-dimensional vibration scaling and blast wave energy

*K.G. Fleetwood, E. Villaescusa, J. Li & R. Varden*

Influence of rock mass discontinuity networks on the seismic response parameters

*E. Hamdi, H. Gasmí & N.B. Romdhane*

An integrated approach of signature hole vibration monitoring and modeling for quarry vibration control

*R. Yang, D.S. Scovira & N.J. Patterson*

Vibration induced by drilling and blasting excavation process in high in-situ stress area

*P. Yan, W.B. Lu, Y. Luo & M. Chen*

Monitoring of blast-induced vibration effects on structures by fiber Bragg grating

*C. Drebenstedt & J. Ortuta*

3D hydrocode analyses of a mechanically stabilized earth retaining wall subjected to production blast vibrations at a surface coal mine

*D.S. Preece, R. Yang, J. Pilz & Z.M. Zavodni*

Blast vibration study to analyse the response of a wind tower close to an open pit mine

*I. Gómez-Márquez, F. García-Bastante & L.R. Alejano*

## 7 Environmental

Mechanistic Monte Carlo models for analysis of flyrock risk

*T.N. Little & D.P. Blair*

Fly rock prediction by multiple regression analysis in Esfordi phosphate mine of Iran

*A. Aghajani-Bazzazi, M. Osanloo & Y. Azimi*

Evaluation of meteorological effects on airblast levels

*A.B. Richards & P.S. Howarth*

Characterising dust generation from blasting

*A. Scott, S. Michaux & I. Onederra*

Greenhouse gas implications of explosives and blasting

*G.F. Brent*

Blast emission criteria and detection methods for the safeguarding of marine mammals in a blast environment

*R.A. Godson*

## 8 Blasting economics and downstream effects

Optimization of blasting in narrow reef mines in South Africa

*F.J. Fourie, T. Zaniewski & M. Cross*

Productivity improvement in an opencast coal mine in India using digital image analysis technique

*A.K. Raina, M. Ramulu, P.B. Choudhury, A.K. Chakraborty, A. Sinha, B. Ramesh-Kumar & M. Fazal*

Throw blasting analysis - a focus on coal uncover and recovery rates

*G.F. Brent & M.J. Noy*

The application of a blast audit for production improvement

*S.G. Giltner & A.E. Koski*

Estimate of support and reinforcement cost increase associated to poor blasting practices in drifting

*L. Alejano, E. Alonso, A. Rodríguez-Dono, C. Ordóñez & D. Córdoba*

## 9 Case studies

Maximizing the throw while controlling vibration within safe limits in cast blasting

*P.K. Singh, M.P. Roy, A. Roy, S.K. Jha & A.K.B. Singh*

Six Sigma® methodology applied to blasting

*S. Mencacci, D. Jacquet, O. Vandenabelle, R. Chavez, J.F. Couvrat & Y. Sarrey*

A practical approach to fragmentation optimization at Kidd Mine

*G. Bekkers*

Infrastructure design effects on the Pipa Norte Mine, Division El Teniente

*H. Constanzo & M. Piérola*

Successful application of bamboo spacers in smooth wall blasting for highway construction in hilly terrain – a case study

*C. Sawmliana, P. Pal-Roy & R.K. Singh*

Controlled blasting for protection of water production wells at Cerro Corona

*E. Diaz-Leturia & Y. Cano-Pérez*

Hard rock dimension stone quarrying using control blasting, case study: Shahkooh granite quarry

*M. Afsharian, M.A. Ebrahimi-Farsangi & H. Mansouri*

A research on the propagation law of the shock wave in underwater blasting and the bubble curtain protection

*Y. Long, Q.J. Xu, L.Z. Shao, Y.Z. Sun, X.B. Xie & Q.M. Xie*

New progress and development of engineering blasting in China

*X.G. Wang, D.S. Liu & J.H. Zhou*

Advances in precision blasting in China

*X.Q. Xie & W.B. Lu*

## 10 Special blasting applications

Explosive synthesis for lithium battery materials

*X.H. Xie, J. Zhu & H.S. Zhou*

Effect of explosion waves on stacked wood chips in a closed vessel

*Y.C. Liu, L.S. Liu, C.P. Wu, J.L. Dou & X.G. Wang*

FEM simulation of a reinforced concrete chimney blasting demolition with separate model

*G.X. Zhang, J. Yang, G.L. Yang & L.L. Jiang*

Demolition of arch portion of brick and mortar constructed railway bridge

*S.K. Mandal, C. Sawmliana, P. Pal-Roy, M.M. Singh & M.K. Gupta*

Measurement of the vibration from the blasting demolition of a tall chimney

*Y. Ogata, S. Kubota, K. Kato, Y. Wada & M. Kato*