BLASTING CONTROL IN MINING FOR LESS ENVIRONMENTAL IMPACT

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ABSTRACT

Conventional method in mining is to use blasting for rock fragmentation. Impacts from blasting were sometimes reported, either fatally or non-fatally, for both surface and underground mining. Case experiences from around the world are needed to avoid those unwanted circumstances.

A number of case experiences are demonstrated for both surface and underground excavations according to various parameters, e.g. explosive charge, blasting pattern (spacing, burden, stemming, sub drilling), delay, etc.

Various monitoring techniques are also illustrated to measure or monitor the effects from blasting.

Keywords: Blasting, Mining, Environment, Impact

INTRODUCTION

The aim of the paper is to obtain the empirical findings and data which will be base for the blast designs which will not hinder the activities for excavation works allowing controlled blasting activities while not damaging any surround residences and convert these data into mining processes. Within this frame initially the ground vibration and air blast produced from blasting will be defined and various damage risk criteria will be created by analyzing the related parameters and the realization of the proper designs will be targeted. Besides, two case studies are shown by applying an interdisciplinary approach under inclusion of the best demonstrated available technologies.

The particular situation of the mining industry which is engaged in the nature of earth's crust, tries to cope with the strain and focus sources of danger. Hazards connected with activities in the mining industry are natural and inevitable (nature-man-machine-system) and besides often quiet large. Therefore safety measures and safety precautions are important factors of considerably significance.

Particular emphasis are focused on blasting works handling by knowing that without safety blasting works wide sectors of mining would be inconceivable. Under this safety-conscious circumstance the starting-point for avoidance of blasting impacts is specified already.

LEGAL REQUIREMENTS ON BLASTING PROCESSES

Blasting activities surface or underground necessarily involve the most sensitive aspect of environment remediation, human response or annoyance and in the worst case impacts with significant effects on humans and/or environment. Such effects are unavoidably characteristic of those activities. For this reason, blasting activities are governed by law and official regulations under surveillance of authorities, where companies and explosives engineers have to proceed within proper limits.

The fragmentation of minerals from their solid state is mostly carried out by blasting works worldwide, which is in turn accompanied by unavoidable emissions like above mentioned already. In addition to noise, dust and rock fly, ground vibrations and sound events caused by blasting include those side effects which can cause impairment of the neighborhood (residents), environment, buildings, and other third party property.

In order to minimize such damage during blasting works it is to ensure that blast induced emissions do not pass a certain level. For such emissions the relevant laws and regulations contain no absolute limit values. However, it is set in all regulations that the blasting activities generally have to perform in such a manner, that preventable emissions remain undone under inclusion the state of the art technologies. The "state of the art" and “best practice” is in reference to the best demonstrated available technology (BDAT) and advanced technological procedures which are based on the appropriate development of facilities and processes, consolidated scientific findings, that functional efficiency is established and proven. In determining the state of the art, especially comparable processes, facilities or operations have to be used.

The numerous contacting points of operations between the aspects of quality, impact protection and occupational safety in blasting, are concentrated in particular objectives where primarily are focused on

1. Protection of persons against a threat to life, health or physical condition as well as an unacceptable annoyance,
2. Protection of third party property (goods of third parties) of hazards,
3. Protection of impairment by environmental pollution,
4. Protection from waters regarding in excess of reasonable measure.

The priority objectives from above as regards content all safety-relevant requirements refers to the impact protection of

- Life and the health of people
- The living conditions of people
- The environment (soil, plants, animals, air)
- Third party property
- The neighborhood and
- Against accidents (occupational accident)
- Against diseases (occupational disease)

DETERMINATION OF HAZARDS

According to the relevant Safety and Health Regulations employees are obliged to determine the necessary methods of occupational safety and health through an occupational exposure assessment by an evaluation. An important basis for this are the safety-related regulations (laws, regulations, prevention of accidents, safety rules, etc.), the possible vulnerability is already found in general terms in which for many areas and activities and appropriate protective methods are described.

Because fields of work and processes change often, current evaluations represent at a given instant situation and should be reviewed by significant changes. Eventually, the purpose of an evaluation is an assessment of hazards and settings of effective methods for the protection of persons and environment. This includes providing further internal rules in many cases (e.g. type of blasts, surface or underground etc.) and its operations (e.g. performing loading activities) to improve practice work, but also the application of safety methods. This applies in particular the planning phase.

DOCUMENTATION

The documentation required in all health and safety laws (result of the evaluation, settled methods, result of the checking), consists not only of the edited checklists for hazards determination, but finally is composed of a variety of different documents (such as organizational instructions, operating instructions, company handbooks, hazard mitigation plans, meetings and inspection protocols, training certificates, work reports, etc.). It means that every blast (even with one cartridge) has to be evaluated about all risks concerning safety, health and environment before firing.

This document is part of the required blasting papers (e.g. prognosis, type of explosives, ignition, calculation, measurements, stemming and so on).

IMPLEMENTATION OF HAZARD ANALYSIS

By carrying out the implementation, it seems useful to work with checklists, in order to meet the required analyses within a reasonable time and - at the same time - to fulfill the required documentation requirements. Checklists for the determination of hazards have been compiled for specific areas. These are quite useful to identify certain threat systematically and to capture them in written form. Therefore, they act for the documentation of this process at the same time.

The following chart gives an overview of the most important hazard factors for blasting works in mining. It facilitates the entry into the determination of potential hazards. Harmful effects by hazardous material are represented in an overview. Also fire, explosion and rock flight hazards need to be determined.

Like in the already above mentioned checklist the main points are compiled, which are to be taken into account on this important aspect. A number of possible hazards are shown in the following chart 1:

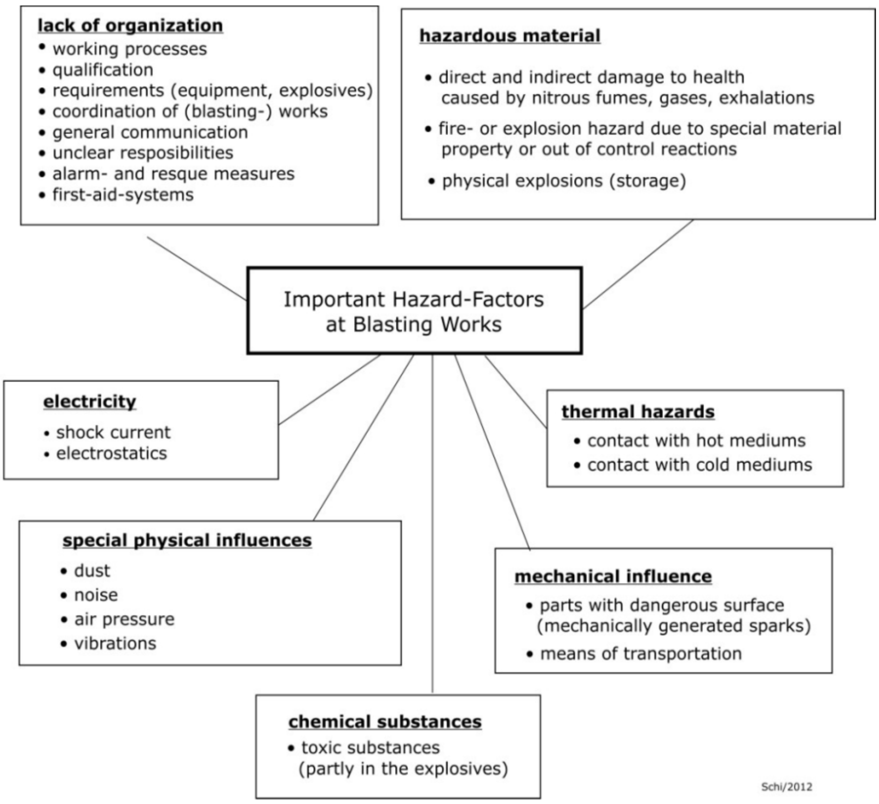


Chart 1: Important hazard-factors at blasting works

OPERATIONAL REQUIREMENTS

The operational efforts are focused on a Continuous Improvement Process (CIP), which means planning, execution, checking and optimizing. Under the previous priorities has the following be understood:

Planning: Definition of the objectives and processes, to achieve the implementation of the environmental policy of the companies;

Execution: Implementation of planned processes;

Checking: Monitoring of processes with regard to the legal and other requirements like standards, as well as possibly objectives of the environmental policy of the company. Publication of environmental performance (the success of a company on their environmental protection measures);

Optimize: If necessary the planned processes are corrected and adjusted;

Ultimately the Continuous Improvement Process (CIP) will only be successful in its processes, if resources, tasks, responsibility and authority are clarified accordingly and distributed. With regard to the latter requirements, subsequent skills must be planned and professionally distributed:

- Ability, training and awareness
- Communication

– Documentation
– Control of documents
– Operational control
– Emergency preparedness and response

By means of the previous listed processes a consistent, as well as ongoing survey will be necessary, specifically in the area of blasting works processes. The survey includes all requirements (also the internal ones) which have been applied on the operational processes. These are usually:

– Monitoring and measurement
– Evaluation of compliance with relevant legislation
– Non-conformity, corrective and preventive actions
– Control of records
– Internal audits

To the previous procedures the Continuous Improvement Process (CIP) must include:

- Information to the involved persons in the working areas;
- Control of drilling and blasting;
- Internal audits concerning the blast system to check the blasting;
- Verification of compliance with the operating instructions (in particular the maximum charge explosives per delay);
- Blasting tests in conjunction with vibration and air blast overpressure measurements in affected areas;
- Analysis of blasting vibrations (data analysis);
- Recording public perception protocols.

DRILLING AND BLASTING

Controlled blasting with high explosives close to structures has been carried out successfully despite the vibration and air blast overpressure damage risk. Crucial factors for success include experienced personnel and detailed blast design including: number of delays, blast pattern, charge per delay, limited sub-drilling, controlled drilling alignment (Fig.1), meaningful test blasts, rigorous quality assurance/control and timely adjustment based on vibration monitoring results. Vibration limits are discussed further below.

To avoid damage by impacts of structures and environment the operator's key responsibility regarding the use of explosives, as in relation to other risks, is to ensure that the work is properly managed, planned, coordinated and supervised. This is the case whether blasting operations are undertaken by a mining or quarry worker (explosives engineer/blaster) or by a specialist-blasting contractor.

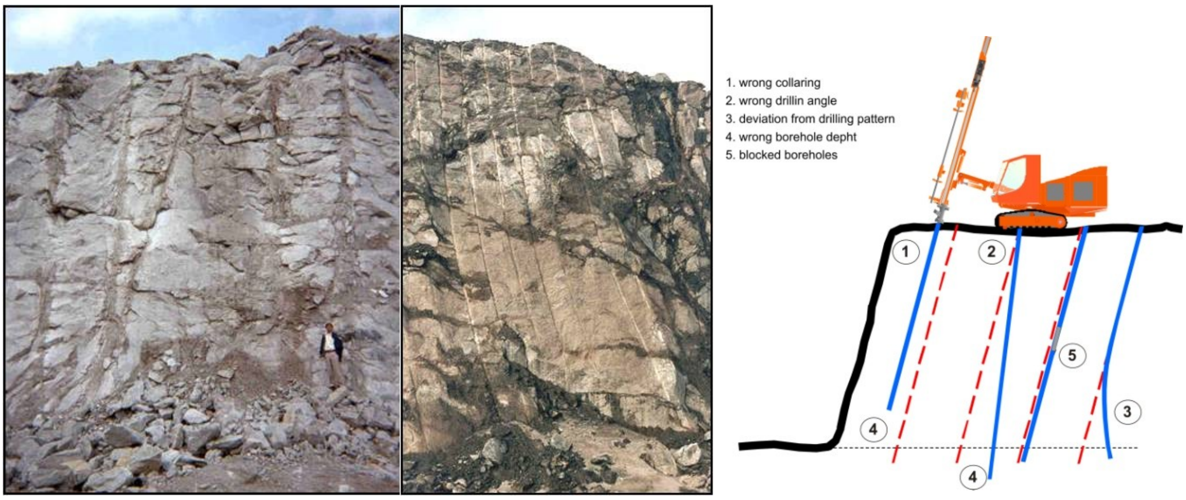


Figure 1: Typical faulty drilling, surface

EXPLOSIVES SUPERVISORY FUNCTION

To execute an explosives supervisory function it has to be in charge one responsible person, in the following called explosives supervisor, needs to be placed in overall, day-to-day, charge of work with explosives at quarrying or mining. Exactly who is appointed, as an explosives supervisor will vary. It may, for example, be the mine or quarry manager, another manager or supervisor, a blasting contractor or an outside blasting consultant.

It is imperative that explosives supervisors must have sufficient practical and theoretical knowledge and experience for the specific work, which is to be undertaken. To obtain the necessary theoretical knowledge an explosives supervisor needs, as a minimum, to have successfully completed a course of training covering:

a) Blast calculation and design surface and/or underground;
b) Detrimental effects on the environment like ground vibration, air blast overpressure and rock fly;
c) Blasting, including geological working knowledge

There needs to be good communication and coordination between them, for example to deal with any handover or maintenance issues.

BLASTING PROCEDURES

To blasters awareness raising belongs that blasting operating procedures have to be set out in writing to ensure that blasting operations at a quarry or mine take place without endangering the workforce, the public or the environment. Besides the procedures must take proper account of local circumstances, for example any risk of accidental initiation due to radio frequency transmitters, electrically powered plant and overhead power lines. If there is such a risk, a suitable method of initiation must be chosen (e.g. nonel ignition).

All needed procedures have to be well publicized throughout the quarry or mine, and personal copies must be given to those who have duties under them. Also the responsible operator must ensure that arrangements have to be made to monitor compliance with the operating procedures.

Furthermore the operating procedures need to cover arrangements for the appointment and authorization of responsible blasters, trainee blasters, storekeepers and others handling and/or working with explosives. Also the explosives supervisor has to check that the equipment provided is suitable and safe and on-site conditions are in line with the elaborated blast specification before work with explosives. Like previous mentioned before has to be underlined!

Figure 2: Rest of explosives in muck pile, surface (left) and in trim-holes, underground (right)

Continuing operating procedures it’s a must to have an inspection of the blast site after firing to check the state of the face and whether a misfire has occurred, and ensuring that normal working is resumed only when the responsible blaster is fully satisfied that it is safe and the all-clear has been sounded. As well as dealing with misfires and the discovery of unfired explosives from previous operations (Fig.2). And, last not least monitoring arrangements for operations to ensure the operating procedures are complied with.

BLASTING SPECIFICATION

Because of changing situations on-site a blasting specification has to be prepared for each blast surface and underground; it must be tailored for each blast, in view of the conditions on the site.

The specification has been designed to:

- Ensure that the risk of fly rock being projected outside the declared danger zone is as low as possible, and must state any special precautions required to achieve this;
- Minimize the risk of misfires;
- Enable the location of any misfired shots to be determined accurately; and
- Ensure that faces are left in a safe condition after a blast.

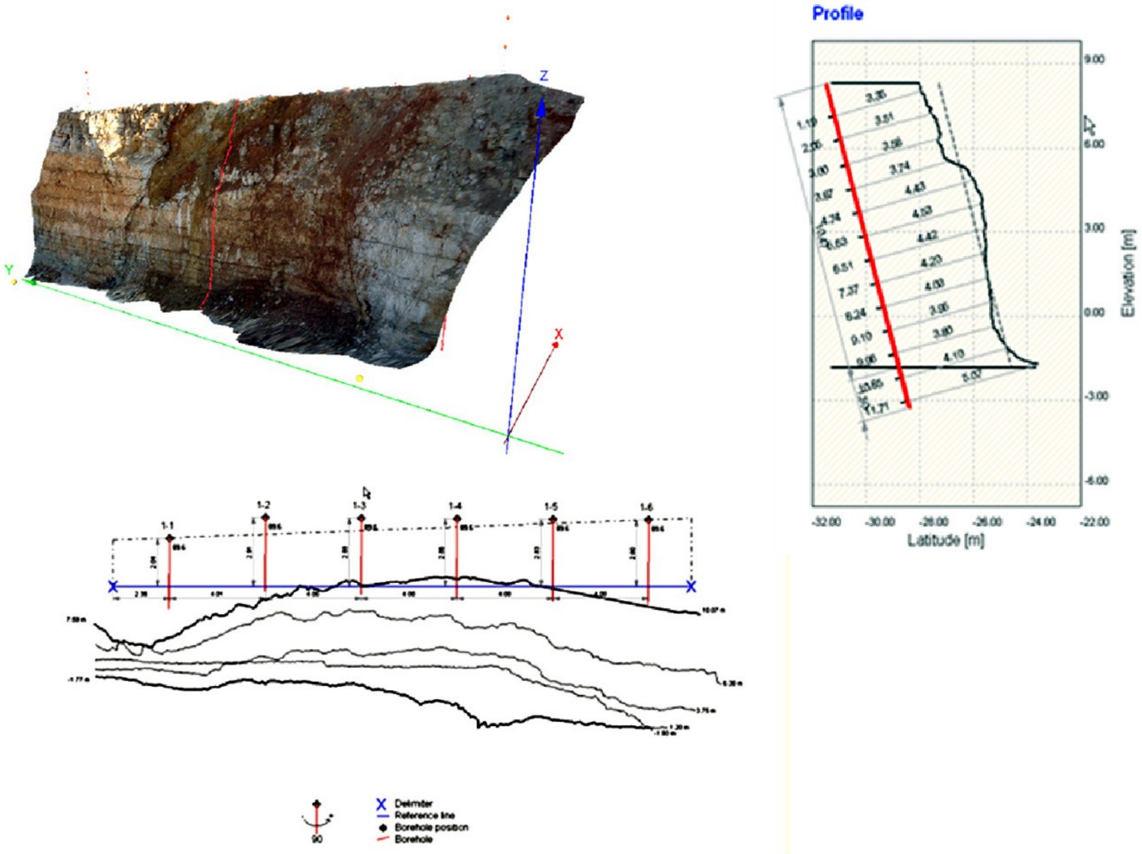
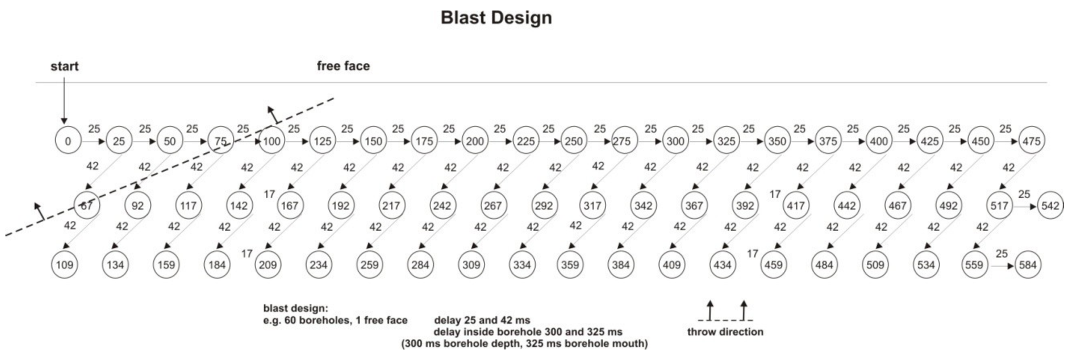


Figure 3: Determining of burden and spacing by surveying

The specification should take account of:

- Experience gained from previous blasts at the quarry or mine;
- Any unusual circumstances which are present or likely to arise;
- The design of the excavation; and
- Shortcomings during drilling, often the cause of fly rock projections; the specification must have regard to:
- A reliable survey of the face; giving details of shot holes (position, angle, depth, direction) in accordance with experience acquired in the deposit (Fig.3).
- During drilling, the intervention of the drill man is essential with regard to:
- Complying with the blast design plan (Fig.4,1-3)
- Identifying and providing information on anomalies encountered during drilling like voids, disruptions, and discontinuity in the bore-hole cuttings (deposit).



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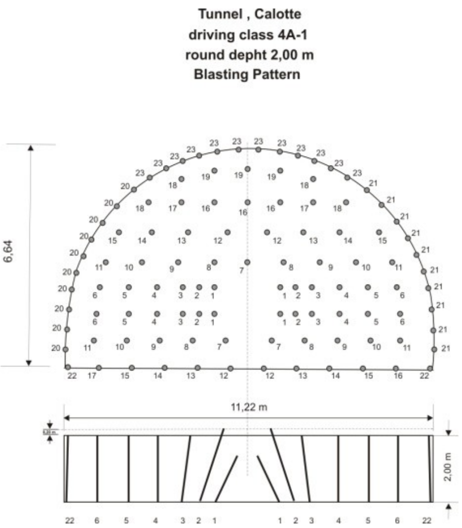

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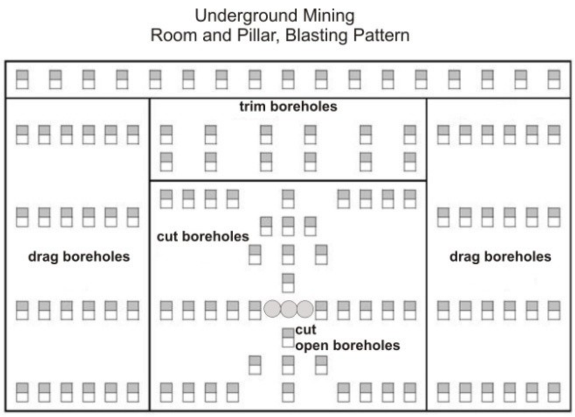


Figure 4: Examples blast design: quarry blasting (1, tunneling (2, computerized blasting pattern room and pillar caving (3

BLASTING OPERATIONS

It has to be clarified that responsible blasters must ensure that blasting operations are conducted in accordance with the operating procedures and the blasting specification. It is important that applied explosives mixed on site must be mixed where they are to be used and only in sufficient quantities for immediate use. Responsible blasters have to be fully satisfied that each shot hole has been drilled and charged in accordance with the blasting specification and, the rise of explosives in holes has to be checked at regular intervals to ensure that the shot hole is being correctly charged.

If it is not possible to be conform to the specification, or the danger zone appears to be different from that shown, blasting operations have to be suspended until any change to the specification has been authorized by its author or other suitable responsible person. It has to be announced that workers have to obey any relevant instructions in relation to blasting operations, for example from the responsible blaster or sentry. Sentries are there to keep people out of the danger zone and should not leave their post until the all-clear signal has been given, or until the responsible person who posted them releases them.

BLASTING VIBRATIONS

Blasting procedures should be correlated to observed or measured results and damage claims. To decrease blasting impact effects, some steps can be made:

- Choice of explosive type and minimize the charge weight per delay;
- Adjustment of blast design parameters such as size and number of bore holes, bore hole diameter and depth, bore hole stemming, individual charges and others;
- Choice of blasting method and direction of blast initiation and blast direction.

Numerous research studies were dedicated to connect vibration parameters such as displacement, velocity, acceleration, and frequency with observed human annoying, disturbances of sensitive devices, and structural damage. It was found that structural damage could be well correlated with the peak particle velocity (PPV) of ground vibrations. Usually they are based on the maximum value v_{max} (maximum vibration velocity of x, y or z axe) at the foundation. The PPV is a common measure of vibration intensity. Nevertheless, displacement and acceleration along with velocity are used for assessment of vibrations effects on sensitive devices e.g. computer disc drives and telephone switches.

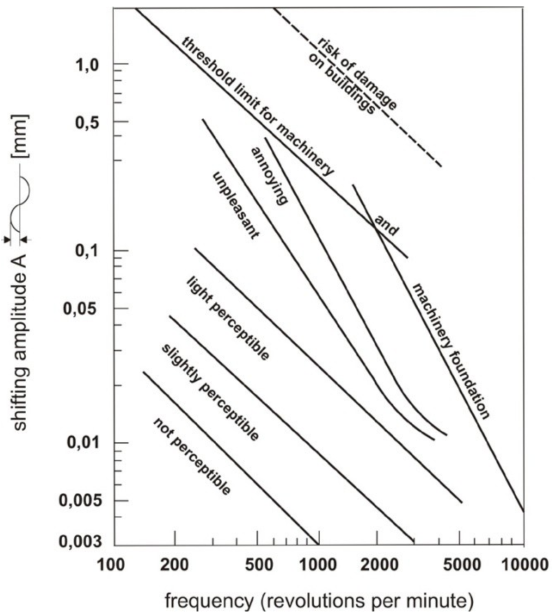


Figure 5: Generally threshold values displacement of vibrations (Richard et al, 1970)

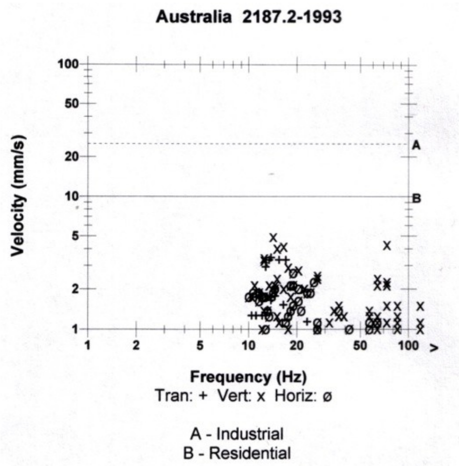
And, this situation may directly affect the safety of property and health of neighborhoods and also may prepare the conditions for some psychological problems. The environmental impact problems produced from blasting are able to bother both companies and neighborhood and bring some judicial problems into existence. In his living room, the everyday life of humans is characterized by the fact that no constantly noticeable vibration immission are affecting, but predominantly only individual events caused by other neighbors. Therefore an acceptance level is very low in this case. There are vibration regulations developed for certain types of structures. However, ground vibrations from construction sources can trigger different soil-structure interactions and vibrations of various structures which are beyond the frames of the existing regulations and standards. At the same time, some practical measures can be used to decrease vibration effects on structures. The PPV of calculated and measured ground vibrations have to be compared with the allowable vibration limits.

VIBRATIONS STANDARDS

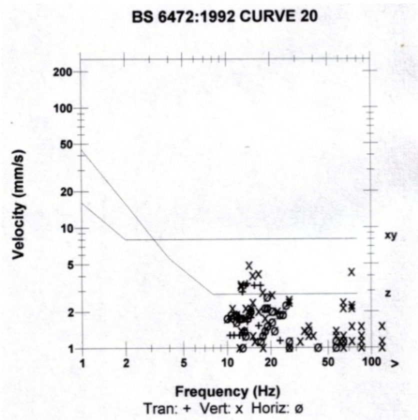
No attempt has been really made to reconcile the variation of regulations between countries. However, the basic scientific studies that form the data base for regulatory decision making are presented and compared, at which minor changes are identifiable. But, regulations respectively standards are needed to keep construction vibrations in tolerable limits. The existing regulations and standards were developed for low-rise residential structures.

Recent years some countries meet several problems related with blasting activities due to the necessity of aggregate and other materials supply for infrastructure services and tunnel construction works because of an increasing urbanization. It has been seen that judicial cases related to these issues increased. As standards and several of case research do exist, some unwanted mistakes can happen anyhow.

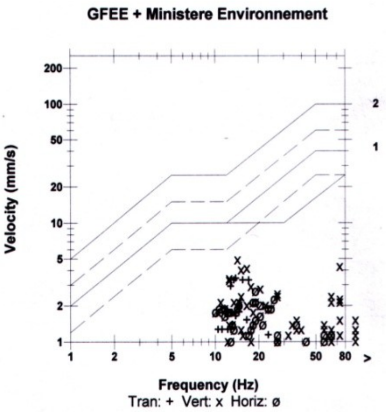
Australian Standard



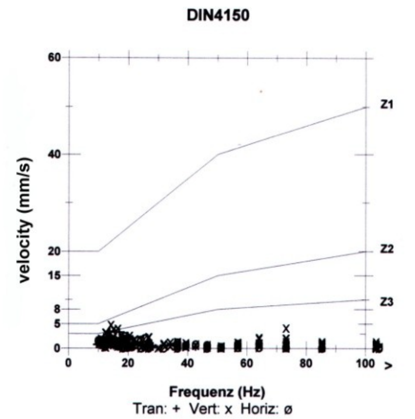
British Standard



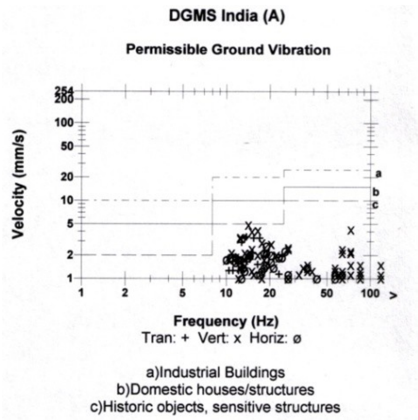
French Standard



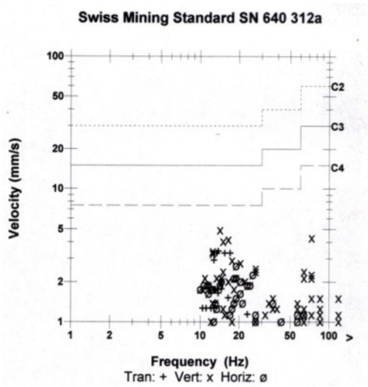
German Standard



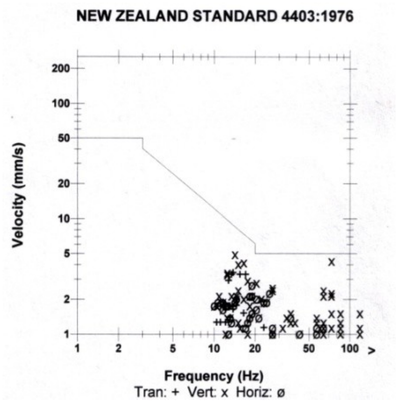
Indian Standard



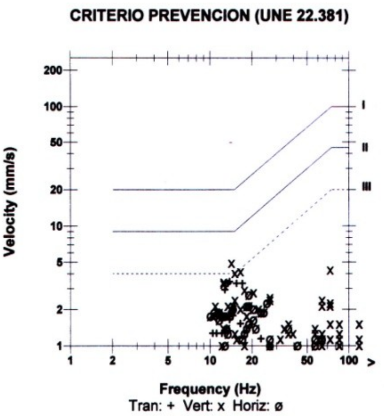
Swiss Standard



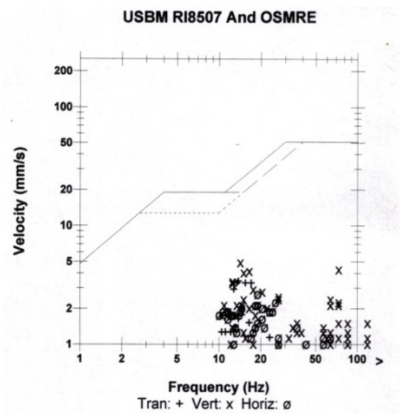
New Zealand Standard



Spanish Standard



US Standard



Graphics: Different standards based on frequency depended scales

The graphics above show some different standards with a consistent peak particle velocity (maximum value v_{max}) of 5 mm/s and whose principle agreement.

As blasting is able to be the most powerful source of construction vibrations, tolerance of calculated and/or measured vibrations is important to eliminate possible structural damage, annoyance of people, and disruption of some quarries or mines business. There are no general regulations of construction and industrial vibrations. The existing regulations respectively standards were developed for ground vibrations from blasting as the threshold of cracking in low-rise structures.

The most important problem in assessment of construction vibration effects is determination of the structural response which is a final goal of vibration monitoring and control. There is a absolutely need for measurement of the structural vibrations.

Specifications for mining blasts surface and underground, have to consider specifics of each site, and sometimes preliminary tests should be made for determination of tolerable levels of structural vibrations. These specifications can require different levels of vibration monitoring and control depending on structure susceptibility rating, proximity to construction sources of vibrations, availability of precise devices, and sensitivity of the local population to annoyance and city, state or government vibration limits as well. It is important to understand that higher vibration limits can be used only for direct vibration effects on low-rise structures when frequencies of ground vibrations do not match natural frequencies of structures.

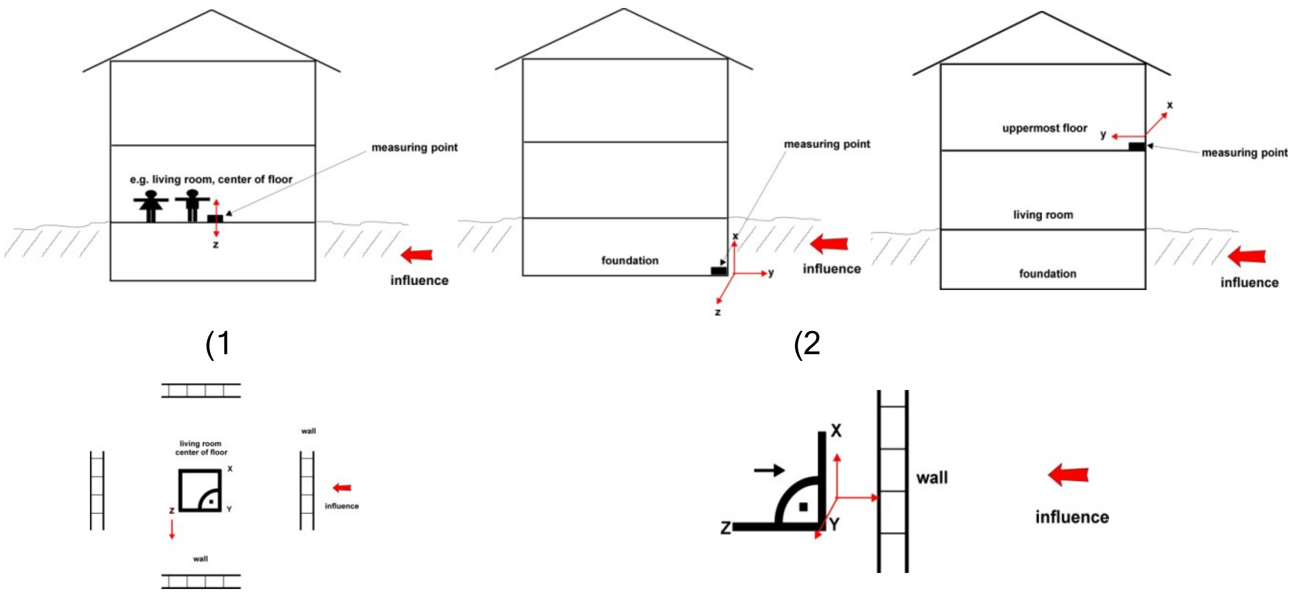


Figure 6: Measuring point: effects on persons (1 and effects on structures (2

A proactive environmental approach has to be used to ensure that no cracking and damage to structures will be originated from construction vibrations and for reducing possible complaints. Some of the existing standards and their application oriented methods are helpful in this case. Most of the standards are immission type scales, basically performed on measurements of the ground vibration velocity.

It was exposed by accepted (international) scientific and technical discoveries, that not a vibration velocity based on the 3 single-components x, y und z and its maximum resultant vibration velocity (maximum vector sum $v_{R,max}$) has been conclusively for an assessment, but the peak particle velocity (maximum value $v_{i,max}$) from one of the three single-components (x,y,z) on foundation must be observed. Besides, the accompanying frequencies must be increasing assessed. There are a number of standards from different countries that can be applied. Most of these standards are built on frequency depended scales.

VIBRATION LIMITS

Typical levels of vibration from construction activities felt by humans do not have the potential for structural damage (BRE 1995). However, more intense activities such as blasting can do damage. Research has shown that peak particle velocity (PPV) is one of the best measures of damage potential. Vibration from a blast occurs over a spectrum of frequencies and there is a PPV for each frequency. Buildings are more vulnerable to low frequency vibration such as that caused by earthquakes. However, most construction vibration is in the mid to upper frequency range (ca.10 Hz to ca.45 Hz), which has a lower potential for structural damage.

Although damage is a major concern for residents near construction sites, the reality is that vibration levels rarely even approach the levels necessary for minor cosmetic plaster cracking. It demonstrated that engineered structures such as industrial and heavy commercial buildings and underground facilities are generally able to sustain higher levels of vibration than those applicable to residential type properties by virtue of their more robust design (BSI 1993).

In terms of underground structures, Langefors (1973) proposed the following criteria for tunnels in rock: a PPV of 305 mm/s results in the fall of rock in unlined tunnels, and a PPV of 610 mm/s results in the formation of new cracks. Oriard (1982) agrees that most rock masses suffer some damage at a PPV above 635 mm/s.

Vibration damage to pressurized pipelines was investigated by Siskind (1994). It was found that ground vibrations of 120 to 250 mm/s produce worst-case strain of only approximately 25% of normal operational and maintenance effects. No pressurization failures of permanent strain occurred even for vibrations of 600 mm/s. However, in practice many engineers adopt more conservative frequency-dependent PPV limits based on standards for nearby residential/ commercial structures and water pipelines.

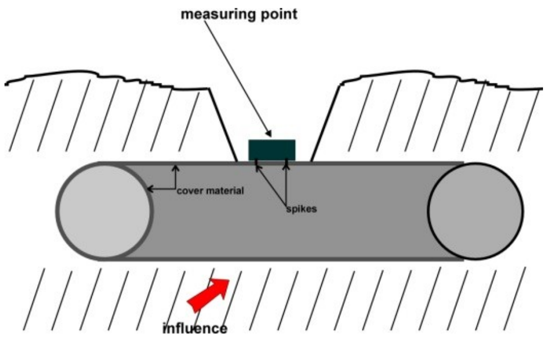


Figure 7: Measuring point on buried pipes

It is common to adopt levels suitable for structures and facilities as defined in national codes and standards. There are a number of standards that can be applied and a sample is provided in Table 1.

Standard	Type of building	Recommended vibration limit	Comments
DIN 4150-3 (1999-02) Structural vibration - Effects of vibration on structures, Germany	Structures of particular sensitivity or worthy of protection	3-20 mm/s at < 10 Hz 3-40 mm/s at 10-50 Hz 8-50 mm/s at > 50 Hz	Limit is for peak particle velocity in x, y, and z directions Measurement on the top floor in x and y directions only
BS 7385: Part 2: 1993 Evaluation and Measurement for vibration in Buildings: Guide to damage levels from ground-borne vibration, UK	Un-reinforced or light framed	15 mm/s at 4 Hz rising to 20 mm/s at 15 Hz then rising to 50 mm/s at 40 Hz and above	Limit is for peak particle velocity in x, y, and z directions
Reinforced or framed structures, industrial and heavy commercial buildings		50 mm/s at 4 Hz and above	
AS 2187: 1993 Explosives - Storage, transport and use. Part 2: Use of explosives, Australia	Houses and low-rise residential, commercial buildings not of reinforced or steel construction	5 mm/s	For buildings particularly susceptible to vibration. Limit is for peak *resultant* particle velocity, measured on the ground adjacent to the structure
SN 640 312 a: 1992. For steady-state vibration, from machines, traffic and construction in buildings, Switzerland	Structures of particular Sensitivity	0,5-1 times of 15 mm/s at <30 Hz 0,5-1 times of 20 mm/s at 30-60 Hz	Limit is for peak particle velocity in x, y, and z directions

Table1. Example of Summary of Current International Vibration Standards

AIR BLAST OVERPRESSURE

Sound immission is the unavoidable side effect of blasting works. At blasts, vibrations, but also sound pressure is transmitted, which spreads all over and only reduces gradually with increasing distance from the source of the emission.

In addition to the inevitable ground sound also air sound exists to assign particular attention. Up to a certain distance from the blast emission (as a function of explosive charges and environmental influences), air sound is strongly felt for humans.

With that in mind, it is indicated that in addition to blasting vibrations with the reference values of the vibration velocity v_i according to given standards, there are still other criteria have to be observed. They are not insignificant and are able to have annoying effect in addition to the vibration influences as well.

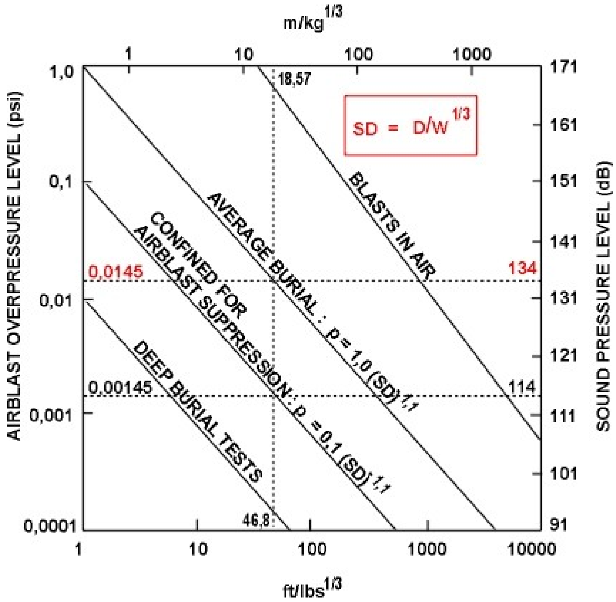


Figure 8: Cube root scaled distance overpressures versus charge burial

Radiated body noise immission is audible, as soon as they exceed the noise level. It is in residential areas relatively low estimated and set down in the relevant regulations. Because humans perceive vibrations and secondary air sound in different ways, different evaluation procedures are necessary. At larger distances sound waves arrive only in terms of seconds after the vibrations. The spread of the sound waves during blasts are in accordance with time response and the detonation sequence.

Due to this influence blasts perceived by humans, also over larger distances, make them often feel the influences as "strong", although the previous seismic influence was hardly perceived (felt), so negative reaction came out. Sound waves depend on gas release pulse GRP

at which

GRP = depends on the possibility of blowouts

GRP = responsible for high blast noise and air blasts

It has to be known that the following values of sound pressures (gas release pulse) are able to cause at

180 dB	(3,0 psi or 20,7 kPa)	some structural damage possible
171 dB	(1,0 psi or 6,9 kPa)	general window breakage
151 dB	(0,1 psi or 0,69 kPa)	occasional window breakage
140 dB	(0,029 psi or 0,2 kPa)	relatively safe to damage
134 dB	(0,0145 psi or 0,1 kPa)	recommended for large scale surface mine blasting

This sound pressure, which moves in the low-frequency range and, thus it is difficult or not at all identifiable as noise, it must be avoided at the blasts site, through appropriate methods at the place of emission. Methods of this kind at the place of emission are the cutting of may be used detonating cord at the bore hole mouth, ignition from the depth of the borehole or bringing down the detonators and detonating cord below the stemming, as well as the careful and sufficient covering of the used ignition material with proper stemming material. After general findings (measurements) the accompanying sound event in dB(A) is (secondary) at blasts, as well as the sound pressure level (primary) LP in dB(L) will be significantly reduced.

At surface blasting does, like obvious mentioned e.g. ignition from depth of the borehole and detonating cord placing below stemming on borehole mouth appropriate sound absorption prevention, which reduces sound pressure amplitudes by a factor of ca. 0,1. (Fig.9)

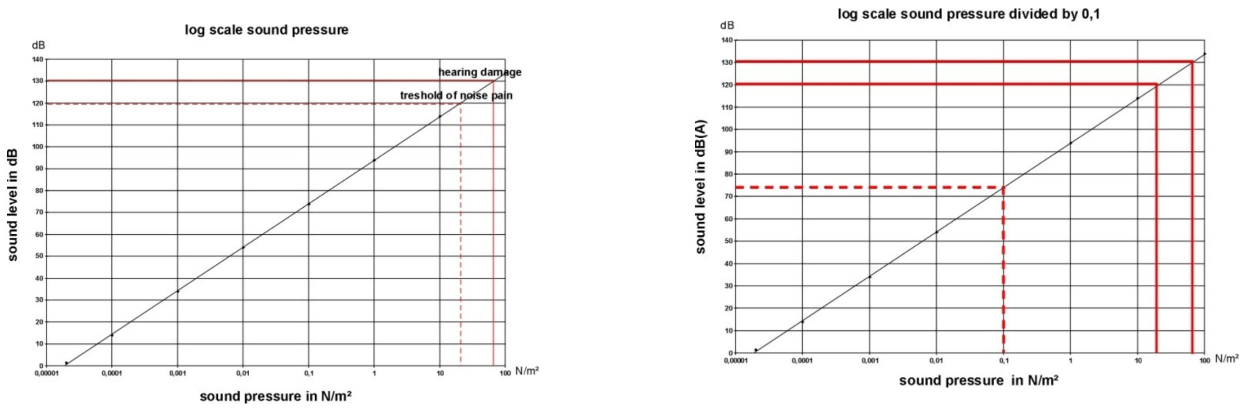


Figure 9: log scale of sound pressure amplitude in (dB) left, reduced log scale of sound pressure amplitude in (dB) right.

Source of all sound emission are all kinds of accelerated movements within the frequency range f between 16 Hz and 20 KHz. Frequencies below 16 Hz are under the faculty of perception for the human ear! To reduce sound immission by air blast overpressure the following measures have to be particularly observed:

- Maximum charge weight per delay;
- Amount and type of stemming material;
- Amount of burden and condition of face;
- Exposed detonating cord on the surface;
- Orientation of face relative to structures;
- Delay interval and direction of initiation;
- Amount of displaced rock;
- Wind direction;
- Atmospheric conditions;
- Topography

CASE STUDY UNDERGROUND MINING: PREVENTION OF HAZARDS CAUSED BY BLASTING WORKS IMPACT AT THE K+S GROUP, GERMANY

Due to some complaints from the mining plant neighborhood a quick response, by using an interdisciplinary approach under inclusion of the best demonstrated available technologies, has been updated for room and pillar mining.
Like previous mentioned the emphasis of all efforts is to obtain the empirical findings and data which will be base for the blast designs which will not hinder the activities for excavation works allowing controlled blasting activities while not damaging any surround residences and convert these data into mining processes. K+S compliance system has create an organizational prerequisites for making sure that the relevant applicable law, their internal regulations and guidelines as well as those regulatory standards recognized by the company are known across the Group and compliance with them can be monitored. Besides, responsibility for compliance is borne by those persons in charge of operations in the mining processes. Therefore obligatory training sessions for (potentially) affected employees are held in relation to specific issues (e.g. environ-mental protection/work safety laws).
At Europe's biggest mining plant an excessive labor on planning and execution was made to be concentrated on the definition of the objectives and processes, resources needed to achieve the environmental policy of the company by implementation of the processes were accompanied by:

- Call in a blasting expert with specific supervisory measure on safety-relevant task;
- Search for the possibility of a controlled immission;
- Survey of blasting works on site;
- Revise of blasting parameters and blast design;
- Verification of blasting works on site;
- Establishment of technical measurements on site;
- Execution of immission measurements.

During the execution phase comprehensive information was given to the involved persons in the individual working zones. The continuous information included

- Control of blasting works on site (internal audits);
- Checking compliance with operating instructions (e.g. max. explosives charging);
- Internal blasting works audits in conjunction with surface vibration measurements;
- Blasting tests in conjunction with surface vibration measurements;
- Record of subjective public perception protocols and information of neighbors;
- Analysis and interpretation of immission measurements.

The experience gained from the actions were analyzed and promptly changed on the blasting site. The resulting methods in the processes run than as follows in the regular blasts:

Involved responsible persons in processing had to monitor

– Daily control of drill- and blasting works by supervising persons in the individual working zones;
– Control of proper operation of drilling machines by the drilling machine instructor (handling, drilling works);
– Temporarily control of drilling- and blasting works by blasting works supervisors. (internal audits);
– Compliance with operation instructions demanded (max..explosives charge per delay);
– Optimizing the activation on ignition sectioning points by the supervising division;
– Continuing operator education at virtually drilling rig control stand (SIMLAB Werra);
– Annual and temporarily briefings of blasting personal;
– Optimizing the sub-process well-hole drilling (depth gauge, deposit, direction).

Regularly blasts are carried out on 2 floor levels in 3 shifts with about 70 blasts per shift a day So, even little modifications in blasting technologies are quite difficult and must be planned in advance and have to be carried on without stopping. One of the 2 floor levels is shown in Fig.10 below.

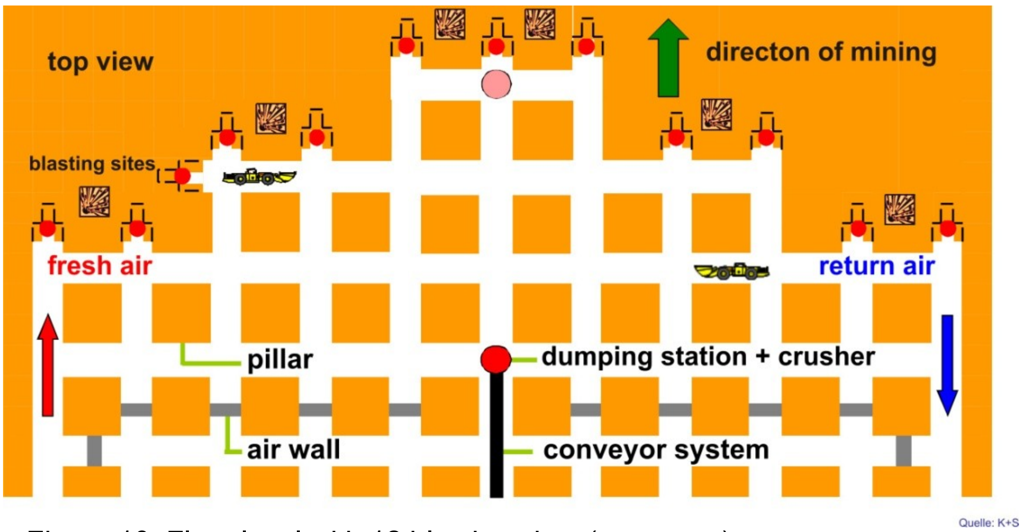


Figure 10: Floor level with 12 blasting sites (*source K+S*)

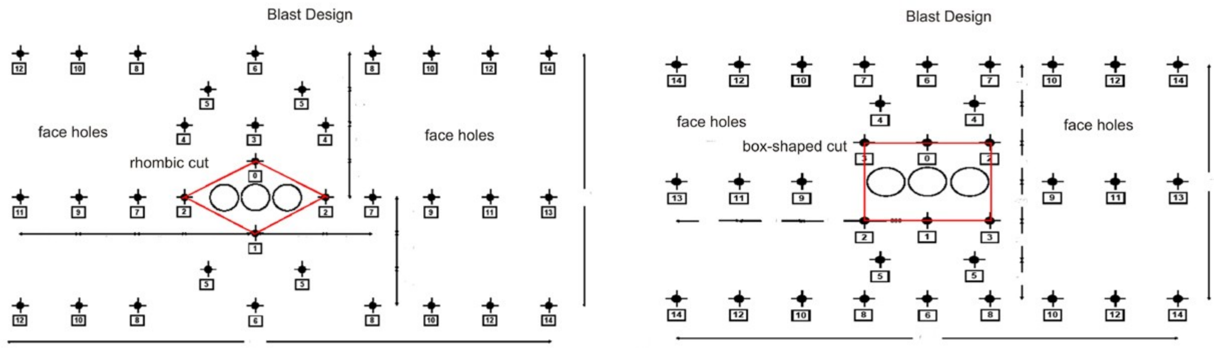


Figure 11: Previous blast design left, and new blast design right (*source K+S*)

Figure 12: Transferred blast design on site (left and right) (*source K+S*)

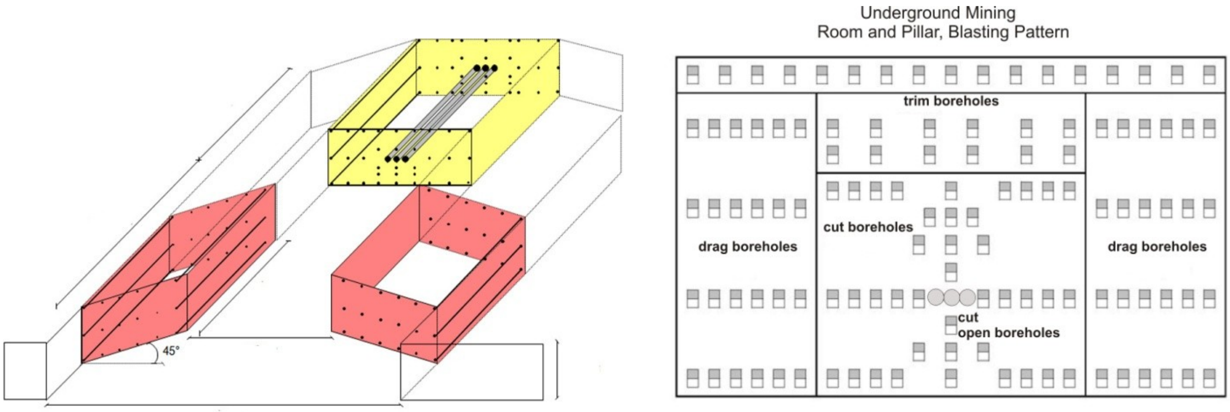


Figure 13: Modified blast design for further excavation (computerized) (*source K+S*)

Already in the above shown processes an improvement of blasting immission, as well as a higher level of acceptance in the neighborhood was visible. The represented actions and their results from the CIP serve as preventative methods to avoid impacts, malfunctions, problems and risks to the employees, the neighbors and the environment from the outset.

In the lights of the data to be obtained in the CIP, it will get the excavation works in the company to be performed in such way that they will be more effective and will cause minimum environmental impact problems, and also these data can give new directions to the ongoing mining processes.

CASE STUDY SURFACE MINING: PREVENTION OF HAZARDS CAUSED BY BLASTING WORKS IMPACT AT HEIDELBERGCEMENT AG, GERMANY

Due to some complaints from the quarry's neighborhood it became necessary to take action, by applying an interdisciplinary approach under inclusion of the best demonstrated available technologies, which has been updated for the quarrying.

In the light of a forthcoming extraction extension into the depth for the quarry Lengfurt, some important environmental principles must be evaluated when blasting in the open cast mining must be strictly adhered to. The operating procedures include in addition to the legal and normative requirements under the state of the art. It is demonstrated how target-oriented measures can lead to a significant improvement of the environmental impact problems.

The mentioned measurements include prediction of blasting vibrations, vibration perception of people in buildings, as well as the assessment of vibration and noise impacts on people and buildings next to the quarry. The quarry and its surroundings are shown in Fig. 14.

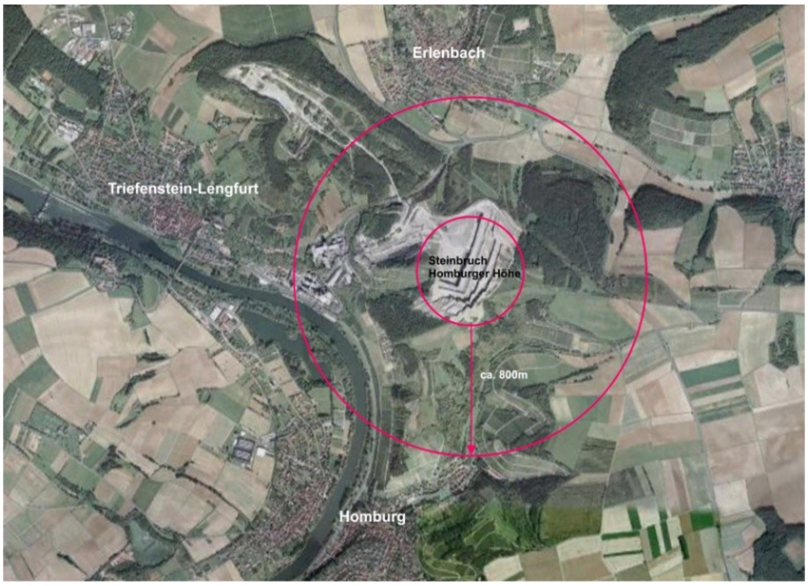


Figure 14: Surroundings of the quarry Lengfurt

Ultimately the Continuous Improvement Process (CIP) will only be successful in its processes, if resources, tasks, responsibility and authority are clarified accordingly and distributed. With regard to the latter requirements, subsequent skills must be planned and professionally distributed:

- Ability, training and awareness
- Communication
- Documentation
- Control of documents
- Operational control
- Emergency preparedness and response

To implement the CIP in the quarry Lengfurt the following methods were introduced:

- Consultation of a blasting expert to check the following possibilities:
- Reduction of Immission
- Survey of blasting works on site
- Revise of blasting parameters
- Change of drilling and blasting
- Establishment of technical methods on site

- Vibration measurements
- Sound pressure measurements
- Data transmission via modem
- Data analysis
- Involving the neighborhood by determining the perceived influence
- Informing the neighborhood

The experience gained from the actions were analyzed and promptly changed on the blasting site. The resulting methods in the processes run than as follows in the regular blasts:

- Ignition from the borehole depth (redundant)
- Detonating cord and detonators placed under the stemming
- Stemming material from defined fish-debris fragmentation
- Reduced borehole diameter from 115 mm to 90 mm
- Change inclination angle of wall face toward 78° (intended 70° - 75°)
- Sub drilling max. 1,0 m if possible less
- Instead of 1 row blasts generally blast design for 2 rows or more
- Data analysis (vibration and sound pressure measurements)
- Involving the affected neighborhood in the process
- Informing the neighborhood via Internet

Normally regulary blast were carried out two times aweek. Since the introduction of the mentioned Continuous Improvement Process (CIP) blasts were reduced to one time a week. That means the frequency of occurrence in the surroundings was reduced up to 50%. The modifications in blasting technologies had to be planned correctly were carried on without any stopping. The modifications in blast design and other parameters are shown below.

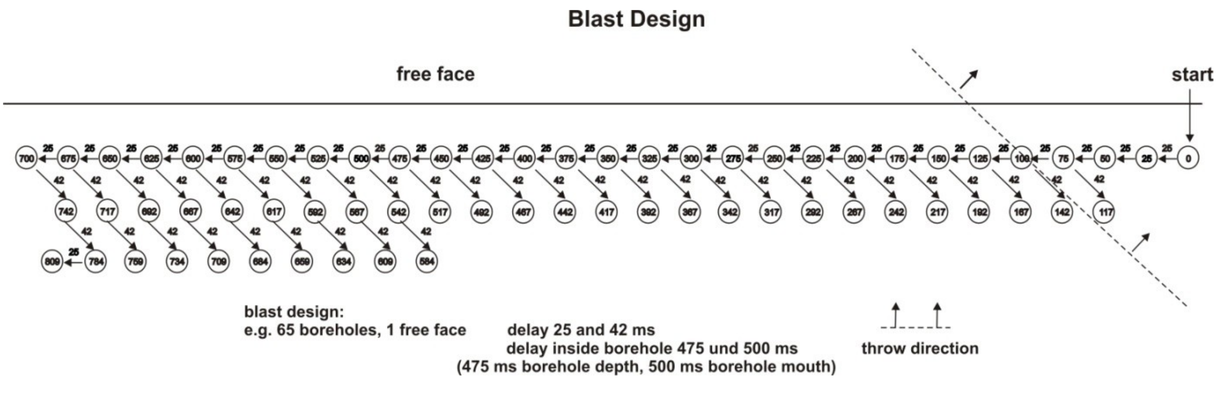
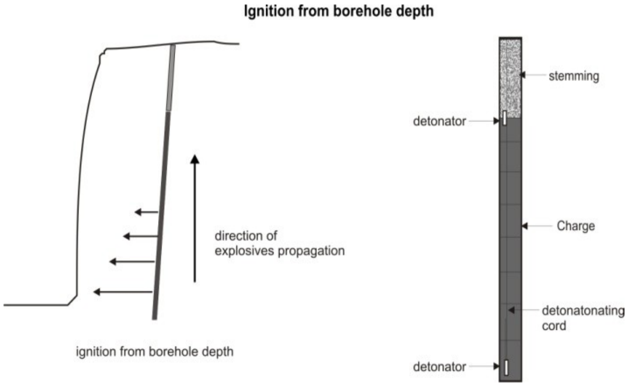


Figure 15: Modified blast design quarry Lengfurt (at least 2 rows)



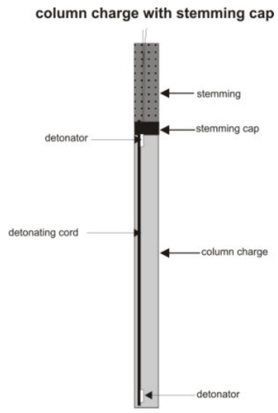
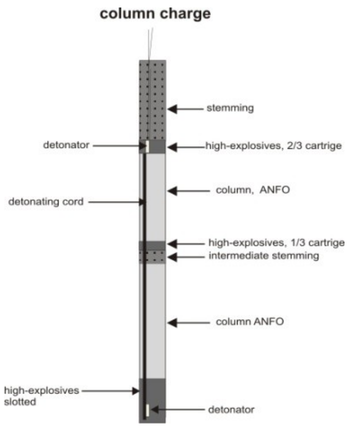


Figure 16: Ignition from the borehole depth only

Figure 17: Generally used charge column



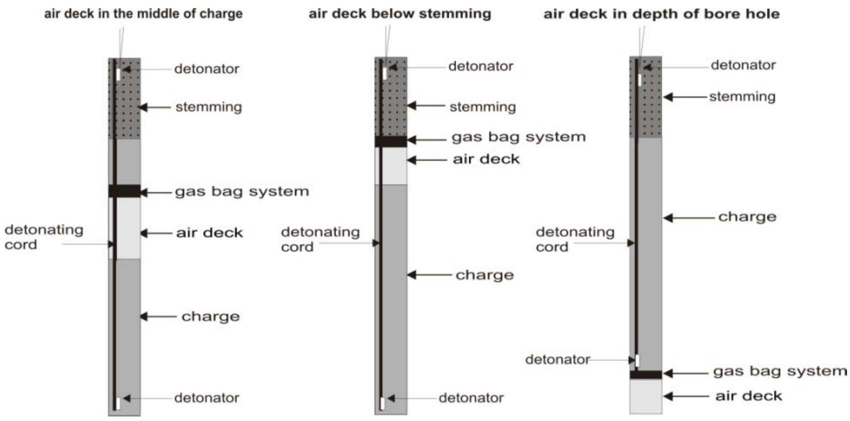


Figure 18: Modified charge column

Figure 19: Enhanced charge columns with air deck

Already in the above shown processes after short time, a large improvement of blasting immission, as well as a higher level of acceptance in the neighborhood was visible. Besides the rock fragmentation was optimized and fairly good adapted for crushing.

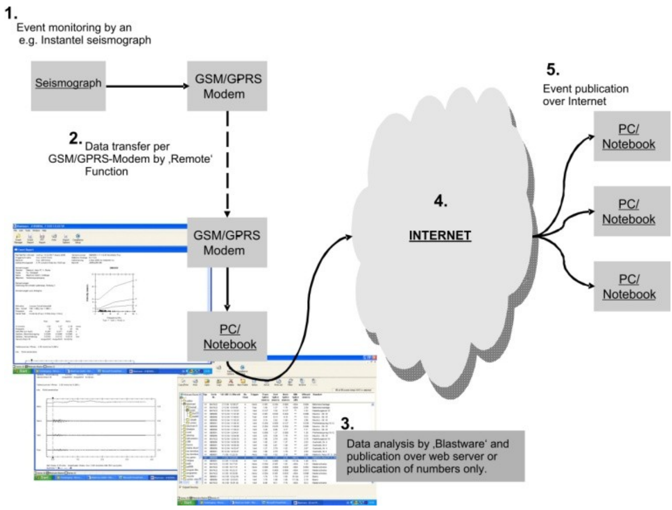


Figure 20: Informing affected persons via Internet

CONCLUSION

In the lights of the data to be obtained in the present paper, it will get an excavation to be performed in such way that they will be more effective and will cause minimum environmental impact problems, and also these data can provide new approach on ongoing researches. Therefore, the persons which are responsible for blasting operations have to make designs which wouldn't give any damage to the surround plants and residences and realize controlled blasting activities. These designs are only available by achieving some systematic analysis on-site studies. The results produced from these studies could ensure solving the problem without hindering excavation and production targets. It will help to eliminate technical, economical, safety and psychological problems that can come up by forming empirical approaches with the data to be obtained.

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