EFEE NEWSLETTER

December 2016

In this edition:

Flexible, modern drilling and blasting in tunnelling

Flyrock: French experience

... and more!

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NEWSLETTER

December 2016

This Newsletter contains the above articles (Click on the headings to jump to the article)

We in EFEE hope you will enjoy the present EFEE-Newsletter. The next edition will be published in February 2017. Please feel free to contact the EFEE secretariat in case:

- You have a story you want to bring in the Newsletter
- You have a future event for the next EFEE Newsletter upcoming events list
- You want to advertise in a future Newsletter

Or any other matter.

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Dear EFEE members, the president´s voice

Somehow we have arrived at the last month of this year as well as at the last issue of our EFEE Newsletter to you for this year. Time is running very quickly and let´s stop it for a while and briefly summarize the most important events in our federation during the year of 2016.

This year 2016 we started with an EFEE Board meeting on the 9th of January 2016 in Stockholm. The Board meeting in Stockholm was mainly focused on the organization of our next 9th EFEE World Conference which will take place in the capital of Sweden from 10th to 12th September 2017.

In April from 11th to 12th 2016 EFEE Council meeting and Annual General Meeting took place in Telford, UK where also a new EFEE Board was elected. The newly elected EFEE Board brought the new faces inside. The first one was Mrs. Viive Tuuna representing Estonian Association of Mining Enterprises (EMTEL) and the second one was Mr. Doru Anghelache from Romania representing EFEE Corporate members as well as Romanian Association of Explosives and Blasting Engineers (ARDE). Unfortunately on the other hand Mr. Ricardo Chavez the representative of French Group of Explosives Engineers (GFEE) left EFEE Board.

We were deeply grieved and shattered to hear of information that Alexander Efremovtsev, representative of Russian National Assotiaton NOEE suddenly and tragically passed away on the 18th of June 2016. We have sent out the Condolence letter addressed to Russian National Association NOEE as well as to the family of Alexander Efremovtsev in which we have expressed sincere and deep condolence. On the 2nd of July 2016 we started our EFEE Board meeting in Bucharest with one minute of silence dedicated to the memory of Alexander. We will miss Alexander very much in our federation.

I´m immensely proud and happy that in the beginning of August 2016 we have noted very good news from Sweden. Our application for PECCS project (Pan-European Competency Certificate for Shotfirers / Blast designers by European Federation of Explosives Engineers) was approved for funding from Swedish Erasmus plus programme. The BEF in Sweden, represented by Jan Johansson, Anette Broman and Viive Tuuna, as the PECCS manager have done a great work which was positively rewarded.

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The next EFEE Board and Council meeting took place in Stockholm, Sweden on the 16th and 17th of September in the same place where the 9th EFEE World Conference on Explosives and Blasting will be held 10th to 12th of September 2017.

The last Board meeting in 2016 took place in Helsinki from 8th to 9th of December 2016 with main focus on the organization of 10th EFEE World Conference in Helsinki 2019. This Board meeting took 2 days as the first day was dedicated to visit the venues where the conference will be organized and the second day was scheduled for the Board meeting.

Except the regular EFEE Board meetings, Council meetings and Annual General Meeting our federation participates also in meetings of Notified Bodies for Explosives as well as on meetings of Explosives Working Group. EFEE is regularly represented on both types of meetings by Jörg Rennert who has done a great work for our federation in this area. Meeting of Notified Bodies for Explosives took place from 9th to 10th of May 2016 in Sibiu, Romania and was hosted by INCD INSEMEX, Petrosani. Meeting of Explosives Working Group took place on 17th of October 2016 in Brussels and a separate article from Jörg Rennert in this Newsletter edition is dedicated to this meeting.

During the year of 2016 our federation was continuously growing and increasing the number of its members. I have to thank all EFEE partners, members and simply all who contributed to our mutual productive work which resulted in fact to a very positive year. Particularly I have to thank very much for excellent work to our Secretary General Roger Holmberg. Thank you very much Roger.

Now when we are approaching the end of 2016 I would like to take this opportunity to extend my best wishes to all of you. May all who celebrate Christmas enjoy the festive season and to all who are able to take a break at the end of the year, enjoy every moment.

Finally please do not finish reading our Newsletter with my foreword but kindly continue to read all the interesting articles prepared especially for you in this newsletter.

Igor Kopal, President of EFEE

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Flexible, modern drilling and blasting in tunnelling

Introduction

During the construction of the new Zierenberg Tunnel, in some areas mechanical excavation was precluded by the increase in rock and excavation strength, necessitating a switch to drill and blast. The dimensioning of the blasting equipment was based on new 3-D underground blasting theory, which has been theoretically developed by physicists and successfully applied in blasting practice. Dynamic examinations of the rock to be blasted (essential for assessing the blasting equipment to be used) revealed the rock's main characteristics and provided the basis for the flexible drill and blast operation set out below.

The new Zierenberg Tunnel construction project

Fig. 1: Listed west portal of the old Zierenberg Tunnel completed in 1896

The existing Zierenberg Tunnel is a railway tunnel built between 1895 and 1897 with a length of 816m. Now 120 years old, it is in very poor structural condition and is therefore to be replaced by a new tunnel with a length of about 900m. The single-track line 3903 Volkmarsen–Obervellmar currently runs through the old tunnel, and will remain in continuous service while the new Zierenberg Tunnel is being built.

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Following the new tunnel's completion, the portals of the old tunnel are to be preserved as listed structures (Fig. 1). The new single-track Zierenberg Tunnel is being built more or less parallel to the old one at a distance of about 20m north-west (Figs. 2 and 3).

Fig. 2: West portal of the new Zierenberg Tunnel ('Monika Tunnel') alongside an embankment reinforced with bored piles

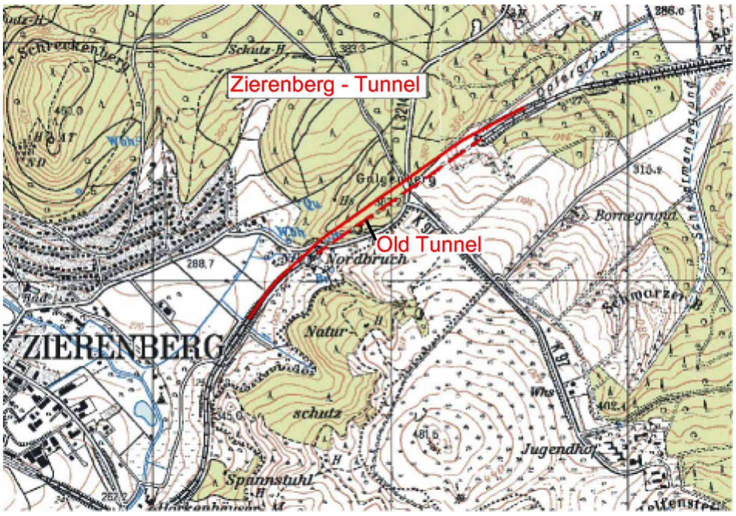

Fig. 3: Position of the old and new tunnels northeast of the town of Zierenberg

The client (Kurhessenbahn, part of DB RegioNetz Infrastruktur GmbH based in Kassel and Frankfurt) is responsible for building the tunnel and the approach routes. The west German branch of BeMo Tunnelling GmbH has been contracted to build the tunnel walls. The new and old chainage differ by about 5m.

The overburden above the tunnel roof has a maximum thickness of around 60m. Drivage took place from the western to the eastern portal by initially excavating the top section with a cross-section of 43.1 m². Hole-through took place on 20 May 2016. Then the rock mass from the bench and the toe was removed together from the east towards the west portal, and related reinforcement work was completed.

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Tunnel geology

The tunnel itself is being excavated in sediments of the Upper Bunter Sandstone (Röt Formation), in basalt transition and in a volcanic pipe filled with breccia. The Upper Bunter Sandstone is superimposed in the roof area by lime-marlstone and limestone from the Lower Muschelkalk (Fig. 4).

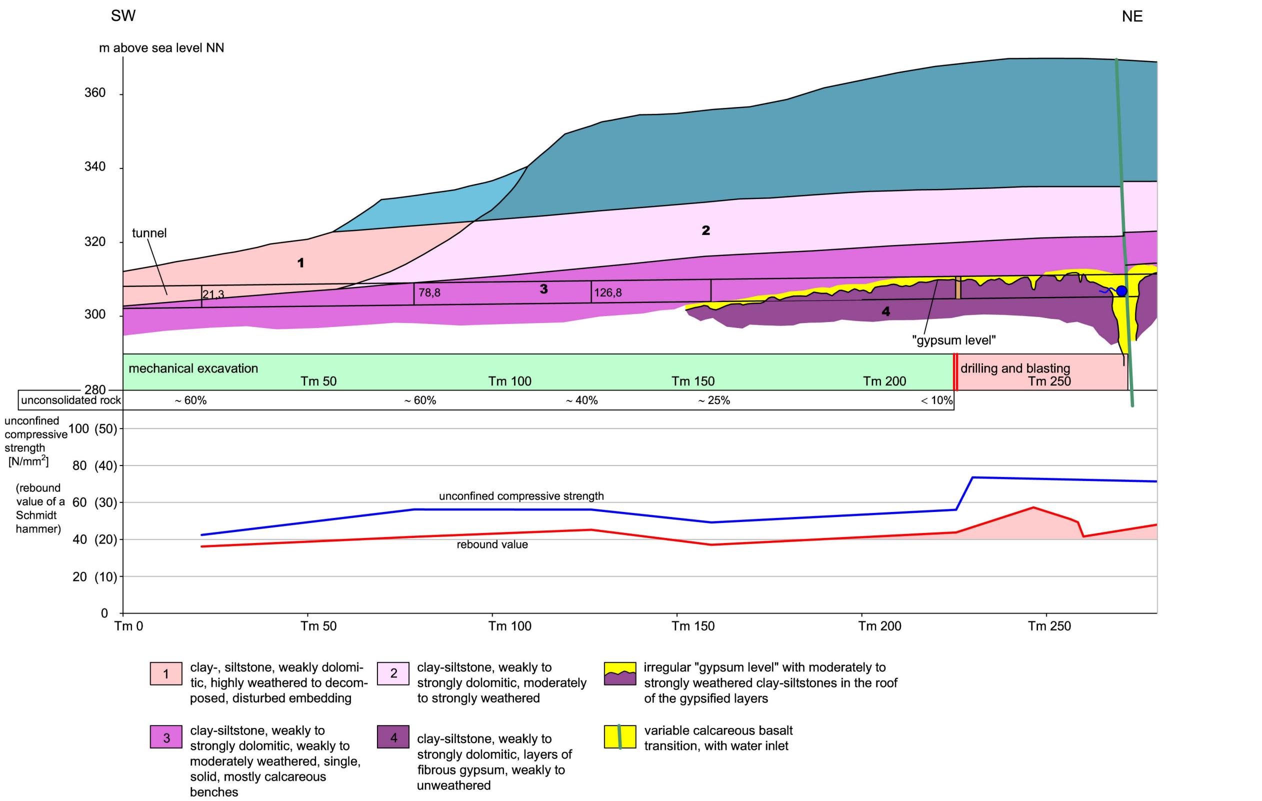

Fig. 4: Extract of the tunnel geology from tunnel metre 0 (west portal) to tunnel metre 280

The sedimentary rocks of the Röt Formation consist of interbedded strata with varying thicknesses of dolomitic to weakly dolomitic clay, clay-siltstones and siltstones with a range of colours (mostly reddish brown, purple, grey and grey-green). At a depth of about 28–30m is the 'gypsum level', where Muschelkalk sediments contain fibrous gypsum deposits with thicknesses of a matter of centimetres and decimetres both in the stratification of clastic sediments and on all joints and fractures.

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Beneath the ‘gypsum level’, the hard rock is completely cemented with gypsum, creating a massive structure (Figs. 8 and 9). Above the gypsum-streaked, mostly unweathered rocks are variously leached, moderately to highly weathered, relatively loose clay-siltstone layers with varying carbonate content (Fig. 4). Due to the increasing strength of the rock from the west to the east portal, mechanical excavation had to be replaced by drill and blast (Figure 4; Table 1). The unweathered rocks in the Röt Formation are medium-hard to hard.

tunnel metre	c_P *(m/s)*	c_S *(m/s)*	*Poisson´s ratio*	*elastic modulus (kN/mm²)*	*shear modulus (kN/mm²)*	*acoustic impedance (10^6 kg/(m²s))*	**unconfined compressive strength** *(N/mm²)*
21,3	1115 - 3362 ∅ 2121	470 - 1800 ∅ 1065	0,299 - 0,392 ∅ 0,338	1,39 - 19,99 ∅ 7,87	0,5 - 7,69 ∅ 2,98	2,52 - 7,99 ∅ 4,93	21,69 - 68,78 ∅ 42,40
78,8	2397 - 3455 ∅ 2892	1228 - 1855 ∅ 1522	0,298 - 0,322 ∅ 0,310	8,11 - 20,62 ∅ 13,97	3,07 - 7,94 ∅ 5,34	4,87 - 7,98 ∅ 6,53	41,94 - 68,71 ∅ 56,20
126,8	2247 - 3217 ∅ 2779	1140 - 1714 ∅ 1454	0,302 - 0,327 ∅ 0,312	7,99 - 18,47 ∅ 13,19	3,01 - 7,09 ∅ 5,03	5,21 - 7,77 ∅ 6,52	44,83 - 66,90 ∅ 56,12
159,3	1342 - 3153 ∅ 2526	604 - 1676 ∅ 1305	0,303 - 0,373 ∅ 0,322	2,28 - 17,18 ∅ 10,89	0,83 - 6,59 ∅ 4,15	3,05 - 7,40 ∅ 5,71	26,25 - 63,73 ∅ 49,15
225,55	2368 - 3473 ∅ 2803	1211 - 1865 ∅ 1469	0,297 - 0,323 ∅ 0,311	8,44 - 21,89 ∅ 13,37	3,21 - 8,44 ∅ 5,10	4,53 - 8,42 ∅ 6,51	38,97 - 72,50 ∅ 56,04

Table 1: Technical and dynamic characteristics of the weakly to strongly dolomitic clay-siltstones of the Röt Formation during drivage up to tunnel metre 226.0

Due to the high proportion of ultra-fine grained (X-ray amorphous), water-binding mineral fractions as well as three-layer minerals, most of the rock types disintegrate on contact with water. Owing to widespread Tertiary volcanism in the immediate vicinity, drivage passed through a basalt transition and a volcanic pipe filled with breccia with a diameter of more than 30m. In order to precisely dimension blasting equipment and the necessary reinforcement measures, the rocks encountered during tunnelling were systematically sampled and examined in situ with respect to the characteristics listed in Table 1 by means of a Schmidt hammer and also non-destructively with a UKS-D ultrasonic measuring device. Ascertaining the P- and S-wave velocities of the solid rock is essential if the new theoretical blasting findings are to be applied. Fig. 5 shows the statistically proven correlation between the two velocities for all types of rock. Whereas the Röt Formation sediments are in the lower range (Fig. 5), gypsum sticks out with velocities exceeding 5,000 m/s.

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Fig. 6 shows the correlation between the acoustic impedance (P-wave) and the dynamic modulus of elasticity. As expected, the variable calcareous clays and siltstones are in the lower range with the exception of gypsum. The uniaxial compressive strength important for geological assessment for tunnelling is calculated using a statistically significant regression correlation with the acoustic impedance of the P-wave velocity as shown in Figure. 7. The uniaxial compressive strength of undisturbed crack-free specimens ranges from 20 to 80 N/mm² in the clay-siltstones of the Röt Formation. Besides these strengths, the joint spacing and in this case in particular gypsification are key factors in excavation strength. In areas with no gypsification and where weathering is associated with leaching, the rock has joint spacing of 0.1–0.7m and is usually mechanically removable. Owing to the cementing and annealing of all joint spacing, the gypsified complex of strata is akin to a seemingly massive rock complex, making blasting very difficult (Figs. 8 and 9).

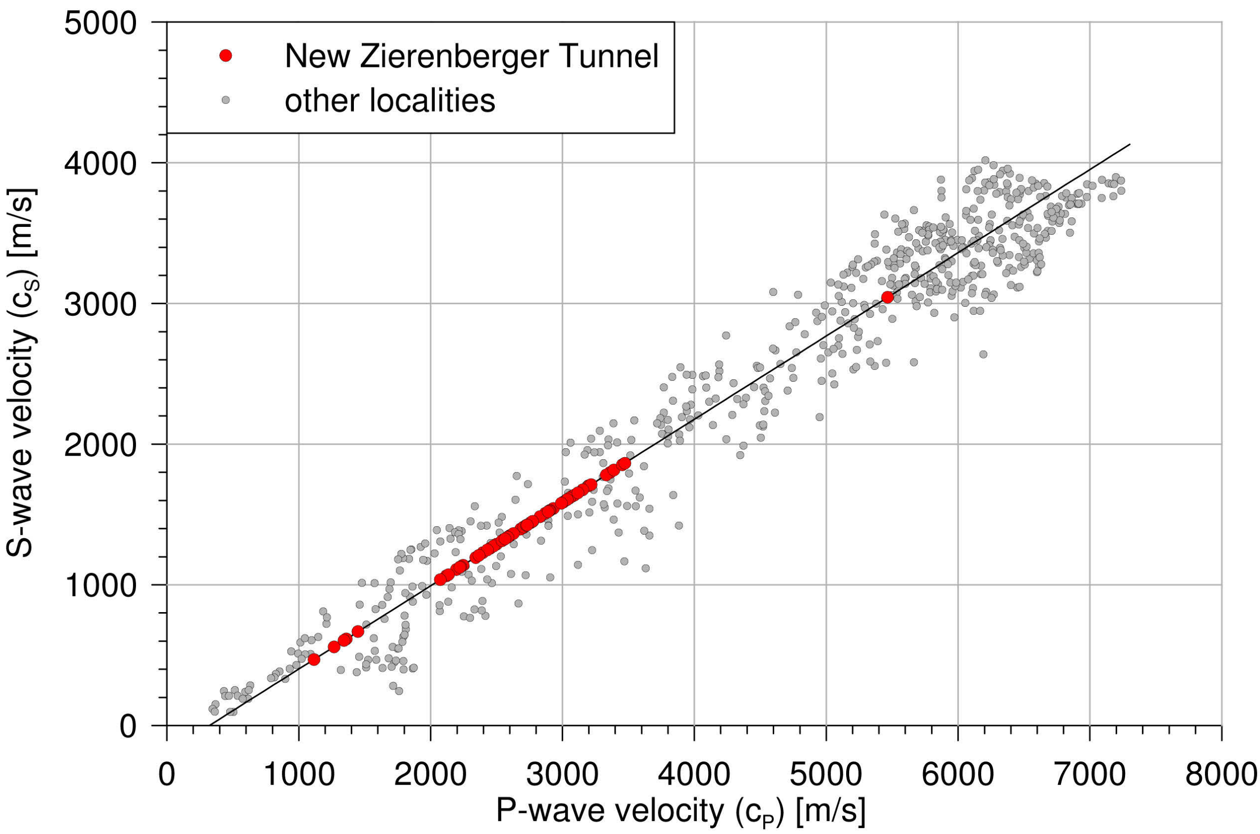

Fig. 5: Correlation between P- and S-wave velocities (red = clay siltstones from Zierenberg Tunnel)

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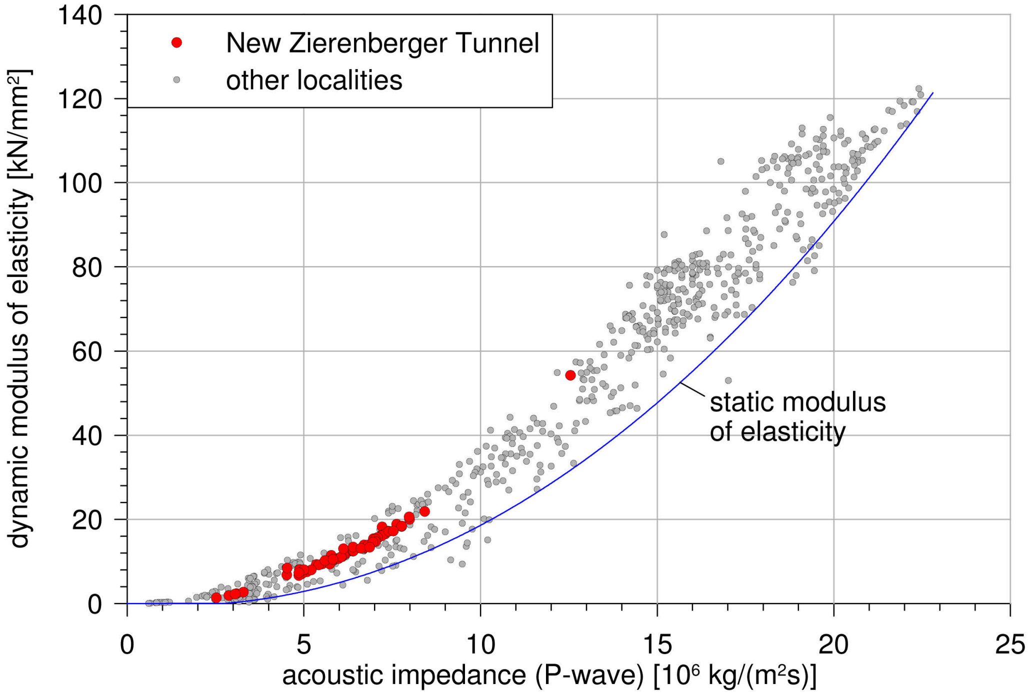

Fig. 6: Correlation between acoustic impedance (P-wave) and dynamic modulus of elasticity (red = clay siltstones from Zierenberg Tunnel)

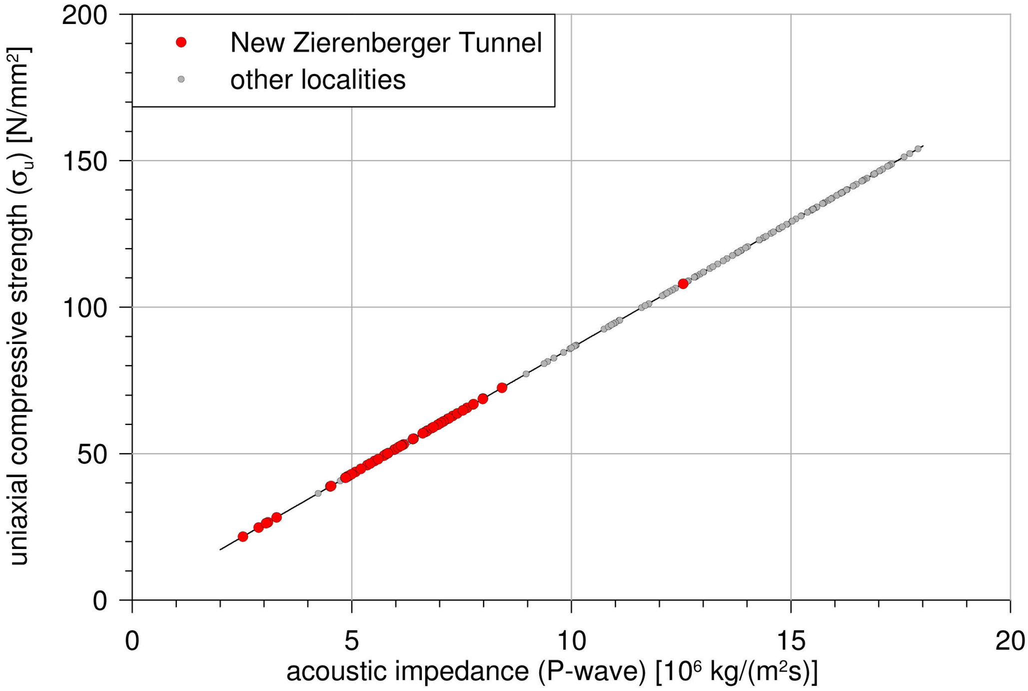

Fig. 7: Correlation between acoustic impedance (P-wave) and uniaxial compressive strength of undisturbed samples (red = clay siltstones with carbonate components from the Röt Formation in the tunnel)

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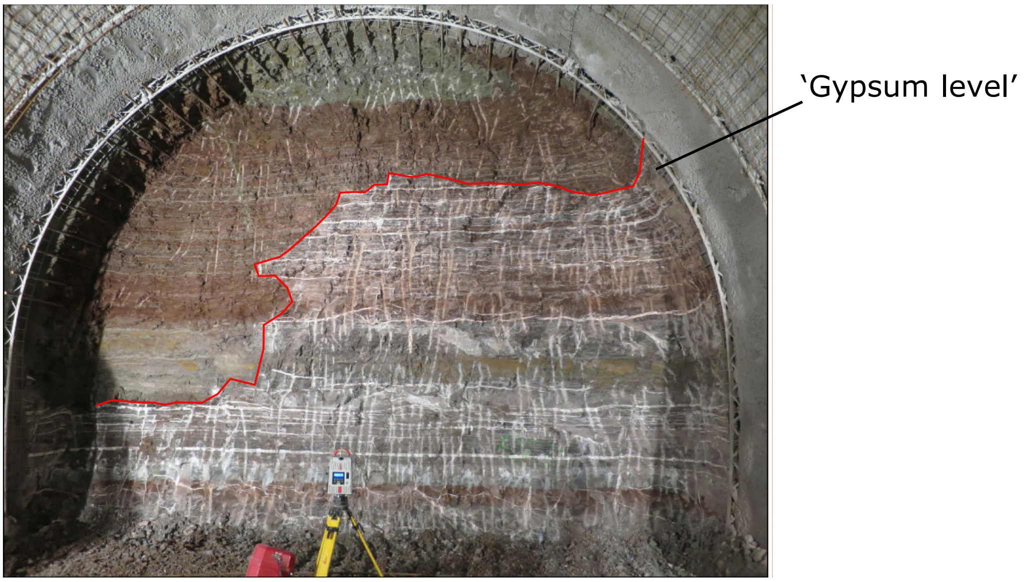

Fig. 8: Example of a tunnel face in the roof section with irregular leaching of the gypsum in the interbedded strata of calcareous clay-siltstones

Fig. 9: Example of a tunnel face in the roof section with unweathered, calcareous, highly gypsified interbedded clay-siltstones with layers of fibrous gypsum

Statistical evaluation of the dynamic characteristics of the rock shows that the full range of possible formations exhibits interdependent characteristics and allows objective evaluation of its fracture behaviour.

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Dimensioning of drilling, blasting and detonation equipment

Theoretical principles

Following firing, the explosive is detonated in an initial dynamic phase, in which the shock wave tears through the explosive at the velocity of detonation. After a delay of 200–300ms, there follows a quasi-static gas phase, in which the afterdamp produced during the chemical reaction penetrates the cavities and cracks [9]. The pressure of these expanding gases is almost completely responsible for the shattering and ejection of rock mass. The shock wave reacts with the P- and S-wave velocity of the rock, creating the sonic effect discovered by Ernst Mach (Fig. 10).

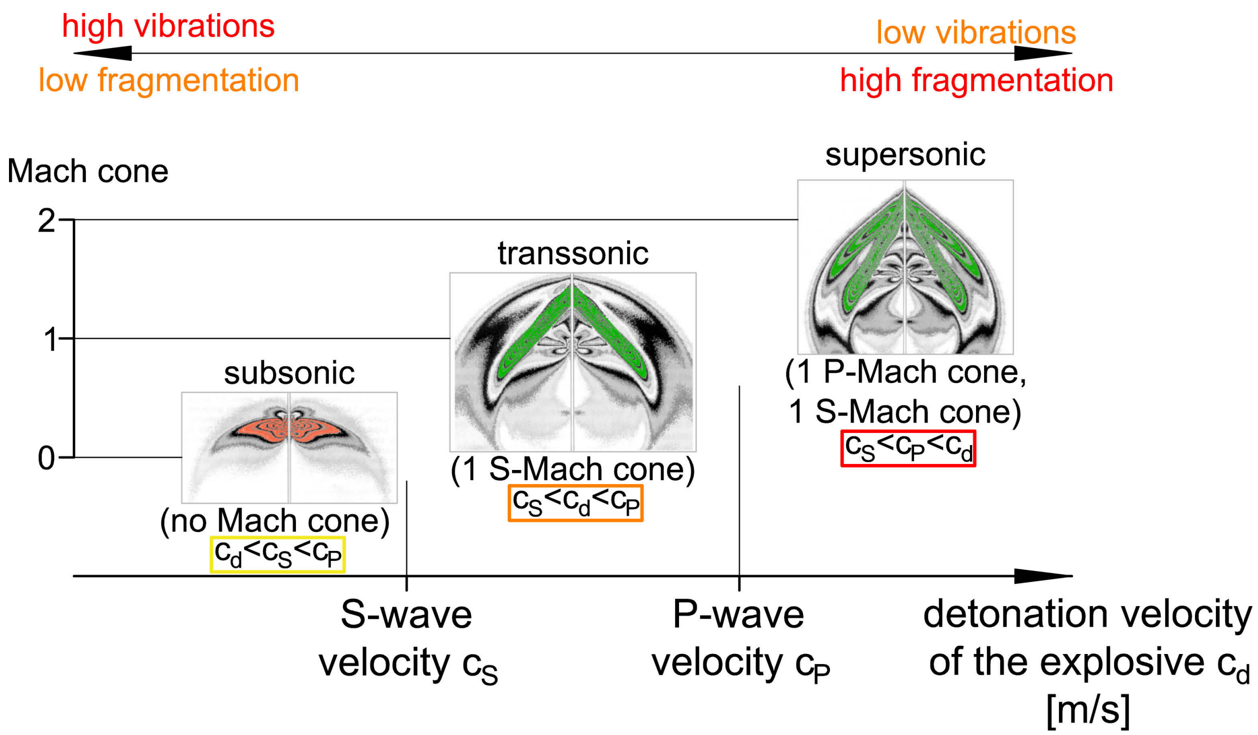

Fig. 10 Schematic representation of sonic effects in relation to velocities cS, cP and cd

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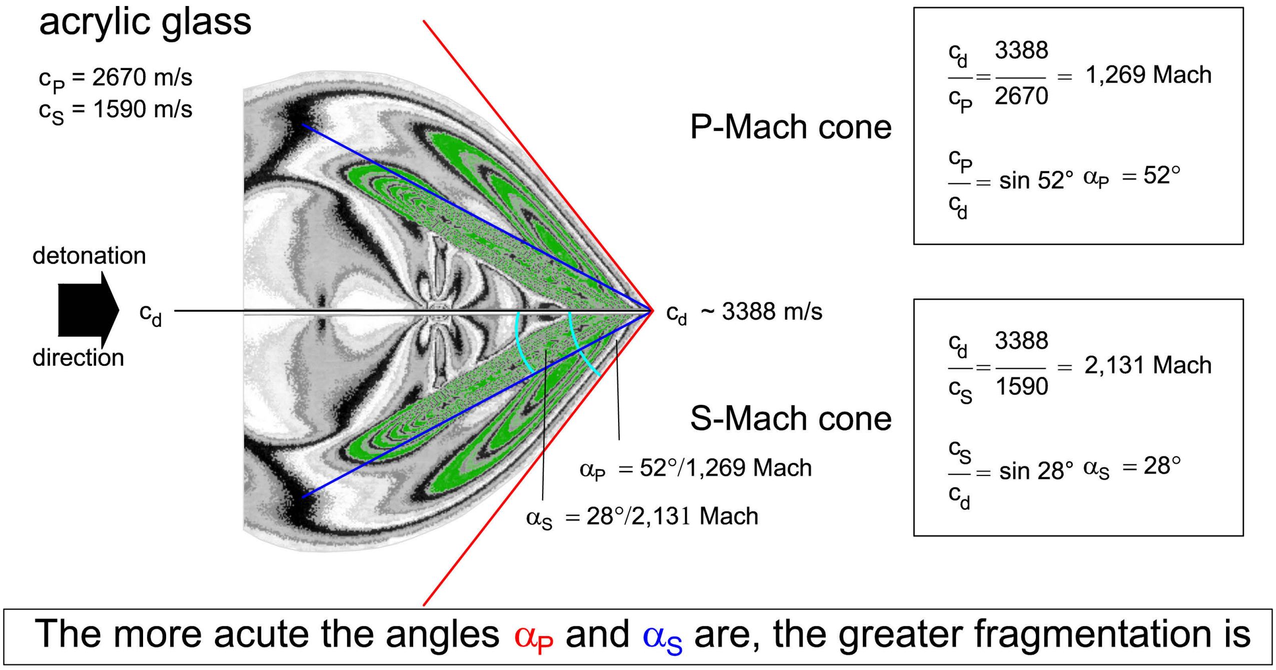

Fig. 11: Supersonic effect in a Plexiglas body caused by the shock wave of detonated explosive (P- and S-Mach cone after ROSSMANITH 1998; cd explosive = 3,388 m/s)

H.P. Rossmanith [8, 14] proved that the shock wave initiated by detonating explosive causes wave interaction in solid materials (Fig. 11). His experiments at Vienna University of Technology conducted on Plexiglas bodies revealed the resulting Mach fronts of the P- and S-waves (Fig. 11). A supersonic effect arises if the explosive's detonation velocity is greater than the P- and S-wave velocities of the substance being blasted (i.e. the rock). This resulting double Mach cone causes very good or even optimum shattering, and moreover results in relatively low vibration input. If the explosive has a transonic effect, medium shattering and moderate vibration input result. In subsonic cases, there is no Mach cone and the detonation velocity is too low (Fig. 10). It can be concluded from the correlations of the sonic effect that there must be a controllable function between shattering and the resulting vibration input [5, 6, 8, 9, 11]. In all wave-mechanical processes, the passage of shock waves is weakened by cracks, fissures, cavities and sudden discontinuities. The fault structure and the fracturing conditions at the tunnel face are factors affecting blasting which must be taken into account when calculating drilling and blasting parameters [9].

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In 3-D blasting underground, the following sequence of phases caused by the special nature of excavation from a three-dimensional state of stress is observed (Fig. 12).

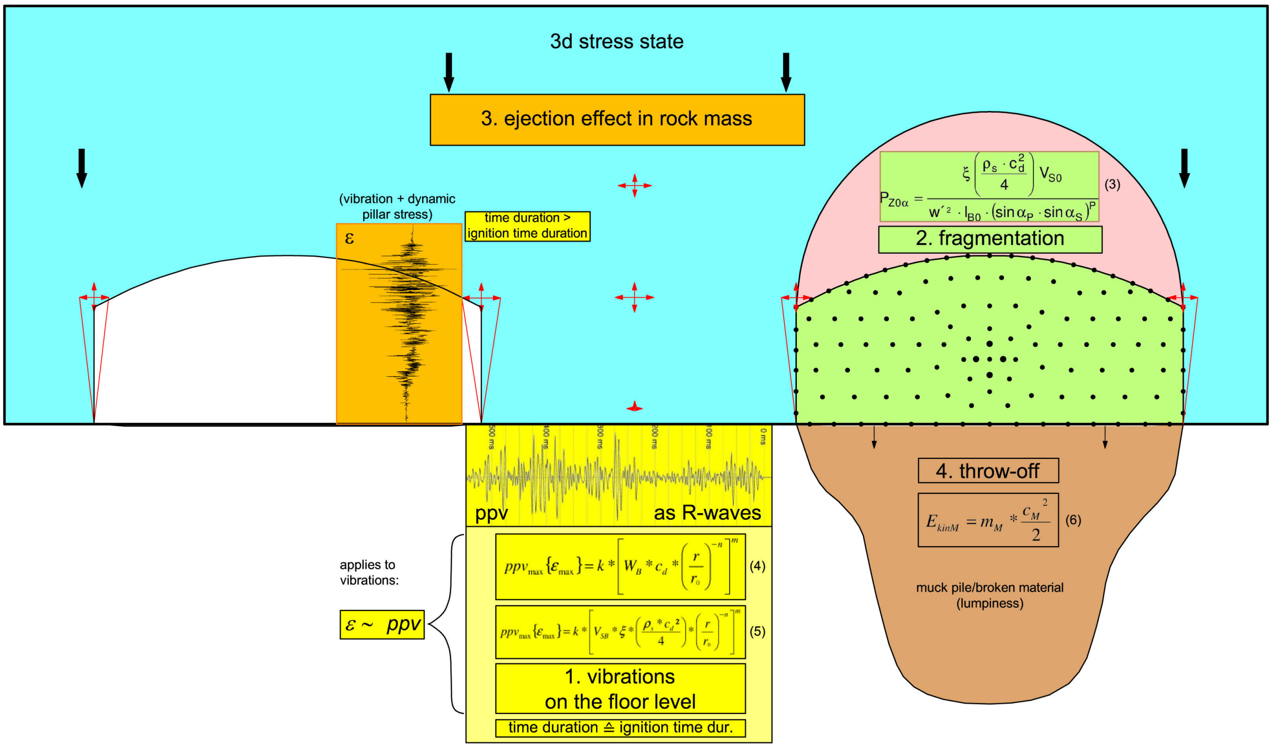

Fig. 12: Four-phase model of 3-D blasting underground

Key:

PZ0 α	=	theoretical, effective detonation pressure taking into account the sonic effect [N/mm²]
ξ	=	filling ratio [-]
ρs	=	charge density [kg/m³]
cd	=	detonation velocity of charge [m/s]
VS0	=	volume of explosive charge per unit volume of rock [m³]
w´	=	detonated burden [m]
lB0	=	unit length of blast hole [1 m]

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$$\sin\alpha_P = \frac{c_P}{c_d} \quad \sin\alpha_S = \frac{c_S}{c_d}$$

cP	=	P-wave velocity, rock [m/s]
cS	=	S-wave velocity, rock [m/s]
P	=	exponent P with a value of 1, 1.5 or 2 depending on detonation [-]
ppvmax	=	maximum peak particle velocity [mm/s]
ε_{max}	=	maximum expansion [mm/m]
WB	=	maximum charge weight per blast hole [kg]
r	=	distance between maximum charge weight per blast hole and measuring point [m]
r0	=	correction factor for dimension reduction [1 m]
V_{SB}	=	volume of explosive charge in blast hole [m³]
k, n, m	=	exponents and factors calculated statistically using regression analysis [-]

Phase (1): Vibrations are caused on the toe of the underground cavity and above ground on the surface by recoil/momentum or energy input in the form of R-waves, which can be similarly calculated using the prediction correlations for 2-D blasting [10].

Phase (2): Shattering is controllable and can be calculated using the effective, theoretical detonation pressure, the input parameters, and the sonic effect.

Phase (3): The excavation effect in solid rock is directly associated with the ejection of rock and the duration of its excavation. The impact of blasting disrupts the previously more or less balanced state of stress for about 2–5 s such that considerable tensile strain of 0.5–3 mm/m has been measured on mine props and in the remaining rock (Table 2, Fig 12). This tensile strain multiplied by the rock's static modulus of elasticity often results in tensile stresses which exceed the tensile strength of solid rock.

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Phase (4): Throw and drop, the last phase as the chemical reaction starts after 200–300ms or after the action of the gas pressure and the resulting initial movements of the rubble, is calculated as kinematic energy from the rock and the ejection speed.

Blasting	***Maximum extension (μm/m***	***Duration of effect = length of firing sequence (ms)***	***Dynamically produced tension (N/mm²) in the vicinity***
1	1,315	3,580	62.08–82.07
2	1,312	3,256	61.94–81.88
3	1,660	4,008	78.37–103.60
4	1,928	3,389	91.02–120.33
5	1,149	5,195	54.24–71.71
6	3,403	4,400	160.66–212.38
7	1,217	5,200	57.45–75.95
8	1,893	2,218	89.37–118.14

Table 2: Results of stress-strain measurements as excavation effects during underground blasting in calcareous rock

It can be concluded from the model in Fig. 12 that there is a direct correlation between the theoretical, effective detonation pressure in Phase 2 and the vibrations triggered in Phase 1.

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Dimensioning of blasting equipment

Dimensioning of the boring, blasting and detonation equipment for tunnelling is carried out using the above-mentioned correlations and the following principles:

- A uniform explosive must be chosen to achieve the best sonic effect using knowledge of the P- and S-wave velocities in the tunnel face rock (Table 1; Fig. 5).
- The specific explosive consumption q is derived based on the excavation strength [7] and the face area in accordance with Fig. 13.

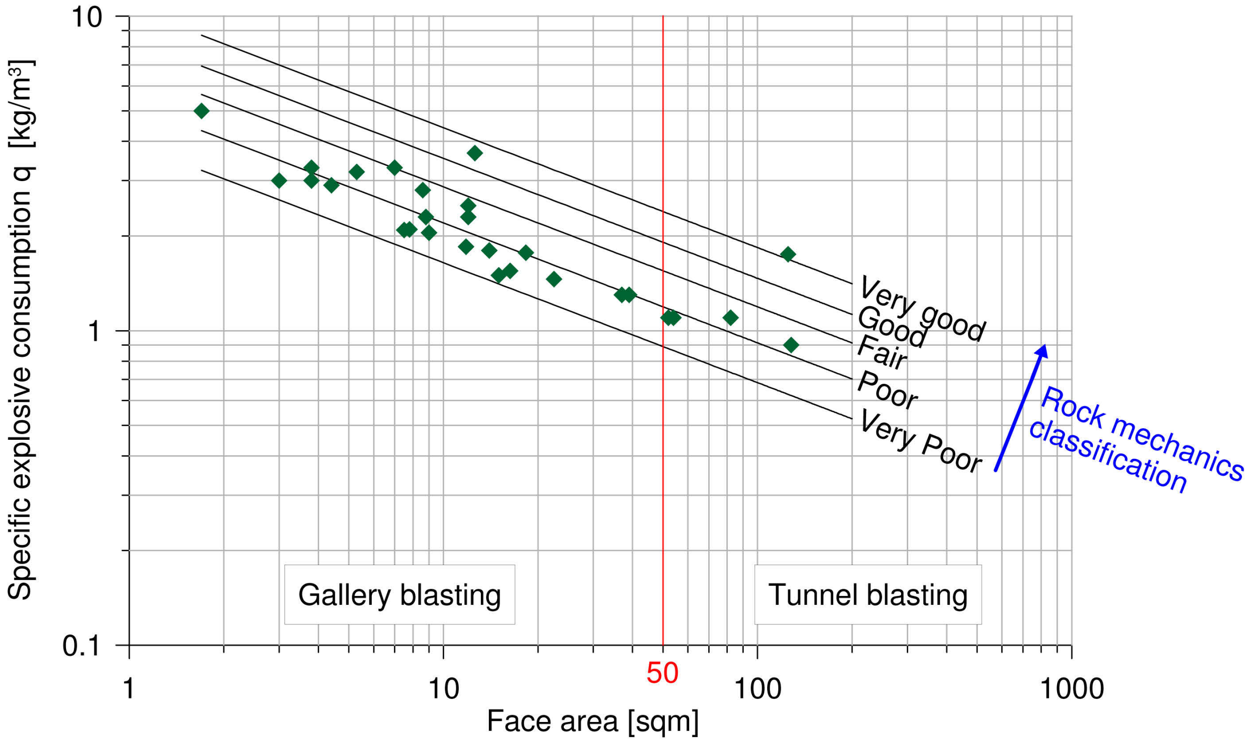

Fig. 13: Graph used to estimate the specific explosive consumption q (in kg/m³) depending on the face area and excavation strength [after 7]

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- The available volume of the production and auxiliary holes should be filled evenly and completely with the highest possible filling ratio.
- The preferred drill pattern is a flexible parallel cut with 2–4 large blast holes.
- Even, harmonious, preferably spiral opening of the cut area reflecting the mechanics of rock breakage and mutually simultaneous detonation in the auxiliary holes taking into account the lead time of the firing sequence in the cut up to 300 ms before excavation movement begins (yellow areas in Figs. 14, 15, 17, 18).
- Serial detonation of the contour holes simultaneously with supersonic array.
- The correlations of the blasting model (Fig. 12) and the parameters it contains allow any adjustment required to the drilling, blasting and detonation equipment including vibrations.

After choosing the explosive and the size of the specific charge consumption, the corresponding parameters are calculated for the various input values according to Tables 3 and 4. Accordingly, to accommodate the charges, 83 blast holes are necessary for $q = 1.7$ kg/m³, and 62 holes for, say, $q = 1.3$ kg/m³.

Parameter	***Dimension***	***Variants***		
		1	***2***	***3***
Cartridges	pcs.	1.5	2	2.5
Length of blast holes	m	1.25	1.5	1.8
Charge per hole	kg	0.9855	1.314	1.6425
Excavation volume	m³	53.875	64.65	77.58
Total explosive	kg	87.924	109.905	131.886
Number of blast holes	–	89.22	83.64 (**83**)	80.295

Table 3: Calculation of blasting parameters for $q = 1.7$ kg/m³

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Parameter	***Dimension***	***Variants***		
		1	***2***	***3***
Cartridges	pcs.	1.5	2	2.5
Length of blast holes	m	1.25	1.5	1.8
Charge per hole	kg	0.9855	1.314	1.6425
Excavation volume	m³	53.875	64.65	77.58
Total explosive	kg	67.236	84.045	100.854
Number of blast holes	–	68.22	63.96	61.4 (**62**)
Average spacing between blast holes	m	0.632	0.674	0.702

Table 4: Calculation of blasting parameters for q = 1.3 kg/m³

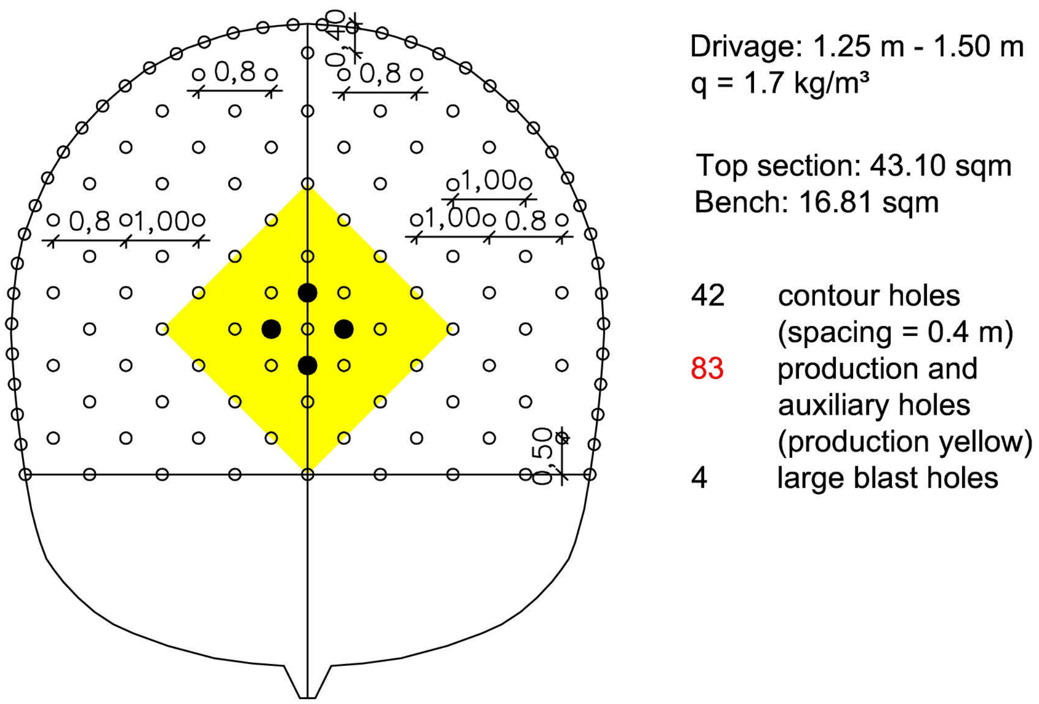

Fig. 14: Drill pattern for drill and blast with a blasting pull of 1.20–1.50m and q = 1.7 kg/m³

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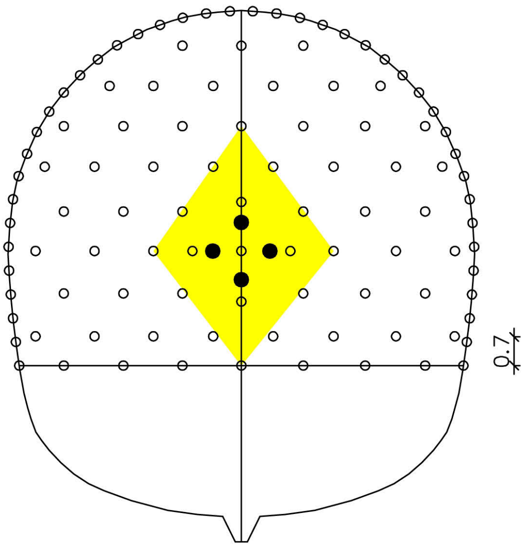

Fig. 15: Drill pattern for drill and blast with a blasting pull of 1.80m and q = 1.3 kg/m³

The translation of the drill pattern into drilling and blasting practice is shown in Fig. 16.

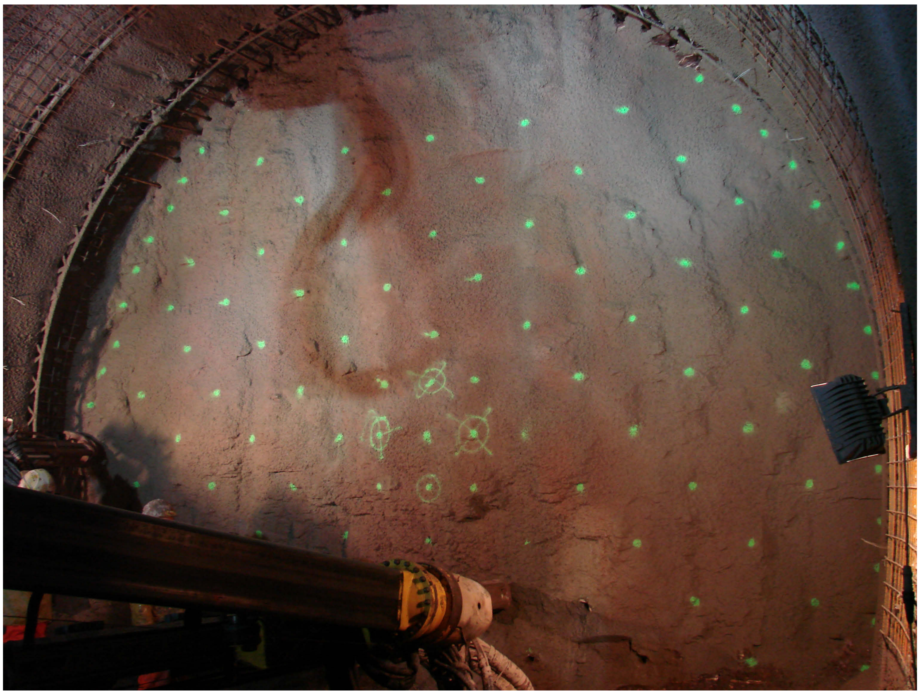

Fig. 16: Drill pattern on the reinforced tunnel face (roof section) marked by a laser theodolite

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Optimum firing sequences for higher shattering and lower vibrations

The advantages of the above-ground firing sequence (excluding contour and toe holes) can be adapted and transferred to underground blasting with the same effects [5, 8, 9, 11]. The cut must be completely detonated after 300 ms so that the onset of rock collapse does not impair the further loosening processes (yellow area in Figs. 17 and 18). The firing pattern shown in Fig. 17 with non-electric, redundant firing shows spiral-shaped excavation with single-hole firing, causing good separation of the solid rock with moderate fragmentation of the muck pile. The firing sequence applied during drilling and blasting in the roof section of the new Zierenberg Tunnel is shown in Fig. 18.

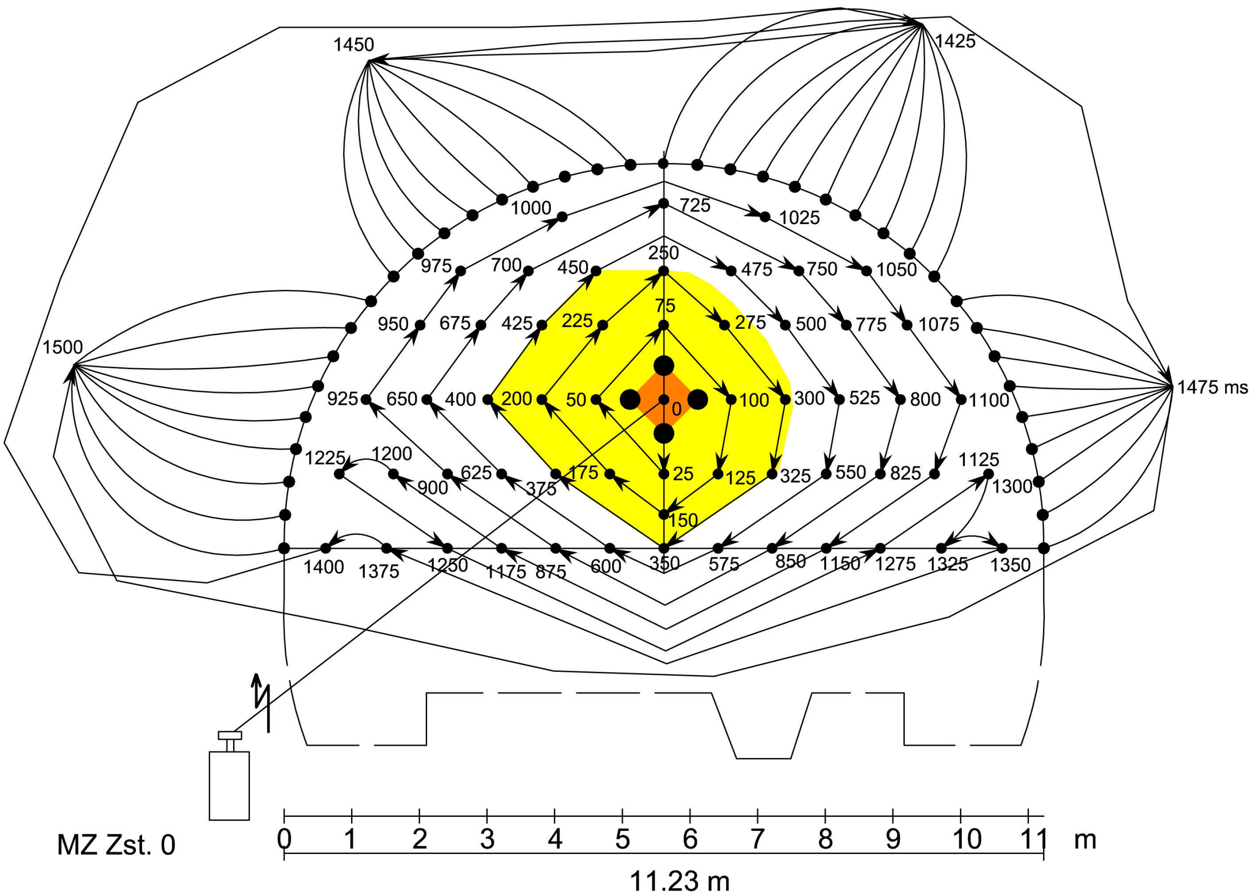

Fig. 17: Blast hole and firing pattern for the roof section of a tunnel with single-hole detonation in the area of the production and auxiliary holes (non-electric surface delay)

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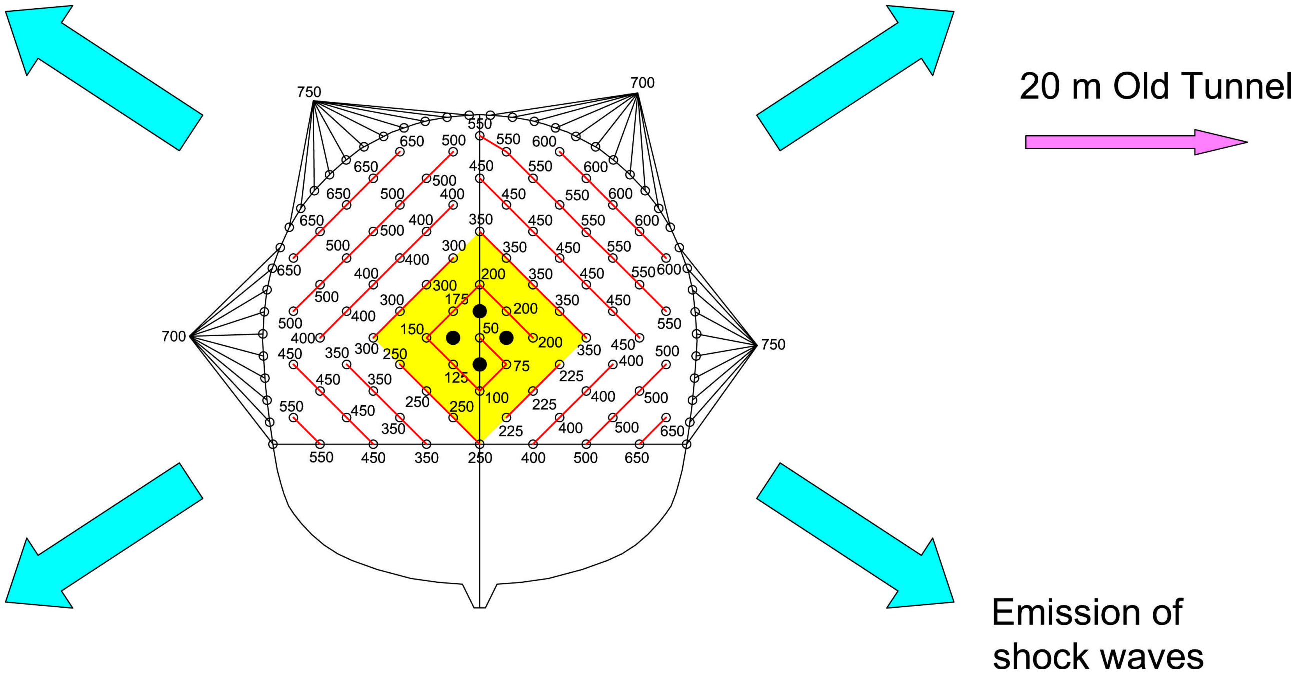

Fig. 18: Firing sequence in the roof section with spiral cut and simultaneous detonation in the auxiliary holes (figures indicate rounds of non-electric detonators at the bottom of boreholes)

This firing sequence enabled optimum lumpiness, a well-positioned muck pile, and high-frequency vibrations to be achieved while complying with the permissible peak particle velocity in the existing tunnel 20m away (Fig. 19). Due to the good blasting results without damaging the old tunnel, the client (Deutsche Bahn AG) decided to increase the permissible peak particle velocities for the old tunnel from 20 to 50 mm/s. The contour was loaded with 100g detonating cord and firedsimul-taneously at four intervals in order to achieve a clean perimeter.

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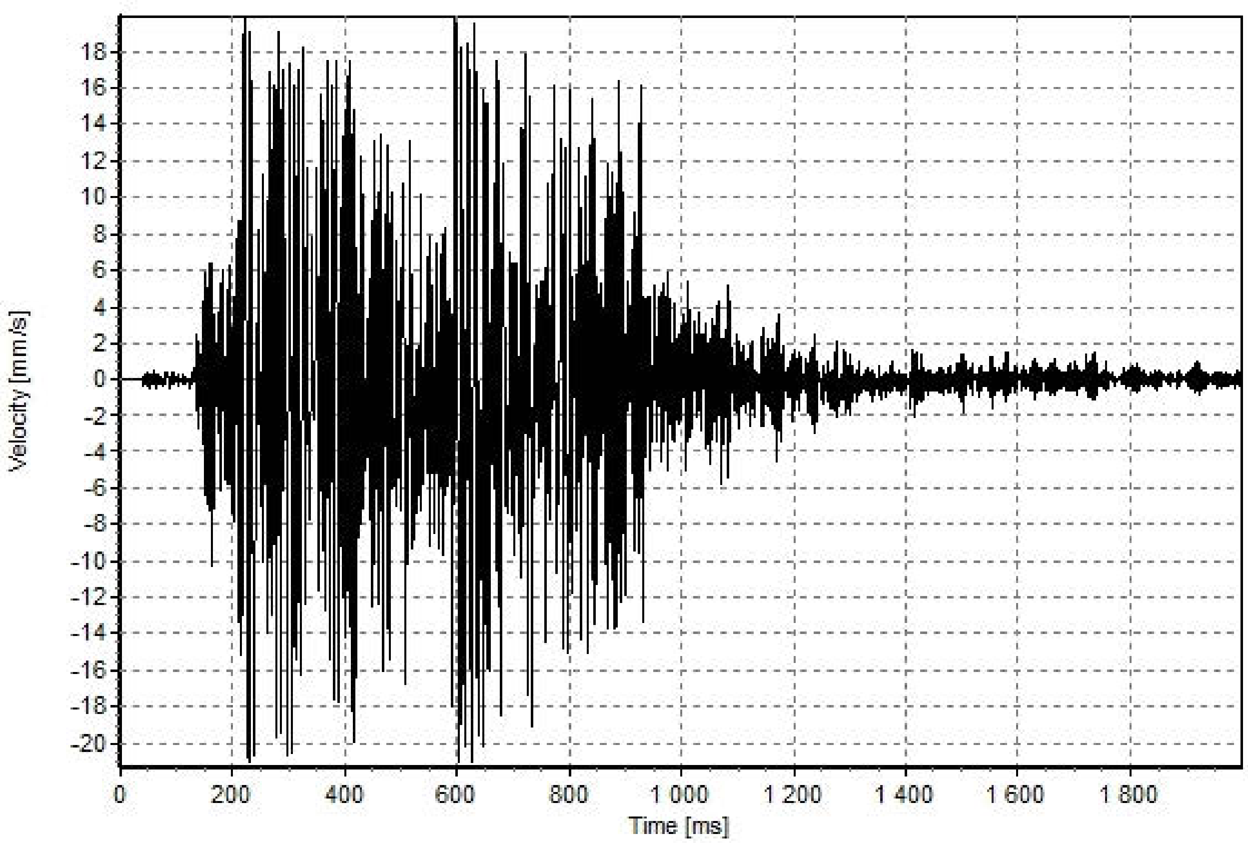

Fig. 19: Example of peak particle velocity measurement of blasting in the roof section in the new Zierenberg Tunnel (ppv_{max} = 20.8 mm/s; frequency 98.9 Hz)

The detonation principle applied can be adapted to any type of rock, blasting pull and tunnel face, enabling the findings to be objectively used in practice.

Drilling and blasting enhanced by correct vibration prediction

It has been proven that owing to the sonic effect there is a correlation between fragmentation and the vibrations triggered:

The greater the fragmentation of the muck pile, the lower the expected vibration input in comparable hard rock [5, 6, 8, 9, 10, 11, 13].

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The lack of previous blasting vibration assessment is made up for by the vibration prediction correlations shown in the blasting model (Fig. 12), the correlations founds, proven influences, and statistically and physically proven prediction correlations (Fig. 12; [10]). Below, examples are used to show important findings and benefits resulting from working with these prediction correlations. The type of explosive used is very important for the vibration input triggered (Fig. 20) as significant differences result in the measurable peak particle velocities despite the same theoretical amount of energy being applied.

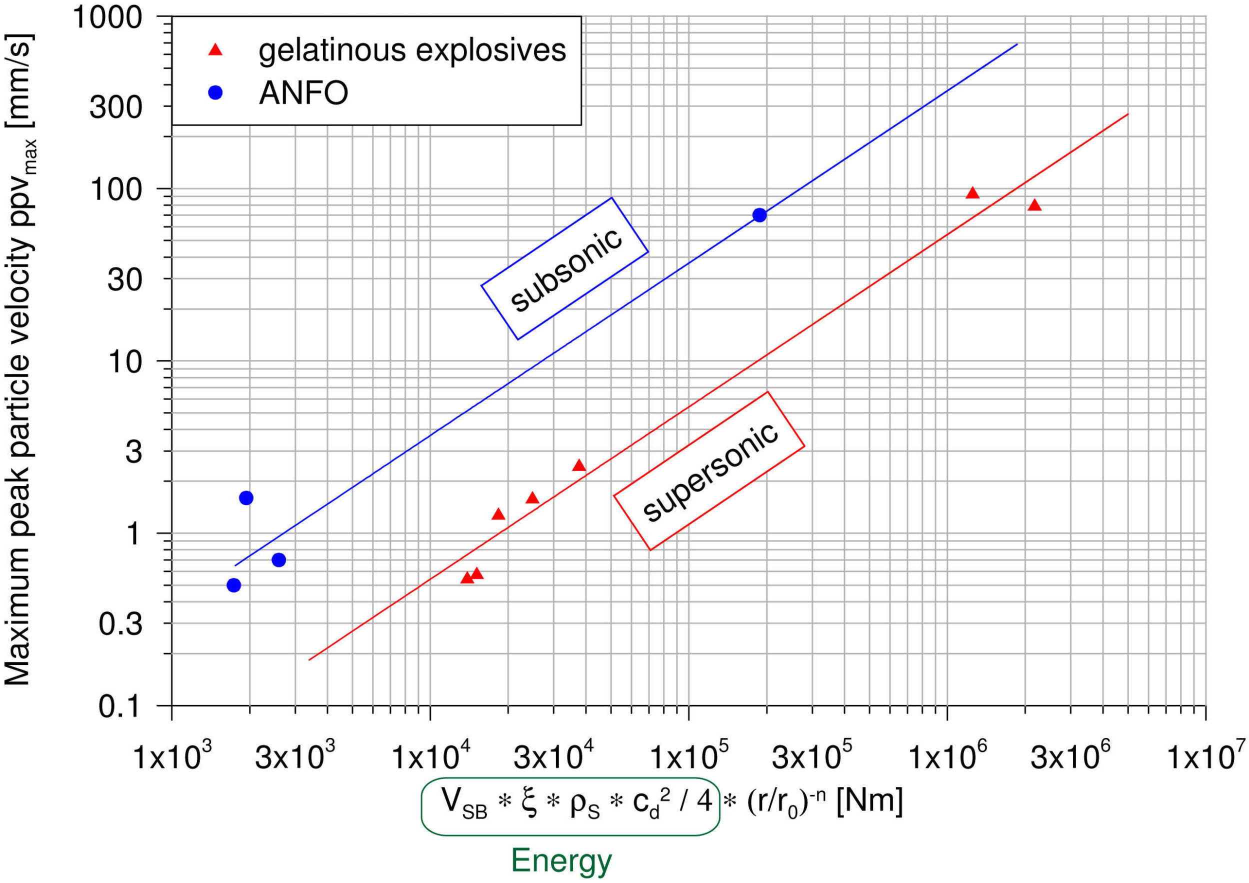

Fig. 20: Correlation between maximum peak particle velocity and the theoretical energy–distance relationship for different explosives (ANFO and gelatinous explosives)

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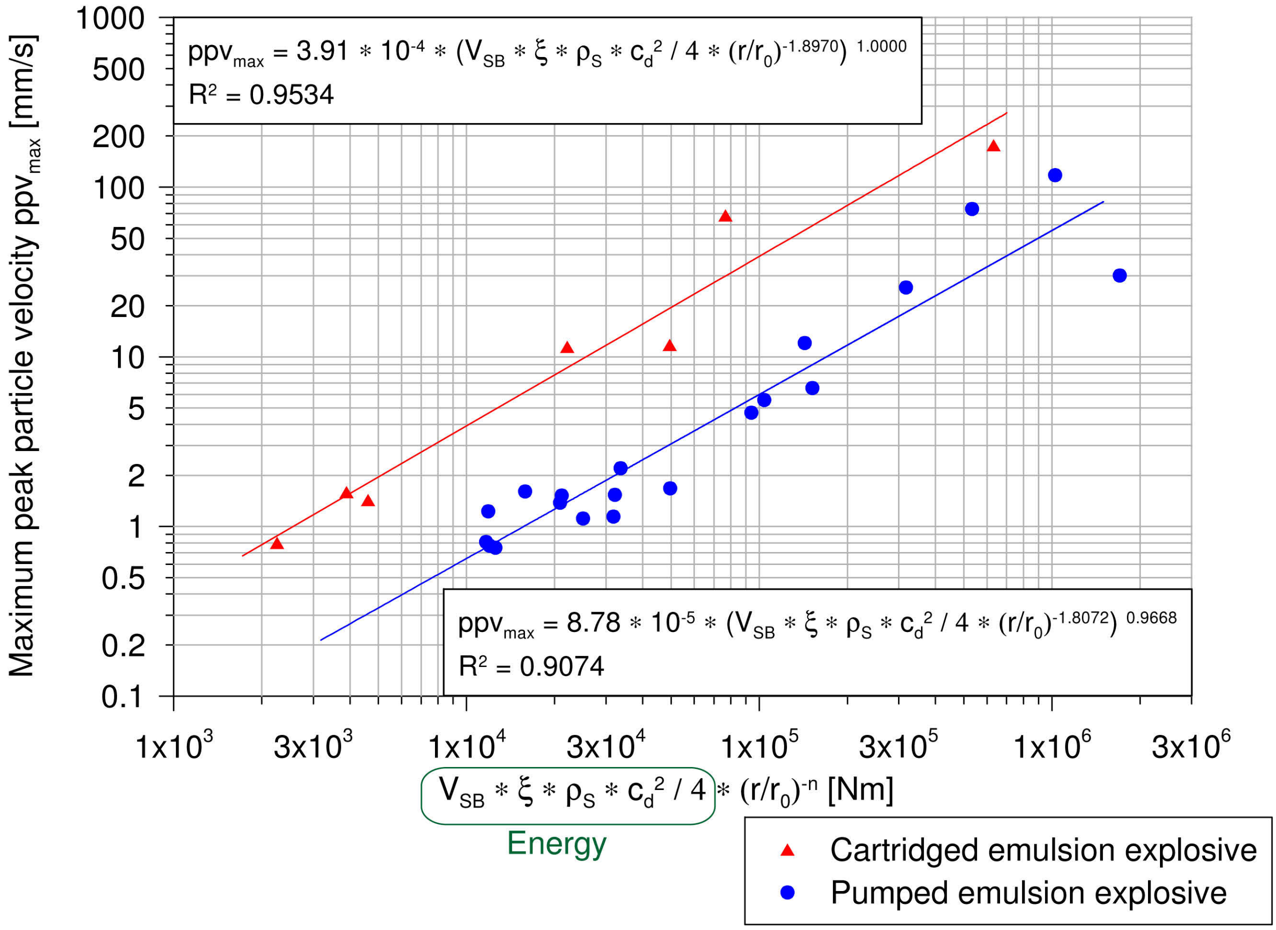

Fig. 21: Correlation between maximum peak particle velocity and the theoretical energy–distance relationship in calcareous rock when using cartridged and pumped emulsion explosive

The measurements from a calcareous rock surface mine analysed in Fig. 21 demonstrate the significant differences between the effects of cartridged and pumped emulsion explosive. The use of pumped emulsion explosive flush with the blast hole wall, releasing the shock wave directly into the solid rock immediately after detonation, results in optimum fragmentation and also decreases vibrations with the same theoretical energy. The procedure for drawing up the vibration prediction correlations and the action mechanisms of detonation are directly comparable for 3-D underground blasting (Fig. 22). When tunnelling in the Zierenberger Tunnel, cartridged emulsion explosive was used with a cartridge diameter of 36mm, equating to a filling ratio of 64%.

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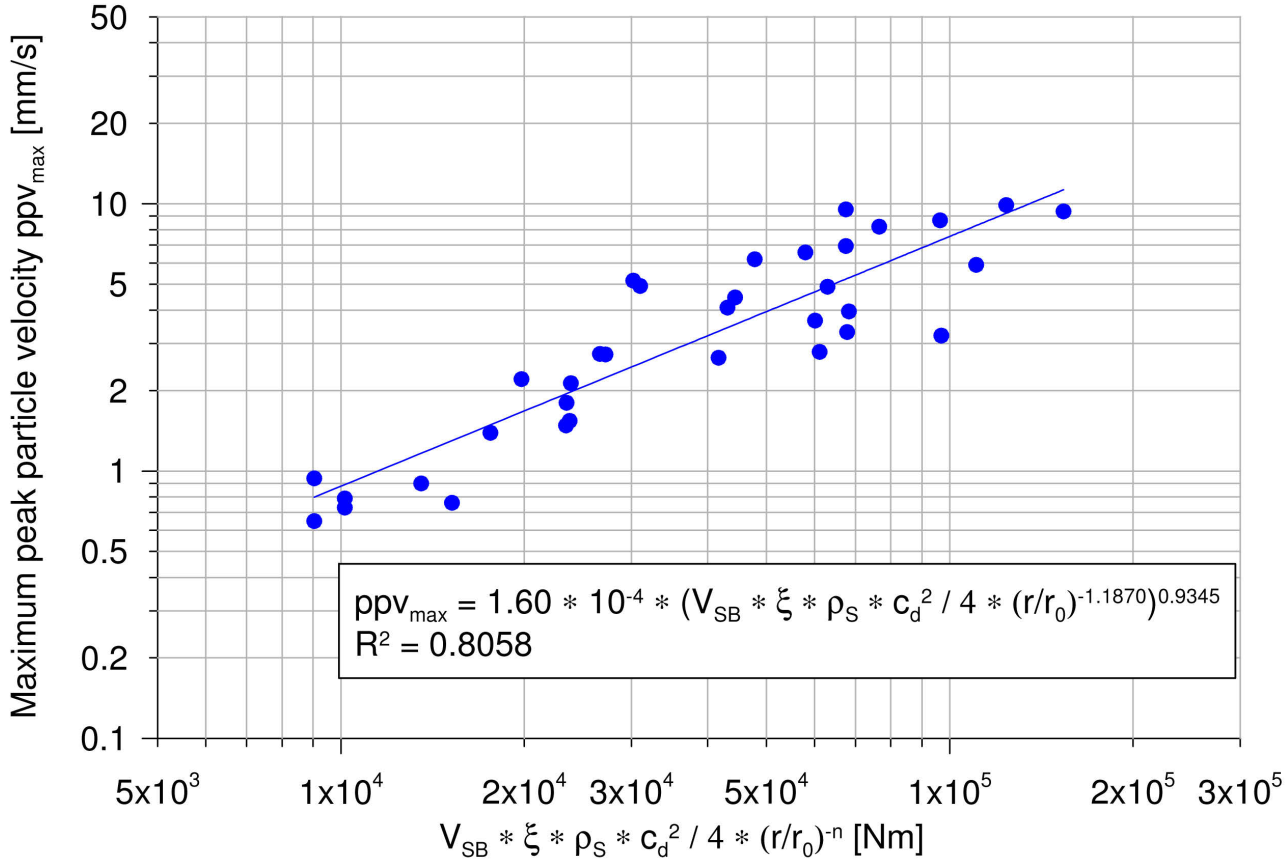

Fig. 22: Theoretical energy–distance correlation of 3-D blasting when tunnelling in calcareous rock

The P-wave velocities range from 2,200 to 3,473 m/s in interbedded strata of clay and siltstone as well as up to 5,465 m/s in gypsum, meaning blasting can be expected to have a transonic effect.

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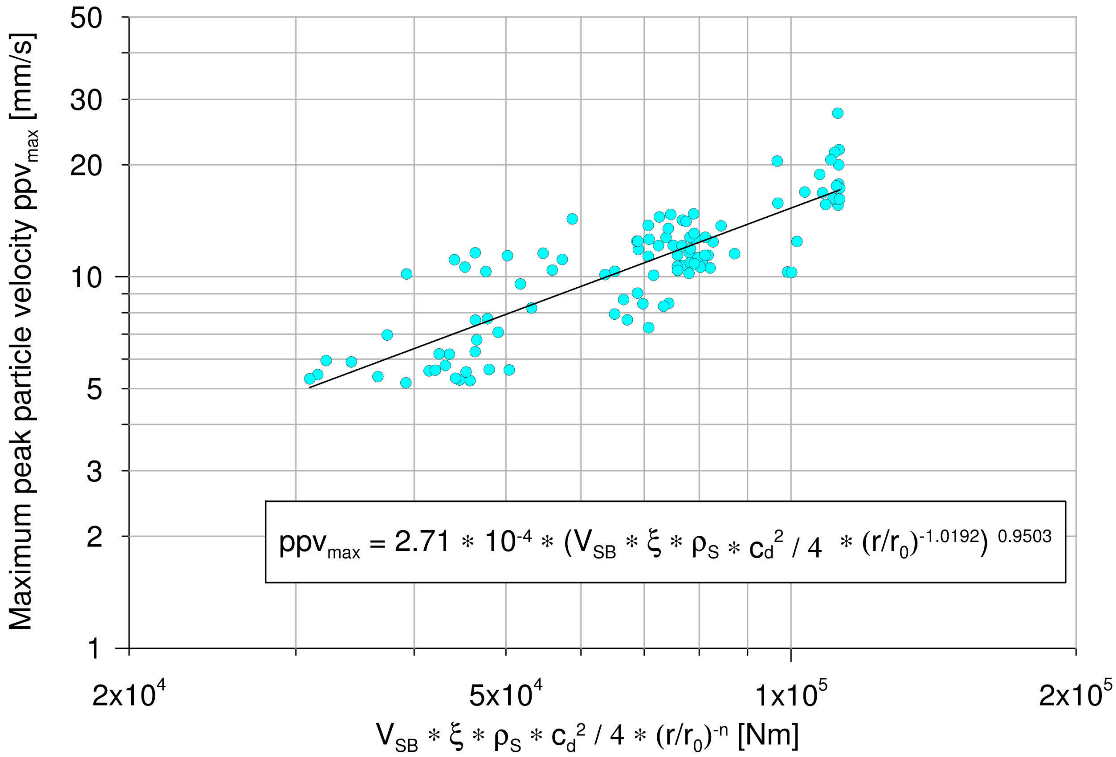

Fig. 23: Theoretical energy–distance correlation from tunnelling in Zierenberg with transonic effect due to the high velocities of the rock in situ

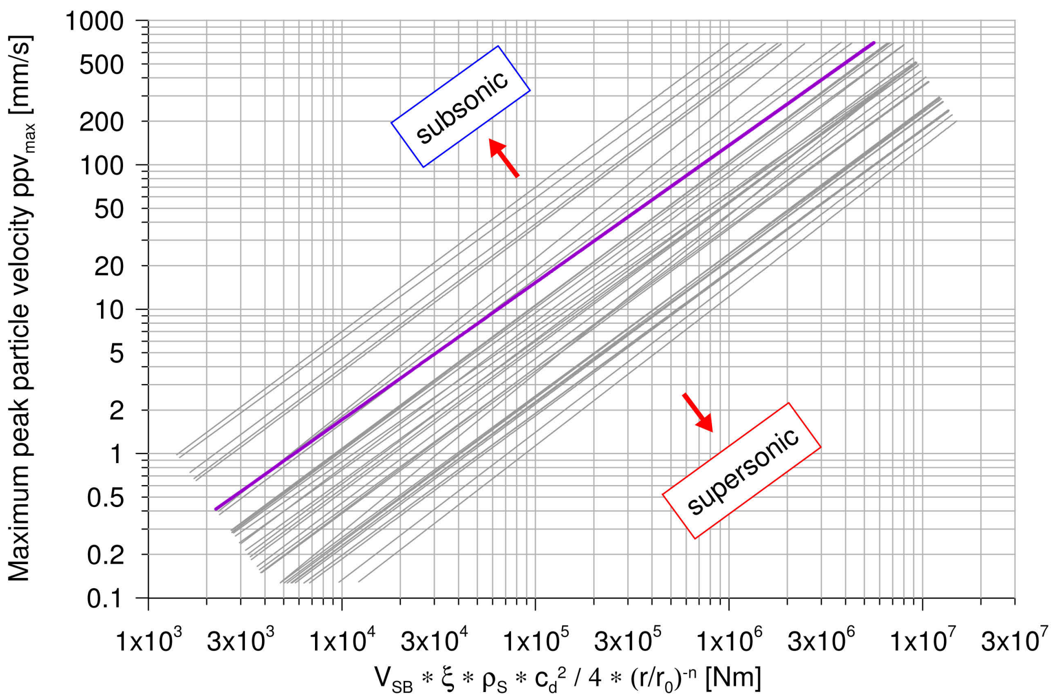

Fig. 24: The importance of the sonic effect is confirmed by comparing 36 regression lines from theoretical energy–distance correlations for different types of solid rock and the tunnel (purple = regression line for Zierenberg Tunnel)

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Figure 23 gives the theoretical energy–distance correlation for drilling and blasting at Zierenberg Tunnel. The transonic effect of the blasting pattern is confirmed (Figure 24) by comparison with other regression lines. The necessary blasting targets are economically achieved without having to make full use of the findings. The use of pumped explosive was not viable due to the low proportion of drilling and blasting within overall drivage.

Results of drilling and blasting in the new Zierenberg Tunnel; outlook

Fig. 25: Position of the muck pile containing small rubble after the first blasting on 8 January 2016

Drilling and blasting was carried out from tunnel metre 225.55 to 571.85 with a few interruptions and dimensional constraints, meaning an adaptable drilling, blasting and detonation regime was required. As drivage continued to the east portal, there were a few more sections where blasting was necessary, such as in the area of breccia.

Drivage of the bench/toe from the east to the west portal was also accomplished by drill and blast in the same tunnel metre segments. Blasting pull was even, the contour was well defined, and the rock fragmented without impairing the lumpiness of the surrounding rock (Figs. 25 and 26). Moreover, the muck pile was thrown onto a central heap (Fig. 25).

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Fig. 26: Position of the muck pile after blasting on 23 March 2016 at about 11.15am

During blasting operations, the permissible peak particle velocities in the old tunnel were not exceeded. Thanks to firing sequences with simultaneous detonation of multiple charges in the auxiliary holes, frequencies of around 100 Hz arose. In addition to photographing the tunnel face, thermograms were produced with a high-resolution infrared camera to detect wet spots or water leakage.

Furthermore, hot spots on the thermogram revealed the drill pattern on the tunnel face where cartridges had been detonated. The harder the bottom of the blast hole, the higher the visible 'residual temperature' (Figs. 27, 28, 29). Infrared cameras can also be used to reveal misfires in the tunnel face and to indirectly check the accuracy of the drill pattern.

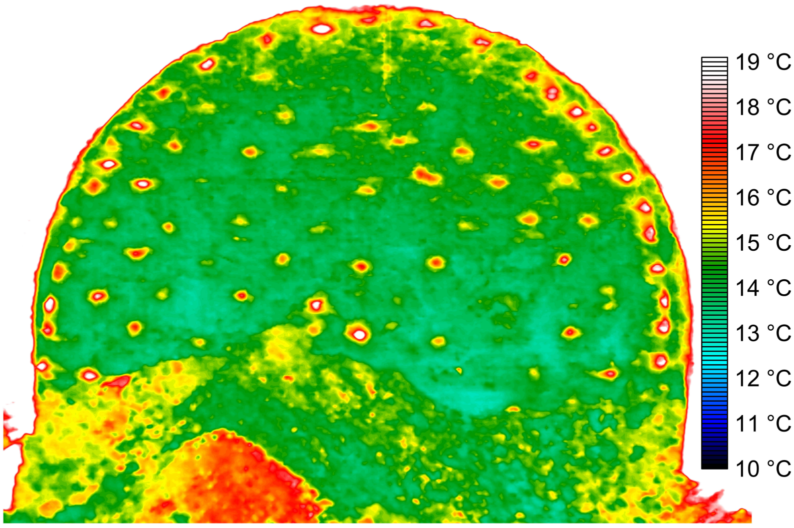

Fig. 27: Thermogram after blasting the roof section showing hot areas near charges detonated in blast holes

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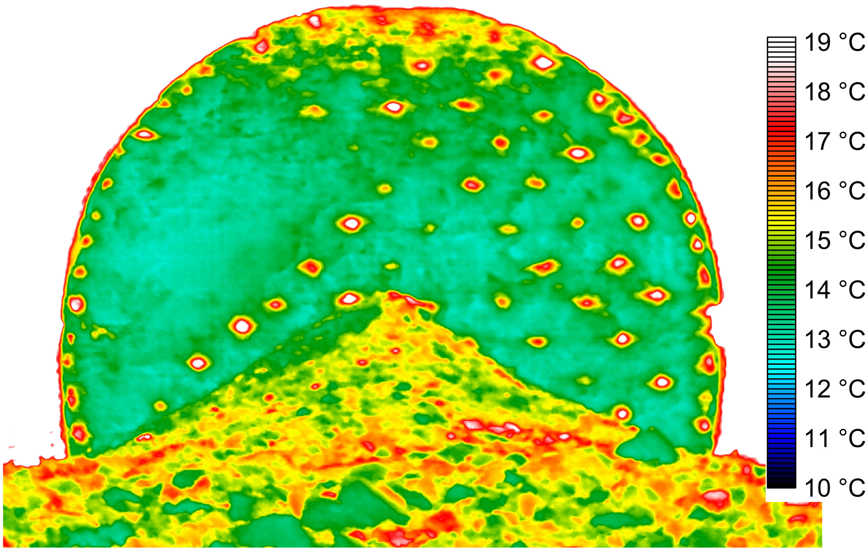

Fig. 28: Thermogram of blasting on 23 March 2016 including muck pile; fully detonated charges are revealed as hot spots on the tunnel face

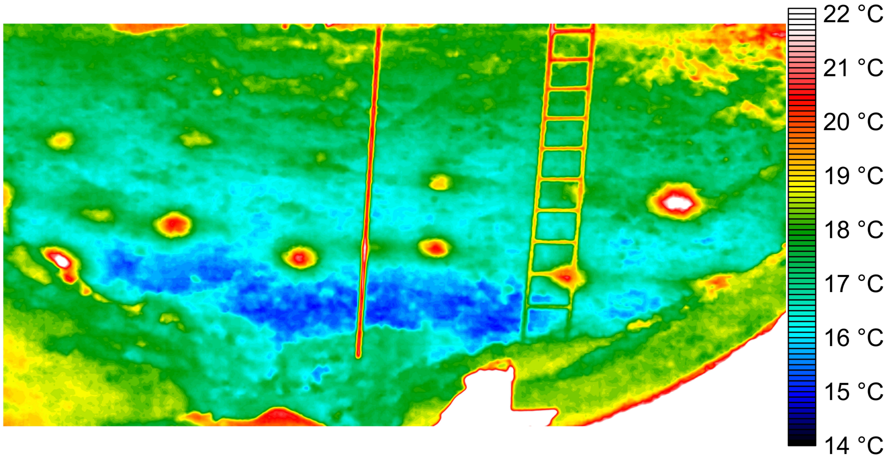

Fig. 29: Thermogram taken about 80 minutes after bench/toe blasting on 28 June 2016

When altered geological conditions were encountered at the new Zierenberg Tunnel, the use of flexible, adaptable drilling and blasting based on new insights and practical findings proved highly successful.

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Summary

The new Zierenberg Tunnel, an 900m-long railway tunnel, is currently being built alongside the old Zierenberg Tunnel for rail operator Kurhessenbahn. Due to the increasing rock and excavation strength of the existing clay siltstones with varying carbonate content, the excavation method had to be changed from mechanical excavation to drill and blast.

The dimensioning of the drilling, blasting and detonation equipment was carried out according to the latest findings. Spiral cut and simultaneously detonated auxiliary holes yielded optimal lumpiness, a well-positioned muck pile, and high-frequency vibrations. The old tunnel suffered no dynamic damage.

The low filling ratio and the high rock strength produced a transonic effect without exceeding the permissible peak particle velocities. Any misfires on the tunnel face were detected by means of thermograms.

Bernd Müller and Uwe Pippig

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FLYROCK: FRENCH EXPERIENCE

The work of the EFEE's Environment Committee has shown in the last few months that it is still very difficult to obtain feedback about incidents or accidents occurring during blasting operations. In France, this information should however be declared in a database managed by the State (www.aria.developpement-durable.gouv.fr), which regroups technological accident feedback.
Although everyone agrees that this feedback is fundamental for preventing probable future incidents and therefore for risk management, the incidents and their causes are still badly indexed. However, civil society, elected officials and especially residents, increasingly demand that these incidents be accounted for by public authorities, companies, and sometimes request information directly via the press or television. Unfortunately, when such situations occur, the company has a duty to provide a pragmatic response and to manage information and communication. We have noticed that the way in which these points are carried out influences the way operations are resumed and their conditions, therefore the financial costs.

We have decided to share our research office experience in incident management pertaining to rocks being projected beyond site roads and quarries in France.

Flyrock cases in France

Indeed, France still has some rare cases of flyrock beyond the safety zone of planned blasting area.

A number of factors particular to France could be at the root of this observation:

- It is possible that our country is one of the few that declares such cases to the responsible authority, and in which investigations are carried out!
- All types of rocks can be found in France, in all possible states of weathering

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- The majority of French quarries are of a small to average size, spread over the whole territory and often close to housing. In the last few years, the development of road networks and residential housing on the outskirts of cities and villages has contributed to the arrival of residents less than 300 m from blasting operations.

In the case of an incident involving pieces of rock being ejected from a quarry or building site, the French Administration generally orders all or part of blasting operations, and therefore production, to stop as a protective measure. Before allowing blasting activities to be resumed, the authorities require that the operator submit proposals on how to improve blasting operations and blasting control processes. Depending on the requests from the local residents mainly affected, this notably requires that the operator is able to guarantee a high level of safety for the duration of future operations.

In this case, as in the examples below which occurred over the last ten years, we become involved by way of an emergency intervention at the request of the operator, after confirmation by the relevant state department. This also implies that our expertise is paid for by the operator, unless the case comes under a judicial framework.

Example 1: Secondary school in the vicinity of a quarry with blocks landing in the play-ground approximately 300 m in front of the blast

In these situations, our work consists of:

1. making an independent study,
2. to draw up a sound diagnosis and justify each of the points included,
3. and to make proposals for the resumption of operations in the very short term,
4. and for the continuation of the operating site in the long term.

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Example 2: Damage to a factory roof and blocks landing approximately 200 m in front of the blast

Our experience firstly strengthened by analysing flyrock cases reported as part of the quality process for a civil explosives producer who was periodically involved in explosives implementation and blasting. This experience then developed with operators' specific requests. As time passed, we were able to study flyrock cases closely in a variety of blasting contexts, with variable levels of gravity and multiple causes.

Parameters of flyrock control

Flyrock, or 'wild flyrock' if we refer to the terminology used by Little & Blair (2010, "Mechanistic Monte Carlo Models for Analysis of Flyrock Risk". Sandrichian (Pub.) *Rock Fragmentation by Blasting*.), corresponds to the propulsion of a rock fragment of varying size over a large distance from the blast, more precisely exceeding the acceptable distance or 'exclusion zone limits' that have been determined or estimated by the blaster.

This propulsion depends on the explosive energy used, the geometry of the confining rock mass and the explosive charges as well as the way the rock mass controls the explosive detonation. The detonation timing of the different explosive charges used in the blast is also an important factor in the occurrence of flyrock in as far as it is likely to modify the way the explosive charges function and to affect the geometry of the faces developed during the blast dynamics.

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Of all the parameters that make it possible to control flyrock, explosive energy and the use of delays are the most controllable. On the other hand, even if the height of the benches is generally an easily controlled parameter, it is not the same case for rock thickness around (confining) explosive charges. These varying thicknesses depend on the structure of the massif and on the orientation of the faces within this discontinued volume, on the blasting plan being adapted to these conditions, and also, on the accuracy of the drilling already carried out.

Controlling these variations mainly depends on the level of equipment used to check the burdens for every blast. But even the best type of equipment does not stop variations in the use of the system from one operator to another: for example, from which bench thickness (more or less) does an operator decide to change the explosive loading?

Initial blasting condition audits make it possible for us to quantify the explosive energy used and the variability of the geometric confinement of the charges.

Flyrock risk is therefore linked to controlling these different parameters throughout the entire operation.

The right reflexes in the event of incidents related to flyrock

The process of carrying out an investigation must begin promptly after the incident, in particular so as to record the impacts, if they are numerous, and information pertaining to the projected blocks in detail (figure 3). This fundamental step should be carried out rigorously, but this task is often made difficult because the operator has the internal and exterior roadways cleaned up quickly, (which can be understood) without necessarily locating the impacts or preserving the blocks. In the last few years, the wider application of electronic photographs has become a good ally when recording information, but this alone cannot suffice. In the best cases, it had become an established routine to take a video of the blasting systematically: if the video frame covers the whole blasting, the number of hypotheses regarding the mechanisms of the cause of the flyrock can be reduced considerably.

All this information is very important as it allows the flyrock to be mapped, to link the blocks to a particular area of the rock mass, and to propose the most probable reasons for the incident.

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The purpose of the on-site investigation is therefore to record:

1. the position of the projected rocks
2. the blocks
3. the characteristics of the blasted rock mass
4. the actual positions of the blast holes
5. the actual charges
6. the succession of drilling-blasting operations and the materials used

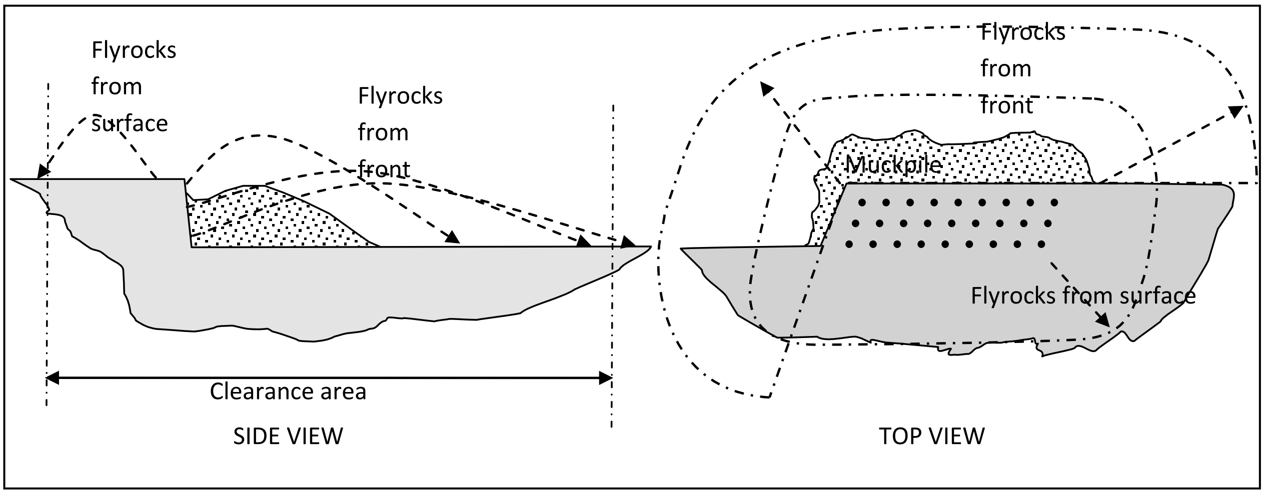

Figure 3: Zones affected by flyrock resulting from blasting

This information completes the more general data:

- ✓ Theoretical and implemented blasting designs
- ✓ Planned drilling and blasting equipment
- ✓ Procedures for drilling-blasting and evaluation
- ✓ Timing scheme
- ✓ Previous blasting designs baked up by measurements of their impact (vibration and overpressure/flyrock)
- ✓ Residents and their activities

The blaster is the person incriminated immediately following the incident. In these situations he is responsible for the whole blasting operation, since in France, even if he is not the designer, he is responsible for the final adaptation of the blasting design in order to respect internal procedures (set up, loading and priming and safety clearances).

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His presence, time and expertise is required after the incident and he must collate all the technical evidence (state of the faces, drilling report, details of the loading and priming, detail of the explosives used, a possible 2D or 3D survey, evaluations of the drilling deviation, bench thicknesses, misfire handling procedure…).

All of the assembled data is then analyzed in order to draw up a list of the possible to probable causes of the flyrock that exceeded the expected safety zone (diagram 4).

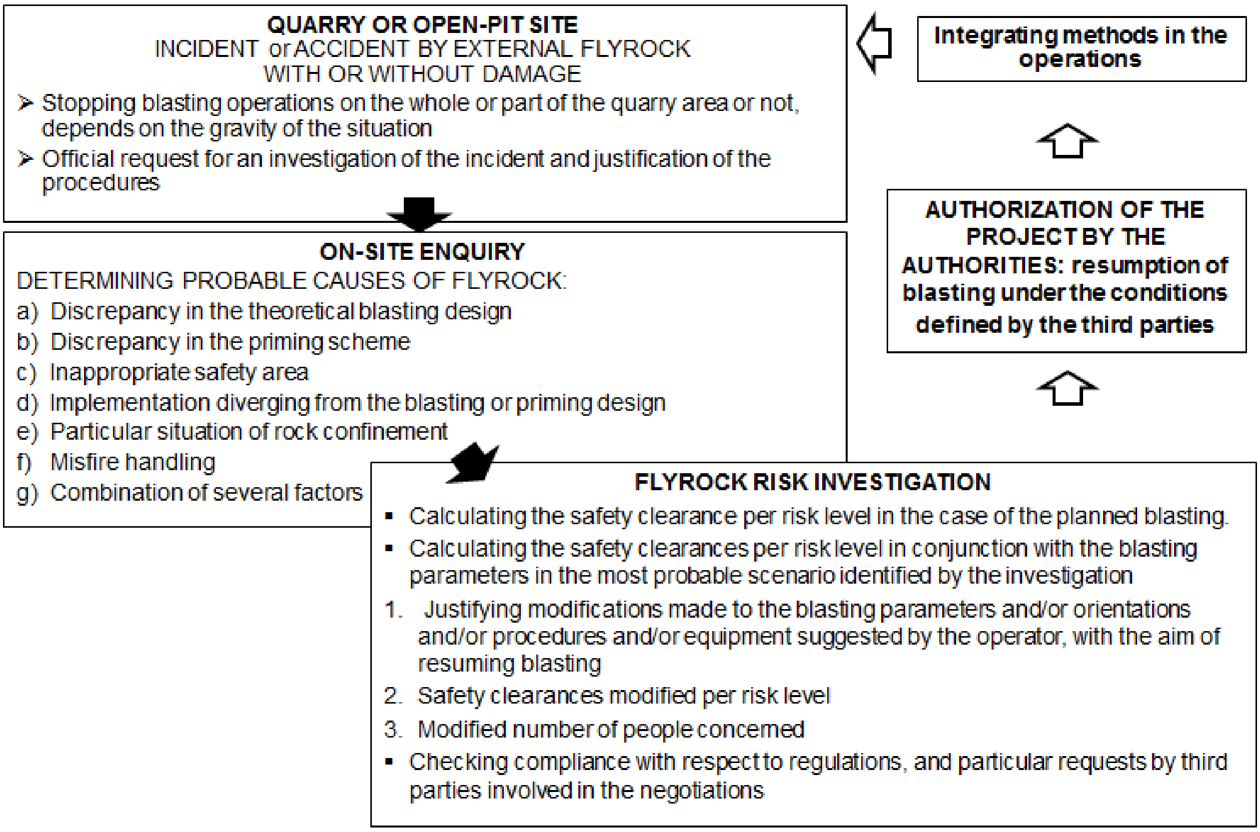

Diagram 4: analysis process of an accidental flyrock incident and conditions of blasting resumption.

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Justifying the resumption of blasting "under acceptable conditions"

Considering the urgency to provide a quantified flyrock risk report to the authorities and to be able to resume quarrying operations promptly, there is a great temptation to set up flyrock calculation and checking tools for every blast.

But the computational tools of isolated blasting operations, even very sophisticated ones, do not take into account the variation in the functioning of explosives, blasting geometries or charge confinement, there being so many different parameters which are the source of flyrock risks during operations.

In addition, day-to-day blasting calculations do not make it possible to anticipate future risks. This situation cannot satisfy the residents or the authorities, neither can it help the blasting organization to diminish their risk over the long term or to control costs.

Therefore, we have fine-tuned statistical studies resulting in calculating the definition of safety clearances depending on the initial flyrock area (originating from surface or the face).

Impact probabilities

Our studies use a method of calculation that takes into account the parameters and the associated variations: it was described in several international publications (see A. Blanchier, Quantification of the Levels of Risks of Flyrock, Proc. of ISEE Conference 2013).

By using the blasting parameters and data specific to the operation, the model makes it possible to determine successively:

- the distance of maximum flyrock for each hole depending on the level of probability;
- the probability that a person be impacted by flyrock from this hole;
- the annual probability of impact.

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Risk and acceptability

In classic risk analyses, the probability of an accident occurring and the effects of this accident on people are analyzed separately. These effects decrease in relation to the distance from the accident area.

In the case of accidental flyrock, the triggering factor is the blasting, meaning that this incident is not random. In addition, the effects of flyrock do not decrease with distance: a 200-gram projectile can be fatal at 20 m, as it can at 1,000 m.

Consequently, the approach to risk is noticeably different from those of other hazards: the effect of flyrock does not change markedly according to the distance; it is only the probability that changes.

In fact, the risk of fatality, being the product of the probability of an accident per the fatal probability in a defined danger zone, knowing that an accident has occurred, corresponds in our case to the probability of impacting a person at a given place, presuming that each impact is fatal.

These risks are compared to the risk of annual 'natural' mortality. In the case of France, the probability of death is given in Graph 5. The values are similar to those from other European countries.

The lowest annual risk of death (between 5 and 14 years of age according to French statistics) is in the region of 10^{-4}. Added-on risks that increase the probability of death by less than 1% are considered as being unacceptable. Levels of negligible risk can also be defined.

In this way, the NATO rulings integrated in the main into different European regulations accept a maximal risk of 10^{-6} for the external environment. These limits are reinforced for areas with a high-density population for which the maximal risk of 10^{-8} is generally accepted.

Flyrock leading to significant effects on people only leads to minor damage on infrastructures: The main risks are indeed risks of glazing breakage or damage to roofs or unsteady partitions.

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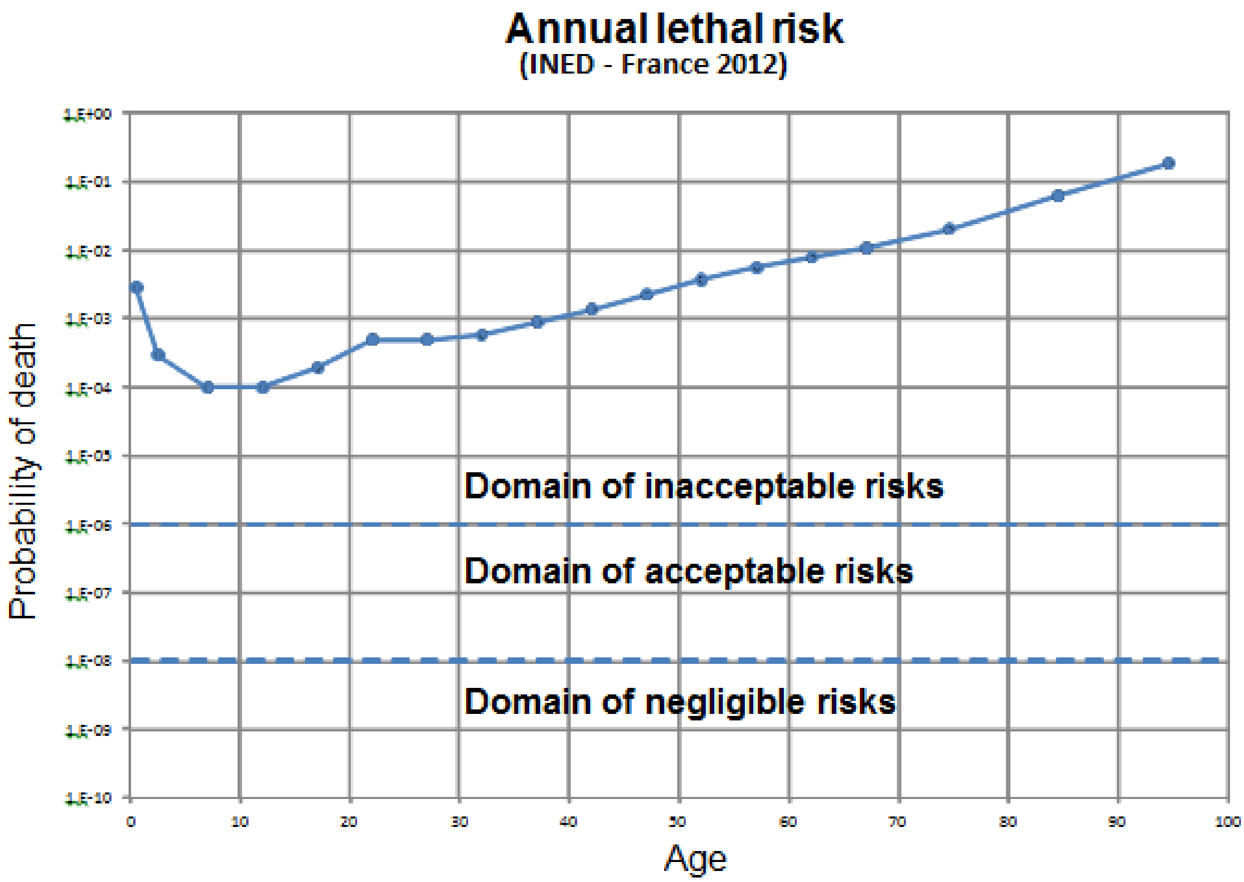

Graph 5: Probability of death in France - INED 2012

Utilization of identified flyrock causes under conditions of blasting resumption

Initially, our calculations were carried out in studies of incidents to compare the risks originating from the theoretical blasting design and those affiliated to the real blasting designs, which were reconstituted after investigation. We run a simulation of the situations under consideration based on gathered evidence: the data entered into the calculations is information from real blasting operations and it is understood that the logical continuation of the analysis consists of proposing adapted modifications to the procedures of these operations and/or to the blasting parameters, depending on the causes of the incident, with a quantified justification of their effectiveness.

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Proposals of conditions to resume blasting are all the more relevant, as the information retrieved on site is precise and thorough: the operator therefore may find it beneficial to cooperate as soon as the data-gathering begins, in order to then find an acceptable solution for the operations or the site.

Example 5: Houses bordering a site road and blocks projected onto the frontage approximately 200 m from the blast

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Any person having experienced an incident linked to blasting outside the operating site involving the intervention of a third party, apart from official representatives of the State, can testify to the complexity added to “crisis recovery”. Indeed, different actors become involved in the bounds of comprehensible safety requirements, but these are disconnected from the regulations and technical rules specific to our field.

Example 6: Blocks landing in a field and another impact on a dwelling more than 430 m from the blast

It is at this time that the independent design office that we are and the statistical method chosen, have their full use in establishing a climate of confidence, in justifying the technical blasting choices and in supporting the resumption of blasting operations, if this is requested.

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Anticipation of the risks for effective prevention

In the last ten years in France, we have seen methods for evaluating risk in industrial activities as a whole become generalized and harmonized, and this has led to flyrock risk studies becoming formalized in the initial stages of a project using explosives.

Our flyrock investigations inevitably begin by examining the actual or planned blasting conditions. This includes not only drilling equipment, the choice of explosives, priming and geometrical parameters, but also methods for evaluating these parameters and the teams' working methods.

Diagram 7 describes the process of a flyrock risk study in blasting operations in the case of extraction which is in progress or planned. It results in checking compliance with the legal blasting requirements established in the local context. It is not only the people concerned and their activities which are taken into account, but also the nearby facilities and infrastructures depending on their respective strategic importance.

These studies, undertaken in the early stages of the works when the operating schedule is being organized, when procedures are being drawn up, when the choice of equipment and the last negotiations with local public bodies and project supervisors are being discussed, reduce the risks and contribute to a better cohesion between all the stakeholders during the operational working phase.

At this stage, choices to be made often concern the orientation of the faces which would be advantageous to risk management when considering external activity, adapting the height of the benches, programming the closure of a road during the blasting phase, or more simply deciding on a higher top stemming after having checked that the charge does not lead to a blasting dysfunction.

Once the highest risk levels have been reduced during the operations, the blasting manager can focus on the residual hazards, such as the modification of confinement around the charges (through a variation in the quality of the rock or in its structure, for example), a change of explosives or initiation system, or an operator or a type of equipment.

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When modifications call the calculation hypotheses into question, prompt, complementary investigation is necessary.

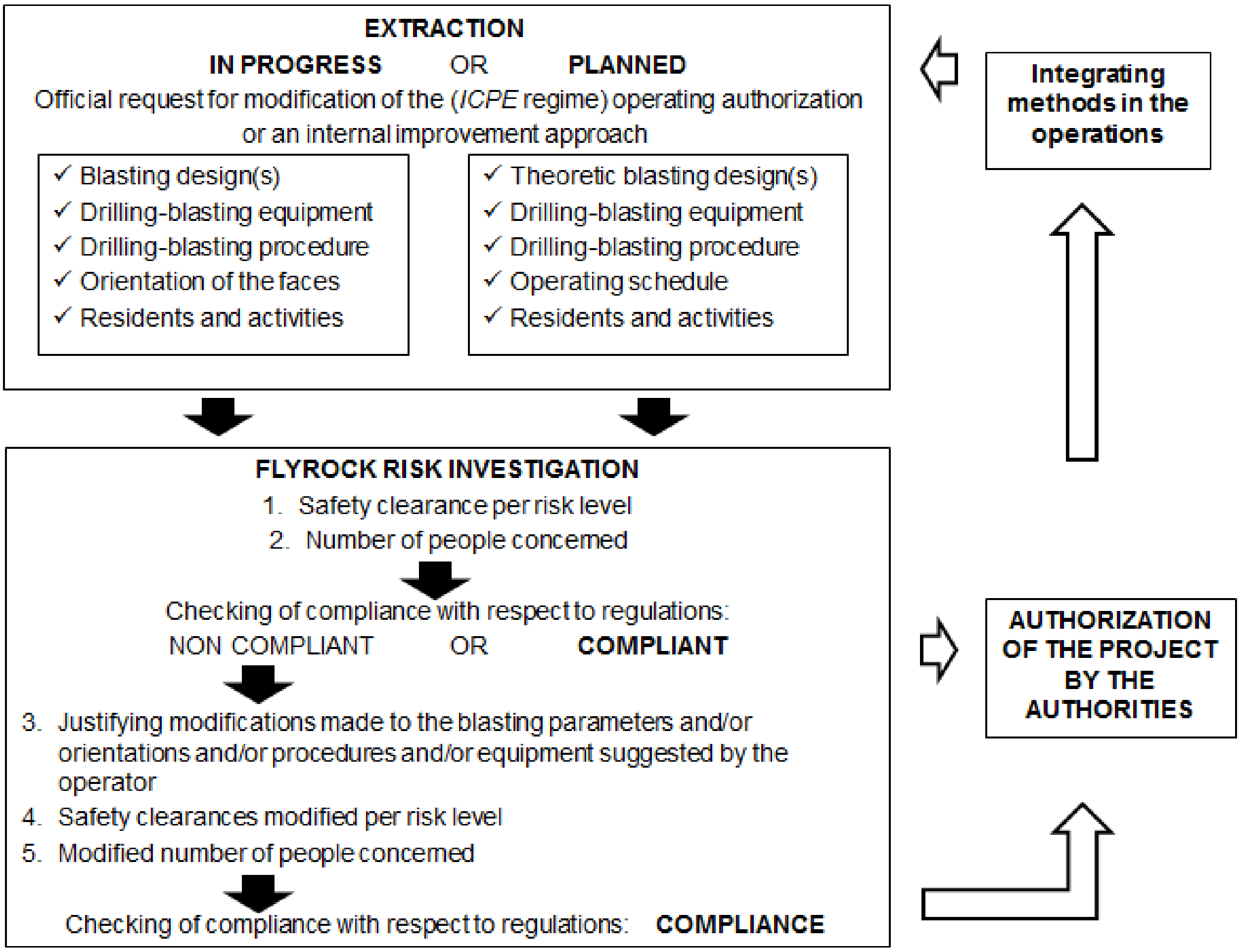

Diagram 7: Process of flyrock risk study and blasting conformity study with respect to regulations pertaining to environmental risks.

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Conclusion

Without the experience of detailed analysis of the origins of flyrock beyond the safety zone, the work relating to the prevention and justification of controlling the risks would have been much more difficult to promote in critical blasting situations.

Declaring an incident such as flyrock, analyzing the causes of the incident and justifying a new organization, are industrial processes that are commonly used in other sectors.

Thanks to accident prevention practices in the pyrotechnical sector, there is a very small number of accidents in our profession, in the opinion of our parent ministries themselves. Flyrock does not occur frequently, however, each time it does take place, it can have significant consequences and occur over a large distance. Consequently, it has a strong impact on the perception of explosives use.

With risk level computational tools now being available, no one can be satisfied with studying these cases without working on a daily basis towards their prevention.

Over and above dealing with a specific incident, preventing flyrock risk requires that this aspect of the environmental impact of blasting be explicitly integrated into blaster and blasting designers training, as well as into regular meetings on work safety organized in accordance with labour legislation.

All technical elements that make it possible to improve the control of blasting parameters and confinement can contribute to reducing flyrock frequency. However, our experience enables us to assert that an increase in blasting technicality (e.g. carrying out 3D surveys of the faces coupled with measuring drilling deviations, or putting in place electronic priming that are easier to implement and presenting results on a more regular basis) does not solely guarantee an absence of flyrock, neither does it alter its range of projection. It is necessary to identify situations at risk in the early stages and to work in anticipation of eliminating occurrences at a critical range.

Anne Charline SAUVAGE,
EGIDE Environnement Sarl

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Meeting of the Explosives Working Group

This year's annual meeting of the Explosives Working Group took place in Brussels on 17th October 2016 with the EFEE taking part as a permanent observer as in the past years. The Explosives Working Group is coordinated by the Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs of the EUROPEAN COMMISSION with its head Federico Musso. The following points were part of this year's agenda:

- Update on the implementation of the Action Plan on Enhancing the Safety of Explosives (DG HOME)

This working group is compiling measures for improving and enhancing safety when handling explosives. When looking at what has happened in the past month, this is becoming more and more important. The industry regards it as crucial to take part in the process actively and attentively so that decisions on the required measures are practice-oriented as far as possible.

- Report on the "Explosive Quality Documentation" (EXQUDO) project

The EXQUDO (EXplosive QUality DOcumentation) project is currently being developed at the instigation of Spanish authorities. It shall serve as an instrument for comprehensively documenting the handling of explosives starting with the manufacturing process, complete information of transport, storage until their final application. This way all companies being part of this cycle shall be included in this system. From the EFEE's perspective, especially the companies working in Spain shall have a very close look at this process and actively take part in it. If not, it could develop in a direction having a questionable effect and possibly not being necessary.

- New recast Directive 2014/28/EU of 26th February 2014
  Tour de table in which all Member States will be asked to provide an update on the state of transposition in their respective countries Update on the re-notification process of Notified Bodies under the new Directive

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In accordance with the agreements made, member states were to transpose Directive 2014/28/EU into national law by 20th April, 2016. During a survey session, representatives of the various member states were asked to report on the state of implementation. Thus it became clear that some of the member states had not completed the process of implementation yet. In this context, the process of re-certification of the Notified Bodies for Explosives also plays an important role because it is not possible without implementing Directive 2014/28/EU. This is of great importance for explosives manufacturers because the Notified Bodies are in charge of type examination being a prerequisite for CE certification.

- Validity of certificates when Conformity Assessment Bodies lose their notification or cease their activities

Overall, it can be observed that the number of Notified Bodies declined over the past few months for different reasons. On the one hand, the member states have not or not yet established the required conditions so that so that no consequent steps can be made. On the other hand, some Notified Bodies have ceased to operate for economic reasons. This raises the question how to deal with approval for explosives granted by these Bodies, being of great interest for those manufacturing and those applying explosives. It was agreed that documentation of these assessments is administered by the member states and it is assured that it can still be accessed in the future.

- Report on first meeting of the new AdCo on Explosives for Civil Uses

This working group is currently mainly dealing with market surveillance issues. EFEE will be part of this working group as well.

- Implementation of Commission Directive 2008/43/EC setting up a system for the identification and traceability of explosives for civil uses
  Presentation by the Explosives for civil uses Task Force: "Outcomes of the 2nd survey on the Mapping of the implementation of the Directive in Europe in 2016"

During this item of the agenda, UEPG and EFEE each presented a survey on Track and Trace of Explosives by the end users (blasting companies). In this context we would like to thank all EFEE members for taking part in this survey. You can find its results on the EFEE home page.

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- International developments: update on the activities of the UN Committee of Experts on the Transport of Dangerous Goods and on the Globally Harmonized System of Classification and Labelling of Chemicals, Sub-Committee of Experts on the Transport of Dangerous Goods, regarding the development of an international traceability system

Based on the Track and Trace System for Explosives introduced in the EU over the past three years, it is considered on UN level to implement an international system making it possible to backtrack explosives worldwide. This system shall be based on the EU version meaning that it will be applied e.g. in the US, North America as well as in the Arab world.

- Regulatory challenges posed by Mobile Explosives Manufacturing Units (MEMUs)

On 18th January 2014 there was a grave accident in Norway involving a MEMU. A fire in the vehicle's engine compartment leads to an explosion completely destroying the vehicle. Only because all persons involved acted very cautiously, no one was harmed. In order to prevent any such accidents in the future, it was suggested by the Norwegian representative to form a joint working group looking at safety issues when using MEMUs. Rules and regulations differing from country to country shall be compiled resulting in a harmonized recommendation.

Finally, we as EFEE can see once more that the contents of the meeting as well as the presentations and discussions are very much of importance for our members. By being part of this committee, we can actively accompany the development and arrangement of processes thus representing the interests of our members.

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All voluntary help is welcome

Peccs – the Pan European Competency Certificate for Shot firers / Blast designers by EFEE

On a sunny morning of the 18th of October in Oslo 8 partners from different places of Europe gathered to finally give wind to the wings of EFEE shot firer education project. As we have talked about the project for several years now, most people already know that it is aimed to create a unified certificate to enable shot firers mobility around Europe. Now that European Commission has financed the project through Erasmus plus programme it is finally possible to make the dream come true.

The partners gathering in Oslo were already familiar with following tasks and duties. A lot of work to do until we have materials ready for courses and then courses to teach future teachers in order to start giving out a EFEE shot firer certificate. Still there were decision to be made besides signing contracts and getting to work. A framework of materials was decided, the exercises for the materials and the quantity of examining questions were also agreed upon. In overall it was a successful meeting were a lot of details were discussed. But a significant issue was noticed – the materials need to be modernised.

In order to reach out to as many people as possible, we created a web page. All the materials, which we are going to work with in order to create courses, are available there to download for free. The address for the web page is www.shotfirer.eu - and we ask for the readers now to go and look at the materials. There are different subjects, all connected to blasting. Only Tunneling is made from the scratch so it is not up there yet.

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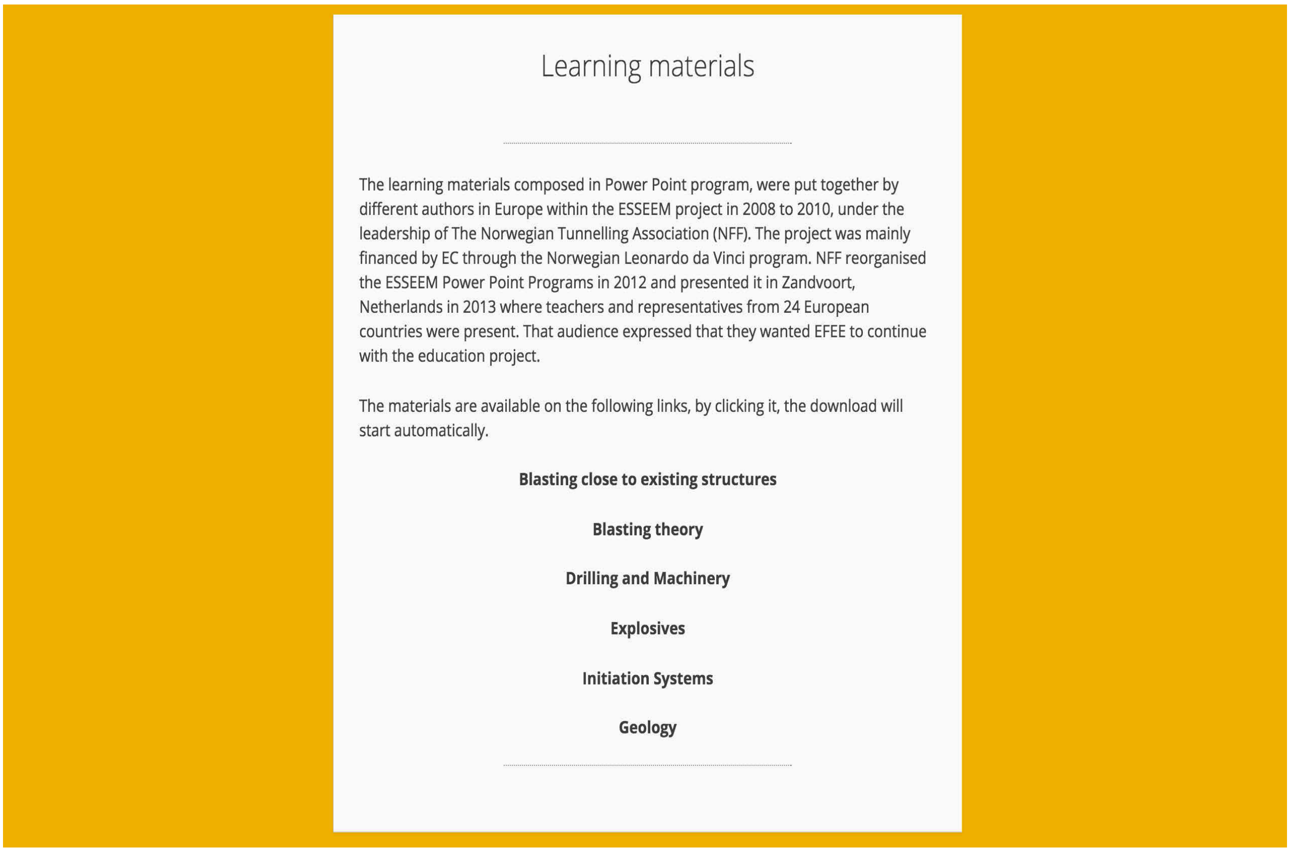

Learning materials

The learning materials composed in Power Point program, were put together by different authors in Europe within the ESSEEM project in 2008 to 2010, under the leadership of The Norwegian Tunnelling Association (NFF). The project was mainly financed by EC through the Norwegian Leonardo da Vinci program. NFF reorganised the ESSEEM Power Point Programs in 2012 and presented it in Zandvoort, Netherlands in 2013 where teachers and representatives from 24 European countries were present. That audience expressed that they wanted EFEE to continue with the education project.

The materials are available on the following links, by clicking it, the download will start automatically.

Blasting close to existing structures

Blasting theory

Drilling and Machinery

Explosives

Initiation Systems

Geology

So we ask everyone who is a specialist in this area of expertise, please visit our web page, and if you find something that needs a strong intervention in these materials, please send us a remark about it to info@shotfirer.eu As the countries differ somewhat in their way of doing things, it would be sorrowful, if we realise that there are big shortages after a lot of work is already been done. All comments would be useful before the end of January, then we would still have time to implement the changes.

The team of PECCS appreciates every input highly, thanking you in advance.

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PECCS by EFEE

Pan-European Competency Certificate for Shotfirers by European Federation of Explosive Engineers

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PECCS

EFEE

With this project called PECCS – Pan European Competency Certificate for Shot firer/blast designers, EFEE's (European Federation of Explosive Engineers) aim is to create a course, according to the valid European Shot firer Requirements, for a standardised assessment of technical competencies for the shot firer / blast designer profession in European Union.

The Course will be based on a material with 6 chapters from a previous project and an additional chapter will be added about blasting tunnels, the materials will be worked through and modernised. During this project all partners collaborate to add exercises, exams to the materials and all this will be put together for a course which also will be available as online course in order to reach as many people as possible.

The outcomes of this project: the materials with examining questions, exercises, the course based on these materials and the online courses, will be available on the internet for free on www.shotfirer.eu. In order to maintain a good quality and appropriate educational outcome of the courses we will create a Guidebook based on the learning material for trainers and shot firers who want to learn independently online.

The project is funded by European Commission under the Erasmus+ programme.

Erasmus+

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New EFEE members

EFEE likes to welcome the following Members who recently have joined EFEE

Corporate Members

Chemical & Mining Industries co., Jordan
http://cmiltd.bloombiz.com/

Individual Members

Karl Kure, KURE-FJELLSPRENGNINGSTEKNIKK, Norway

Catherine Aimone, Aimone-Martin Associates, LLC, USA

Jerry L. McMahan, McMahan Drilling and Blasting, Inc., USA

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Upcoming Events

ISEE 43rd Annual Conference on Explosives and Blasting Technique
January 29 – February 1, 2017
Orlando, USA
www.isee.org

IExpE AGM and Conference 2017
Monday 3rd April 2017 and Tuesday 4th April 2017
QHotels, Norton Park, Sutton Scotney, Winchester, SO21 3NB,
please contact Vicki Hall by email: secretariat@iexpe.org

World Tunnel Congress 2017
June 9-16, 2017
Bergen Norway
www.wtc2017.no

EFEE 9th World Conference on Explosives and Blasting
September 10-12, 2017
Stockholm, Sweden
www.efee.eu and http://efee2017.com/

Fragblast 12
2018
Luleå, Sweden
http://www.ltu.se/research/subjects/Mining-and-Rock-Engineering/Nyheter/FRAGBLAST-to-Lulea-2018-1.143098?l=en

EFEE 10th World Conference on Explosives and Blasting
2019
Helsinki, Finland

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EFEE
9th WORLD CONFERENCE
THE BREWERY,
STOCKHOLM, SWEDEN
BERGSPRÄNGNINGSKOMMITTEN
STOCKHOLM 2017
10th – 12th September
The World Conference on Explosives and Blasting is an excellent platform for becoming familiar with the current developments in the blasting sector.
Stockholm provides an excellent arena for experts from all over the world to extensively exchange their experiences in the home of Alfred Nobel.
The conference includes:
- Large Industry Exhibition
- Technical Programme Featuring
Blast vibrations
Explosives
Blasting experiences,
Demolition etc
Instrumentation
- Partner Programme
- Industry Specific Workshops
- Gala Dinner at Alfred Nobel's Factory
Supported by
EPC GROUPE
International Society of Explosives Engineers
Lubrizol
ORICA
For further details visit www.efee2017.com
or email info@efee2017.com

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43RD ANNUAL 43 CONFERENCE ON EXPLOSIVES & BLASTING TECHNIQUE

January 29 – February 1, 2017
Orlando, Florida USA

Deadlines

May 13, 2016
Last day for submission of abstracts.

June 15, 2016
Notification of abstract acceptance.

August 15, 2016
Last day to submit completed papers.

November 1, 2016
Notification of final acceptance of papers.

December 1, 2016
Conference registration deadline for authors.

January 29 - February 1, 2017
Annual Conference - presentation of papers.

Call for Papers

The International Society of Explosives Engineers is issuing an industry wide Call for Papers to be presented at the 43rd Annual Conference and published in the Conference Proceedings.

Ideas should be submitted in the form of a 200-400 word abstract (summary) highlighting the major points of your 8 to 10 page paper. Papers may not be commercial in nature.

Abstracts must be submitted by completing the online abstract submission by May 13, 2016. The submission site, guidelines, instructions and deadlines can be viewed at www.isee.org. Please contact us if you do not receive confirmation within two weeks of submitting your abstract.

Abstracy 13 line Mat Dead 2016

International Society of Explosives Engineers
www.isee.org | 440.349.4400

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STOCKHOLM 2017
10th - 12th September

BERGSPRÄNGNINGSKOMMITTÉN

1st Circular - Call for Papers

President's Foreword

At the beginning of my foreword and on behalf of the European Federation of Explosives Engineers - EFEE I would like to invite you all to our next 9th World Conference on Explosives and Blasting which will take place in Stockholm from 10th - 12th September 2017.

The EFEE World Conference on Explosives and Blasting has established itself as one of the most important international blasting events. It all started in year 2000 with 1st EFEE World Conference in Munich and after Prague 2003 it continues on regular basis with a 2 years period. All eight of our previous EFEE World Conferences with great success proved how really important events where we can mutually share our different experiences and skills are.

We expect the EFEE 9th World Conference on Explosives and Blasting to be as successful as our previous World Conferences and will attract participants and delegates not only from Europe but also from all over the World. The Conference is organised in cooperation with the Swedish national association - Swedish Rock Construction Committee (Bergsprängningskommittén).

Stockholm is the cultural, medial, political, and economical centre of Sweden. It hosts the annual Nobel Prize ceremonies and banquet at the Stockholm Concert Hall and the Stockholm City Hall. The earliest written mention of the name Stockholm dates from 1252, by which time the mines in Bergslagen made it an important site in the iron trade. Stockholm is located on Sweden's south-central east coast, where the freshwater Lake Mälaren — Sweden's third largest lake — flows out into the Baltic Sea. The central parts of the city consist of fourteen islands that are continuous with the Stockholm archipelago. Over 30% of the city area is made up of waterways and another 30% is made up of parks and green spaces. The city's oldest section is Gamla stan (Old Town), located on the original small islands of the city's earliest settlements and still featuring the medieval street layout. Stockholm is one of the cleanest capitals in the world. The city was granted the 2010 European Green Capital Award by the EU Commission; this was Europe's first "green capital".

The most important fact which has to be highlighted in relation to our Conference - is that on 21st of October 1833 was born in Stockholm Alfred Bernhard Nobel the Swedish chemist, engineer and innovator worldwide known for inventing the dynamite. During the Conference the participants and spouses can choose various options which is offering attractive Stockholm for sightseeing and visit of different interesting places.

EFEE 9th World Conference on Explosives and Blasting 2017 will take place at the Brewery - Conference Centre Stockholm a short walking distance from city centre. The venue offers unique conference room and halls, is bright, spacious and modern with excellent loading and logistic possibilities coupled with great interior structural design, which enables a natural flow for the participants. During breaks, participants can enjoy some fresh air out on the 40-meter long terrace or just savour the breath-taking panoramic view of the city centre of Stockholm and the sparkling waters surrounding it. Experiences like these really confirm the feeling of being in one of the best conference spaces in Stockholm.

The Conference will start on Sunday 10th September with registration, workshop and welcome reception and will continue on Monday 11th September and Tuesday 12th September with technical sessions and exhibition. The Gala dinner is planned for Monday evening and will take place at Winterviken in former Alfred´s Nobel factory. Superb building that dates back to 1891 with wooden beams and classic features will host this event. In accordance with experiences from our previous eight Conferences we expect attendance over 450 delegates and professionals from over 50 different countries with a large industry exhibition. This will enable to create really unique forum for meetings and discussions of professionals from tunnelling, construction, demolition, quarry as well as mining industry. We have to share mutually everything new, good experiences - as well as bad experiences to avoid mistakes in the future and improve the techniques. It applies to all of us - explosives end-users, manufactures, drilling and blasting operators, consultants and contractors.

Finally please let me point out one more time the importance of EFEE 9th World Conference on Explosives and Blasting and I´m really looking forward to meeting you all in Stockholm from 10th - 12th September 2017.

Igor Kopal
EFEE President

Organised by the European Federation of Explosives Engineers

EFEE

About the Conference

The EFEE World Conference has established itself as one of the key international explosives forums. Our Lyon conference in 2015 was attended by over 450 delegates from 55 countries with a large industry exhibition.

The conference includes technical presentations, an industry exhibition, educational workshops, welcome drinks reception, gala dinner and partner activities. The event draws attention from explosives users, manufacturers and equipment for drilling operations as well as researchers and professionals involved in the construction and mining industry.

Our Objectives

To bring together explosives and blasting professionals to share knowledge, network and develop the industry. The conference will provide us with an excellent forum to share the latest developments and technical practices combined with a fantastic opportunity to network with peers throughout the world.

Technical Programme

The technical sessions will be divided into key themes. Authors will present their papers in English to an audience in a lecture style format with some time for questions from the audience.

Each presentation will run for 20-25 minutes which will be overseen by the Program Committee. Those papers of high quality that cannot be presented due to the time constraints of the conference may be shown in a specific poster session adjacent to the exhibition area. The conference will focus on practical papers on the following themes:

- EU Directives and Harmonisation Work
- Health, Safety and the Environment
- Blast Vibration and Seismology
- Technical Development
- Shot Hole Development
- Blasting Work Experiences
- Construction Blasting
- Clearance and Decontamination
- Management Blast Design
- Explosive Detection for Security
- New Applications and Training

Call for papers

Members and non-members of EFEE are invited to submit abstracts for papers to be presented at the Conference. All accepted papers will be published in the conference proceedings which are available in both hard copy and USB formats.
Authors **must** be prepared to present their papers in person and in English. Each participant including authors and speakers are expected to pay the full registration fee.
Please note that papers **must not** be of a commercial or advertising nature.

Abstracts

Authors are invited to submit an abstract in English. The full paper **must** be submitted and **presented in English**. An abstract condenses a proposed paper by summarising and highlighting its major points into 200 - 400 words. The abstract should be a written summary of work done on the project, what conclusions have been drawn and recommendations made as a result of the project. The proposed paper should **not** be of a commercial or advertising nature.

Author's paper formatting and presentation guidelines as well as our online submission form are available on the conference website: www.efee2017.com.

Submit your abstract online, visit www.efee2017.com

Official Languages

The official language of the conference is **English**.
[A translation service will not be provided.]

Publication Policy

All accepted papers received by the deadline and presented at the conference will be published in the conference proceedings in both USB memory stick and printed formats. Proceedings will be distributed to all registered delegates at the conference.

Exhibition

A large industry exhibition will be held in parallel to the technical presentations. The exhibition provides an ideal opportunity for users of explosives, consultants, suppliers and manufacturers to demonstrate their latest developments to a wide cross section of the industry.

If you are interested in exhibiting at the conference please indicate your interest by emailing exhibition@efee2017.com or by visiting http://www.efee2017.com

Sponsorship

There are a variety of sponsorship and advertising opportunities available which will raise your company profile at this international event. For further information on sponsorship please email exhibition@efee2017.com

Offsite Workshop and Site Visit

For the first time in EFEE Conference history the workshop will include a site visit to the biggest road construction project in Sweden - E4 The Stockholm bypass – Förbifart Stockholm.

E4 The Stockholm bypass – Förbifart Stockholm is a new route for the European highway (E4) past the Swedish capital connecting the southern and northern parts of Stockholm.

This essential new section of Stockholm network is 21 km long with over 18 km being routed underground, to reduce the impact on Stockholm's natural and cultural environment, requiring a huge amount of drilling and blasting work using the very latest research and technology.

After this superb visit we will have the unique opportunity to discuss the project with the client, contractors and consultants including key areas of the design, environmental impacts, challenges in blasting and much more.

The workshop will be conducted in English only. Further information on the workshops will be available on our website: http://www.efee2017.com

Partner Activities

A varied and interesting selection of activities will be available, giving visitors the opportunity to see Stockholm's spectacular Drottningholm Palace, old town, beautiful lakes, scenery and culinary delights.

Venue Information

The 2017 EFEE conference will take place at The Brewery a short distance away from Stockholm's beautiful city centre and overlooking the Mälaren water. The Brewery is in close proximity to public transport making it a easy to explore this stunning capital. High speed internet access is available throughout the venue.

We are working in association with the Hilton Stockholm for accommodation which is a short walk from the venue.

http://m-b.se/en/

Location

To view the location please visit the Google map link:
https://goo.gl/maps/zS6Pmgm4TAP2

Registration Fee

The early bird registration fee for participants will be:

Delegate (Non EFEE Member): 6,800 SEK (excluding tax)
Student: 500 SEK (excluding tax)
EFEE Members: 6,100 SEK (excluding tax)
Including: Individual, Company and Associate Members - one discounted registration only.
EFEE Corporate/National Members: 5,400 SEK (excluding tax)
Corporate/National Members are entitled to one discounted registration only.

All participants including authors are expected to pay the registration fee.

Participation

If you are interested in attending the conference please register at **http://www.efee2017.com**

Accommodation

There are many accommodation options in Stockholm to suit all preferences and budgets. Accommodation has been held at the adjacent Hilton Stockholm will be available to book through the conference website. To view all of the local accommodation options please click on the hyperlink below:
http://www.booking.com/city/se/stockholm.en-gb.html

Conference Committee

Heinz Berger (Chairman)
José Carlos Gois
Roger Holmberg
Donald Jonson
Jari Honkanen
Johan Finsteen Gjødvad
James Tyler

Deadlines

Abstracts & Papers

10 February 2017	**Deadline for submission of abstracts**
10 March 2017	**Notification of acceptance of abstracts**
31 March 2017	**Distribution of 2nd Circular with Preliminary Programme**
10 May 2017	**Submission of final papers**
10 June 2017	**Final notification of acceptance of paper**

Registration

January – July 2017	**Early Bird Registration**
August – September 2017	**Standard Registration**

Technical Committee

Roger Holmberg (Chairman), Sweden

After graduation 1972 he was working as Blasting Research Engineer for the Swedish Detonic Research Foundation (SveDeFo), performed research in many quarry and mining operations and wrote computer codes for bench, tunnel blasting and thermodynamic codes for explosives performance calculations. Roger was President for SveDeFo 1982-86. Roger has been involved as a blasting consultant in many parts of the world, for construction and mining companies and for governmental bodies. He was one of the founders of the International Society of Rock Fragmentation by Blasting. He paid four years' service as a Board of Directors of the Int. Society of Explosives Engineers (ISEE) and two years as President for the European Federation of Explosives Engineers (EFEE). Roger has had various positions at Nitro Nobel, Dyno Nobel, Orica and Nitro Sibir. Today he is working as Secretary General for EFEE. Roger is author and co-author of over 100 publications.

Robert Farnfield, UK

After graduating from Leeds University with a degree in Mining, Rob carried out research into the environmental impact of surface coal mine blasting for more than 10 years with funding from the UK's National Coal Board Opencast Executive. Rob then moved on to become a lecturer in Mining Engineering at Leeds and completed a Ph.D. in the environmental impact of surface mine blasting. For the last 17 years he has worked for EPC-UK, initially as Technical Services Manager dealing with all aspects of the use of explosives. In 2007 he was appointed Technical Services Manager for EPC Group Area B with a watching brief over technical matters in Northern and Eastern Europe. He is now Head of Explosives Engineering for EPC-UK. Rob is a Member of the UK's Institute of Explosives Engineers and The International Society of Explosives Engineers. Rob has published many papers relating to explosives engineering and is a well-known speaker throughout the industry.

Finn Ouchterlony, Sweden

Finn Ouchterlony graduated from the Royal Institute of Technology in Stockholm, Sweden in 1980 (Tekn.Doktor) and received his honorary degree from Montan-universität Leoben (Dr.mont.h.c.) in 2007. His skills include fracture mechanics, blast damage and blast fragmentation

From 1967 to 1984 he was employed by Atlas Copco and worked mainly at the Swedish Detonic Research (SveDeFo) labs in Vinterviken. During 1987-1993 he was head of the SveDeFo labs, during 1993-2003 head of the blasting research at SveBeFo and 2003-2010 head of the Swedish Blasting Research Centre, Swebrec. He has held academic positions at Luleå Univ. Technology (1985-88), Yamaguchi Univ., Ube, Japan (1991-92), Luleå Univ. Techn. (2003-2010) and Montanuniversität Leoben, Austria (2011-2014).

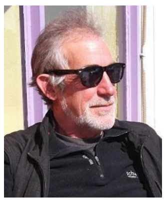
Finn Ouchterlony was co-author of the EU funded projects "Downhole Abrasive Jet Cutting Operations in Quarrying, Mining and Civil Engineering" (BE-1671; 1996-99) and together with Prof Peter Moser of "Less Fines Production in Aggregate and Industrial Minerals Industry " (GRD-2000-00438; 2001-2004). He has a long experience of working with industry related explosives and blasting projects.

He was the co-ordinator of the ISRM working group WG on Fracture Toughness Testing of rock, which led to suggested methods in 1988. He is a member of the editorial boards of the journals: i) Blasting and Fragmentation (ISEE), ii) Int. J. Rock Mechanics and Mining Sciences and iii) Rock Mechanics and Rock Engineering. He is a member of the int. organizing committee of the triennial Fragblast symposia. He discovered the Swebrec distribution during the Less Fines project. This led to the Douglas Hay award in 2005.

Jörg Rennert, Germany

Jörg Rennert (Dipl. –Ing. –Päd) is a German Citizen, born May 22, 1965, in Roßlau, Germany. His educational achievements include a high-school graduate in steelworking for metallurgical engineering and a diploma: Dipl.-Ing.-Päd. from the Technical University of Dresden. Jörg's professional career includes being a steelworker for metallurgical engineering in the steelwork in 1985. A scientific employee of the Technical University of Dresden in 1991. Assistant professor at Sprengschule Dresden GmbH from 1992 to 1998. Jörg progressed to managing director of The Dresdner Sprengschule GmbH and leader of business fields Blasting Technology and Pyrotechnics in 1998. In 2001 Jörg became president of the German Blasting Association (Deutscher Sprengverband e.V.). In 2010 he was elected as vice president of EFEE and was the president of EFEE between 2012 and 2014. Since 2008 Jörg is also the Chairman of the EU-Directives in EFEE.

Jerry Wallace, US



Jerry R. Wallace came into blasting naturally – as a 5th-generation logger in the U.S. Pacific Northwest. A licensed professional blaster for over 35 years, Jerry founded Wallace Technical Blasting, Inc. in 1992. The firm specializes in close-in civil construction blasting, and now includes Jerry's two sons who are earning their own stripes in the industry. Jerry studied Forest Engineering at Oregon State University, including coursework in explosives engineering. He has taught numerous professional blasting courses including within the University of Washington (Seattle) Professional Engineering Program. An active ISEE member since 1984, Jerry served on the ISEE Board for 12 years including a two-year stint as president. Jerry is one of the many co-authors of the 17th and 18th editions of the ISEE Blasters Handbook. Jerry has served on several governmental advisory committees dealing with explosives and industrial safety laws and regulations in the U.S. Jerry has been active in EFEE since the first conference in Munich in 2000, has attended each of the 7 previous EFEE conferences and presented papers at 3 of them.

Previous Conferences

1st World Conference
Munich, Germany 2000

2nd World Conference
Prague, Czech Republic 2003

3rd World Conference
Brighton, UK 2005

4th World Conference
Vienna, Austria 2007

5th World Conference
Budapest, Hungary 2009

6th World Conference
Lisbon, Portugal 2011

7th World Conference
Moscow, Russia 2013

8th World Conference
Lyon, France 2015

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Tyler Events
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82 Loughborough Road,
Hoton, Leicestershire,
LE12 5SF, UK

Telephone: +44 (0) 1509 631 530

http://www.efee2017.com