EFEE

NEWSLETTER

In This edition:

New Standardisation Tasks under the European Explosives Directive: Electronic Detonators, On-site Mixed Explosives

Development of nitrogen free environmentally friendly blasting explosive

and the Photoreportage of EFEE 10th World Conference in Helsinki

...and much more!

NEWSLETTER

November 2019

We in EFEE hope you will enjoy the present EFEE-Newsletter. The next edition will be published in February 2020. Please feel free to contact the EFEE secretariat or write to newsletter@efee.eu 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 an upcoming Newsletter edition

or any other matter.

Doru Anghelache, Chairman of the Newsletter Committee and the Vice President of EFEE

and Teele Tuuna, Editor of EFEE Newsletter - newsletter@efee.eu

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Dear EFEE members,
the President´s voice

The 10th conference on Explosives and Blasting was successfully held in my home town Helsinki, Finland in September. I wish to thank all 485 people and 57 companies from 51 different countries attending the event as delegates and exhibitors, you made the conference successful in the end! This is a new EFEE record and all events and the exhibition area were sold out. I must apologize for those who did not get tickets to our gala or the post conference tour. Due to excess demand we increased the number of seats by 10% above original maximum for the gala but there were still not enough seats for everyone and the kitchen of the venue was already performing on its limits. We arranged a post conference excursion for the first time in EFEE history. The original maximum number of tickets was set to 50 which we increased also by 10% due to high demand but there was probably another 50 who had to be left out. Unfortunately it was not possible to take more people into a working explosives factory due to safety reasons. I am sure though that everyone respects and accepts safety aspects within explosives industry.

I was more than delighted to receive many emails from conference delegates after the conference, thanking us for the event and congratulating for a successful conference.

On the last day of the conference I heard many positive comments saying for example that the technical presentations were really interesting, all arrangements and the exhibition area worked well, food was good, workshop and excursion were interesting and also program including the fireworks at the gala were highly appreciated. There were many people working hard for the conference and these words warm our hearts.

We thrive to constantly develop the quality of our conferences at EFEE, so everyone who attended the conference will get a detailed survey to be able to give us feedback on our efforts. I urge all of you to take a little time and give us your opinion. We would very much appreciate any suggestions on where we could still improve and we will of course take all good ideas and suggestions into consideration during the planning stages of our 11th conference in 2021 in Bucharest.

I'm also delighted to announce that it was decided in our Council meeting just prior to the conference, that the 12th EFEE conference will be held in Dublin, Ireland in 2023. I would like to congratulate Ireland and IMQS for putting in a winning suggestion for this event! It was also decided following an excellent presentation that Maastricht, Netherlands will host the 13th EFEE conference in 2025. My personal thanks to both countries for their presentations and suggestions and good luck to both Dublin and Maastricht!

Another important moment to highlight is that Rolf Schillinger from Germany was nominated as EFEE´s 4th honorary member in Helsinki and he was awarded the gold plated EFEE pin as a symbol of this status during the opening ceremony of the conference. There is more information on Rolf and his impressive career later in this issue but one of the main achievements of Rolf was to start this series of EFEE conferences by actively participating in organizing of the 1st conference in Munich in year 2000. Thank you Rolf for starting this great tradition and my sincere congratulations to you! We will do our best to nourish our conferences and to develop this tradition further to meet the future expectations and requirements from our members and guests.

Jari Honkanen, President of EFEE

"...with our lovely gala dinner hostess and entertainer mentalist Noora Karma"

Rolf Schillinger honorary member nomination

Rolf Schillinger is a leading expert in the blasting field with international recognition in the explosive and blasting industry.

In addition, he is a lecturer in blasting techniques in Germany and Austria. He was a former member of the study group Blasting Vibrations in Germany from 1992 until 1996. He is a member of the Technical Scientific Society, Mining Association of Austria, since 1997 and was a lecturer for blasting techniques at the Department of Mineral Resources & Petroleum Engineering University of Leoben, Austria, from 1996 until 2011, and guest lecturer at the Department of Mineral Resources & Petroleum Engineering, Chulalongkorn University, Bangkok, Thailand, in 2013.

He has conducted numerous official environmental expertise commissioned by authorities, insurers, underground mines and quarries in the field of blasting works and blasting vibrations.

Rolf has also authored more than 100 technical papers in the field of blasting works, blasting vibrations and environmental protection. He has served as a member of the Board of Directors of the German Society of Explosives Engineers from 1995 until 1999, and as the President of the European Federation of Explosives Engineers (EFEE) from 1998 until 2000. At this time, he was the organiser of the 1st World Conference on Blasting Techniques, in Munich in 2000.

He has also served on the Board of Directors of the International Society of Explosives Engineers.

(ISEE), Cleveland, Ohio, from 1996 until 2003.

During this time, his main activities were concentrated around Safety and Environment and International Affairs.

According to Rolf, the philosophy for the great circle of success is based on: Consulting – Conception – Implementation – Customer Liaison and support in Continuous Improvement.

- 1970 Blasting license surface. Independent contractor since 1972.
- 1980 Blasting license underground.
- 1989-1998 EFEE Board of Directors (European Federation of Explosives Engineers).
- 1995-1999 DSV Board of Directors (German Explosive Engineers Association).
- 1998-2000 EFEE President and Organizer of the 1st World Congress for Blasting Technology, Munich, 2000.
- 1996-2003 ISEE Board of Directors (International Society of Explosives Engineers)
- 1996-2003 Chairman International ISEE Committee on Safety and Environment and International Affairs.
- 2003 International Society of Explosives Engineer's Award for serving on the Board of Directors

The blast of stacker 747 in the big open pit "Inden"

by Michael Schneider

The dismantling by explosives of an approx. 2,000 t heavy stacker in the Rhenish brown coalfields is explained. A comparison of the documentations showed relevant differences. Alterations had been hardly documented in the construction plans. The experienced blast crew recognized this in spite of time pressure and the staff investigated this by test blasts. All recognitions up to dismantling of parts and pre weakening for the fixing of the linear shaped charges had been revised completely and taken into the blast design. An absolutely precise execution for fixing of so many charges in a confined space became necessary. This was completed by far reaching preventing safety measurements to fence in possible fly of scrap splitters and avoid misfired shots.

Spreader 747 was located in the big open pit "Inden". It belongs to RWE Power AG in the Rhenish lignite (brown coal) mining area. The spreader itself was built in 1958 and it was used for the refilling of dredged excavation area. It weighed more than 2,000 tonnes and had a height of 50 meters up to the top of its pylon, being able to pile the overburden 25 m high in one pass filling the area. The delivery rate of material was 100.000 m^3 in 24 hours (Fig. 1).

As an alternative, there was a demand for dismantling the stacker, making it no longer usable. Simply taking the device out of service was however not an acceptable choice.

Management of RWE Power AG decided that in the construction of big open pit "Inden", the stacker would be scrapped by an external company. The bidders were invited to appointments in May 2018, they were made unequivocally aware of the task to scrap the stacker. Date of 28th August 2018 was set for the blast.

In addition to that, IFF ENGINEERING & CONSULTING GmbH, abbreviated to IFF, from Leipzig, as a builder of static calculations necessary for the development of assemblies and pre-weakening, was hired (Fig. 2).

At the end of July, R. Liesegang, a company of BENDER Recycling GmbH & Co. KG from Leverkusen, having received the complete order for disassembly and scrapping, received the order for demolishing the stacker.

Fresh explosive technology of IFF Leipzig in hand, first inspection of spreaders took place on 1st August 2018 along with responsible persons from the company Bender and the company R. Liesegang. When comparing the shown components to be blasted with the actual existing technology, some important differences were determined which would create different profiles. The reason for this is as simple as almost unbelievable.

Fig. 1: Stacker 747 in big open pit "Inden"

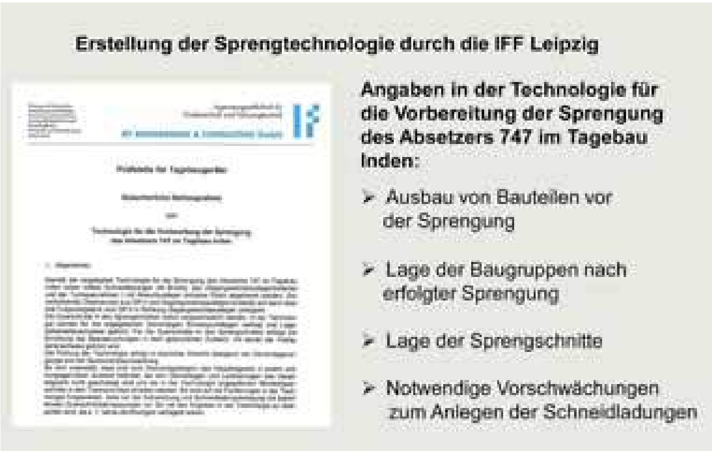

Fig. 2: Creation of the explosive technology

The stacker boom was broken off one day during operation. Then a new one was made of other steel profiles. Other components were simultaneously reinforced or rebuilt. However, these changes were never incorporated into the design plans of the stacker.

This meant that the race against time became a sprint. No longer were there four weeks for blowing the stacker up. It took a week from the first cutting charge application to ignition readiness. Meaning that in three weeks, the blasting technology had to be reworked, various subassemblies had to be expanded and cutting load applications had to be pre-weakened. Simultaneously, various explosives needed to be ordered and prepared for use.

Our philosophy which we have all learnt by heart: "First, I must forget the finished paper". Much can only be done by a call. The whole process is nevertheless almost noiseless and slipped on the construction with an incredible calm. This is thanks to the never-before-seen trust that all the involved companies showed towards their respective counterparts.

Figures 3 and 4 show the location of blast cuts and the planned behaviour of the assemblies during crashing down. The blast cut 1-1 was to cut through the 12 lifting winch ropes on the pylon. These need to be eased up and pulled down. Blast section 3-3 should divide the lifting crane so that it could crash next to the landing gear. The main beam and the pylon should tip sideways, as section 4-4 is "split" from the entire base unit. It is usual that these parts are separated with a separate section from the base unit.

A lot less blasting technology has to be used. The aim of this section through a large number of huge components of the basic unit was to facilitate further disassembly.

Middle section of the base unit between section 4-4 and 3-3 cannot fall off the undercarriage and should lay down on it due to the shift of weight. Sections 2-2 and 5-5 were reserved for the so-called Bridge. Here, a vertical crash was planned.

Practical execution of the blasting technology began with experimental blasting on rope sections of the hoist winch cables (Fig. 5-6 a-b).

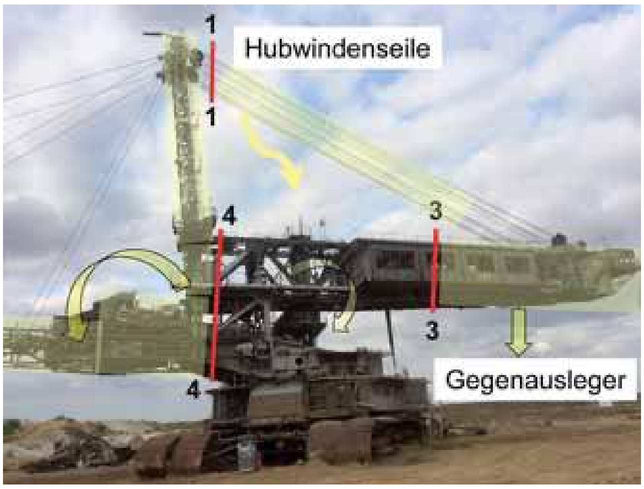

Fig. 3: Planning of the blasting sections on the base unit for the separation of stacker boom and pylon

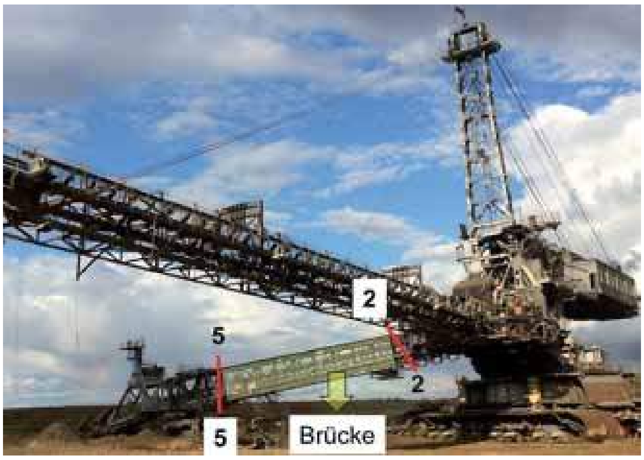

Fig. 4: Planning of the blast cuts at the bridge

Fig. 5: Rope before sample blast

Fig. 6 a: Sample blast rope - 1. attempt: separation is not complete

Fig. 6 b: Sample blast rope - 2. and 3. attempt: complete clean separation

Steel ropes behave differently than full material during a blast. A cutting load that safely cuts the material thickness in St 37, which corresponds to the diameter of a steel cable, will not necessarily cut a steel cable as safely or completely. In addition, these steel cables had at least a diameter of 45 mm. As was to be expected, several attempts were needed to obtain optimal separation. The 155 cut-to-length applications, 40 of which were two-sided, sometimes proved to be extremely problematic (Fig. 7 a).

IFF Leipzig generally only allowed 5 cm large recesses. If you want to get even results, then the optimal starting distance is I approx. 5 cm, which should be allowed for cutting loads, there is hardly any room left for attaching a safe detonator device. A dose of creativity and a bit of courage to be able to put aside old things can certainly be of considerable benefit here (Fig. 7 b).

Fig. 7 a-b: Example of cutting charge application

If many cutting charges are put up in a confined space, such as in U-profiles, then installation must be done with absolute precision. The danger of an unwanted mutual influence is particularly high here. Failure, e.g. by throwing away not yet initiated charges has possible consequences. Very often, several strong sheets were riveted to each other in such constructions for stability.

The secure cutting of all sheets is another challenge. Unfortunately, there are never any pieces of such laminated cores on which experimental blasting could be performed.

The fact that it is possible to achieve 100% results in spite of the problems listed here, which there are a few, is shown by the images of the sections after the blast (Fig. 8).

The largest components to be separated by blasting were the main walls in section 4-4 (Fig. 9).

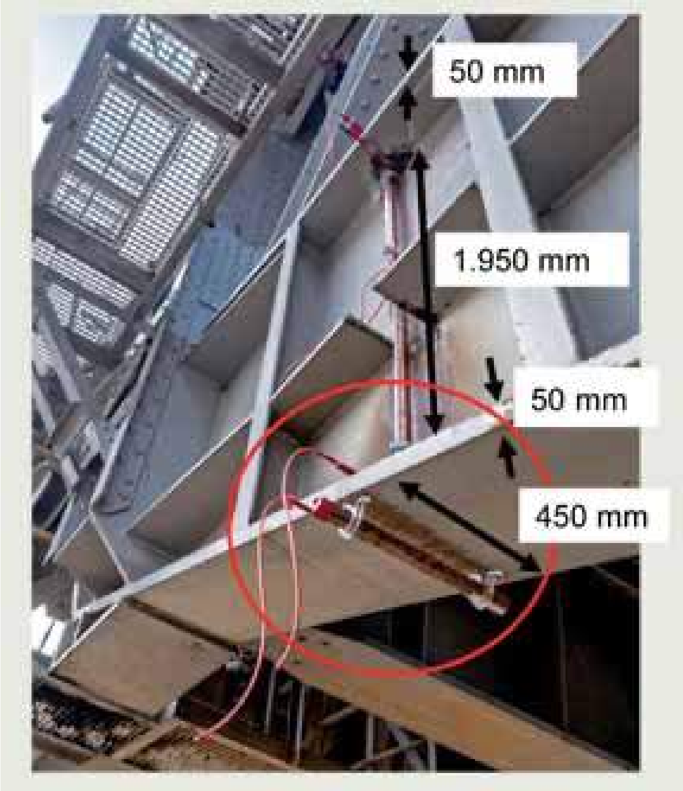

Fig. 9: Cutting charge application on the main wall

Fig. 8: Examples of cut profiles

In the area of the separations, the height was at least 2 m. The upper and lower straps were almost half a meter wide and 5 cm thick.

These straps presented us with the next considerations to be taken. The existing linear shaped charge LC 935 cuts according to the manufacturer were 57.2 mm, but in steel grade St 37. The entire stacker, however, was built with steel grade St 52. The manufacturer of the used linear shaped charge of type Linear Cutter (LC) recommends in its application description to reduce the specified cutting performance by 20%, if a grade of steel other than St 37 is present and no test blasting can be performed. Test blasts could not be carried out due to missing material. So, the only way to solve the problem was to apply reduced cutting performance: 57.2 mm - 20% = 45.76 mm.

Thus, there was the possibility that not all upper and lower girths would not have been completely separated. We decided to create the linear shaped charge LC 935 opposite LC 85. LC 85 cuts in steel grade St 37 according to the manufacturer 14 mm (14 mm - 20% = 11.2 mm). The mathematically reduced cutting performance of both cutting charges was now 45.76 mm + 11.2 mm = 56.96 mm.

Thus, there was enough reserve for a safe separation. However, at least as far as we know, no that huge charges have ever been created. The possibility of being able to use such combinations safely was demonstrated by all cut straps (Fig. 10, 11).

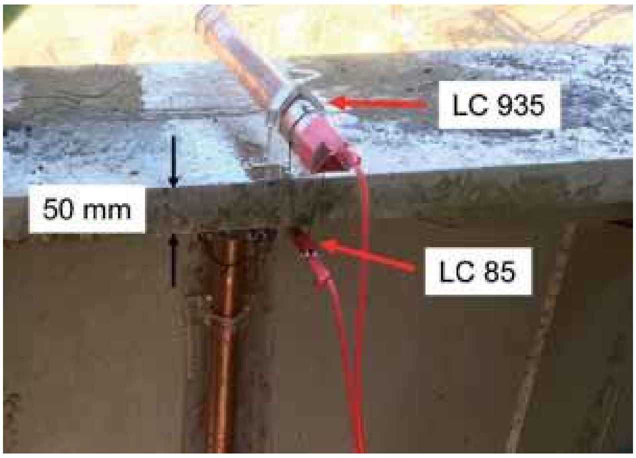

Fig. 10: Upper and lower flange of the main wall

Fig. 11: Main wall after blasting – cutting surfaces upper chord

A total of 55.2 m cutting load with 26.4 kg net explosive mass was needed for the demolition of the stacker. Almost the entire product range of the Linear Cutter, from the LC 53 to the LC 935 and Razor 15, 25 and 30, was used.

A problem that emerged was the scattering of the copper pieces from the incompletely burned cutting back of the linear cutter. Figure 12 shows impressively the effects caused by the cutting load back of the LC 935.

Another problem that is not to be underestimated is the rivets of the construction. In the event of a ground impact, the components are subjected to such forces that the rivets can be loaded beyond their tension limit. When that happens, the rivet heads snap off and behave like bullets. In those cases, rivet heads can reach distances of 150 to 200 m. Of course, this fact must be taken into consideration when considering the shut-off area during demolition. Shut-off area = danger zone + safety margin.

Fig. 12: Scattered flight of the copper pieces from the cutting charge

How far a distance the rivet heads can reach, is not possible to be determined exactly in advance. Thus, the danger area cannot be safely distinguished. More precisely the danger area can be delimited, the larger area must necessarily be enough for the safety margin. Result: The shut-off area increases. There was plenty of room around stacker 747 in the big open pit "Inden". Thus, it was very easy to set the shut-off area with a radius of 500 m, even if that was certainly very generous of an assessment.

In Figure 13, the result of the demolition of stacker 747, which took place on 28.08.2018, can be seen very well. All assemblies behaved as planned during the decline. The middle part was later pulled with two bulldozers from the undercarriage.

After intensive inspection of the blast cuts, it was found that all components were separated exactly. Thus, it was clear that neither failure nor scattered explosives were to be feared. All participants were more than satisfied with this result.

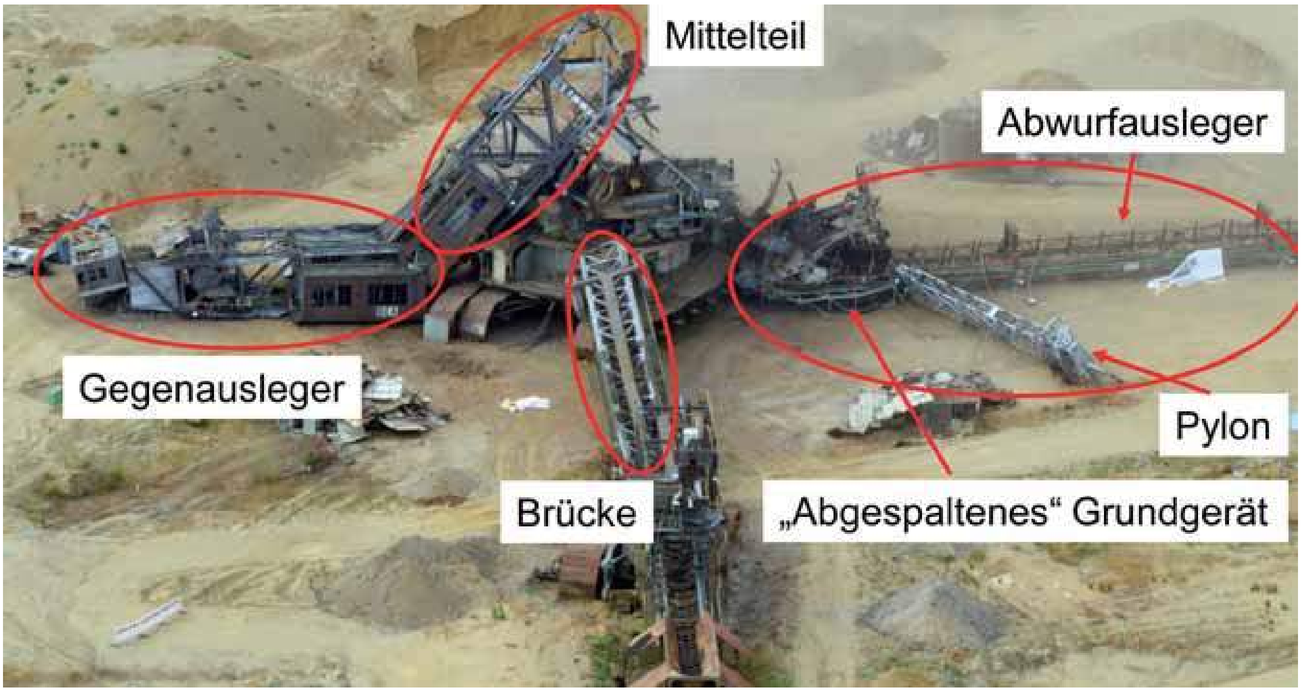

Fig. 13: Blast result

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Credits / ©:

Fig. 1, 3, 4, 7a-b, 9: David Domjahn

Fig. 2, 5, 6a-b, 8, 11, 12, 13: Author

Development of nitrogen free environmentally friendly blasting explosive

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Oy Forcit Ab, Finland

ABSTRACT: Recently there has been activity to develop nitrogen free mining explosives to avoid nitrogen oxide fumes (NO_x) in blasting gases. Hydrogen peroxide (HP) has been the main nitrogen free environmentally friendly alternative to ammonium nitrate (AN) which is the most commonly used oxidizer in mining explosives. Another environmentally important factor is water soluble nitrogen releases into mine waters from unreacted AN-based explosives. Depending on local conditions some part of water-soluble nitrogen can migrate in surrounding water systems causing eutrophication and even acute toxic effects to water organisms. This article deals with steps and test results which are considered relevant on the way of developing HP based environmentally friendly mining explosive. Basic performance parameters like energy, gas volume, VOD and sensitivity to initiation look promising. Challenges will arise from very reactive nature of HP. Handling safety requires very rigorous routines, product sleep time and resistance to water are quite limited.

1. NITROGEN RELATED ISSUES

Most mining explosives contain AN as main oxidizer where an ideal detonation of oxygen balanced explosive nitrogen react fully into harmless nitrogen gas. In fact, several factors cause nonidealities leading to formation of toxic gases like nitrogen oxides NO_x. In some large open pit blasts huge clouds of NO_x have been observed causing danger to surrounding communities. In underground mines occupational health is influenced by NO_x. The trend of electrically driven vehicles in UG mines will reduce exhaust gas related NO_x and EU regulations for occupational exposure are increasingly stringent. Hence, it is not surprising that purity of blast gases becomes a focus.

Another issue is water solubility of AN. It can be leached out by water at different rates depending on the product formulation. Additionally, circa 5-20% of explosives used in blasting remain unreacted in muck. Depending on local water conditions, storing and further processing of rock material, unreacted explosive material can release water soluble nitrogen. In aquatic environment nitrogen can cause eutrophication and even acute toxic effects to water organisms.

A third issue is ammonia gas which forms when AN reacts with alkaline materials. Some minerals or mining methods create alkaline conditions. In UG mines concrete reinforcing is commonly used and in tunnel development concrete injection is used to reinforce badly fractured rock before loading and blasting. In this environment AN-based explosives will immediately lead to release of ammonia gas. The exposure risk exists during loading explosives and unloading the muck but also during processing, for example, in crusher and refinery processes. Ammonia gas has a limiting HTP value.

2. HP PROPERTIES AND PRODUCT FORMULATION

HP is a powerful oxidizer widely used in chemical and pulp industry. It's also used in medical and cosmetic purposes. Industrial grade HP is usually available up to 60 w-% solution. HP grades over 70 w-% are only available for some special purposes for example as oxidizer in rocket engines. Properties of aqueous HP solutions are well known and documented and basic instructions for safe handling are given in MSDS. HP suppliers are actively advising end users on best practices to guarantee safe handling. Even if HP in general is more reactive than AN it is known that aqueous solutions of HP are not capable of detonating as AN. It is important to note that certain impurities can cause a fast decomposition of HP into water and oxygen. This reaction is exothermic and produces large volumes of vaporized water. This type of decomposition is one of the biggest risks and must be considered in planning processes and operating procedures. Another risk is ignitability of combustible materials. MSDS for both AN and HP warn that mixtures with combustible materials can ignite spontaneously and ignition can lead to explosion. According to incident reports the general impression is that spontaneous ignition of combustible material with HP is more likely than with AN. These risks will be discussed in later chapters.

Regarding occupational safety and handling of HP it is important to note that the 8 h HTP value in air is 1ppm - which is very low. If there's a risk to exceed this limit a pressurized air mask is needed because no filter against HP is yet available. The need of air mask makes practical loading work impossible. In lab and pilot scale testing HP concentrations in air has been monitored with Dräger X-am 5100 HP selective sensor and concentrations over 1ppm have occasionally been observed. Keeping concentration below limit remains an open question for the future work and it will be one of the critical factors to be monitored.

The formulation of HP product is based on water gel structure where oxidizer and fuel exist as a mixture, i.e. no chemical bonding. Industrial grade HP solution was used in concentration of 40…60 w-%. The main fuel can be selected from a group of water-soluble organic compounds like glycerol, sugar, etc. Usually some water-soluble polymer, xanthan gum for example, is added to modify rheology. The HP gel itself isn't capable of detonation and it must be sensitized with hot spots just like in case of emulsion explosives. This will be discussed in detail in chapter 4. According to MSDS information HP does not have significant environmental effects. It decomposes into water and oxygen and half-life is minutes to hours in soils depending upon microbiological activity and metal contamination. Other raw materials of the formulation can also be easily picked from environmentally friendly biodegradable alternatives.

3. SAFE HANDLING OF HP PRODUCT

The product is an explosive; hence it is imperative that all handling shall be performed with at least the same care and diligence as handling of any other explosive. Basic handling safety properties in will be tested in CE approval process which is one of the coming tasks. The product is designed to be on site manufactured and pumped directly to borehole without any handling. Still there may be sampling or unplanned situations where some manual handling is unavoidable.

The product structure is a water gel and its components are in form of a mixture where most of the chemical properties are similar as with concentrated HP. Reactivity in general is expected to be slower compared to HP solution due to other components diluting HP in a gel. Increased viscosity may reduce mass transfer and thus limit the reactions leading to decomposition.

Strongly oxidizing nature of concentrated HP may cause spontaneous ignition of combustible materials like paper or cloth rags, clothes, etc. During the last years of testing one occurrence of spontaneous ignition was experienced in Vihtavuori. Some HP gel contaminated paper and cloth rags were collected in plastic bag and it was put to place where such material is burned. The bag ignited spontaneously and burned when it was left to burning place. This case is tried to replicate with no success. Paper and cloth rags and bits of with 60% HP solution and HP gel product and left under sunshine for 4 hours with no reaction. Similar setup in +40C heat cabin was done for 8 hours with no reaction. Still this one occurrence is enough as a warning signal and working routines must be accordingly strict.

Vaporization of HP and water occurs from gel. Same risk arising from HP concentration in workplace air mentioned in previous chapter will also concern the product. A simulation of underground loading was done in Vihtavuori pilot plant. On a wall of a room in basement floor a simulation of tunnel face drilling was done. Volume of the room is approximately 30m^3 and no forced ventilation. 20pcs plastic cups filled with HP gel were put in square array in 60cm x 60cm pattern. HP selective Dräger sensor was put at 1,6m height from floor and 0,8m distance from the wall. HP concentration of air was measured for the next 24h. The max value was 0,3ppm and it occurred shortly after the start. During the following hours the value decreased gradually to zero and stayed there for the rest of the measuring period. This is encouraging sign that in loading the risk of having HP in air can be low because potential vaporization can take place only through the contact area between the product and air. Anyhow, one of the critical points to monitor in further testing is HP concentration in workplace air during loading but also after blast.

An observation in lab scale has been that fresh HP gel sample doesn't burn unconfined in absence of external fire. But when a sample is left in open air for 1-2 days and ignited with flame the material continues burning smoothly by itself. This is probably due to vaporization of water from the sample making water content lower and increasing reactivity of the gel. Further testing is needed to study this aspect to be sure that it's not going to become a risk. Deflagration to detonation tests are also needed to be done.

Product stability in borehole is potentially a challenge. As mentioned earlier half-life of HP in soil can be just minutes or hours depending upon microbiological activity and metal contamination. From biodegradability point of view this is very positive aspect but the product must remain stable till the blast. Borehole usually contains some drill cuttings, material fallen from surface and water. There's probably components which cause or accelerate decomposition of HP. Plastic liners are available and will work to some degree if isolation is needed. But liners can become punctured and use of them will increase work and material cost. The above mentioned speculated hindering effect of product viscosity into reactivity is expected to be of help in this matter but this must be clarified with further testing. The same what is said about reactivity concerns also resistance to water.

Because of water gel structure there's not so high expectations for resistance to water. Some preliminary testing is done by observing penetration of dyed water into the HP gel sample but the results so far are just indicative and profound measurements are part of future work.

4. HP PRODUCT TECHNICAL PROPETRIES

In following subchapters some detailed technical properties of HP gel product are presented. The samples were prepared and tests done in Vihtavuori plant test facilities. Product samples are made in batches of 0,5…3,0kg.

Sensitization of HP gel needs to be done with hot spots. Usually hot spots are gas voids or microspheres. Hot spot sensitization defines the density range of the product. According to VOD and sensitivity test results the upper limit for density range of used formulation is ca 1,16g/cm3. Density less than 1,0g/cm3 isn't usable in wet boreholes so the usable density range for the product is between 1,0 and 1,16g/cm3. Hydrostatic pressure of explosive column itself will press gassed product into density of 1,16g/cm3 in approximately 20m vertical borehole if free density is 1,0g/cm3. This can be estimated by solving modified barometric formula numerically for p at depth h:

$$\frac{p-p_0}{\rho_g} + \frac{nRT}{m} ln \frac{p}{p_0} = gh \quad (1)$$

and using p to calculate density:

$$\rho = \frac{1}{\frac{1}{\rho_g} + \frac{nRT}{pm}} \quad (2)$$

p_0 is atmospheric pressure, P_g is density of ungassed gel, n/m is moles of gas per weight unit of product assuming that pressure doesn' t affect this, g is gravitational acceleration, R is ideal gas constant and T is temperature in K.

Mechanical strength of glass microspheres against external pressure is typically so high that in ordinary conditions no changes due to hydrostatic pressure is expected so density of the product stays constant through the whole column. This is the reason why glass microspheres were selectedhe method of sensitization. Chemical gassing and even air entrapment were also tested and seen potential alternatives but utilizing them belongs to future work.

4.1 CALCULATIONAL PROPERTIES

The HP gel formulation is easy to prepare oxygen balanced because it's homogenous except hot spots. The formulation can be done even oxygen positive to minimize CO formation without risk of getting additional toxic detonation gases because there's no nitrogen. In AN based explosives positive oxygen balance leads to formation of NO_x.

The calculational properties (Explo 5.0) for a formulation based on 60 w-% HP, oxygen balanced and in density 1,08g/cm^3 are shown in table Table 1.

Table 1. Calculational properties for HP gel:

Heat of detonation, MJ/kg	3,74
Energy at 100MPa cut-off pressure, MJ/kg	2,64
Volume of gases at stp, dm^3/kg	1134
REE % (ref ANFO 2,3MJ/kg, d 0,8g/cm^3)	165
VOD (ideal), m/s	5704

4.2 Velocity of detonation

VOD has been measured in several different diameters and confinements. Because critical diameter is handled separately in chapter 4.5 the VOD values presented here are measured in conditions which are relevant to application. Inner diameter 54mm steel pipe was the selected dimension and confinement. Formulation was based on 60 w-% HP solution, oxygen balanced and adjusted to different densities with glass microspheres. VOD was measured with MREL Datatrap. Samples were packed in 0,5m long inner diameter 51mm plastic pipes (wall thickness neglibly small), VOD probecable taped in the side of the pipe and that put inside steel pipe.

A standard detonator in combination with Forprime booster (~25g high explosive) was used for initiation. Three samples per test point were measured. VOD trace was 0,5m long as expected and VOD value was read from the last 20cm of the trace to avoid any booster effect on VOD. Results as average of three samples are shown in Table 2 and in Figure 1.

Table 2. Measured VOD values for HP gel in id 54mm steel pipe (*=1 of 3 didn’t detonate)

Density g/cm^3	VOD m/s
1,16	5422*
1,12	5452
1,08	5567
1,05	4898
1,02	4694
0,91	4100

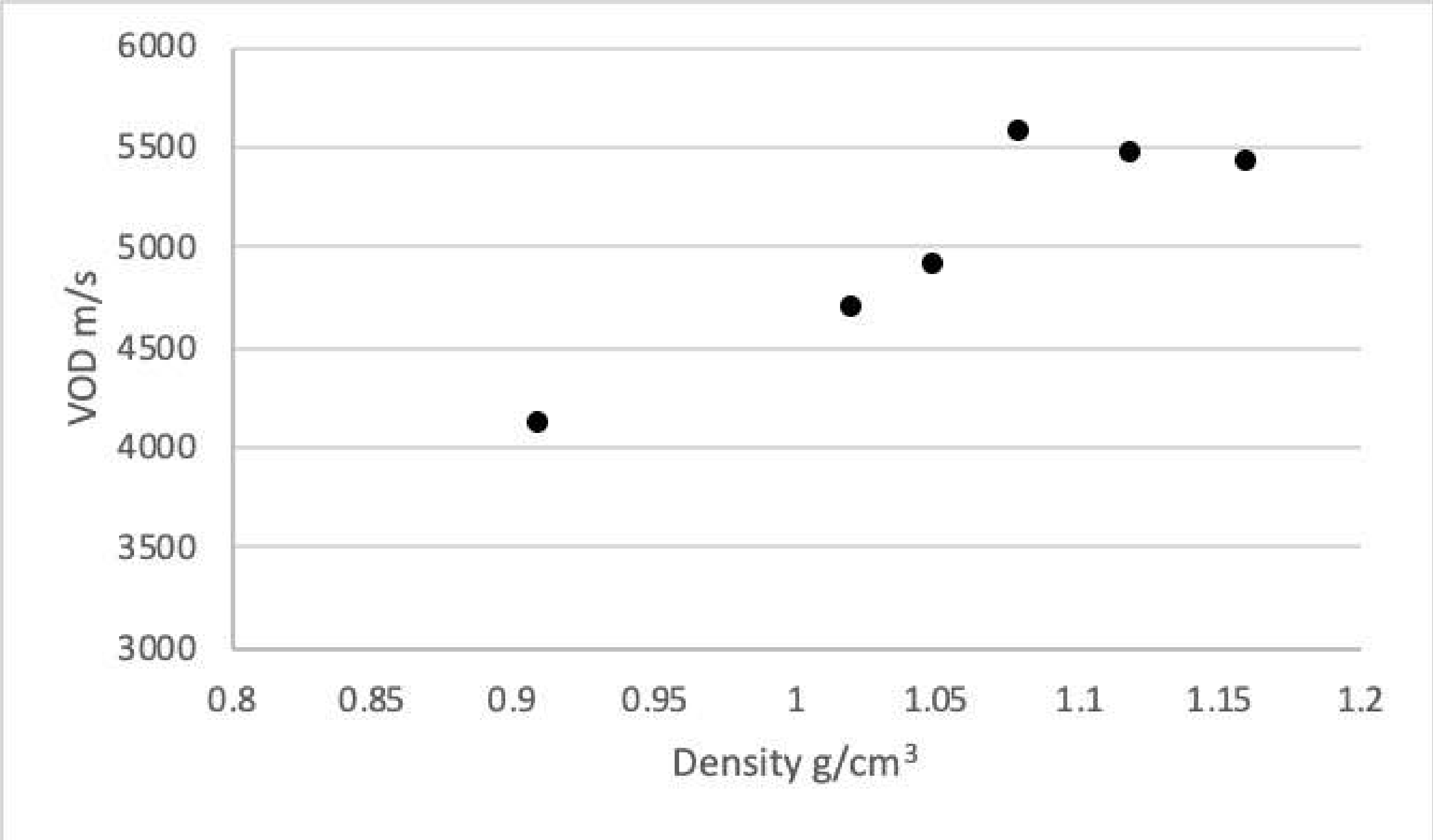

Figure 1. VOD vs density for HP gel

From this data it can be concluded that 1,08g/cm3 is the ideal density. At density 1,16g/cm3 one sample of 3 didn’t detonate. This is considered as a signal of upper limit of density range. In the same test set-up a standard bulk emulsion explosive VOD was measured, the value was 4839m/s. So VOD of HP gel is well comparable to emulsion products.

4.3 DETONATION GAS COMPOSITION

Measurement set-up for detonation gases was such inaccurate that the results can be considered mostly indicative. A blast chamber wasn't available for this work so tests were done in a small cave in Vihtavuori test facilities. The cave has approximate volume of 100m3. A sampling pipe was put in cave and gas sample was sucked with channel fan inserted inside the sampling pipe. In the other of the pipe two Dräger gas sensors were inserted such that they were inside the pipe. A maximum value for CO and NO_x was taken as a result. The test arrangement was considered too primitive to make any more sophisticated analysis. The main point was just experimentally prove the obvious result that HP gel detonation gases doesn't contain any NO_x. One standard emulsion product was also included for comparison. Measured concentrations for CO of HP gel samples on density range 1,12…0,91g/cm3 were 111…32ppm. Of 9 samples 7 showed 0ppm for NO_x and for 2 samples got readings 0,3 and 0,4ppm. The reason to these exceptions may be for example gases form booster. For a standard emulsion product CO concentration was 51…71ppm and NO_x 1,6…2,2ppm. The conclusion from these results is that HP gel detonation gases may contain higher concentration of CO than emulsion product but probably no NO_x. HP gel product formulation can be modified oxygen positive which should decrease CO and no NO_x produced.

4.4 SENSITIVITY TO INITIATION

HP gel sensitivity to initiation was tested using three different concentrations for raw material HP; 40, 50 and 60 w-% solution. The formulations were in oxygen balance and microspheres was used to adjust density. The sample density was 1,02…1,04g/cm3. The test material was packed in slightly conical Styrofoam cups having diameter of 113mm on the top and 75mm on the bottom. A steel witness plate was used to observe possible detonation. For initiation standard detonator and/or Forprime booster (25g HE) was used. Sample temperature in this tests series was ca 20^{0}C. The sensitivity decreased with decreasing HP concentration. With 60 w-% HP solution as a raw material the sample was cap sensitive. With 50 w-% HP solution standard detonator + Forprime was needed for detonation and with 40 w-% HP solution there was no detonation. Sensitivity of 60 w-% HP containing sample was tested also at -30^{0}C temperature with identical method. The samples were initiated with Forprime booster and detonated properly. The sensitivity to initiation at low temperatures is important to know when the product is planned to be used in Nordic climate.

4.5 CRITICAL DIAMETER

Critical diameter was determined by packing the sample into triangle shaped shell made on plexiglass. The length of shell was 72cm, width 4,3cm (assumption that critical diam is much smaller than this) and height on the thick end 4,9cm, in the other end sample thickness was 0cm. A VOD probecable was taped on the inner bottom of the shell and the rear (thinner end) part of the shell was put on a steel plate. Sample was prepared using 60 w-% HP solution, oxygen balanced and in density of 1,07g/cm_3. Three samples were tested, initiation with standard detonator. The place of detonation interruption could be determined from VOD trace and also from the dent on steel plate. The values from VOD and dent coincided with ca 2cm accuracy and taking the geometry of the sample into account interruption at 62…67cm distance means critical diameter of 4…7mm. More accurate result can be obtained by using longer shell but in this study the increased accuracy wasn't in scope.

5. SUMMARY AND CONCLUSION

The work so far has demonstrated that on basis of technical properties like energy, gas volume and VOD HP gel explosive has potential of becoming a nitrogen free alternative to AN-based products on the markets. The open questions regarding chemical stability and resistance to water doesn't give higher expectations than on site manufactured load and shoot product. Increased sleep time is a task for further development.

Strong emphasis must be put on safety at every step of development. The planned next steps are getting CE approval for the product, designing and building a safe and suitable loading method to make field tests. Field test results will eventually show if the product and loading method fulfil requirements for safe use and are economically and technically feasible.

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New Standardisation Tasks under the European Explosives Directive: Electronic Detonators, On-site Mixed Explosives

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ABSTRACT:
Since the early drafting of the European standards for civil explosives, harmonised under directive 93/15/EEC and 2014/28/EU, blasting technology has developed notably. This is particularly evident for electronic detonators and electronic firing systems, and the EU commission agreed to initiate a standardisation initiative, also noting that the currently existing document on electronic detonators is "only" a *Technical Specification* (CEN/TS). This paper addresses the current activities in the area of standardisation. The EU is about to launch a formal standardisation request to cover the most recent technological developments not addressed by the current standards. The request would also include various adjustments of references to the new Directive for civil explosives, and in addition the task of developing a *Technical Specification* for on-site mixed explosives and corresponding manufacturing units. The latter has been included to address the nowadays frequently found mobile production on the basis of ammonium nitrate prills or emulsions.

1. INTRODUCTION

Two areas have been identified recently, where the technical evolution in the field of explosives has moved considerably further, significantly beyond what the harmonised European standards would fully cover. In the first place this concerns electronic blasting systems consisting of an electronic detonator being operated by electronic devices for programming and firing the detonators. Such systems offer a much greater flexibility in use, as compared with detonators with pyrotechnic delay components, while at the same time being usually also much safer against misfiring or misuse by unauthorised persons. However, the significantly higher inner complexity of electronic systems makes it much more difficult to understand and verify the technical provisions installed to guarantee the functional safety of the electronic blasting system. In addition, there is a tendency to use and trust stream-lined applications where you only have to press buttons in a logical sequence, where the functioning is easily demonstrated by a hands-on demonstration. But what happens inside the system remains hidden. And it is extremely difficult to tell, which failures inside the system are possible (or impossible) to occur. This is the big challenge where the current re-drafting of a standard comes into focus, the "electronic detonators including remote firing systems" as it is currently written in the draft standardisation request by the EU commission.

The other main aspect of the planned standardisation work is on-site mixed explosives. The explosives are in principle covered by the existing standard series EN 13631 for high explosives. However, the manufacturing units used on-site are so highly integrated that the question arises, whether and how the properties of the produced explosives can be controlled. At the time of the drafting of the currently applied standards emulsion explosives were known, but not used as wide-spread as nowadays.

Both topics are dealt with in the CEN/TC with the number 321 and the title "Explosives for civil uses". This paper marks out various areas, where the author sees particular challenges to be addressed in the near future. This paper should be seen as a thought starter, and as the work in the CEN/TC 321 further develops, more information should become available to be shared.

2. ELECTRONIC BLASTING SYSTEMS AND STANDARDISATION

As already indicated in the introduction, there are various questions to be asked and solved as the drafting of a new standard for "*electronic detonators including remote firing systems*" is picked up. And these questions not only concern the non-explosive parts of the entire system and whether these can be subjected to the European Directive on placing on the market of civil explosives or not. In some countries, such as in Germany, the non-explosive parts are subject to national laws as "blasting accessories" and not necessarily certified together with the explosive components, which are only the detonators.

However, technical solutions are so varied, that some would combine a larger part of the functionality of the electronic blasting system with the explosive components, while other systems have electronics mostly in a firing box and the detonators could even be conventional. Therefore it would be unsuccessful to try to standardise the electronic detonator singly, while having an artificial border line to the non-explosive devices operating the electronic detonator.

On this basis, firstly several questions are raised from the perspective of the author:

- How much is the existing technical specification CEN/TS 13763-27 of help to draft the future standard "*EN 13XXX on electronic detonators including remote firing systems*" (as it is worded in the draft standardisation request)?
- Considering (and studying) current technical solutions for electronic and remote blasting, as produced by a number of renowned blasting system manufacturers, would they compare well and could they be described by a common set of concepts? (Or do they differ too largely?)
- Will it be possible to implement features (or technical solutions) which allow the responsible blaster to maintain an ultimate control on the operation, i. e. the firing or not-firing fully to his decision, e. g. by some sort of hardware kill-switch?

- How can the "functional safety" of a blasting system be thoroughly proven, given that the inner components are already highly complex? Is the effort for this endeavour manageable and justifiable?

With regard to some question the author has a preference in some directions. But it should be clearly seen, that the process of standards development is a collaborative. It will be the responsibility of all experts in the CEN/TC 321 to find a consensus on the most appropriate approach to standards and technical requirements set out in the standards. And in the end, the standards will have to be assessed against the "essential safety requirements" given in Annex II of the aforementioned Directive.

Regarding the existing technical specification CEN/TS 13763-27 the author sees limited usability for the future work. For the purpose of the new standard, the terminology has to be revised and amended by new terms and concepts. The technical requirements are mostly addressing the same known mechanical verifications as they would apply to electric detonators, and this principle should be kept for the future standard. However, additional tests such as checking the sensitivity of the electronic parts incorporated in the detonator to shock from a neighbouring blast and the consequences on functioning may be necessary. And a significant part of the assessment suggested in CEN/TS 13763-27 addresses a risk based analysis, which in the opinion of the author should at least be re-evaluated.

Overall the CEN/TS 13763-27 offers a fairly concise collection of relevant tests, but as it is worded now, leaves room for variations on the grounds of seen as applicable or not. Perhaps a more stringent list of mandatory verifications on the system level would be beneficial for both, the manufacturers and the certification bodies – though the author admits not to have any precise suggestion so far.

Some further consideration should be given to what is mentioned in the third bullet of the above list. Two completely opposite designs can be conceived as models for discussion: (A) A system with all functions fully integrated into programmable electronics, which in turn drives power sources, relays, and electronically switched connections. The programmable electronics bridges between the user panel and the hardware ultimately firing the bridge wire in the detonator. Or (B) a system which is working very much on classical concepts, where electronics only assist the accuracy of the functioning, but the supply of power, switching to the firing cables etc. is done by mechanical switches hand-operated by the blaster.

It is quite evident, that both systems A and B would benefit or suffer from several issues. While A could offer a high level of fault analysis features and prevention of out of sequence operations, there remains a degree of uncertainty as to the software in the programmed circuits and the question, whether the software is free of errors.

Ultimately no software can be proven to be error-free, and the relatively high rate at which software updates are issued by manufacturers, even for current electronic firing systems, demonstrates that the software "never" is final. This is a persisting problem already implemented by choosing such design.

In version B, errors in parts of the control or software could be compensated by the ultimate control the blaster would have, and the blaster would remain responsible for any untimely ignition or error in operation. Here safety is generated by organisational and procedural provisions. Possibly such solution would be more costly, spacious, and less configurable. The principal questions are similar as with autonomously driving vehicles on roads. The autonomous system may statistically generate less car accidents due to its never failing attention, as compared with the normal car driver who's behaviour is subject to random error. However, where a car accident occurs by cause of a system failure, which the "driver" or passenger couldn't prevent, questions of responsibility arise – this being one of the reasons why autonomous driving develops only slowly.

3. ON-SITE MIXED EXPLOSIVES

Explosives based on ammonium nitrate (AN) as prills or based on AN solutions should fulfil all requirements already present in the existing standard series EN 13631. At the level of product development and type testing there is no general problem with applying the tests given in the standard. When it comes to monitoring the quality during or after production the situation changes, because the given tests can hardly be performed. One reason is, that the explosive is transferred immediately after production from a hose directly into the bore hole. I. e. the explosive is not available "from the shelf" or storage for a later inspection or an inspection prior to loading. In addition the explosive has a limited life-time and changes its properties quickly over time. Of course, sampling the explosive is not impossible at all, but the situation is quite different from a plant production. Another reason why it is impossible to use a subset of the existing tests for verification purposes, i. e. the same which were done during type examination, for quality control is, that in the field situation none of the methods used during type examination are practically available.

This is the background why one should reconsider, which properties and examinations could be used, much better tailored to the specific nature of on-site produced explosives. Again one may ask a number of questions:

- Which properties are specifically relevant for emulsion explosives, in contrast to what is already in the standards, and which should be examined for type testing and for verification during production?
- Which verifications are feasible on-site and are they sufficient to guarantee a product in accordance to the type as examined during module B?
- Which verifications are currently being used?
- How do the on-site verifications (as ultimately agreed to be suitable or necessary) impact on the need to have a specifically trained operator, and can there be given any guidance on qualification and authorisation?
- How would the newly required on-site verifications have an influence on the design of on-site machinery or accompanying equipment and can there be given guidance to those designing this machinery and at the same time to those inspecting on-site manufacture (namely Notified Bodies)?

One perhaps obvious aspect as a property to be observed, is the density. The emulsion is in most cases not explosive before it has been sensitised. The conversion to an explosive takes place by a reduction of density by various means such as chemical gassing or addition of glass micro-ballons. The use of glass micro-ballons is the more predominant solution for cartridged emulsion explosives produced in stationary plants, which is however not being discussed here.

It is an intrinsic feature of chemical gassing that this process progresses once initiated and leads to a continuous reduction of density over time, within some bounds of course. The methods for the determination of density currently described in EN 13631-13 address free flowing materials and solid materials, but do not specifically address paste materials with a tendency to dissolve in water, and surely do not address materials with a density quickly changing over time. Also in the requirements part, which is EN 13631-1, explosives with a changing density are not addressed.

Here perhaps guidance is needed, which densities are to be recorded during type examination, at which times, which densities are allowed at maximum to guarantee explosive properties etc. Without this information being established during the type examination phase, the later inspections during quality control monitoring remain somewhat at will of the people involved. To shortly address ammonium nitrate fuel oil (ANFO) explosives: owing the apparent extreme simplicity of the product, it is less obvious which verifications should be done or have to be done accompanying on-site production.

Second the fact, that the on-site machinery operator acquires the role of the person manufacturing the explosive, puts a higher responsibility on this operator and calls for a specific competence and training.

What is in a normal production plant distributed over several members of staff, from raw product verification, to production, laboratory controls, etc., is now in the sole responsibility of the on-site machinery operator. And this responsibility should be expressed by corresponding documentation which the operator signs and thus takes full responsibility over his product, not least to mention the affixing of the CE mark upon successful confirmation of the product properties.

This second aspect may not be primary subject of a standard addressing explosive material, however, at the stage of drafting the *Technical Specification* such information should be collected. The steps taken during type examination, and the properties relevant for the product quality will also impact the construction of the machinery used for on-site manufacture, and elements to be inspected by a Notified Body. All this understanding should be retained in an Annex to the *Technical Specification*.

And another aspect brings the discussion back to what has been addressed with electronic and remote firing systems: due to the high degree of integration of technology of on-site production with automatic electronic controls, it is evident that the operator has by design little influence on the production process. This brings about the question, how he should take responsibility for something he seemingly cannot ultimately control. Therefore one may have to consider possibilities of breaking down the on-site machinery into logical units with defined functions and entry points for verification.

2. CONCLUSIONS AND SUMMARY

The discussion showed, that a number of technological question need to be addressed with regard to new standards for electronic and remote firing systems, but that perhaps also more general design principles should be re-considered. The consideration on whether a risk based approach is acceptable or a safe-by-design based approach is preferred needs to be part of the process. Concerning explosives produced on-site possibly some new aspects need to be addressed at the level of type examination, and test methods for properties so far and not addressed may have to be taken on board. And for any of the automatised parts of the mentioned technologies, be it firing systems or on-site manufacturing machinery, a consensus has to be found, whether preference is given to a risk based approach or an approach fostering inherent safety by design.

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Local and global effects in steel buildings frames due to blast load

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ABSTRACT: Explosions may have severe consequences on the integrity of structural or non-structural elements of a building. Being considered events with a low probability of occurrence, they are not considered directly in the design, except in certain special situations (accidental design situations). In the case of deliberate attacks, placing explosive devices at short distances or even attached to building elements can cause major local failures. Local failure and potential loss of load carrying capacity are dependent on local conditions in the structural elements (load and end support conditions, mechanical properties of material). The paper presents the results of recent research carried out on the response of steel building frames under blast loading. The data of the experimental testing, combined with the numerical modelling, allowed to investigate the local failure mechanism in the elements and the global response of the structure to the applied blast load.

1. INTRODUCTION

The capacity of a structure to resist a variety of extreme events without being damaged to an extent disproportionate to the original cause is called robustness and is required by design codes and standards. Raising awareness concerning these risks requires adequate measures during the design and construction of building structures. Explicit analysis and design that accounts for the possibility of an explosion can pose difficulties (compared to other types of design), both in terms of load assessment (i.e., the maximum value of the resultant pressure, or its variation, on elements or structures) and the effects on materials and elements, such as the effect of the loading rate on the mechanical characteristics of steel or explosion–structure interaction. As the stand-off distance from the explosion decreases, the effects on the building become more complex. In such a case, the use of numerical analysis may lead to more accurate results, especially when results are validated by experimental data. As very few experimental studies have been carried out on the resistance to blast of framed buildings, there is a high interest in such investigations. A more convenient approach is the Alternate load path method (APM) , where for simplicity it is assumed that one column is lost due to explosion, then the capacity for carrying the redistributed loads is checked . However, it is not yet well established if APM is representative of all types of explosive threats.

The paper presents the results of recent research carried out in the FRAMEBLAST project (2017-2018) on the safety of building structures under extreme actions. A two-bay, two-span, and two-story steel frame building was tested for different blast loading conditions to evaluate the consequences of near field explosions on the structural elements. The experimental data were combined with the numerical modelling to investigate the residual capacity of steel columns and the potential for progressive collapse resulting from such extreme loading. Numerical modeling was done with Extreme Loading for Structures ELS.

2. EXPERIMENTAL BLAST TESTING

The steel frame building model has been constructed in an explosive testing site. The steel frame building has two bays, two spans, and two stories (Figure 1). The bays and spans measure 4.5 m and 3.0 m, respectively, while stories are 2.5 m high each. The structural system is made of moment resisting frames on the x-direction (transversal direction), while on the y-direction (longitudinal direction) concentrically braces are introduced in each frame. The secondary beams are spaced at 1.5 m intervals. The extended end-plate bolted beam-to-column connections at the moment resisting frames are designed as fully rigid and fully restrained connections using M24 gr.10.9 bolts on a 16 mm thick end plate. Secondary beam-to-column connections and secondary beam-to-main beam connections are pinned.

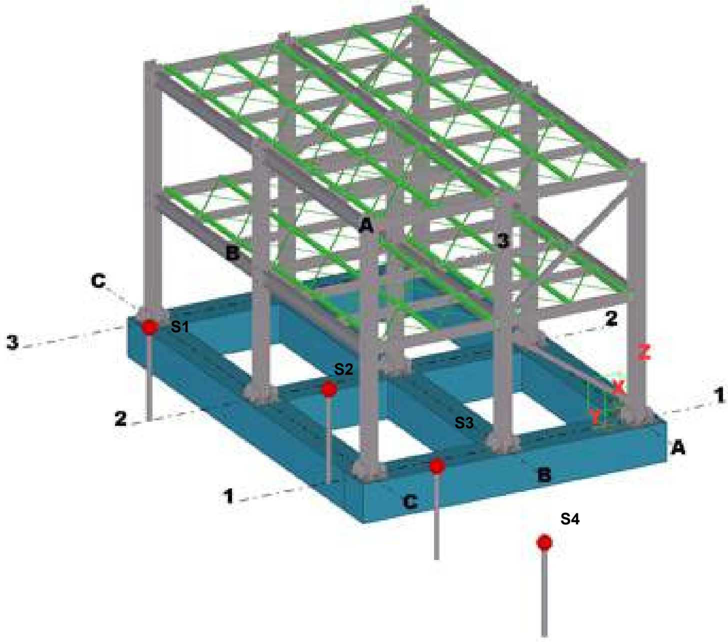
The column bases are welded to steel plates bolted to reinforced concrete girders, that constitute the foundations of the structure.These connections are fully rigid and restrained. The design of the structure was done considering the seismic design condition, combining the permanent actions (dead load D = 5 kN/m^2), the variable actions (live load L = 4 kN/m^2) and the seismic action (low seismicity, horizontal acceleration = 0.10 g). Horizontal and vertical tying requirements for accidental design situation were also verified using EN 1991-1-7 [1] provisions.

The design resulted in HEB260 section for columns, IPE270 section for main beams, IPE200 section for secondary beams between columns, and IPE180 section for intermediate secondary beams. Note that structural steel in beams, columns, and plates is S275 (yield strength of 275 N/mm^2) and bolts are class 10.9 (ultimate strength of 1000 N/mm^2).

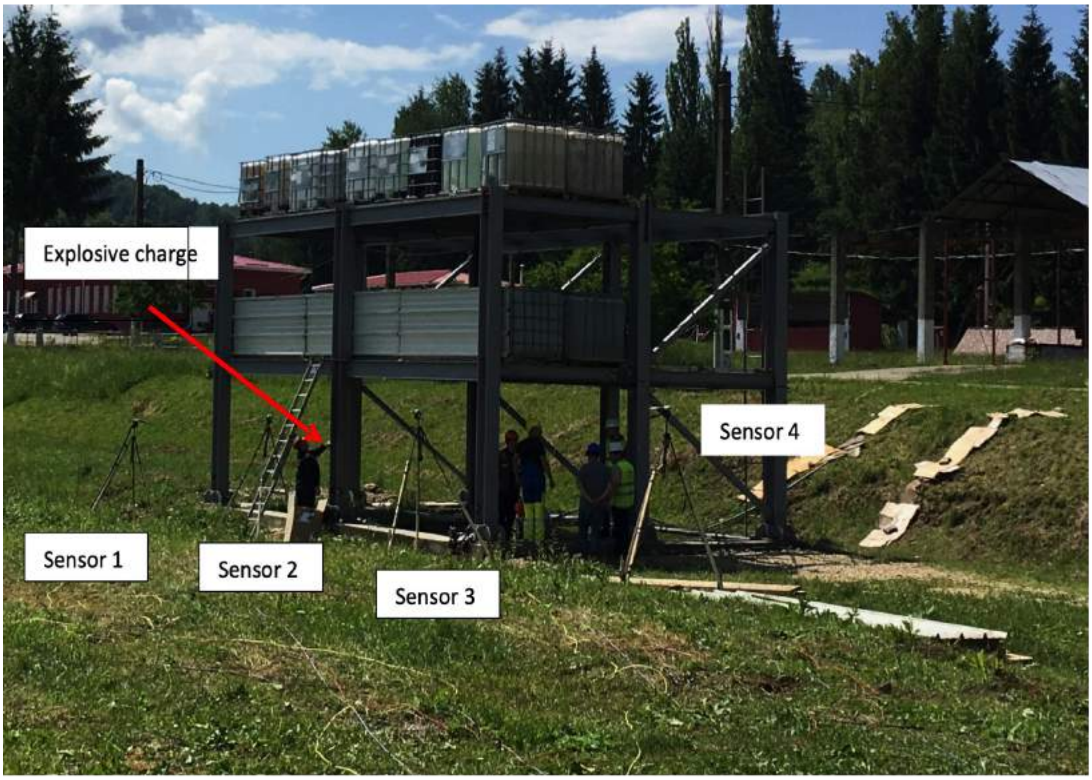
Four pairs of sensors have been used for pressure measurements at four different locations near the structure (see Figure 1a):

- 1st location: 2.5 m from the middle perimeter column C2, and collinear with the explosive charge (S1);
- 2nd location: in front of the corner column C1 and in line with the explosive charge (S2);
- 3rd location: 4.5 m away from the 2nd location and in line with the explosive charge (S3);
- 4th location: 4.5 m away from the 3rd location and in line with the explosive charge (S4).

Strain gauges were arranged on the structural elements to measure the history of strains in the elements, that is, columns (web, flanges), beams (web, flanges) and the end plates of the beams at the beam-column joints. A total station was also used to measure global deflections in 20 different locations. 14 tracking marks were tagged on the front frame (R1 to R14), and six on the left side frame (L1 to L6). Two high-speed cameras were used to record and analyze the blasting events. Before testing, gravity loads with an equivalent load of 7.5 kN / m^2 were placed on the floors. Note that the loads were added only on the first bay (B-C/1-3). During the loading process, strains and deflections were measured in the points indicated in the previous section. With the structure loaded, eight blast tests were performed on the structure, but only the first 6 tests are reported here. The details are given in Table 1.



a)



b)

Figure 1. Overview of the steel frame specimen. a) 3D geometry, with the position of pressure sensors S1-S4; b) photo before testing

Table 1. Blast testing, with mass and position for charges E1 to E6

Test name	Charge mass [g]	Distance, D [mm]	Height, H [mm]
E1	286	500	1750
E2	572	500	1750
E3	1144	500	1750
E4	2288	500	1750
E5	2288	200	1750
E6	2574	200	1750

Note:

- Distance D is measured from the front face of the central perimeter column C2
- Height H is measured from the column base plate

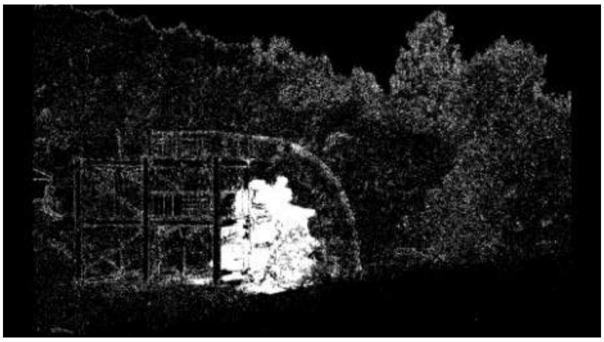
a)

b)

Tests E1 and E2 did not produce any plastic deformations in the steel members (column, beams). Following the E3 test, residual deformations were measured at the level of the column web and flanges. Test E5 produced the first fracture in the column web (Figure 2a). Residual out of plane deformations were also recorded (Figure 2b). Test E6 completely removed a large part of the column web and caused large distortions of the section and continuity plates in the beam-column joint above the point of detonation (Figure 2c). Figure 3 presents the wave propagation around the structure for tests E6.

c)

Figure 2. Central column after test: a) test E5, front view; b) test E5, side view; c) test E6, front view



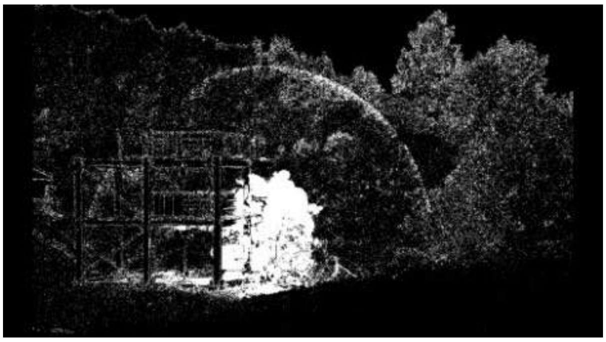


Figure 3. Shock wave propagation, test E6

3. NUMERICAL MODELLING OF SITE EXPLOSION

The numerical analyses were performed using Extreme Loading for Structures (ELS) software. The experimental data obtained from the blast tests were used to calibrate the numerical model, see Figure 4. ELS uses a non-linear solver based on AEM and allows the automatic detection and computation of yielding, hardening, failure of materials, separation of elements, contact at impact, buckling/post-buckling, crack propagation, membrane action, and P-Δ effect. In the AEM modelling technique, the structural elements are modelled as small solid elements connected by normal and shear springs that follow the constitutive law of the corresponding material (Figure 5a, b).

These elements are considered rigid and the displacement one to the other is expressed through the springs, which will generate stresses and strains. The material volume property of these springs is represented by the interface spring tributary surface and distance between the centroids of the elements (Figure 5c). The rigid AEM elements have six degrees of freedom (three for translations and three for rotations), and no simplification are made on their possible displacements and consequently on springs deformations, see Figure 6. Two neighbouring elements can be separated once the springs connecting them are ruptured. Fully nonlinear path-dependent constitutive models were used for materials, see Figure 7. Structural steel S275 was assigned for all steel elements (beams, columns, plates) and class 10.9 bolts were used for connections. The dynamic effects in the material were modelled based on the maximum strain rates derived from the numerical simulation, that is, 300 s^{-1}. Figure 8 shows a detailed view of the AEM model, with the position of small elements (1 to 9) located in the column fracture zone. The elevation of the blast charge is also indicated in the figure.

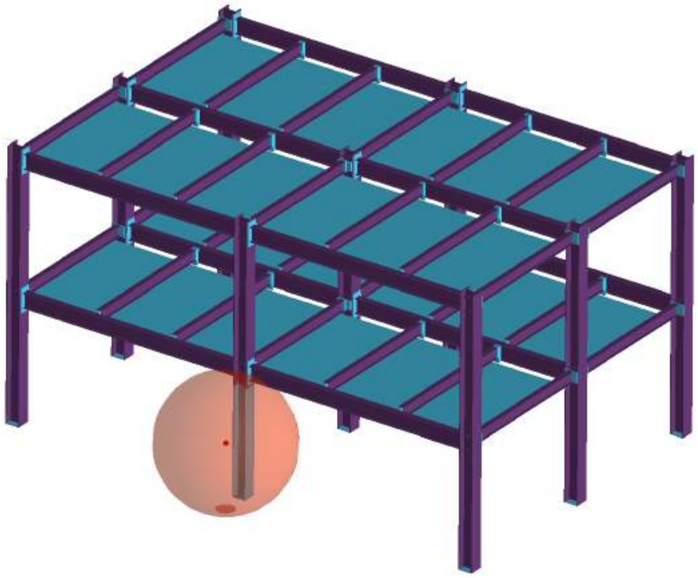
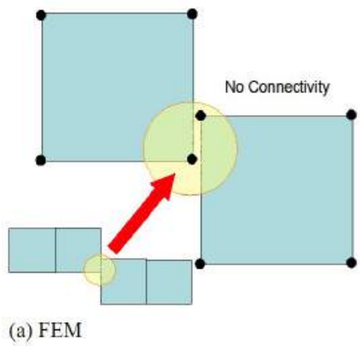


Figure 4. Three-dimensional numerical model developed using ELS ([14])

a)



b)

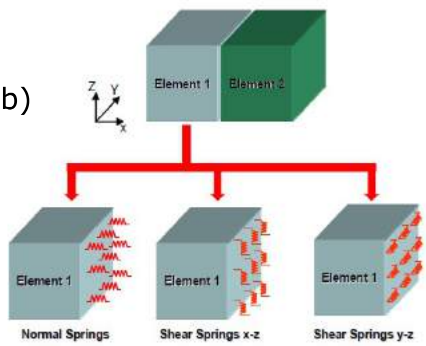
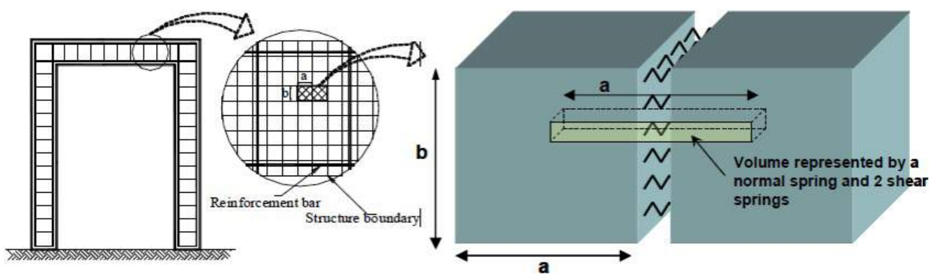


Figure 5. Modelling connectivity with AEM and spring generation on element faces: a) partial connectivity; b) connectivity matrix spring; c) spring distribution and tributary area.

c)



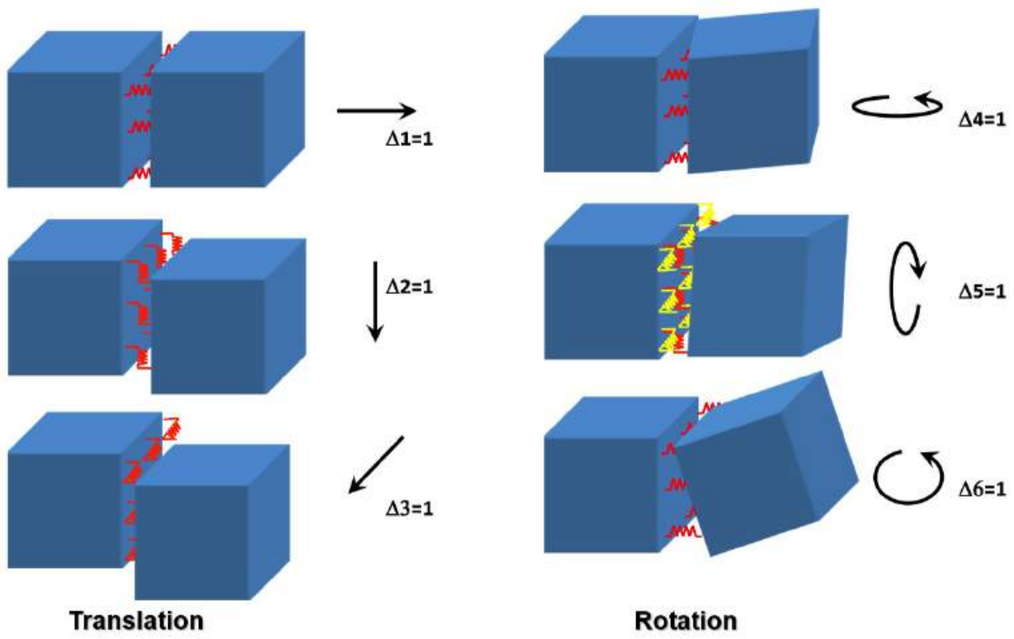


Figure 6. Relative displacements of AEM elements

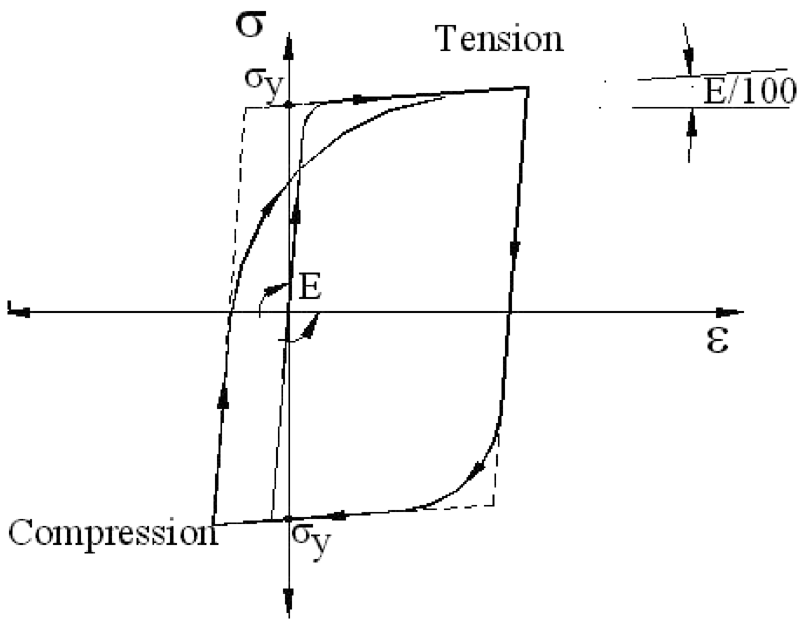
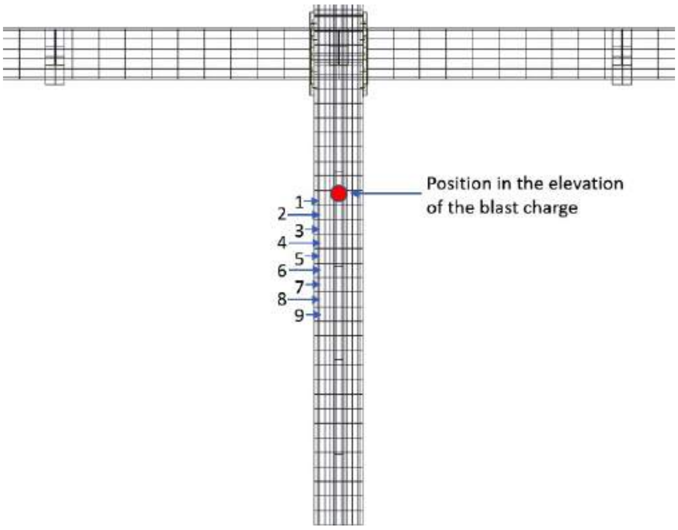


Figure 7. Constitutive model for steel under axial stresses used in ELS



The pressure histories measured at the four points indicated in Figure 1b were used for the calibration of the pressure load in the numerical model. Figure 9 shows the pressure histories, experimental vs. numerical, for test E5. For clarity, pressures S1, S2 and S3, S4 are presented on separate graphs. It may be seen the pressure is well approximated at points 2, 3, and 4, the only significant difference is at point 1, possibly due to some local effects or sampling rate in the data acquisition system. Note that only the positive phase is modeled in ELS.

Figure 8. Detailed view with AEM model, with the position of small elements (1 to 9) and elevation of the blast charge

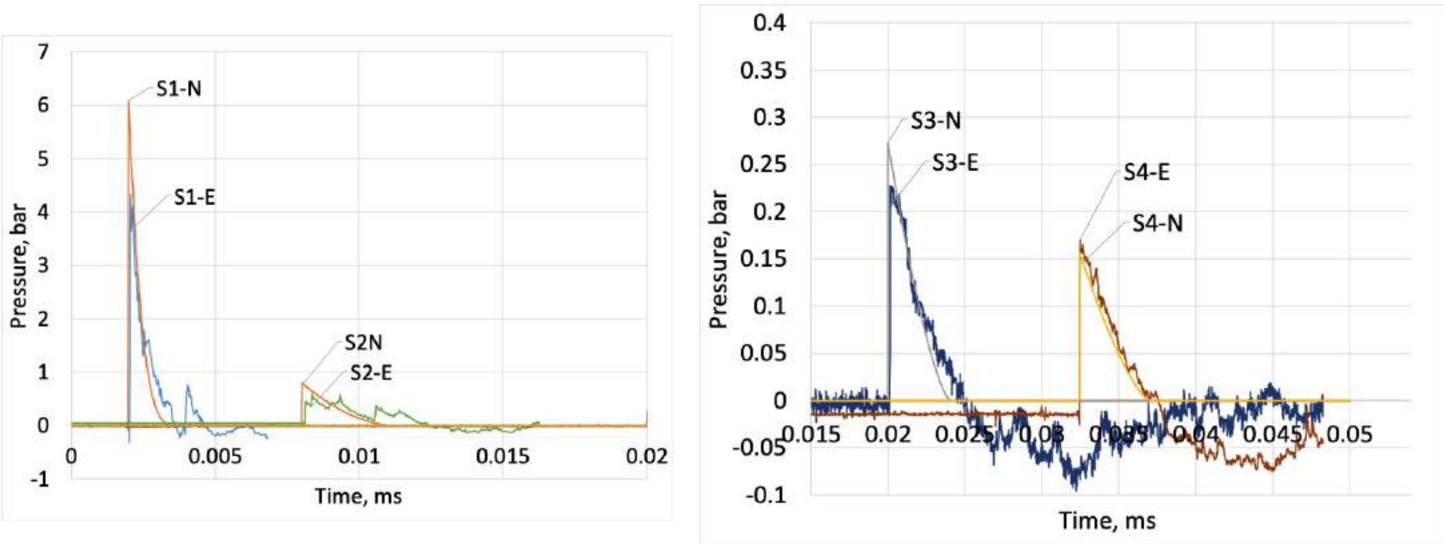


Figure 9. Pressure history at points S1 to S4, experimental (E) vs numerical (N), test E5

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Figure 10 shows the main phases of deformation in the column. As seen, the strains are highly localized in the web toe of the fillet, symmetrically above and below the center of the explosion. The partial fracture of the web is initiated at 0.3 ms from start and extends over a length nearly double the height of the column. The initiation and propagation of fracture is complex and is caused by the combined bending and shear. Thus, Figure 11 shows the evolution of strains (normal strain and resultant shear strain) in time at nine points from the web toe of the fillet in the central column, beneath the center of explosion (see also Figure 8). Note that similar effects are expected at similar locations above the point of explosion.

As seen from the figure, the normal and shear strains get the fastest increase rate in the group of springs 1,2, and 3, and the fracture is caused by the attainment of the ultimate shear strain, before the fulldevelopment of the normal strains. The deformations extend also to points 4, 5, and 6, then last to points 7,8, and 9, which all develop fracture from shear.

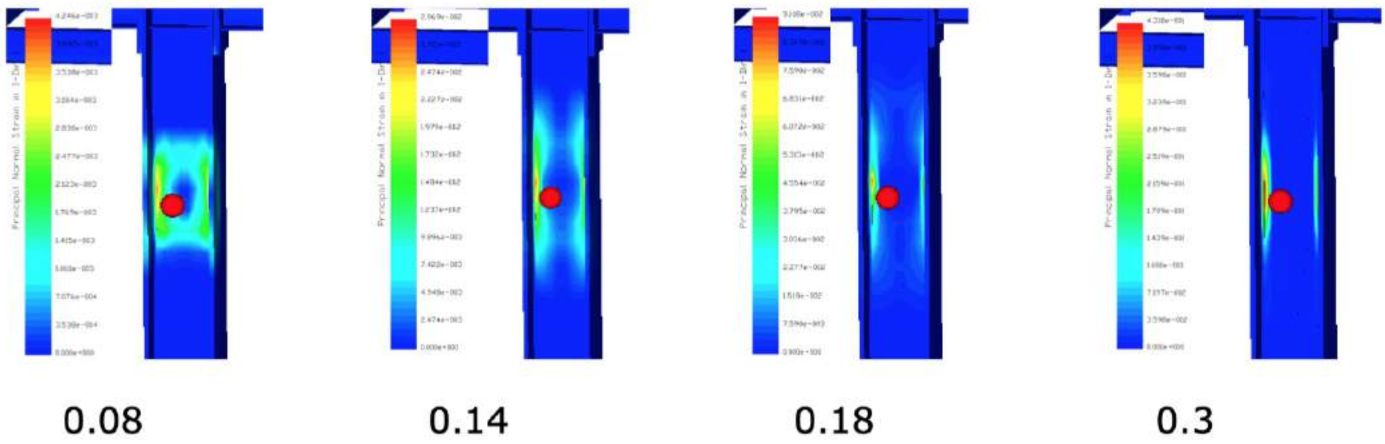
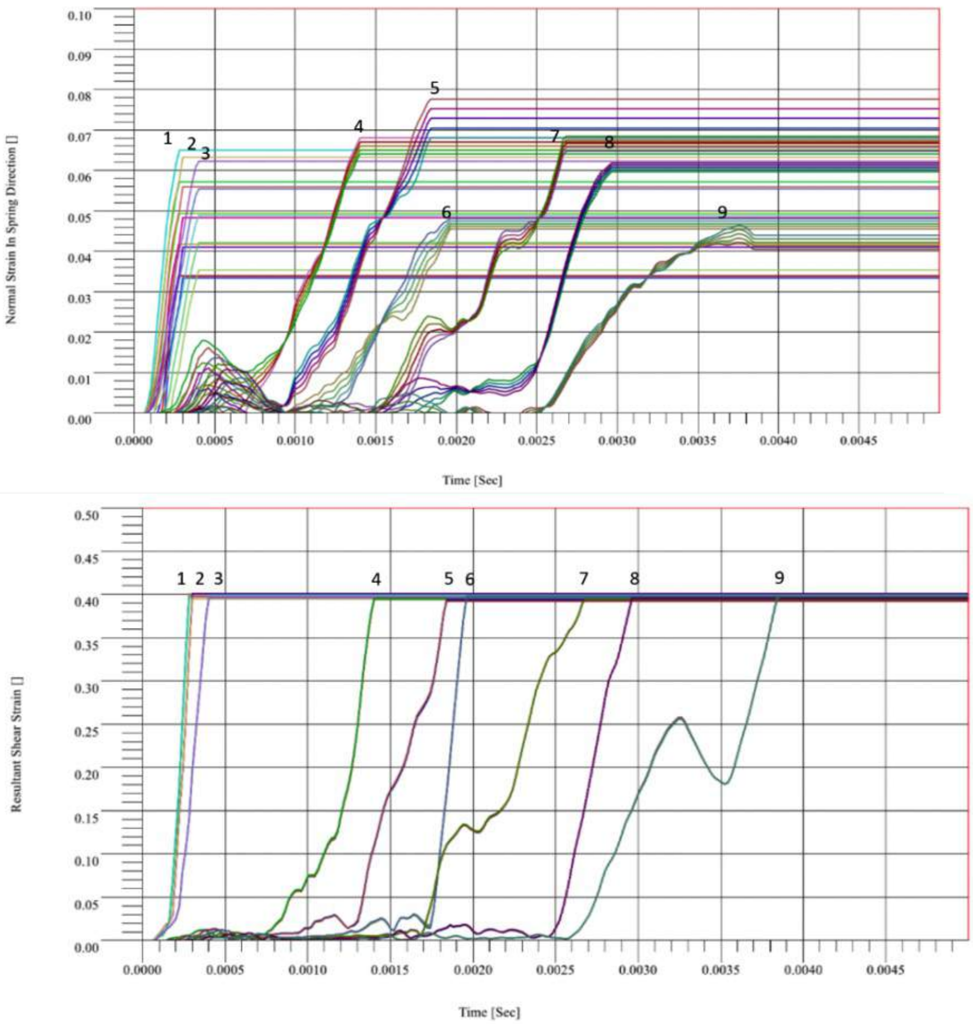


Figure 10. Evolution of the out of plane deformations in the column, test E5 (deformations in mm, time in ms)



a)

b)

Figure 11. Strain history in springs, fibres F1 to F9: a) normal strain; b) resultant shear strain

4. CONCLUSIONS

Explosions produced near buildings pose a special threat to structural integrity and implicitly to occupant safety. The ability of a structure to withstand such action depends both on the capacity of the most affected elements and on the ability of the structure to limit the extent of damage and to avoid progressive collapse. Increasing the safety distance is the most effective measure to reduce the damage level in the structure.

The interaction between the shock wave and the structure results in a significant increase in the maximum pressure and implicitly in the state of strains in the structure. For this reason, a two-bay, two-span, and two-story steel frame building model was tested for different blast loading conditions to evaluate the consequences of near-field explosions on the structural elements. The results of the blast tests showed that the interaction between the shock wave and the structure may result in a significant increase in the maximum pressure and implicitly in the level of deformations in the structure.

Also, increasing the safety distance is the most effective measure of damage reduction in the structure. The specific instrumentation (pressure, strains, video) provided extensive data that allowed to calibrate the numerical models and to go deeper into the blast- structure interaction process and sequences of failure.

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10th EFEE World Conference in Helsinki

It is not unusual in Helsinki, Finland to see many explosive engineers and shot-firers wonder through the city, although they are usually not from all around the world – like it happened near the Scandic Marina Congress Center for a special occasion on the 15-18th September for the 10th EFEE World Conference of Explosives and Blasting. The conference started with a workshop, where all participants actually had to brainstorm to solve different issues with explosives and blasting. Not long after that, everybody had a chance to discover the granite world underneath the Helsinki city, which is overwhelmingly huge – a clever way for Helsinki to organize product deliveries, waste management and other transportation issues in city center.

First of all – brainstorm!

Helsinki - city of granite tunnels and shopping

Unfortunately it was not possible to see any blasting though, instead the quests were guided through underground tunnels to Stockmann shopping center for a well organized coffee break. The scene itself was worth the visit – around 50 people wearing hi vis vests walking through all 5 floors of a busy shopping center. Though no shopping was actually done, as most people hurried back to the conference center near a marina to enjoy the welcoming drinks. As the tickets were all sold out it was expected that the place for the welcoming drinks would be crowded, but no – after a few speeches people were invited to go upstairs where the conference exhibition was already open.

Welcoming drinks – or drinks and exhibition

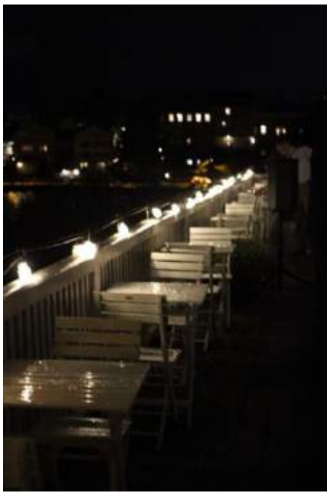
What a pleasant way to start a business meeting, having a fresh drink and walking through the exhibition area, already having a chance to create a map of most interesting exhibition booths in ones minds. See also how Twitter and LinkedIn buzzed with the hashtag #efee2019.

The exhibition lasted for 3 days, and not even a spectacular gala dinner could hold guests away from interesting booths and presentations, if only for a short while. The gala dinner itself was actually very adventurous. Guests were collected on busses in every 15 minutes from the hotel and transported to another marina, where a boat was waiting to take everybody on a little island called Klippan and then a small pathway lead up the hill, to a romantic wooden house.

It was already almost dark, especially as heavy rain was pouring down, which made the welcoming warm lights of the Restaurant Saaristo even more fairytale-like. The atmosphere was very festive, people gathered to tables and admired a great view to the vast sea outside the windows. The evening went too fast, with great speeches, magic, wonderful fireworks on the sea nearby and very good food.

Such a place was indeed more like a great experience rather than just a nice evening out and it suited well to have scheduled boat trips and busses back to the hotel so that the next day everybody was again in business mood. The conference did not really just end there with very interesting technical presentations, good setup of the exhibitionists and possibilities to do business, it also included an excursion the day after.

A wonderful evening out of down, on a little island for good food and company – Gala dinner



The destination for that excursion was first one of the Forcit explosives factory, which has a very clever layout and infrastructure of its own, and it has been that way already for over a 100 years, then the quests were taken to a Tytyri Mine Experience – an old mine turned to a museum, featuring also one of the deepest Kone elevators in the world.

All in all, the EFEE Conference has improved yet again, opening our minds, educating us and also bringing friends and old contacts together in a very pleasant businesslike way.

Teele Tuuna, Newsletter editor and Council member of EFEE

More pictures here: http://voglers.ee/Teele/failid/EFEE%202019/album/index.html

Who are the EFEE Members: INSEMEX

INSEMEX Mission

Fundamental and applied research, technological development for the regulated domains, for national public interest on the evaluation and prevention of risks which may occur during the operations performed in the atmospheres with toxic and explosive hazard, including the use of explosives, the environment protection within the areas adversely affected by the mining and the related operations, testing and certification of equipment, training and certification of personnel, rescuing operations and operations related to mine closures, together with the development and the implementation of regulations related to these operation.

SHORT HISTORY

NATIONAL INSTITUTE FOR RESEARCH AND DEVELOPMENT IN MINE SAFETY AND PROTECTION TO EXPLOSION – INSEMEX PETROSANI was founded in 1949 under the name of Research Station for Mine Safety, as a branch of ICEMIN Bucharest.
Its foundation was determined by the need for solving problems related to safety in the Romanian mining industry. The name under which this institute is known within the mining industry as well as within other industries like the machinery, electro-technical, chemical or oil and gas industry, frames into the tradition developed by its staff in their over 65 years of activity.

INSEMEX activity is conducted in two premises in which the surface designed for research in the 4 pavilions is of about 6000 square meters, and the volume of testing installations consisting of tunnels and experimental galleries exceed 1000 cubic meters.

INSEMEX disposes of a training facility for rescuers, a testing facility for civil use explosives and pyrotechnic articles, located outside Petrosani area, at approximately 5km, and a testing hall for electro-mechanical equipment and installations.
INSEMEX performs its activity within 4 research departments, consisting of 10 specialized research laboratories.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Bill Adamson, AdamSol Engineering SpA, Chile

Carlos Alberto Aguiar Correia, Mota-engil, Engineering And Construction, S.a., Porto, Portugal

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Dariia Ruchkova, FSE "Plant Named After Y.m. Sverdlov", Dzerzhinsk, Russia

Upcoming International Events

ISEE 46th Annual Conference on Explosives and Blasting Technique
January 26-29, 2020
Denver Colorado, USA
https://www.isee.org/conferences/2020-conference

SME Annual Conference
February 23-26, 2020
Phoenix, Arizona USA
www.smeannualconference.com

WORLD TUNNEL CONGRESS 2020
May, 15-21, 2020
Kuala Lumpur, Malaysia
www.seacetus2017.com/4/443/welcome-to-malaysia/

SAFEX International Congress #20
May 27-29, 2020
Salzburg, Austria
https://iexpe.org/safex-congress-bulletin-call-papers/

EUROCK 2020
June, 15-19, 2020
Trondheim, Norway
http://www.eurock2020.com/hjem.cfm

HILLHEAD 2020
June, 23-25, 2020
https://www.hillhead.com

15TH INTERNATIONAL CONFERENCE ON DRILLING AND BLASTING TECHNOLOGY–2020
September 16th-18th, 2020
Velence, Hungary
www.mare.info.hu

SME Annual Conference
February 28-March 3, 2021
Denver, CO, USA
www.smeannualconference.com

World Mining Congress
July 20-22, 2021
Brisbane, Australia
www.wmc2021.org

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whose main tasks will be:

- **marketing of advertisement space in our Newsletter**
- **marketing of EFEE memberships**
- **finding additional advertisers and members**

The applicant should be self-motivated and have adequate written and verbal English and an enthusiasm for sales work. Knowledge of the explosives engineering industry is an advantage. The position is also suitable for a student.

This position is for part time work with estimated working time of 10-20 hrs / month with potential to increase.

Enquiries and applications with CV and salary request should be sent to Mr. Doru Anghelache chairman of the Newsletter and Marketing & Membership committees at office@ar-de.ro before 15th of November 2019