COST C25 - sustainability of constructions

Sustainability of Constructions

Integrated Approach to

Life-time Structural Engineering

Proceedings of Seminar

Dresden 6, 7 October 2008

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Blasting Technology for Demolition and Deconstruction

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ABSTRACT: Blasting technology is one of several possibilities for Demolition and Deconstruction. There are some important advantages especially for employment protection and environment protection. This paper points out the historical development, the explanation of how blasting works and gives some examples for different applications.

1 INTRODUCTION

In recent years the importance of blasting technology increased. The improvement for this technology is fast-paced. Everybody has watched pictures of blasting in TV: collapsing high-riser in a smallest area, chimneys falling exactly in predefined direction, bridges tumbling down or the spectacular fountain of blasting an damp biotope.

Why blasting? Blasting technology is firstly used where other technical facilities are not sufficient or too expensive. The intent for blasting technology is increasing for environment protection and employment protection. Mechanical demolition of buildings puts pressure to residents for a long time by noise and dust. Especially for employers exist an risk by particles falling down or by fall for themselves. The possibility of demolition by press a button in a save distance is minimizing this risk extensively (fig. 1).

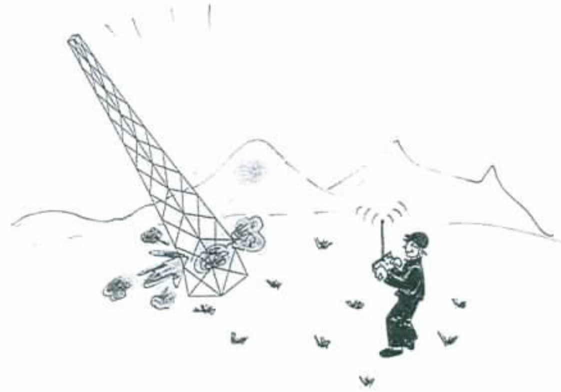

Figure 1. Initializing the demolition with an safe distance.

2 HISTORY

The history of blasting technology is coupled with and until today influenced by military technology (Heinze 1993). The first explosive mixtures are known in asia and the Mediterranean area. In 232 describes Julius Africanus the so called greec fire, an powder containing sulfur, flammable organic matters, liquid asphalt, quicklime and salts.

In Europe the monk Berthold Schwarz (ca. 1330, fig 2 left) was long time recognized as inventor of the gun powder named Schwarzpulver. But in in 846 Marcus Graecus describes in his book liber igenium an mixture of sulfur, carbon and saltpeter in the proportion 1:2:6. 1267, earlier than Schwarz, the Englishman Bacon was engaged in this kind of mixture. The use of gun powder for shooting is attributed to Schwarz. The commercial use of gun powder starts in 17. century. The tyrolean miner Caspar Weindl arranged the first mining technique blasting with gun powder, which is first mentioned in records.

Principal in the 2nd half of the 19. Century begins the design and practice of explosives with high brisance. 1799 the chemist Howard developed the mercury fulminate. 1846 succeeded Shönbein the production of gun cotton by covering cotton with sulfuric acid and nitric acid. 1848 invented Sobreto the nitroglycerin by nitration of glycerin with nitric acid.

Figure 2 left: Berthold Schwarz, right: Alfred Nobel

The Swede Alfred Nobel was the first, who succeeded the technical production of nitroglycerin. But production, transport and application were highly dangerous, because of nitroglycerin is detonating at lowest vibration. Nobel was investigating in a solution. Meanwhile there were some serious accidents in his factories. He solved the problem and fabricated the first explosive safe in handling. But he is not the inventor. This is the Claustaler Friedrich Shell (Oberharz), who had the genius idea to soak sand filled in paperboard roll with nitroglycerin. With this method the dangerous explosive become safe in handling without loosing his explosive strength (Liessmann, 1997). In this time Nobel traveled through the Oberharz and took this method, replaced the sand by kieselguhr from the Lüneburger Heide and named the new explosive Dynamit. In 1875 he added collodion wool to the nitroglycerin and succeded in production of gelatin explosive – the gelatin dynamite as one of the most powerful commercial explosives. Based on ammonium-nitrate based explosive invented by the Sweden Olsen and Norrbin, he developed the ammonium-nitrate based gelatinous explosive by combination with solified nitroglycerol. This explosive is until today in practical use. A particular problem was the save initialization of the detonation. The until today ordinary blasting cup was invented by Nobel too.

At the turn of the century started the electrical firing, later the electrical firing with delay and in the time of now the electronic firing which means significant advantage in safety. After 2^{nd} world war special explosives were designed: permitted explosives with high safety, explosives for seismic investigations, heat-proof explosives, special charges, detonating cords, pumpable explosives and matters, which are firstly mixed to explosives at blasting point or in the bore hole.

3 TECHNICAL TERMS AND DEFINITIONS

(Autorenkollektiv 1985)

3.1 *Deflagration*

The deflagration is a chemical reaction of explosive material like gun powder with low velocity (100 to 1000 m/s), effective only by gas pressure. The oxygen needed is present in the reactive system. The decomposition products, the combustion gases, are streaming against the direction of deflagration.

3.2 *Detonation*

The detonation is a chemical reaction of brisant matters with an shock, which initiates the transformation and which is extending ultrasonically with a speed over 1000 m/s till 9000 m/s. The coupling of the materials delivering the energy occurs in the detonation area. The combustion gases are streaming in the direction of detonation. The detonation velocity signs the brisance, the capability to demolish the environmental material.

3.3 *Explosion*

The Explosion is a sudden efficiency caused on the expansion ambition of gases and vapors. It based on an exothermal reaction, which releases suddenly high potential energy

3.4 *Explosion pressure, efficiency, explosive strength*

The explosion pressure is the pressure, which evolves from the explosion. Hereby is it equal if the cause is deflagration or detonation. By deflagration the explosion pressure is equal to the gas pressure. By detonation the explosion pressure is the addition of shock and gas pressure.

4 CHARACTERISTICS OF EXPLOSIVES

The slogan "much is helping much" is not valid for the blasting technology. Contrawise: in case of overloading damages in the environment occur and the appointed blasting success, to attain an defined grade of demolition, is missing. The overloading adverts to the mass of the explosive and also to the brisance of the explosive.

In a stone pit for marble slow explosives with high gas volume are used. An pushing force is desired to get large blocks without cracks to process them into plates. The use of high brisant explosives will result small unusable pieces. Depending on the chemical composition of the marble donarite or gun powder are suitable for explosives.

An other fact is the blasting of Buildings. Here it is considered to demolish the structure by the shock an afterwards eject the material by the expanding gases. The explosives used for this job has detonation velocities at 3500 m/s in the bore hole. The higher the reinforcement the higher should be the detonation velocity.

More extremely are seismic blastings or shaped charges to cut steel. The gas volume is not needed. The only fact is the work of the shock, depending on the detonation velocity.

5 BLASTING OF STEEL WITH SHAPED CHARGES

The conventional method today of cutting steel with shaped charges is linked to the invention of hollow charges. It was recognized that the formation of the explosive, assisted by an inlay of metal, increases the impact in the depth. For shaped charges explosives with high brisance are used.

The cross section and the construction of an shaped charge is pointed in figure 3. After initializing and detonation of the explosive the copper inlay is accelerated under high pressure with impact. It collapses in the hollow (fig. 3 middle). Out of the collapsing lens begins the projectile called stinger, which moves with a velocity nearby 9000 m/s. If this projectile hits the target, the penetration takes hydrodynamically place because of high pressure and high velocity. The projectile is dissipated in the ground of the crater and is eroding the base material. The penetration is finished, when the projectile is completely dissipated. (Loose 2003)

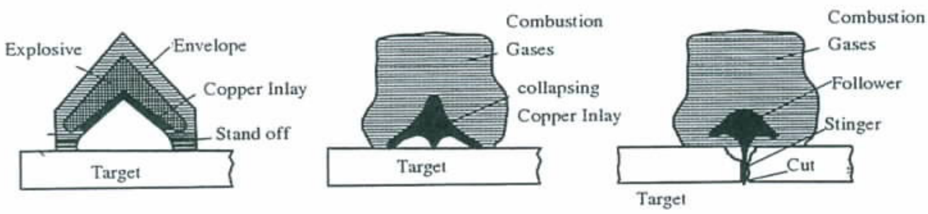

Figure 3: Shaped charge, cross section and mode of operation

6 BLASTING FOR DECONSTRUCTION

6.1 *Buildings*

Depending of the free area next to the building two methods are applicable: Method 1: tilting, method 2 collapsing. The loading is applied in bore holes. The holes were filled with clay, wet newspapers or polyurethane foam, so that the explosive is not detonating inefficiently. For both methods the bore and blasting technology is the same. The different is in the arrangement and the detonation time of the loadings. For the objects to be tilted, there has to be blasted an so called jaw. (fig. 4 left)

For the dimensioning of the jaw the center of gravity has to be considered. The jaw is a complete cut through the blasting object. Stairways, elevators and chimney needs a special treatment. They have to be degraded, completely taken out or blasted in first order. Often the object is completely cut in the horizontal line by a line of single loads (fig. 4 right and fig. 5)

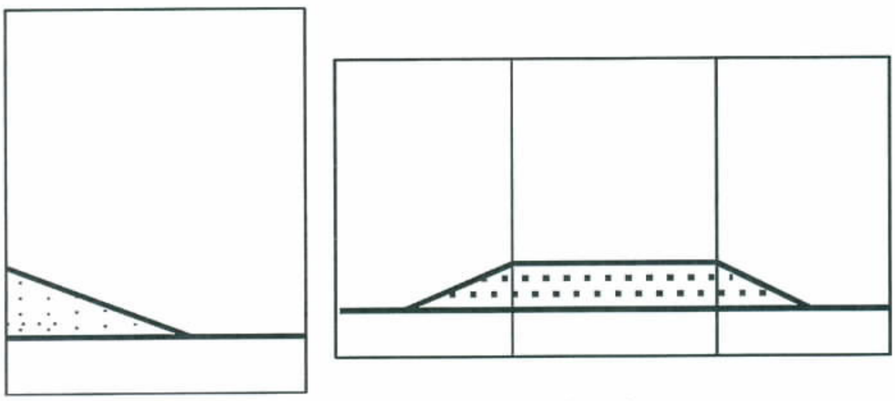

Figure 4 left: profile with jaw, right: development drawing front view

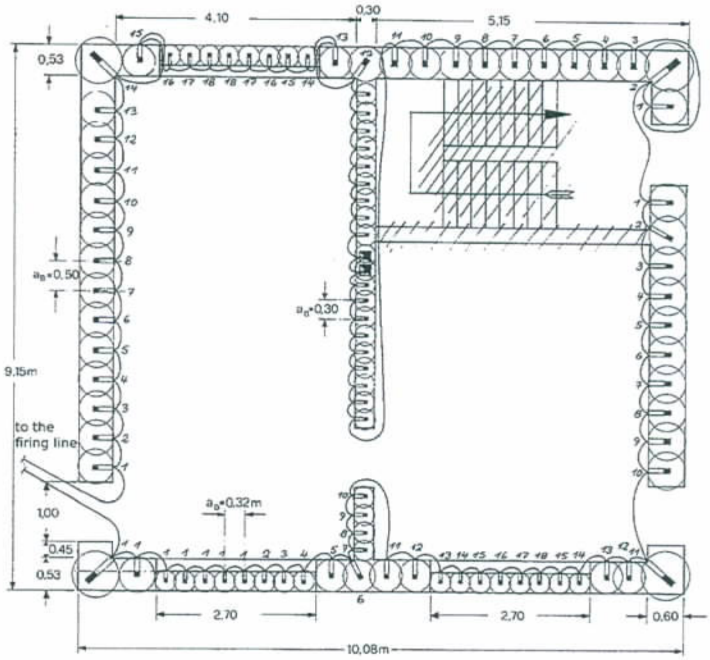

Figure 5: Footprint

High-riser were get to collapse by blasting because there is less free area and the ground motion is increasing if the were tilted. In the base and in the middle some structural levels were completely blasted out (fig. 6). The firing is for every line in the construction level at the same time. Otherwise it will generate an jaw, which has to be impeded.

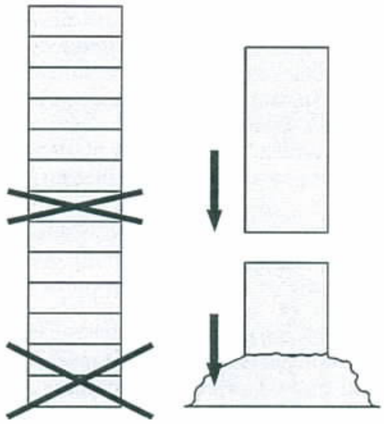

Figure 6: Collapse method for deconstruction of high-riser

6.2 *Chimneys*

In Germany it is not allowed anymore to blast chimneys by the collapse-method. There is an great risk, that the upper part sits on the base without collapsing and tilting in any direction without control. For that reason only the tilt-method with blast jaw is applied. The cross section is blasted out over more than 55 %. Next to the edge of the jaw were two fissures stemed, to stabilizes the tilting (fig. 7.). Difficulties occurs when the chimney has an inner chimney or if the chimney is filled with demolition waste.

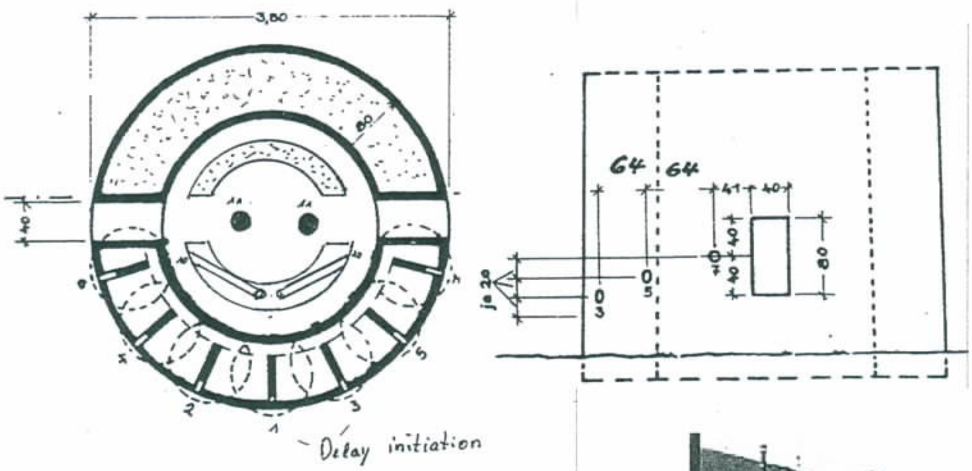

Figure 7 left: footprint of chimney, right: profile with fissure

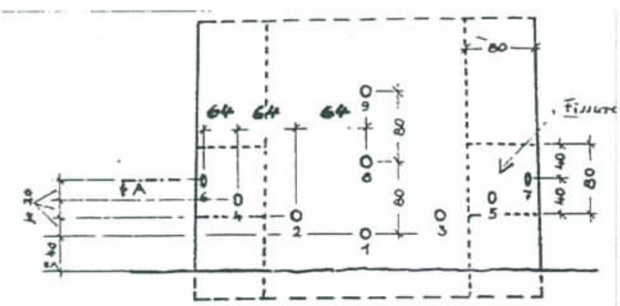

Figure 8 left: development drawing front view, right: chimney falling down

An example of such an difficult blasting object is shown in the figures 7 and 8. In the same way like building the jaw is blasted at the outer chimney. The inner chimney is bored at the side and loaded with detonating cord.

An pivoted joint in the base of the fissures is used for thin walled chimneys of reinforced concrete. This effected that the falling is stabilized and that the chimney is not able to break away laterally.

6.3 *Foundation*

A new scope of duties is the deconstruction of windmills. The constructional systems were carefully decomposed for reselling. Finally the steel-ring, which anchors the windmill, remains in the concrete of the foundation in a depth of 2 m. The steel-ring is exactly manufactured and it is recommend, that he did not deforms during deconstruction. Mechanical deconstruction is not practicable because of strong reinforcement.

The blasting method used is like the blasting method in tunneling. The reinforced concrete is enclosed in the steel-ring and therefore constrained (pressure). First item is blasting a hole in the middle with higher loading. Next item is blasting the other loadings around with delay in the hole. Last item is the blasting of the outer foundation. The direction is from outwards to inwards, circular and with time delay. An example for such blasting object and the blasting result is shown in figure 9.

Figure 9 left: Foundation with steel ring, right: blasting result

6.4 *Steel constructions*

The blasting method for steel is separating the steel with shaped charges. The steel is cutted by blasting. Figure 10 shows an example. With shaped charges an opening 200 mm x 300 mm is blasted in an 10 mm thick steel plate.

For the deconstruction of steel construction the same methods, tilting or collapsing, were applied as for buildings of concrete or brickwork. Supporting columns or beams are separated by shaped charges in the way that the construction is tilting or collapsing.

Wired pylons can be disposed when the cables in one direction are cutted. Caused by the tension in the other cables, the pylon is accelerated in the so defined direction.

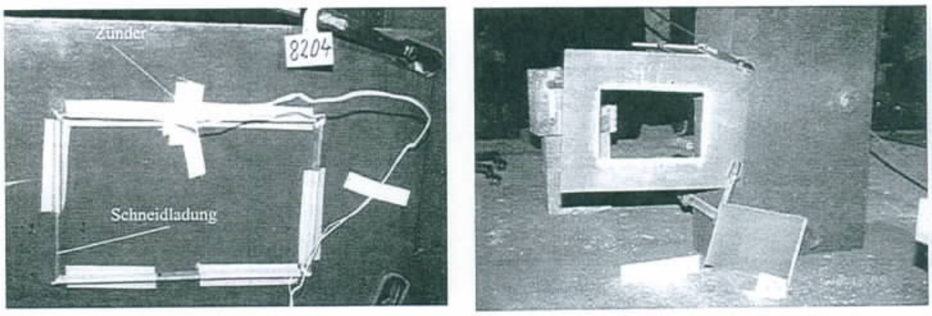

Figure 10: Example for blasting steel

7 CONCLUSION

The possibility to initiate explosives in a secure distance enables the blasting technology to deliver an significant contribution for employment protection in deconstruction and demolition. Starting with the history of explosives, this paper points out several operation conditions for different explosives. The physical effectiveness is explicated and focused for several kinds of blasting jobs. The blasting technology is shown in examples for deconstruction of miscellaneous kinds of constructions and building classes.

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