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Investigation of the Effects for Point of Initiation for Military Explosive-PE4 on the Blast Profile

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Abstract: For several decades, a blast wave profile due to explosive detonation has been investigated extensively. Base on a significant amount of experimental data, the blast wave propagation profile has been predicted at specific conditions. However, only center point of initiation for spherical shape explosive has been considered in most studies. The objective of this research is to investigate the effects of different point of initiation for military explosive (PE4) on the blast profile. In this experiment, a total 500 g of military explosive was initiated at three different initiation point which are top, bottom and also center of explosive. The explosive were detonated at a different distance from 0.5-4.0 m. The blast peak overpressure was captured using free field pencil probe and also high speed data acquisition system. The results shows that the top initiation produce the highest peak overpressure as compare with the center and also bottom initiation.

INTRODUCTION

Explosive is defined as solid, gases or liquid substances mixed with one another which are capable of undergoing a rapid chemical reaction that will release a large amount of energy[1]. Explosives are substances which contain fuel and oxidizer when react, it will release of large amount of potential energy. The energy from the explosion dissipated as a blast wave, gas and also heat. The gases produce by the detonation of an explosive consists of carbon dioxide, nitrogen, carbon monoxide and oxides of nitrogen. Generally, an explosive is used for breaking rocks into a smaller sizes for the application as gravel that will be used in the concrete or the asphalt roads. In wars, the explosives can also be used for the military operations to defend the country from Foreign intrusions by destroying the tanks, shells and bombs.

Classification of explosive: Explosive can be classified into high and low explosives as shown in Fig. 1. High explosive can be further categorized as primary high and secondary high explosives. The military and commercial explosives are grouped under the secondary high explosive.

Military explosives: Military explosives are commonly used in the demolitions, bombs and war head. These

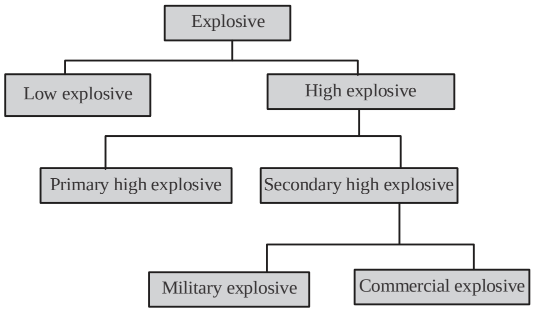

Fig. 1: Explosive classification[2]

explosives are very stable, insensitive to shock, heat and friction. They have long self-life, high density, high detonation velocity, good storage capability and also to adopt under a wide range of temperature and environment. The most common military explosives are TNT, C-4, RDX, HMX and PETN[3].

Plastic explosive-PE4: Plastic explosive-PE4 is a military explosive. It is white solid which has a texture similar to modeling clay and can be molded easily into any desired shapes. It is known as PE-4 by the British Army and C-4 by the United States Armed Forces. This explosive contains 91% of RDX as the basic agent and plasticizer. PE-4 is a very stable and insensitive to most physical shocks. It does not explode when set on fire or exposed to microwave radiation. It can only detonate by using detonator. When detonation occur, PE-4 will rapidly decompose to release nitrogen and carbon oxides as well as other gases. It has a detonation velocity of 8.092 m sec^{-1} and it is widely used for cutting steel, timber, breaking concrete structures and also for the demolition works[4].

Point of initiation: High explosive normally can be initiate using detonator. It was first invented by Alfred Noble in 1864. There are many types of detonator available in the market such as plain detonator, electric detonator and also electronic detonator. The most commonly use detonator is electric detonator and its normally will be insert at the center point of explosive to initiate the secondary explosive. The point of initiation is refers to the position of the detonator inserted in the secondary explosive (Fig. 2).

Blast wave profile: An explosion from the detonation of explosive produces a very high temperature which is about 3000-4000 Celsius releasing gases such as carbon monoxide, nitrogen oxide and also high pressure waves up to 30 GPa[5]. This pressure wave is also known as a blast wave which travel at speed of sound is illustrated in Fig. 3.

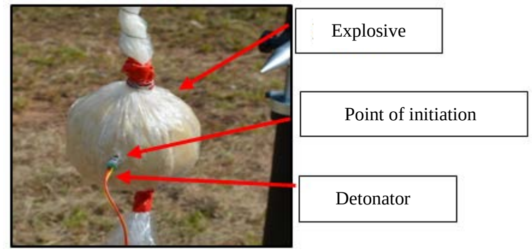

Fig. 2: Point of detonation

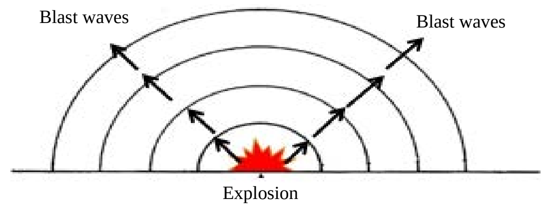

Fig. 3: Illustration of blast wave profile from an explosion

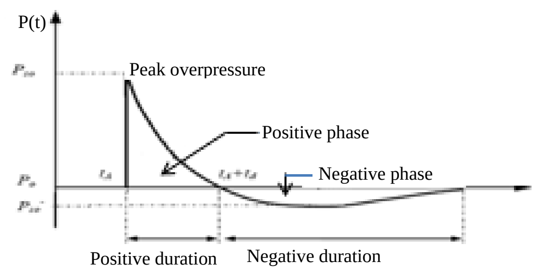

Fig. 4: Typical blast wave profile

The blast wave which is produced from a detonation of an explosive can be presented in an idealized profile of the pressure-time history which is shown in Fig. 4.

Hryciow *et al*.[6] stated that the point of detonation has a significant influence on the overpressure distribution. Another studies conducted stated that the point of detonation within the explosive will also effect the spatial distribution of overpressure, especially for cylinder shape. The point of detonation within the explosive will also affect the spatial distribution of overpressure, especially for a cylindrical charge. The placement of the detonator and booster charge at the end of the cylindrical charge led to a highly non-uniform pressure distribution in the near field.

The objective of this research is to investigate the effect to the blast peak over pressure due to different point of initiation for military explosive PE-4.

MATERIALS AND METHODS

Details experimental

Materials and procedures: Military explosive PE4 is

Fig. 5: Military explosive (PE-4)

Fig. 6. Field blast test set up

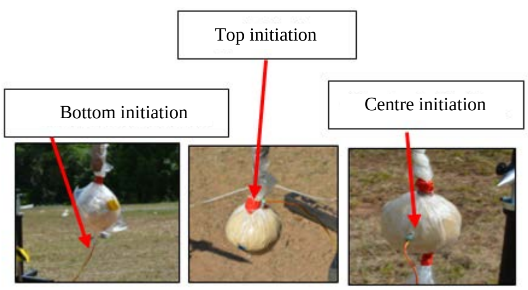

Fig. 7: Point of initiation for military explosive (PE-4)

used in the research. This explosive were provided by the Malaysian Arm Forces. The sample of military explosive PE4 is shown in Fig. 5.

Field blast-test was conducted at the disclosed military camp in Malaysia. A wooden timber supporting the explosive was erected to hold the charge. All of the charge was placed at the height of 1200 mm from the ground in order to ensure that there is no reflection from the soil interfering the measured pressure.

There are 8 pencil probes has been set on the site to record the pressure from the explosion which are from 0.5-4 m for all different types of explosives, shapes and also point of detonation. The field blast testing setup is shown in Fig. 6. These explosives will be weighted and molded into spherical charge. The explosive were detonated using electric detonator at three different point of initiation as shown in Fig. 7.

Fig. 8: Free field blast pencil probe

Fig. 9: High speed data acquisition system

The peak over pressure were measure using free field blast pencil probe as shown in Fig. 8. High speed data acquisition system includes software, a signal procedure, sensors, transducers and cables that are connected to test specimens, PXI instrumentations, including a Tetra RPC PXI chassis from Logic Instruments, NI PXI-8110 embedded controller and NI PXI-6133 multifunction DAQ device can be used to capture the data from the sensors. Meanwhile, LabVIEW to program the system and display test results. The high speed data acquisition system is shown in Fig. 9.

RESULTS AND DISCUSSION

The experimental results is shown in Table 1. From the experimental results it shows a small difference between each point of detonation with the top initiation produce the highest peak over pressure of 4.21 MPa while the center point of initiation produce the lowest pressure with 3.703 MPa.

The result for blast profile at different point of initiation for military explosive is shown in Fig. 10. Figure 10 shows a clear downward trend in the pressure distribution of PE4 spherical shape charge for top, centre and bottom of initiation. The highest peak overpressure value has been noted to be 4.216 MPa for top point initiation. The pressure value for the top, centre and bottom point of initiation can be seen in the graph where the remarkable reading is recorded by the top point initiation. The lowest value from the graph was recorded by the centre point of initiation where the highest value of the peak overpressure is 3.703 MPa.

Table 1: Experimental result for PE4 spherical shaped charge with different point of detonation

Items	Charge weight (g)	Distance (m)	Point of detonation	Peak pressure (MPa) experiment
1.	500	0.5	Top	4.216
			Centre	3.703
			Bottom	3.991
2.		1.0	Top	0.802
			Centre	0.734
			Bottom	0.787
3.		1.5	Top	0.323
			Centre	0.296
			Bottom	0.336
4.		2.0	Top	0.150
			Centre	0.139
			Bottom	0.149
5.		2.5	Top	0.108
			Centre	0.105
			Bottom	0.116
6.		3.0	Top	0.074
			Centre	0.069
			Bottom	0.072
7.		3.5	Top	0.070
			Centre	0.053
			Bottom	0.071
8.		4.0	Top	0.044
			Centre	0.041
			Bottom	0.043

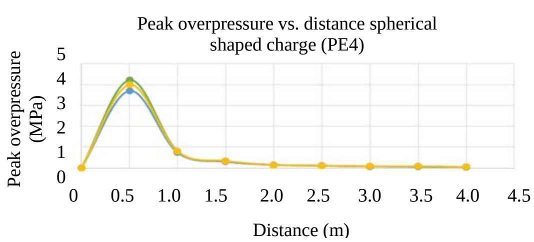

Fig. 10: Blast wave profile for different point of initiation for military explosive

CONCLUSION

The experimental results conclude that the top initiation produce the highest pressure and follow by bottom initiation while the center point initiation produce the lowest pressure among all this three point of initiation.

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