Performance Evaluation of Emulsion/Water-Gel Explosives and Comparison with Dynamite in Sri Lankan Quarrying/Mining Practice

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Abstract: In the Sri Lankan context, Gelatin Dynamite has been one of the widely used explosives for rock blasting purposes. Water-gel (WG) explosive is in the process of being introduced to the Sri Lankan mining industry. So far there had been only a very few tests conducted to assess the suitability and to evaluate the performance of this explosive with other available explosives. Complaints made by the users as regard to the performance of WG have been a cause of concern.

In this research, performance comparison of WG with Dynamite as regards rock break-out in underground tunnelling has been carried out. Comparison of fragmentation with the evaluation of particle size distribution in concrete block blasting, using three types of explosives (WG, Dynamite &Emulsion) has been one of main tests. Gap sensitivity, density and the determination of Velocity of Detonation has also been carried out.

Keywords: Dautriche Method, Gap Sensitivity, VO

1. Introduction

Water-gel (WG) was introduced to Sri Lanka in 2011 as a substitute for Dynamite. So far only a very few tests have been conducted to assess the suitability and to evaluate the performance of this explosive in comparison to other available explosives.

In this research project, a comparison of the performance of Water-gel explosive currently in use, with Emulsions and earlier used Dynamite, with a view to identify its deficiencies and propose measures to overcome them with a view to optimize its usage in Sri Lankan mining practice.

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Fragmentation ability of explosives has been compared using blasting concrete blocks. Digital images of resultant fragmentation after the blast were analysed using SPLIT specialized software.Underground tunnelling has been carried out using identical cut-hole configurations and with blasts using both WG and Dynamite and the resultant tunnel advance rates in each case were compared .Density measurements of explosives and gap sensitivity tests have been conducted to crosscheck the manufactures specifications on WG.

Measurement of VOD using Dautriche method was carried out for the first time in Sri Lanka for WG, Emulsion and Dynamite.

2. Methodology

2.1 Test Blasting on Concrete Blocks

Concrete blocks of the size 0.5m*0.5m*0.5m were made with a 32mm diameter centre hole of 30cm deep to insert the explosive

charge (Figure). Average strength of concrete blocks after curing was 40.6 Nm^{-2}

Three explosive types namely WG, Dynamite and Emulsion were charged in quantities of 25g and 30g respectively to study

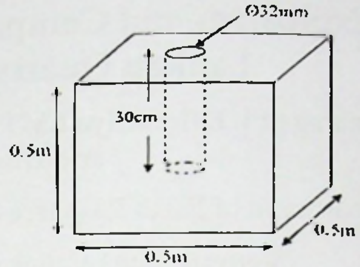

Figure 1: Concrete block dimensions

The fragmentation level by each explosive. Quarry dust was used as stemming material and no ANFO was used. After the blast all fragments were collected, weight was measured, photographed, and digitally analysed using SPLIT software.

2.2 Test blast of Water-gel vs. Gelatin Dynamite in underground

Cross-cut tunnel advancing (as at June, 2012) of Bogala Graphite Mine, (Sri Lanka), in 109 fathom level (-191m) was used for the study. Gelatine Dynamite manufactured in Sweden and Sri Lankan made Water-gels by Kelani Fireworks Company were used as explosives. Swedish millisecond and half second delay No. 08 detonators were used in every blast as initiators.

Drill pattern adopted in tunnel blasting is shown in Figure . Tunnel face was charged with one explosive type at a time and respective advance rates were measured. Tests were repeated changing the explosive type.

2.3 Density measurement

Density measurements were done by weight and volume measurements by water replacement. A graph was produced with weight over volume with different observed values.

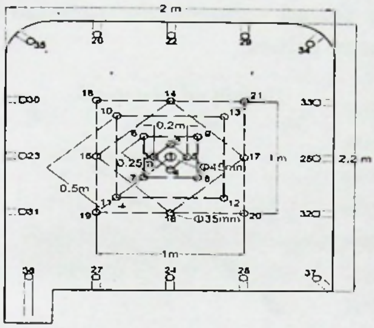

Figure 2: Drilling pattern

2.4 Air Gap sensitivity

Two half cartridges of explosives were placed at varying distances (~2cm) and blasted by means of an electric detonator. For Water-gel, this test was a cross checks of the manufacturer's specification.

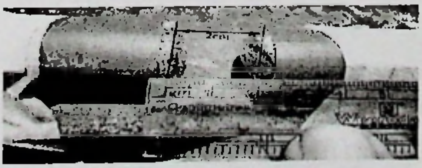

Figure 3: Gap sensitivity arrangement on field

2.5 VOD Measurement

Velocity of Detonation in unconfined conditions was measured using Dautriche method (Figure).

VOD of the Detonating Cord (DC) was obtained from the manufacturer. Knowing the offset distance (a) after the blast and DC separation (m), VOD of the explosive was calculated.

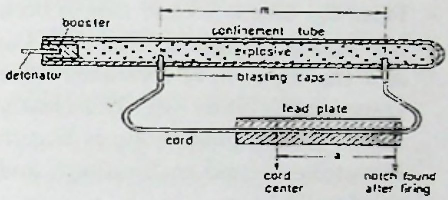

Figure 4: Schematic arrangement for Dautriche method

3. Results & Discussion

3.1 Results of Concrete Block Blasting

Figure 5 and 6 show the particle size distribution after the blast using 25g and 30g of explosives respectively.

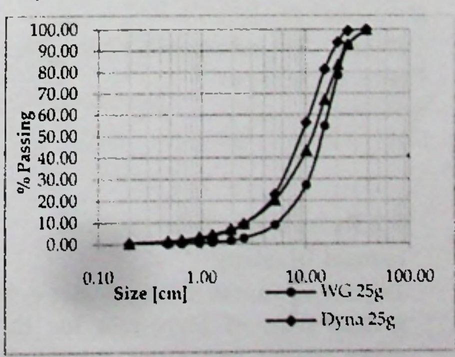

Figure 7: Particle Size Distribution graph for 25g of explosive charge

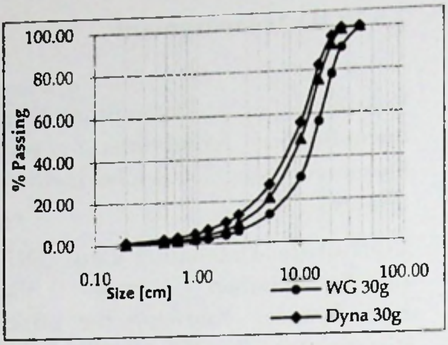

Figure 6: Particle Size Distribution graph for 30g of explosive charge.

From fig. 5&6 it is clear that in both 30g and 25g tests all D_{10}, D_{30}, D_{50} and D_{60}values have increased from Dynamite to Water-gel. This clearly shows that fragmentation is best in Dynamite second in Emulsion and third in WG.

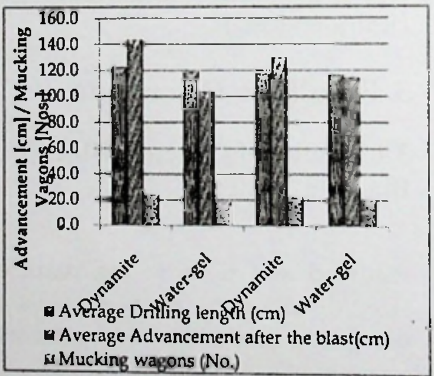

Figure 7: Tunnel advances with different types of explosives

3.2 Results of underground tunnel blasting

Tunnel advances using Water-gels is less than of Dynamite for the same charge and same cut whole configurations? (fig. 7)

3.3 Results of density measurements

Error! Reference source not found.8 shows the mass over volume measured. The gradient of the regression line hence become the density. Error! Reference source not found. shows the resultant density values.

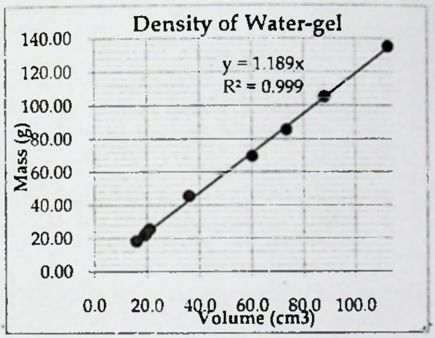

Figure 8: Mass Vs. Volume of WG

Explosive Type	Average Density (g/cc)
Water-gel	1.19
Emulsion	1.21
Dynamite	1.29

Table 2: Average densities

From the above table it is clear that Dynamite has the highest density of 1.29g/cc. Density of Water-gel and Emulsion lies close by (0.02g/cc) although Emulsion has slightly higher density.

3.4 Results of gap sensitivity for Water-gel

Air gap sensitivity test was positive for both 2cm and 3cm of air gap for WG. Burn marks were clearly visible in the area of the receptor area indicating the successful receive of detonation wave.

3.5 Results of VOD measurements

Following Table 3 presents the results of Dautriche test.

Table 3 - Resultant VOD values from Dautriche method

Explosive Type	DC separation (mm)	Offset gap(mm)	VOD of DC (m/s)	VOD (m/s)
Water-gel	100	84	6750± 250	4018
Emulsion	100	68	6750± 250	4963
Dynamite	100	60	6750± 250	5625

It is clear from the above Table 3 that Dynamite has the highest VOD of 5625 m/s and Water-gel has the lowest of 4018 m/s. Emulsion is in between having a VOD of 4963 m/s.

4. Conclusions

Water-gel is a low energy explosive than Dynamite and Emulsion. Fragmentation of Water-gel was found to be less than of Dynamite as demonstrated in surface concrete

block blasting and underground muck pile analysis.

The conclusion to be arrived is that detonation characterised by the low velocity of detonation creates a weak fracture system affecting the level of fragmentation of the rock in the immediate aftermath.

In underground blasting, WG is environmentally more comfortable than Dynamites. This is due to the toxic fumes emanating from Dynamite inducing headaches and dizziness in underground environments.

WG is of low cost than other commercial explosive types. (722, 1081 and 1320 LKR/kg for WG, Dynamite and Emulsion respectively as at Nov. 2012). Although this low price is effective in open cast mining, in tunnelling this advantage has been overrun due to the low tunnel advancements and consequent additional blasting rounds with Water-gels.

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