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

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Abstract: At present, Dynamite is currently manufactured only in a few countries as a commercial explosive due to its high cost hazardousness. Therefore import and supply do not match the demand patterns which inevitably result in considerable inconvenience to the quarry industrialists to certain degree affecting the development of this industry which has a direct bearing on the country's infrastructure development. Consequently, there is great necessity to manufacture high quality explosive of low cost and less hazardousness as a substitute for Dynamite. By using Magnesium/micro glass bubbles/Aluminium, instead of the main sensitizer (Nitro Glycerin) of Dynamite, Slurry explosives (Water-Gel) are manufactured under the similar process as a powerful explosive. In this instance, the industrialists have been compelled to use the low cost but almost untested explosive as a substitute. Research so far carried out only show that the product is substandard which dictates further the investigation.

Keywords: Main sensitizer, Water-Gel, Nitro-Glycerin, Power full explosive, Detonator

1. Introduction

An explosive or a blasting agent is a compound or a mixture of compounds, which, when initiated by heat, impact, friction or shock, undergoes a very rapid self-propagating exothermic reaction.
Explosives are the major component used in Sri Lankan quarry practices. It is found that the most efficient method in rock breaking is with use of explosives. There are many types of explosives using in blasting activities. In Sri Lankan quarry practices Dynamite is the widely used type of explosive in blasting activities. Because of large number of drawbacks, Dynamite is being replaced with Water-gel.

Major drawbacks of using Dynamites are environmental impacts such as toxic gases, high ground vibration and air blast. When comparing with Dynamite, Water- gel does not have that much of environmental impacts. As a whole, despite some of drawbacks of using Water-gel, it is clear that it has greater advantages in blasting activities.

There are two types of explosives such as high explosive and low explosive. High explosives can be divided into two categories such as primary and secondary explosives.

Dynamite is a mixture of $NaNO_3$, wood meal and NG. Wood meal can be replaced by flour or sawdust, and even a portion of the NG by other organic compounds or by $NaNO_3$. Dynamite has a high velocity of detonation creating shock waves.

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Emulsions are a mixture of two or more liquids that do not normally dissolve in each other but are held in suspension by small amount of emulsifiers such as gums and surfactants. Emulsions create a low level shock wave compared with Dynamite.

Slurries (Water-Gel) are mixture of oxidizers such as $NaNO_3$ and, fuel-sensitizer, either explosive or non-explosive and water usually about 15%. (Allsman - 1990)

2. Methodology

Field studies and observations:
Locations (Four quarries) in the Western Province were chosen for the study. Site locations selected to collect samples were as follows:

- Hyundai quarry
- Heisei Constructions (quarry)
- B- grade quarry
- Hovel Constructions (quarry)

Test blasts carried out with varying blasting geometries and varying quantities of explosives Dynamites, Water-gels and Emulsions.

Blasts to be carried out using concrete blocks which made to compare performance of Dynamite and Water-gel with same blasting conditions.
During the concrete test blasts, ground vibration and air blast over pressure measurements will be monitored using Blast Mate (vibration monitor).
A questionnaire has been issued among all quarries in Sri Lanka, requesting their feed back in use of newly issued explosives, Water gels and emulsions. This will be helpful for the project to get a clear idea of practical problems faced in quarry industry.
Cost comparison of explosives also to be carried out.

After the concrete test blasts, results will be analyzed and finalized. Conclusions will be included in the final report.

2.1 Procedure

Procedure of the project mainly includes following four major sections;

1. Literature Review.
2. Collection of data from field visits.
3. Data evaluation.
4. Recommendations

Field studies carried out for an extended period in selected quarries. Rock samples taken out from quarry sites were tested to determine their properties.

2.2 Lab testing

Prepared core samples were tested with diametrical test method by using UCS (Uniaxial Compressive Strength) testing machine.
It was assumed that several rock samples cored from a given boulder had similar properties. It was often possible to get several PLI (Point Load Index) values from a core barrel, and a separate prepared core barrel from the same boulder was used to get the UCS values. Average values for the UCS and PLI were obtained.
(Singh - 1996)

3. Results and discussion

During field visits, blasts were carried out by using Dynamite and Water-Gel separately and results of Ground vibration, Air blast over pressure and fragmentation for each blast were obtained. But the conditions such as ground conditions, amount of explosive, types of rocks and numbers of holes etc, could not be controlled as same. Therefore blasts of Dynamite and

Water-Gel separately with same conditions must be carried out to get proper performance comparison.

Two consecutive bore-holes were selected in same rock and blasted with equal quantity of Water- gel and Dynamite separately with ANFO. But it To get the accurate results, ANFO must be eliminated.

Therefore each blast of Dynamite and Water-Gel will be carried out by especially prepared Concrete Blocks. difficult to compare each blast results, because ANFO directly affect the blasting performance. The results of the two single-hole blast were also shown in table1. (V4/B1 & V4/B2)

Blasting of these blocks is to be carried out with the same amount of Dynamite and Water-Gel without ANFO.

According to the powder factor for concrete, weight of explosive will be calculated.

Ground vibration and air blast over pressure will be recorded for each blast.

After the concrete blast, distance from the blasting location and distribution of blasted rock pieces will be analysed and weight of each pieces will be measured.

Observed data was not sufficient to make a reliable conclusion. Below data were prepared with use of real data taken from a well known A-grade quarry in Sri Lanka. Explosive usage and the production in four months are given in the table 2.

Table 1 - Measured Blast performance at different Quarry Sites

Visit /Blast No	Blasted Holes	Production (m^3)	Dynamite (kg)	Water-Gel (kg)	ANFO (kg)	Emulsion (Kg)
V1/B1	27	2316.11	297	0	0	0
V1/B2	25	2144.55	275	0	0	0
V2/B1	21	1801.42	0	0	0	231
V2/B2	25	2144.55	0	0	0	275
V3/B1	20	717.60	0	0	200	20
V3/B2	20	717.60	0	0	200	20
V3/B3	15	538.2	0	1.875	150	5.625
V4/B1	1	-	0.125	0	0.5	0
V4/B2	1	-		0.125	0.5	0

Table 2 - Historical Blast Performance at Hoavel Quarry

Month	Blasted Holes	Production (cubes)	Dynamite (kg)	Water-Gel (kg)	ANFO (kg)	Cubes/ kg	Cubes/ Hole
Dec	2613	7675	504.325	0	2447.0	15.2183	2.94
Jan	1904	5400	386.550	0	1908.0	13.6997	2.94
Feb	2087	5730	443.490	0	2142.3	12.9202	2.75
Sub Total	6604	18805	1334.365	0	6497.3	14.0928	2.85
Apr	945	2590	0	159.425	875	16.2459	2.74
May	1870	5141	0	352.800	1747	14.5720	2.75
Jun	2366	6567	0	440.050	2244	14.9233	2.78
Sub Total	5181	14298	0	952.275	4866	15.0146	2.76

According to their observations powder factor of each explosive are shown bellow.

Powder factor of Dynamite - 2.40
Powder factor of Water Gel - 2.45

5. Conclusions

According to our field visits our own observations, information passed on by technical personnel in the above quarry site indicates fragmentation with regard to water-gel under similar conditions is subsidized.

In water-gel, low level of shock energy when compared to dynamite results in incomplete detonation through the entire column.

In this regard further research to be carried out using concrete blocks and results will be obtained.

We believe that to justify future use of water-gel.

Packer should issue detail standard technical information.

For greater performance below improvements should be considered;

- Primary requirements
- Enhancing velocity of detonation can be detonation further purpose of obtaining better fragmentation and eliminating of misfire can be research into.

6. Acknowledgements

The authors would like to convey sincere gratitude to Prof. P. G. A. Puswewala (Dean, Faculty of Engineering) and Dr. S. Karunarathne (Head, Department of Earth Resources Engineering) for granting permission and providing all necessary facilities to carry out the field works.

Special thank for Mr. W. Gajasinghe (senior mining Engineer- Hovel Construction Pvt. Ltd.) for for facilitating us to carry out the test blasting..

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