THE OPTIMIZATION OF FIELD PARAMETERS OF NON-EXPLOSIVE DEMOLISHING AGENT

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Abstract: Demolition of concrete and rock is a common process in many construction, renovation and rehabilitation projects. Non-explosive Demolishing Material (NEDM) has been a popular alternative for explosive or mechanical demolishing activities due to the lack of noise and vibration. NEDM is a dry, powdery material that expands considerably when mixed with water. When two consecutive drill holes in rock or concrete are loaded with NEDM, the pressure developed by NEDM gives rise to stress concentrations among the holes causing the rock to fracture. However, NEDM is not yet economically competitive, with explosives and any means of optimizing on their use is considered desirable. This study examines the factors affecting the performance of NEDM in the laboratory environment using unreinforced concrete blocks by analysing crack initiation and crack expansion. It was found that the performance of the NEDM is a function of water content, water temperature, field temperature and the brand used. Further Research was conducted to examine the possibility of adding an inert material to the NEDM in order to reduce the cost. Research was also conducted to improve the workability of the NEDM by the addition of super plasticizer to the slurry.

Keywords: Expansive Cements; Stress Concentration; Workability; CaO expansive agent

1. Introduction

Demolition of concrete and rock is a common process in many construction, renovation and rehabilitation projects. Demolition includes removal from the site of existing features such as buildings, in-situ rock boulders that interfere with the new construction activities. Among the well-known methods, the most common are explosives and mechanical crushing and breaking.

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However, these methods require a large staging space on the site and/or generate a considerable amount of vibration, fly rocks, gas and dust. Non Explosive Demolishing Material (NEDM) has been a popular alternative compared with methods using explosives or mechanical demolishing activities due to the absence of noise and vibration associated with above methods.NEDMs are powdery materials that expand considerably when mixed with water through chemical hydration, by the formation and development of crystals.

Under confinement, this expansion can generate significant expansive pressure, which causes cracking of rock or concrete when it exceeds the tensile strength of materials.Several chemical compounds have been proposed in the past, but quicklime is the most common compound found in present NEDMs due to their intensive expansion force upon hydration and low cost of material (Hanif et al., 2007).

Despite their versatility, NEDM's performance is subject to compromise in certain instances. One drawback of NEDM is the cost. When compared to common explosives, NEDMs are often more expensive. Other drawbacks are workability and ease of placement. Although adding water enhances workability, it reduces maximum pressures generated.

2. Literature Review

Arshadnejad (2010) suggested that Poisson's ratio, hole diameters and hole spacing's are the main parameters that affect the stress concentration between two consecutive circular holes.

Gomez and Mura (1984) proposed $L = D * k$ for determination of hole spacing for various material strengths, where L is the distance between holes, D is the hole diameter k is an in-situ material property where;

$k<10$ for Hard Rock

$8 < k < 12$ for Medium Rock

$12 < k < 18$ for Soft Rock and Concrete

$5 < k <10$ for Pre-stressed Concrete.

3. Methodology

The research methodology chosen was the application of NEDM in concrete blocks in a laboratory environment to study the crack formation while changing the variables. Concrete blocks were chosen instead of rock blocks, in order to limit the strength variations, which occur due to mineralogical and geological variations in rocks.

Following types of tests were conducted to study the factors affecting the performance of NEDM.

Preliminary Crack Tests- Conducted in order to familiarize with the material, to determine the best drilling parameters, find a method for capturing results to assessing the general cracking patterns and destruction of the blocks.

Time recorded Crack Tests -Tests focused on the effect of field parameters (water content, temperature, inert material and brand) for the performance of crack formation. The extent of cracking observed in this set of tests was recorded at regular intervals after application of the NEDM. Data recorded were crack dimensions, pattern consistency, crack migration, blocks destruction, and other notable results.

Crack Migration Tests- These tests focused on the effect of non-injected hole with NEDM for the crack formation and migration. Crack migration demonstrates whether it would be beneficial to drill extra holes in order to create a more ideal crack pattern and control crack direction while reducing costs by using less amount of NEDM.

Phase2 Version 6.0 (Rocscience Inc., 1990- 2007) based on the finite element method Mini Slump Test which was originally developed by Kantro (1980) and later modified by Zhor and Bremner (1998) was used to observe changes in the NEDM slurry workability with the field variables. ImageJ, Java-based image processing program was used to process the images obtained from the laboratory tests.

4. Results and Discussions

Two distinct crack patterns observed across the top of the block: a Y-shape and a bisecting line. Samples that cracked latter bisected, where those that cracked earlier did so in a Y-shape. Furthermore, it was observed that Y-shaped cracks generated a wider crack width at 24 h than bisected blocks.

The coefficient of correlation between crack with and crack area, of above test, is 0.984.Therefore it was decided to monitor crack width as the indicator of crack formation.

It was also noted that NEDMs are capable of generating cracks with hole diameters as small as 8 mm which can be used to form controlled cracking of concrete as suggested by Gambatese (2003).

Temperature was previously identified as a critical variable (Hinze and Brown, 1994).The effect of water having a temperature ranging from 10^{0}C to 50^{0}C was tested with NEDM. Considering the time to first crack initiation, the minimum time was recorded in the test block with 50^{0}C water for mixing NEDM. The time lag with other test block was around 4 hours in each case. Time for first crack initiation was found greater when the water temperature got lower. As a percentage of reduction in the cumulative crack width, it was approximately 16% and 69% with respective temperatures of 10^{0}C and 30 ^{0}C compared with the maximum cumulative crack width (22.679mm) obtained with 50^{0}C.

Performance of the NEDM depends on the water content. The most effective result was shown when the water content was as low as 26%, which is 4% below the recommended 30% for mixing NEDM, resulting in the lowest time for first crack initiation and maximum cumulative crack. But, at 26% water content, the workability of the NEDM mixture was quite stiff. This makes it clear that the recommended 30% water content in the NEDM by manufactures is based on workability concerns rather than optimum expansive pressure generation.

Figure 1 Bisected Crack Pattern

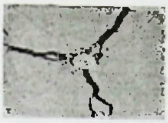
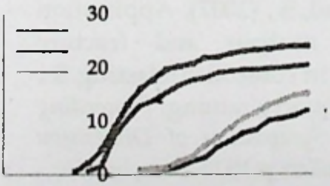


Figure 2 Y Shaped Crack Pattern

Among the brands compared "Sino Crack" and "Crack ING" overperform other two brands ("Crack Stone & "Break AG"), which showed a relatively slow expansion in demolishing the test cubes under the controlled conditions.



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The results showed that there was an overall reduction in the performance of the NEDM when mixed with sand. The reduction of the cumulative crack width was around 5% and 13% with respective sand content of 10% and 20%, compared with the controlled block. Results showed that even at 40% sand content, a significant expansive pressure is developed. The crack formation after 24 hours were noticeably lower in those test cylinders containing sand, but the reduction was not proportional to the amount of sand contained in the mixture. It was observed that workability was reduced with increasing sand content. When the sand content is over 30% w/w, the workability of the NEDM mixture was quite stiff. With 30% water content, it has been found difficult to pour into drill holes. Therefore, the maximum amount of sand, which can be mixed with NEDM, will be 30% w/w.

Results from numerical analysis shows that stresses concentrate on the outer edges of the unfilled drill hole on the line passing through centre of the NEDM filled holes. The stress concentration around the empty hole is 4-6 times higher than the standard condition. It was evident that stress concentration and crack migration is affected by the non-injected holes.

5. Conclusions:

The performance of NEDM is a function of water content, water temperature, field temperature and the type of brand used.

When using water with a high temperature, the generated expansion stresses are much higher. But, higher water temperatures tend to result in "Blow Out" in hot climatic conditions , this could only be useful to improve performance of NEDM when used in colder climatic environments.

The results indicate the presence of non-injected holes found to be beneficial for the crack migration, which could be utilized to reduce the amount of NEDM required for demolishing work.

The addition of sand to the NEDM slurry showed significant potential to reducing the cost of demolition with NEDMs.

As the addition of 1% super plasticizers improves the workability by more than 12%, further research could examine the possibility of improving the total performance of NEDM by both the lowering the water content and addition of sand along with the super plasticizers.

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