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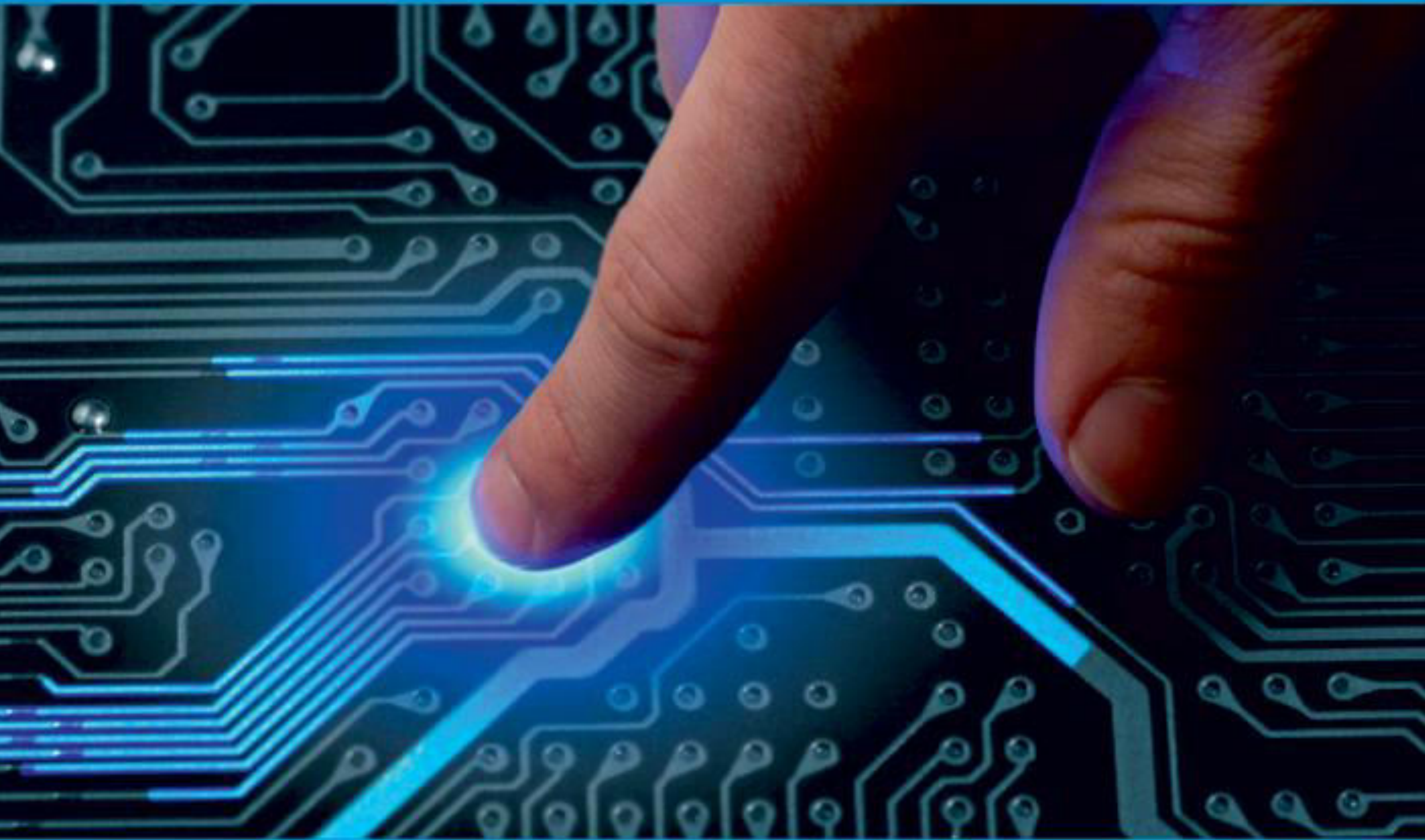

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Prediction of Flyrock Distance Induced by Mine Blasting using a Novel Harris Hawks Optimization-based Multi-Layer Perceptron

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ABSTRACT: This paper deals with the excavation of 19500 m2 area in granitic hard rock to a depth of 10 m by controlled blasting to accommodate foundation for 75 m tall, 16 floor commercial building in the city of jaipur, India. The major task was to excavate granitic hard rock close to constructed residential structures (10 m) and under construction (60 m). To start with, trail blasts were carried out at a distance of 50 m from the existing residential structures. In order to restrict the maximum charge per delay and the air overpressure from trunk lines, blasts were initiated with shock tubes. In the blasting zone, excavation was carried out in five different locations at varying distances from the structures. Controlled blasting in urban areas does not end with controlling the flyrock, vibrations or air overpressure levels within the permissible limits, but the most contributing factor happens to be the human perception. The human response with regard to vibrations and the structural response too was studied. Blast designs were altered site specifically and in addition to that continuous monitoring of ground vibration was under taken to ascertain that the intensities were within the limits. Sufficient number of rubber blasting mats of 1.1t each were used for muffling the blasting area and the flyrock was restricted within 10 m from the blasting area. It was observed that the rubber mats were not only effective in controlling the flyrock but they have reduced the air overpressure levels too considerably. In total around 80000 m3 of hard rock was successfully excavated without any grievances as the vibrations were limited to below the perception level of the residents rather than the transmissible level of the structures from the neighbours/residents.

KEYWORDS: Controlled blasting; blast vibration; structure response.

I. INTRODUCTION

Large infrastructure projects like multi-storeyed buildings, underground metros, under passing's, over bridges etc. are currently being planned and executed worldwide, many in highly populated areas. Expansion is leading to land crunch in cities and is necessitating construction of high rise buildings to create residential structures, office spaces, parking lots etc and below ground to facilitate transport, storage, etc. To build these infrastructure, large quantity of earth work has to be carried out which engages different activities and machineries. Excavation of soil is done by means of hydraulic excavators and hard rock by mechanical means or by drilling and blasting. Any excavation in urban area needs special measures due to existence of buildings and other civil structures nearby.Inadequate project assumptions, lack of funds, incorrect priorities, ignorant project engineers or misjudgments of project operations can lead to structural damages, increased costs and unexpected delays. Unfortunately, knowledge of how to perform a proper risk analysis is often missing.Hard rock excavation by drilling and blasting generates noise and vibrations which can affect nearby residents and industrial activities in the vicinity. Lacking understanding of risks associated with blasting projects may lead to over-conservative design assumptions, resulting in unnecessary costs. Alternatively, underestimating vibration risks can result in unexpected damages to buildings, complaints from the public and unforeseen costs and delays. By applying a planned risk management concept, the cost-effectiveness, can be enhanced without generating uncontrollable risks. Proper management of risks associated with blasting projects requires fundamental understanding of vibration propagation in soil and rock and their interaction with structures. Rapid technical advances in rock excavation by blasting have taken place. Relatively inexpensive, vibration monitoring and data acquisition systems are available today, which provide valuable information about wave propagation in the ground and dynamic interaction of structures and foundations. Jaipur is one of the fastest developing cities in the world. At one of the business districts of Jaipur , , are constructing World Trade Park Business Park. In this project it was proposed to construct ten commercial complex towers each consisting of 13 to 16 floors. Two towers are already under use. In view of expansion, the management planned to construct two towards adjacent to the existing towers which are about

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60m apart and residential layout is located at around 10 m from the planned excavation boundary. The strata in the proposed construction area of 19500m2 needed to be excavated to a depth of 10 m from the existing surface level.

The authors were involved in designing of controlled blasting operations for excavating hard rock in proximity to urban structures and establishments. Controlled blasting in urban areas does not end with controlling the ground vibrations or air overpressure levels within the permissible limits, but the most contributing factor happens to be addressing the human perception. Our broad challenge was to control blasting effects through regulation, project design, specifications, and on-site execution and field oversight. Blasting was designed in such a way that the vibration levels at these structures falls within the safe limit of vibration levels and acceptable to human perception.

II. ROCK EXCAVATION BY BLASTING

The rock to be excavated was huge (80000 m3) and the granitic rock mass was not amenable for breakage with heavy rock breakers and drilling and blasting method was only method of excavation. Though drilling and blasting is perhaps one of the fastest and economical means of rock excavation, it have some adverse impacts like ground vibration, flyrock and air overpressure. Properly designed and executed blasts could mitigate the adverse impacts to desirable extent but the ill effects due to malfunction of the initiation systems and explosives are beyond the control of the designer and the executioner. Control of flyrock, ground vibrations and air overpressure under these circumstances becomes extremely difficult, expensive and time consuming. Controlled blasting method was adopted to excavate the rock to create a vertical wall needed to construct retaining wall close to the structure.

Before starting the actual blast close to the structure, trail blasts were carried at a distance of 50 m from the structures to know the attenuation characterises of the excavation area.The blasting area was cleaned for soil and loose stone pieces prior to marking to minimise the risk of flyrock and to minimise the effect of dust which is one of the environmental concern in urban area. The marked locations were drilled by jackhammer drilled holes of 32 mm. Accuracy with respect to holes position, verticality, spacing, burden, depth, numberof holes was maintained. Plastic plugs were used to avoid choking of drilled holes from water, mud, drill cuttings etc.

After completion of drilling, all the holes were checked up with respect to design. Required explosives were transported to the blasting site. No simultaneous drilling and charging was carried out at any instant. Priming of explosive was done at site and the holes were charged as per the approved design (Table 1). The blasts were initiated with shock tube initiation systems comprising of down-the-hole delay (DTH) of 200 ms in combination with surface trunk line delays (TLD) of17 ms, 25 ms and 42 ms. Soft, wet clay sticks were used as stemming material.

TABLE I. BLAST DESIGN PARAMETERS FOR REGULAR BENCH BLASTING

Parameters	Specification (Jack hammer)
Hole diameter, mm	32 to 38
Burden, m	0.8
Spacing, m	0.8
Hole depth, m	1.5
Number of rows	<3
Number of holes in a row	<10
Total number of holes	<30 (all vertical)
Charge diameter	25 mm
Charge length	200 mm
Charge weight	125 g / cartridge
Charge per hole, kg	0.125 - 0.5
Charge length, m	0.8
Stemming length, m	0.5-1
Stemming material	Wet clay sticks
Total charge	Varying
MCD*, kg	0.125 - 0.5

III. GROUND VIBRATION AND AIR OVERPRESSURE MONITORING

When an explosive charge is detonated inside a blasthole it is instantly converted into hot gases and the expanding gases exert intense pressure on the blasthole walls. A high intensity shock wave travels through the rock mass which attenuates sharply with distance. As seismic waves travel through the rock mass, they generate particle motions which

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are termed as ground vibrations. The velocity of oscillation of rock particles is called "particle velocity" and its maximum value is called "peak particle velocity (PPV)". It is measured in millimetres per second (mm/s). Damage caused by ground vibration is dependent on peak particle velocity and the frequency (Hz) of the ground motion. Apart from ground vibration, blasting is accompanied by a loud noise called air blast or air overpressure. Air overpressure, or air blast, is the term used to describe the pressure waves in the air exerted from an explosion [2][3](Dowding, 1996,. Siskind, et. al., 1980). Air overpressure, however, is not simply the sound that is heard, it is an atmospheric pressure wave consisting of high frequency sound that is audible (20 to 20,000 Hz) by human beings and low frequency sound or concussion that is sub-audible (<20 Hz) and cannot be heard by human beings.

To know the attenuation characterises of excavation area, six calibrated seismographs were used for monitoring ground vibration and air overpressure (Minimate Plus from Instantel, Canada). These instruments are microprocessor-based portable units and each unit consists of a standard external transducer for monitoring ground vibration and a mike for measuring air overpressure. Radial distances between the blast location and the monitoring stations were measured using binocular type laser based instrument for short distance and for long distance Global Positioning System was used. The trigger level set for ground vibration was 0.51 mm/s and for air overpressure it was 121 dB.

IV. GROUND VIBRATION LIMITS FOR URBAN BLASTING

Mining by blasting is largely regulated, whereas the blasting for construction is limitedly regulated. Normally the excavation for construction occurs in more populated areas than mining areas but the regulations for construction is not stringent. [4]Jeff and Dwayne (2014) observed that while analysing blasting related complaints in the Canadian municipalities, regulations typically do not prescribe the need for notification of planned blasts, pre-blast surveys and blast monitoring.

A structure readily catches the blast induced ground vibration when the frequency of ground vibration falls close to the natural frequency of the structure [5] [3] (Dowding, 1985; Siskind et al, 1980). At resonant frequency, the structure absorbs most of the energy of ground vibration and oscillates with a larger amplitude for a longer period.Because of this amplification, structural damage may occur even at a relatively low peak particle velocity. Amplification factor is defined as the ratio of structural vibration to that of the ground vibration. It has been found to vary between 3.2 and 5.2 [3] (Siskind et al, 1980), and between 1.00 and 2.82 (2000) report that with regard to high rise structures (up to 22 floors) the blast vibrations decreased in the upper floors.

V. CONCLUSION

With proper planning, design and communication blasting can be carried out in densely constructed areas in any urban environment.The human response with regard to vibrations revealed that whenever the vibrations were below1.5 mm/s there were no complaints from the residents, and when the vibrations were between 1.5 mm/s and 2 mm/s they were uncomfortable and when the vibrations were above 2 mm/s they complained of excessive vibrations. In total more than 500 blasts were carried out to excavate 80000 m3 of hard rock by increasing the blast size from 45 to 250 m3 per blast. Though the control of flyrock happens to be the most challenging while blasting in proximity to structures, equally of concern are the air overpressure levels. Muffling in urban environment should address two aspects namely control of flyrock and air overpressure. This paper demonstrates the importance of compliance of vibration levels based on site specific human response requirements rather than to standards for successful completion of the project. Controlled blasting with design changes from the site specific vibration monitoring inputs ensure blasting activities without any legal hassles and delays.

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