Project Title: Advice for optimization of blast design parameters at Bailadila Opencast Mine, Bacheli Complex, NMDC to improve productivity of the mine with effective utilization of explosive energy and reduction of blasting hazards.

Project No.: CNP/4869/2019-20

Executive Summary:

This report relates to the scientific study carried out by the Rock Excavation Engineering Division of CSIR-Central Institute of Mining and Fuel Research (CSIR-CIMFR), Dhanbad at Bailadila Opencast Mine, Bacheli Complex, NMDC, Chhattisgarh. The main objective of the study was to review existing blasting practices at the mine and suggest subsequent modification to improve productivity of the mine with due safety of the nearby surface structures. M/s NMDC have awarded work order to CSIR-CIMFR for this purpose. The necessary field work was carried out in two visits. The data were gathered and analysed at CIMFR laboratory.

The results of the study, analyses of data, conclusions and recommendations made in the report are summarized below.

1. Altogether 19 experimental blasts consisting of 15 production blasts and 4 signature hole blasts were conducted during the two visits. Total 9 blasts were conducted at Deposit-5 and 10 blasts at Deposit-10 during the visits.

2. At Deposit-5, the blasts were conducted for blast hole diameter of 150 mm and 250 mm. The hole depth during experimental blasts were in the range of 8.3 m- 15.5 m. The holes were charged with Site Mixed Emulsion (SME) explosive. Total explosive charge fired in a blasting round during experimental blasts was in the range of 230 kg- 16475 kg. The holes were charged keeping maximum explosive weight per delay in the range of 230 kg- 1000 kg. Blast holes were connected with Nonel initiation systems.

3. At Deposit-10, the blasts were conducted for blast hole diameter of 250 mm. The hole depth during experimental blasts were in the range of 8.3 m- 13.7 m. The holes were charged with Site Mixed Emulsion (SME) explosive of M/s Orica IEPL Ltd and M/s Keltech Energies Ltd. Total explosive charge fired in a blasting round during experimental blasts were in the range of 230 kg- 8759 kg. The holes were charged keeping maximum explosive weight per delay in the range of 230 kg- 2160 kg. Blast holes were connected with Nonel initiation systems.

4. Seismographs were deployed to record the vibrations at different locations in and around mine premises at Deposit-5 and Deposit-10. Altogether 33 and 29 vibration data were recorded for blasts conducted at Deposit-5 (D-5) and Deposit-10 (D-10) respectively.

Attempts were made to record the vibrations at a radial distance within 100m, near mining machinery/equipment, near industrial buildings and in the township. The locations of the seismographs were finalized by considering the location of blasting face and nearby surface structures. Distance of vibration monitoring from face ranges between 44m– 920m and 75 m– 2427 m for blasts conducted at Deposit-5 & Deposit-10 respectively.

5. Seven types of rock deposits are found at Bailadila Iron ore mine. The physico-mechanical properties of these rocks have been assessed at Rock mechanics laboratory of CSIR-CIMFR. The cubical rock samples were collected by the mine management for this purpose. Joint mapping was also performed to investigate the presence of major joint sets during the field visit.

6. Rock fragmentation outputs and muck-profile were studied during the field visit. Image analysis were done for the blasted muck pile. The blast was also monitored by high speed videography. Back-breaks and restricted movement of blast faces was observed through image analysis.

7. Flyrock ejections were studied using high speed videography.

8. Explosive quality assessment was done by monitoring of in-the-hole VOD. The VOD was monitored using Data-Trap II instrument. The VOD probe has been put inside the hole for this purpose.

9. Scattering tests of delay detonators were performed with High speed video camera. The recorded video is analyzed by analyzing frames of images in the video.

10. Ground vibrations were monitored in terms of peak particle velocity (PPV) that varied from <0.5mm/s to 71.4 mm/s and <0.5 mm/s to 46.46 mm/s for blasts conducted at Deposit-5 and Deposit-10 respectively depending upon the distance of measuring transducers of seismographs from the blasting face and the amount of explosives detonated in particular delay of the blast.

11. The maximum level of vibration recorded from blast at D-5 was 71.4 mm/s at peak dominant frequency of 4.00 Hz for blast conducted at BHD-10 blast face on 01.12.2018. The vibration was recorded at a distance of 55 m in left back side of the blast face. The blast was conducted with total explosive charge of 2580 kg and maximum charge per delay of 320kg. The maximum vibration recorded near the surface structure was 6.93 mm/s at peak dominant frequency of 5.43 Hz. The surface structure crusher house was located at a distance of 290 m from the blast face. All the recorded vibration near surface structures were within limit as per the standard prescribed by DGMS.

12. The maximum level of vibration recorded from blast at D-10 was 46.46 mm/s at peak dominant frequency of 3.375Hz for blast conducted at B1 North blast face on 22.02.2019. The vibration was recorded at a distance of 79m in back side of the blast face. The blast was conducted with total explosive charge of 8759 kg and maximum charge per delay of 660 kg. The maximum vibration recorded near the surface structure was 9.559 mm/s at peak dominant frequency of 6.18 Hz. The surface structure crusher house was located at a distance of 265 m from the blast face. The recorded vibration near tunnel and at NMDC township was <0.5 mm/s during the experimental blasts. All the recorded vibration near surface structures were within limit as per the standard prescribed by DGMS.

13. The principal frequencies of ground vibrations recorded were in the range of 2.5 Hz- 15.3 Hz and 2.1 Hz- 8.13 for blasts conducted at D-5 and D-10 respectively. Plot states dominance of frequency falls below 8 Hz for both the deposits. So blast induced ground vibration should be restricted within 10 mm/s for safety of nearby industrial structures and 5 mm/s for the safety of domestic houses not belonging to owner as per DGMS standard.

14. The air overpressure levels recorded from different blasts varied between 91.5 dB(L)- 148dB (L) and <88 dB(L)- 180dB (L) for blasts conducted at D-5 and D-10 respectively. However, the maximum air over pressure near surface structures were below 130 dB(L). the levels of air overpressure near surface structures recorded during blasts were well within the safe limit around structures**.**

15. In all the blasts, ejections of flyrocks were within limit. The throws of the blasted materials were also controlled and restricted within the blasting area only. The control of flyrock was achieved mainly by implementing proper blast design patterns along with their strict supervision and guidance of the total blasting operations.

16. The ground vibration data recorded at various locations during field investigations were grouped together for statistical analysis. Site specific predictor equation has been generated for both the deposits of the mine. The equations can be used to compute maximum charge weight per delay for blasting faces at different distances from the surface structures.

17. The maximum explosive charge per delay and total explosive charge in a blasting round for the deposits have been computed based on statistical analysis of the gathered data.

18. The photographs of blasted muck-pile along with a scale were taken during the experimental blasts. The fragment size analyses of blasted muck pile have been carried out using WipFrag software. The fragmentation analysis shows improvement in screen fragment size due to reduction in blast geometry. However, the scope for further

improvement exists, which can be achieved by proper planning, sequential excavation and increasing confinement in the blast holes.

19. Optimized powder factor & burden-spacing has been computed for different rock types available at the mine using various empirical models.

20. The delay timing between the holes in a row and between rows has been optimised for the mine keeping fragmentation, flyrocks and over breaks control, reduction in vibration and air over pressure in to account. Signature hole blast were conducted at different blast faces of the mine for this purpose.