Project Title: advice for improvement in rock fragmentation to enhance production and productivity with greater safety at Noamundi, Katamati, Joda East and Khondbond Iron Mines of Tata Steel Project No.: CNP/4821/2019-20	This report relates to the study conducted by CSIR-Central Institute of Mining and Fuel Research (CIMFR), Dhanbad to optimise the blast design parameters at Noamundi, Katamati, Joda East and Khondbond Iron Mines of Tata Steel to achieve optimum fragmentation and to control vibration, air over-pressure/noise and fly rocks within safe limits for the safety of buildings and other structures in close proximity to the mine. The study involved experimental trials with varying blast designs and charging patterns, monitoring of ground vibration and air over-pressure/noise in the concerned locations/villages. The results of investigation, analyses of data are summarised below: ***Noamundi Iron Mine:*** ❖ Four blasts were conducted at different benches of Noamundi Iron mine. The maximum vibration recorded was 9.49 mm/s with dominant peak frequency of 5.75 Hz. The blast monitoring instrument was placed at Chemical filling station (at 130 m) from the Hill 04, 588 mRL bench face of Hill 04. In the same blast the vibration recorded near Mine Canteen (at 612 m from the blast face) was 2.59 mm/s with dominant peak frequency of 7.375 Hz. ❖ The maximum air over-pressures recorded was 124.4 dB (L) at 150 m Near Mine Pit office due to the blast conducted at Hill 04 face, 588 mRL on 24.05.2019. There was no ejection of fly rocks. ❖ All the recorded data (blast vibrations, air overpressures and fly rocks) were well within the safe limits at the houses/structures concerned in the periphery of the mine. The dominant peak frequencies of ground vibrations were in the range of 4.188 to 7.375 Hz. So, the safe level of vibration has been taken as 5 mm/s for the safety of houses/structures not belonging to owner and 10 mm/s for the houses/structures belonging to owner as per DGMS standard. ❖ The recorded in-the-hole VODs of the SME explosives of M/s IDL Explosives Limited was found in the range of 4521 to 5230 m/s. The surface VOD of emulsion boosters (125 gm) of M/s IDL Explosives Limited was recorded 5494 m/s. The density of the rock is very high (4.2 gm/cm^3), so the high strength explosives (in-the-hole VOD of explosives of more than 4800 m/s) are essentially required to achieve desired fragmentation. ❖ The scattering issue should be addressed to the suppliers/manufacturers. Scattering tests of delay detonators revealed that the sequence of detonation is not in order for few delays and scattering was observed in the entire NONEL delay detonator, which requires attention. In terms of controlling ground vibration amplitudes and frequencies, the choice of delay times is also crucial.

	❖ The blast designs followed during the blasting were found to be safe. The analyses of data with linear superposition technique confirmed that the delay interval between the rows should be 25-30 ms/m of effective burden. ❖ The recommended blast designs (Figures A1) should be followed in day-to-day blasting operations for safe and efficient blasting operations with judicious modifications. ***Katamati Iron Mine:*** ❖ Four blasts were conducted at different benches of Katamati Iron mine. The maximum vibration of 11.53 mm/s with dominant peak frequency of 9.438 Hz was recorded back side of blasting face of 636 mRL bench at 122 m. The recorded vibration from the same blast at 214 m near mine office from the same blast was 3.65 mm/s with dominant peak frequency of 8.00 Hz. In this blast 4800 kg of explosives were distributed in 67 holes and were detonated keeping the maximum explosives weight per delay of 216 kg. ❖ The maximum level of air over-pressure recorded was 128.6 dB (L**)** at the Security gate of Katamati at 139 m from the blast conducted at 636 mRL bench on 31.08.2018. In this blast, 67 nos. of holes were initiated with Nonel or Shock tube initiated system with total amount of explosives of 4800 kg. ❖ Vibration data recorded at different places in the periphery of the mine viz. Back side of blast free face, Security Gate of Katamati, Near Mine office, Near Mine Canteen, Near Weighing Bridge, Near Mine office rest shelter, Near Metso plant etc. were well within the safe limits. ❖ The dominant peak frequencies of ground vibrations were in the range of 5.125 Hz to 9.438 Hz. So, the safe level of vibration has been taken as 5 mm/s for the safety of houses/structures not belonging to owner and 10 mm/s for the houses/structures belonging to owner as per DGMS standard. ❖ The recorded in-the-hole VOD of SME explosive was detected 4516 m/s. In the hole VOD of 4800 m/s and more are essentially required for hard rock formations to get desired fragmentation. The recorded VOD for 125gm PG-2 emulsion booster was 4941 m/s respectively. ❖ The overall fragmentations resulted at 636 mRL, 658 mRL & 666 mRL BD ore type benches were optimum for loading. The blast detonation was photographed and there was no ejection of fly rocks from any of the blast. The fragmentations achieved from the blasts were excellent. The blasted muck pile was properly distributed

for loading.

- The cup density of SME explosives at the time of charging was in the range of 1.30 gm/cc and after gassing of 20 minutes it was found 1.1 gm/cc.

- The recommended blast designs (Figures A1-A2) should be followed in day-to-day blasting operations for safe and efficient blasting operations with judicious modifications.

Joda East Iron Mine

- Twelve blasts were conducted at different benches of Joda East Iron mine. The maximum vibration recorded was 3.776 mm/s with dominant peak frequency of 4.625 Hz recorded at 382 m (Near View Point) from the blasting site (G-3 bench). In the same blast the vibration recorded Near Primary Crusher (at 769 m) was 0.696 mm/s.

- The maximum air over-pressures recorded was 125.6 dB (L) at 382 m near View Point due to the blast conducted at G-3 bench face on 30.08.2018.

- All the recorded data (blast vibrations, air overpressures and flyrocks) were well within the safe limits at the houses/structures concerned in the periphery of the mine. The dominant peak frequencies of ground vibrations were in the range of 2.75 to 20.94 Hz. FFT analyses of blast vibration frequencies confirmed that concentration of frequencies is in band of 3.75-10.6 Hz. So, the safe level of vibration has been taken as 5 mm/s for the safety of houses/structures not belonging to owner and 10 mm/s for the houses/structures belonging to owner as per DGMS standard.

- The recorded in-the-hole VODs of the SME explosives of M/s IDL Explosives Limited & of M/s IEPL (Orica) were in the range of 4601 to 5507 m/s. The surface VOD of emulsion boosters (125 gm) of M/s IDL Explosives Limited was detected 4953 m/s recorded on 26.07.2019 whereas the recorded surface VOD of Aquadyne cartridge emulsion explosives of 125 mm was 5385 m/s on 26.07.2019. The density of the rock is very high (4.2 gm/cm^3), so the high strength explosives (in-the-hole VOD of explosives of more than 4800 m/s) are essentially required to achieve desired fragmentation.

- The overall fragmentations resulted from all the blasts were optimum for loading. The average mean size of the block is 223.36 mm (diameter of an equivalent sphere) and the most common size of the block is 263.689 mm (diameter of an equivalent sphere). The maximum size of the boulder is of 1.49 m (diameter of an equivalent sphere).

- The blast designs followed during the blasting were found to be safe. The analyses of data with linear

	superposition technique confirmed that the delay interval between the rows should be 25-30 ms/m of effective burden. ❖ Analysis of the recorded data of high speed video camera for NONEL scattering test confirmed that scattering was observed in all the delay detonators. The delay scattering value ranged from (-) 35.7 to 50.8 %. The acceptable scattering for TLDs are ± 5 ms and for DTHs are ±10ms. The scattering issue should be addressed to the suppliers/manufacturers. The scattering issue should be addressed to the suppliers/manufacturers. Scattering tests of delay detonators revealed that the sequence of detonation is not in order for few delays and scattering was observed in the entire NONEL delay detonator, which requires attention. In terms of controlling ground vibration amplitudes and frequencies, the choice of delay times is also crucial. ❖ The recommended blast designs (Figures A1-A2) should be followed in day-to-day blasting operations for safe and efficient blasting operations with judicious modifications. ***Khondbond Iron Mine*** ❖ Five blasts were conducted at different benches of Khandbond East Iron mine. The maximum vibration recorded was 8.774 mm/s with dominant peak frequency of 12.63 Hz recorded at 60 m (Near Pit 1 Security check post) from the blasting site (720 mRL J ore body). In the same blast the vibration recorded at behind the blast face (at 562 m) was less than 0.5 mm/s i.e. the pre-set trigger level for recording the ground vibration. ❖ The maximum air over-pressures recorded was 138.6 dB (L) at 100 m Near Guard Cabin due to the blast conducted at Pit-1 Ore body face on 18.03.2019. The total explosive weight detonated in this blast was 7300 kg whereas maximum explosive weight/delay was 122 kg. ❖ All the recorded data (blast vibrations, air overpressures and fly rocks) were well within the safe limits at the houses/structures concerned in the periphery of the mine. The dominant peak frequencies of ground vibrations were in the range of 3.188 to 12.69 Hz. So, the safe level of vibration has been taken as 5 mm/s for the safety of houses/structures not belonging to owner and 10 mm/s for the houses/structures belonging to owner as per DGMS standard. ❖ The recorded in-the-hole VODs of the SME explosives of M/s IDL Explosives Limited & M/s IEPL (Orica) were in the range of 4853 – 5384 m/s. The surface VOD of emulsion boosters (125 gm) of M/s IDL Explosives Limited was detected 5020 m/s. The density of the rock is very high (4.2 gm/cm^3), so the high strength explosives (in-the-hole VOD of explosives of more than 4800 m/s) are essentially required to achieve desired

	fragmentation. ❖ The overall fragmentations resulted from all the blasts were optimum for loading. The average mean size of the block is 219-268 mm (diameter of an equivalent sphere) and the most common size of the block is 313.4-500 mm (diameter of an equivalent sphere). The maximum size of the boulder is of 1.75 m (diameter of an equivalent sphere). ❖ The scattering issue should be addressed to the suppliers/manufacturers. Scattering tests of delay detonators revealed that the sequence of detonation is not in order for few delays and scattering was observed in the entire NONEL delay detonator in the range of (-) 36 to 41.5%, which requires attention. In terms of controlling ground vibration amplitudes and frequencies, the choice of delay times is also crucial. The acceptable scattering for TLDs are ± 5ms and for DTHs are ±10 ms. ❖ The blast designs followed during the blasting were found to be safe. The analyses of data with linear superposition technique confirmed that the delay interval between the rows should be 25-30 ms/m of effective burden. ❖ The recommended blast designs (Figures A1) should be followed in day-to-day blasting operations for safe and efficient blasting operations with judicious modifications.