Project Title: Advice for optimization of blast design parameters at Rawan Limestone Mine to improve productivity with due safety to the structures in the periphery of the mine.

Project No.: CNP/4932/2019-20

Executive Summary:

This report relates to the study conducted by CSIR-Central Institute of Mining & Fuel Research (CIMFR), Dhanbad to optimise the blast design parameters at Rawan Limestone Mines of M/s Ambuja Cement Limited to control ground vibration, air overpressure/noise and flyrock within safe limit for the safety of houses/dwelling with improved production and productivity. The study involved experimental trials with varying blast designs and charging patterns, monitoring of ground vibration, air over-pressure/noise at various locations in the periphery of the mine as well as near the important surface features. The results of investigation, analyses of data and recommendations, made thereof, are summarised below:

- Altogether eleven experimental blasts were conducted at different benches of Rawan Limestone Mine. The blasting output were analysed by measuring blast induced ground vibration, Air-overpressure, Flyrock ejections, muck pile movement and fragmentation achieved with the help of necessary equipment.

- Seismographs were deployed to record the vibrations at different locations in and around Rawan Limestone Mine and altogether thirty-six blast vibration data was recorded for eleven blasts. Attempts were made to record the vibrations in back side of the blast face, near Pousri village temple, near highway and around the structures located in the vicinity of the mine.

- Maximum vibration (in terms of peak particle velocity, PPV) recorded was 25.23 mm/s with associated dominant peak frequency of 55 Hz at 100 m backside from blasting face (1028-NB0-NW1). The explosives weight per delay and total explosives used in this blast were 66 kg and 2900 kg respectively. The PPV recorded at 300 m from the same blast was 4.461 mm/s with associated dominant peak frequency of 17.75. Fast attenuations in the vibration level were recorded.

- The maximum air over-pressure recorded was 139.0 dB(L) at 85 m due to the blast conducted at 1029-NB1-NE2 blasting face. In this blast, explosives detonated in a blasting round and explosive weight per delay were 2000 kg and 67 kg respectively. Proper stemming and the Nonel initiation system reduces the air over-pressure to a greater extent and improves the blasting performance too.

- All the recorded blast induced ground vibration near different surface features were well within the statutory limit as per the DGMS standard. The ejections of flyrocks were monitored for the blasts using High speed videography and the maximum distance travelled by throw of the blasted materials was up to 65 m.

- The dominance of frequencies for recorded blast vibrations are in the range of 14.88 to 82.94 Hz. So the threshold level of blast induced ground vibration should be restricted within 10 mm/s for safety of nearby structure not belonging to owner and 15 mm/s for the own structures of owner. The safe limit of ground vibration for the safety of National Highway may be considered as 20 mm/s considering as industrial structures not belonging to the owner as per DGMS standard.

- Propagation equation for the prediction of blast vibration has been established and it is given as Equation 1. The permissible explosive weight per delay may be computed from the Equations to ascertain vibration within safe limits for distances of houses/structures concerned. For convenience, the explosive weight per delay along with total explosives detonated in a blasting round has been computed and are given in Table A3. The predicted blast vibration level for different explosives weight per delay is also presented in Table A4 for day to day blasting activity.

- A uniform VOD is essentially required throughout the blast holes in harder formations in order to produce sufficient detonation pressure to the blast hole walls. In-the-hole VOD of SME explosives of M/s SBL Energy Limited and M/s Solar Industries India Ltd. was measured during the trial blasts conducted at Rawan Limestone Mines. The recorded VOD of SME explosives of M/s SBL were 4085 m/s and 4871 m/s on 14.10.2019 and 15.10.2019. The recorded VOD of SME explosive of M/s Solar was 4524 m/s and 4872 m/s on 16.10.2019 and 17.10.2019 respectively.

- Surface VOD of emulsion boosters were also measured using VOD-Mate. The recorded VOD of 250 gm emulsion booster manufactured on 04.07.2019 was 5350 m/s. The recorded VOD of 150 gm booster having manufacturing date of 09.08.2019 was 4903 m/s. The old 250 gm booster manufactured on 23.03.2019 was not recorded, as only one booster could be detonated in this test.

- Scattering test of delay detonators was performed using Blaster Ranger II, High speed video camera. The scattering in the delay detonators were in the range of 1.8 % to 29.4 %.

- The delay interval between the holes in a row should be 17ms whereas between the rows, it should be 65ms or more depending upon the number of rows and effective burden in front of the particular hole. If the numbers of rows are more than two, the delay interval between rows should be increased by 20% in successive rows.

- The overall fragmentations resulted from all the blasts were optimum for loading. The average mean size of the block is 0.256-0.362 m (diameter of an equivalent sphere) and the most common size of the block is 0.15-0.30 m (diameter of an equivalent sphere). The maximum size of the boulder is of 1.776 m (diameter of an equivalent sphere). The 90% passing of the blasted fragment is within 1.2 m diameter of an equivalent sphere.

- The fragmentation achieved in most of the blasts were excellent but due to filled clay of about 20-40 cm in joints and bedding planes caused generation of boulders from top portion of the bench in a few blasts. The optimised delay timing helped enabled in reducing the back breaks and stable bench profiles were achieved after blasting without having any hanging boulders.

- The recommended blast designs should be followed for day-to-day blasting operations for safe and efficient practices. The blast designs Annexured as Figures A1-A3, will ensure the safety of the houses/structures, life of human beings and other property in the periphery of the mines.