Impact of Initiation Sequences in Opencast Blasting on the Intensity of Vibration in Underground Openings

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Abstract

Vibrations are of concern not only for the safety of surface structures but also for the stability of underground openings. A number of parameters affect the intensity of vibration in underground openings due to blasting in adjacent opencast mine viz. total explosive weight detonated in a round, maximum explosive weight per delay, propagating media, depth of cover, RMR of the roof rock, age of the underground openings etc. Although a few researchers have tried to study the impact of parameters stated above, the impact of initiation sequences on generation of vibration in underground openings due to opencast blasting has yet remained untouched. A study was planned to evaluate the impact of initiation sequences on the magnitude of vibration in underground openings due to blasting in opencast mine. Nine production blasts with top and bottom initiations were performed at Samleshwari opencast project in India and eighteen vibration data were monitored in the roof of Hingir Rampur underground colliery in both the initiation sequences. The result indicated that the vibration produced in the underground openings from bottom initiation was lower than that of top initiation.

Experimental site

The study was conducted at Samleshwari opencast project and vibrations were monitored in Hingir Rampur colliery of Mahanadi Coalfields Limited, situated in Jharsuguda District of Orissa State in India. The area is free from major faults, In this area, outcrop of seven coal seams have been found viz. Hingir Rampur (HR) seam I, II, III, IV, V, Lajkura top and Lajkura bottom HR seam. I and IV are being depillared and HR seam V is partially developed by Bord and Pillar method of mining. The dip of HR seam IV is S84°30'W and gradient is 1 in 20. The Lajkura top and bottom seams are being worked by opencasting. The positions of opencast and underground workings are shown in **Figure 1**.

Experimental Blasts

The people involved in the production did not want to hamper their production, so it was decided to have experimental blasts as practiced in the mine because it was not possible to have experimental blasts with top and bottom initiations at the same bench. Nine blasts each with top and bottom initiation were performed and eighteen vibration data were monitored in the roof for both of the blasting operations. In bottom initiation, the location of primer was at the bottom of the blastholes whereas in top initiation the primer was at the top of the

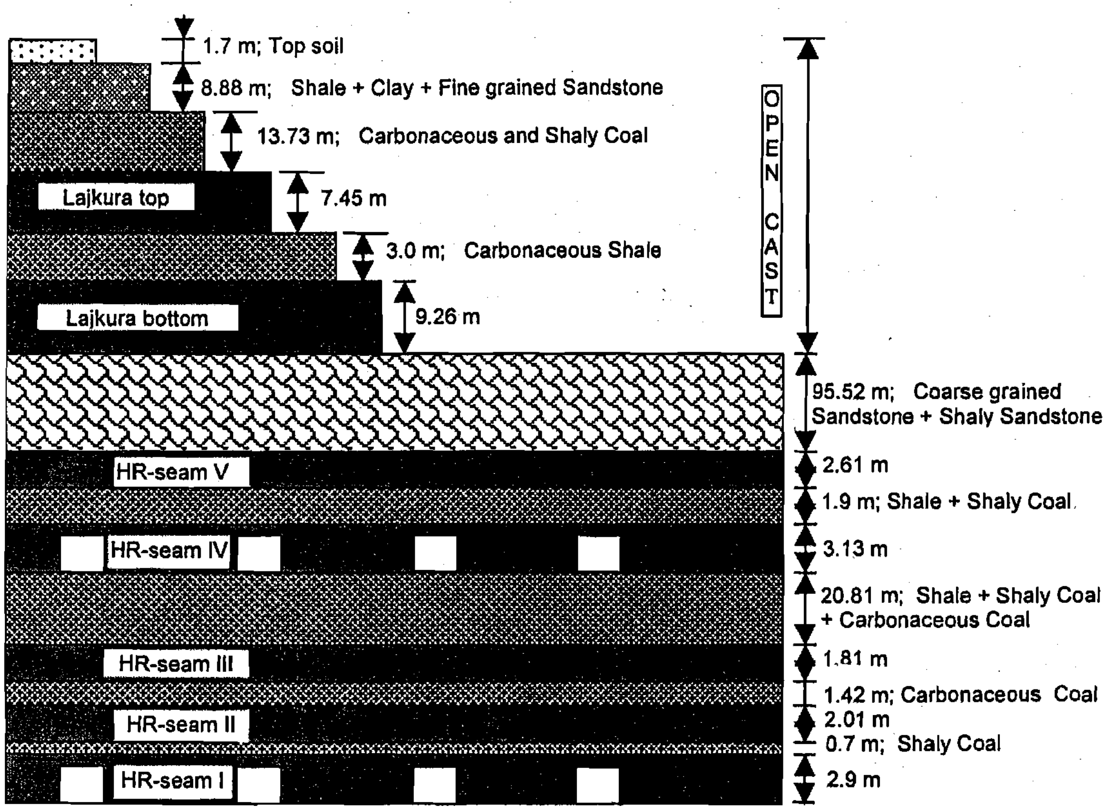

Figure 1. Positions of opencast and underground workings at Samleshwari OCP and Hingir Rampur colliery.

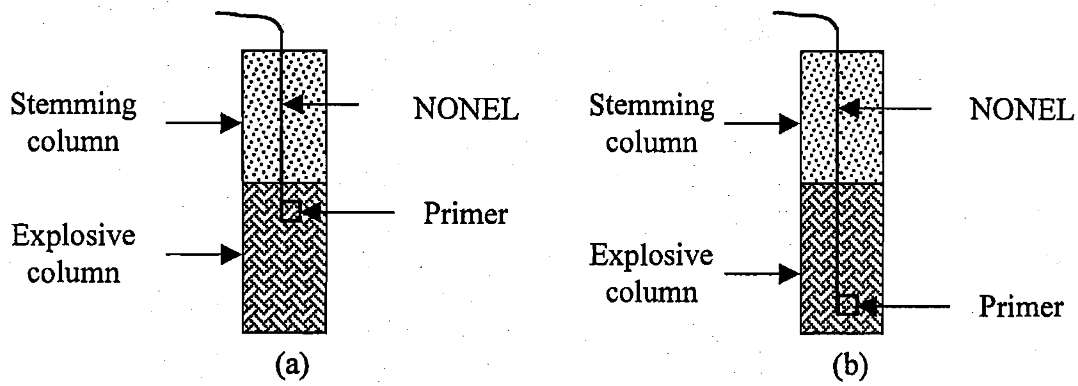

Figure 2. Location of primers in top (a) and bottom (b) initiations.

Strata Blasted	Hole dia. [mm]	No. of holes	Hole depth [m]	Burden [m]	Spacing [m]	Stemming column [m]	Total explosive weight [kg]	Maximum explosive weight per delay [kg]	Radial distance [m]	Peak particle velocity in roof [mm/s]
Sandstone	160	12	7.5	4.5	5	4.4	781	65	143 195	25.5 7.46
Sandstone	160	29	7.5	4.5	5	5.1	2785	121	156 188	29.4 18.04
Shale	160	29	6.5	4.5	4.5	4.3	1803	373	185 210	18.64 16.55
Sandstone	160	38	6.5	4	4.4	3.5	2530	786	260 312	17.9 6.2
Shale	160	25	6.5	4.5	4.5	3.5	1586	442	292 326	10.74 6.86
Coal	160	41	6.5	3.8	4.3	3.5	2414	883	321 359	35.8 20.9
Sandstone	160	37	6.5	4.5	4.5	3.7	2179	291	359 414	5.07 2.24
Sandstone	250	47	8	7	6	5.3	5431	819	399 418	7.90 7.75
Coal	160	5	6.5	4	4.5	4	250	250	485 514	2.09 1.94

Table 1. Summary of blast designs and recorded vibrations from top initiation.

explosive column (**Figure 2**). The explosive used was an emulsion explosive manufactured by ICI Ltd. The density of the explosive was 1.05 gm/cc. The details of experimental blasts and monitored vibrations data are given in **Tables 1 and 2.**

Analysis of Vibration data

Vibration data recorded in the roof of the underground mine due to top initiation blasting in opencast mine were grouped together for statistical analysis and best-fit empirical relationship was established. The established relationship is given as Equation 1. Similar analysis was done for the vibration generated due to bottom initiation blasting and the established equation is given as Equation 2. Both equations have been established for prediction of vibration with 95% confidence level. Propagation plots of peak particle velocity recorded vs scaled distances from top and bottom initiations are depicted in **Figures 3 and 4** respectively.

$$v = 4113 \cdot \left(\frac{R}{Q_{max}^{0.5}} \right)^{-1.78}$$

Correlation co-efficient = 0.752

Equation 1

$$v = 820 \cdot \left(\frac{R}{Q_{max}^{0.5}} \right)^{-1.32}$$

Correlation co-efficient = 0.777

Equation 2

Strata blasted	Hole dia. [mm]	No. of holes	Hole depth [m]	Burden [m]	Spacing [m]	Stemming column [m]	Total explosive weight [kg]	Maximum explosive weight per delay [kg]	Radial distance [m]	Peak particle velocity in Roof [mm/s]
Coal	160	22	6.5	3	4	3.8	1013	47	355 553	3.58 1.79
Coal	160	56	6.5	4	4.5	4.2	2500	281	392 426	10.4 8.9
Coal	160	8	6.5	4.5	5	3.3	500	63	408 438	3.13 2.54
Coal	160	13	6.5	4	4	3.8	716	110	481 501	2.09 1.49
Coal	160	25	6.5	4	4.5	3.8	1400	168	491 495	2.98 2.83
Coal	160	81	6.8	4.5	4.5	3.9	4858	421	504 563	7.01 3.58
Coal	160	6	6.5	5	5	3.5	400	69	506 543	1.64 1.19
Coal	160	38	6.7	4.3	4.5	4.1	2190	240	519 548	3.58 1.64
Coal	160	41	6.7	4.3	4.5	4.1	2365	275	529 553	4.77 2.38

Table 2. Summary of blast designs and recorded vibrations from bottom initiation.

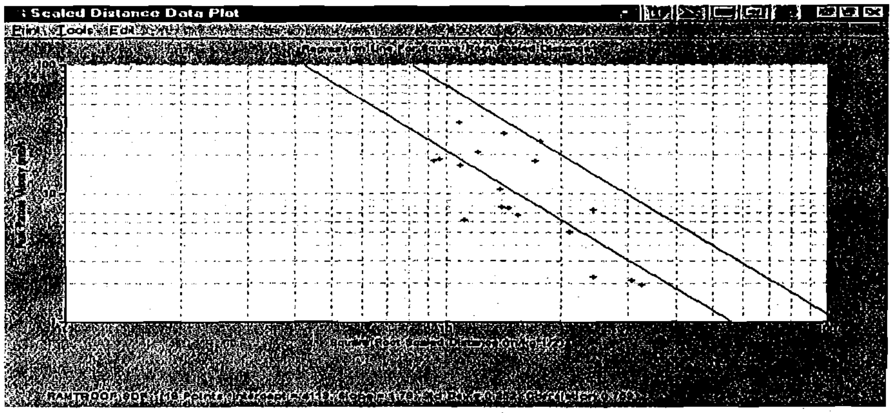

Figure 3. Propagation plots of data recorded in the roof of Hingir Rampur colliery due to lasting at Samleshwari opencast mine with top initiation.

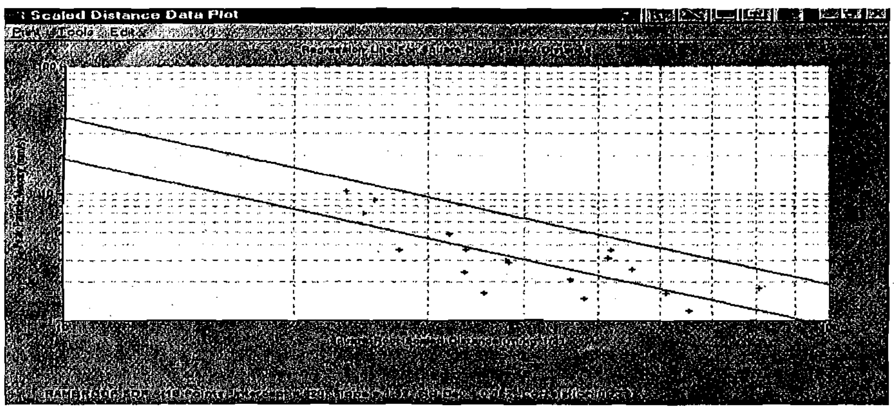

Figure 4. Propagation plots of data recorded in the roof of Hingir Rampur colliery due to blasting at Samleshwari opencast mine with bottom initiation.

Conclusion

It is evident from the above equations that for the same scaled distance the vibration will be more in the case of equation 1. This can be confirmed by computing the vibration. For example taking an explosive weight per delay of (say) 250 kg and radial distance of (say) 200 m from the blasting face, the vibration predicted from Equation 1 comes to 45.2 mm/s. Now, keeping all the blast design parameters the same, and changing the initiation sequence only from top to bottom, the Equation 2 computes the magnitude of vibration at 29 mm/s only. This example illustrates that the blasting with bottom initiation generates less vibration in underground openings compared to top initiation. The possible reason may be attributed to the advancing detonation front upward in case of bottom initiation, whereas in top initiation the advancing detonation front is downward towards the underground workings which in turn may be the cause of higher vibration in underground workings compared to the bottom initiation.

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