**Govt. of India/भारत सरकार**
**Ministry of Labour and Employment**
**श्रम एवं रोजगार मंत्रालय**
**Directorate General of Mines Safety**
**खान सुरक्षा महानिदेशालय**

No. DGMS (Tech) (S&T) Circular No. 06 of 2007 Dhanbad, May, dated 28th 2007

To

All Owner, Agent & Managers of
Indian Coal & Non – coal Mines

**Sub: Damage of below ground structures due to blast induced vibration in nearby opencast mines**

Sir,

As you are aware, stability of below ground coal mine openings, coal pillars, water dams, and ventilation & isolation stoppings in close proximity to operating opencast mines are likely to be affected from blast induced vibration. In India, presently an increasing trend has been observed to win top coal seams, whether it is virgin or developed and standing on pillars, by opencast method wherever it is economical. The blast dimensions are also large with high explosive density as well as quantum of explosives per blast, generating seismic disturbances which may in turn affect the stability of roof and pillar, support system, ventilation / isolation stoppings, water dams in below ground etc.

As the blast – induced vibration is likely to have an impact on the stability of the below ground structures as mentioned above, it is imperative to assess the magnitude of the effect and formulate a guideline for controlling damages to belowground structures due to surface blasting.

A study in this regard was carried out by CMRI in a number of coal mines under varying geo-mining conditions. A committee was constituted by the undersigned, comprising representatives from mining industry, academic & research institutions and DGMS to discuss and deliberate on the inferences of CMRI report and forward their suggestions regarding framing guidelines on this issue.

With due consideration of the recommendations made by the committee, the methodology for conducting trial blast, instrumentation strategy for measurement of blast induced vibration, damage etc. and the threshold limits of vibration for different ranges of RMR are finalized, and furnished as a guideline in **Annexure I**.

It is suggested that the mine operators will take adequate measures to optimize the blast design parameters in such a way that blast induced vibration in no way endanger the stability & safety of the below ground workings & structures.

**Director General of Mines Safety**
**Dhanbad**
Encl: As above.

**Annexure I**

## Guidelines for Stability of Belowground Coal Mine Workings Due to Opencast Blasting

### 1.0 Introduction

The safety and stability of belowground coal mine openings, coal pillars, water dams, ventilation and isolation stopping in close proximity to operating opencast mines are often endangered from blast induced vibrations. The serious concern is possible damage to above belowground structures from nearby large surface blasts. Any vibration produced rock fall or minor cracks in isolation stoppings would be recognized as an unacceptable hazard.

### 2.0 Damage Criteria

Peak particle velocity has so far been considered as the best criterion for evaluating blast vibrations in terms of its potential to cause damage. Extensive studies on the problem have established that frequency of the wave has no significant impact on damage to belowground coal mine openings. The damage to the belowground openings in reference to opencast blasting is generally classified into four categories.

1. No appreciable damage : No visible damage.
2. Threshold damage : Formation of superficial cracks in pillars, roof, isolation and / or ventilation stoppings, air crossings, dams and other below ground structures.
3. Minor damage : Detachment of loosened chips from roof and/or pillars, opening and lengthening of old cracks, loosening of joints.
4. Major damage : Fall of rock/coal blocks from roof and/or pillars, Cracks in isolation/ventilation stoppings, serious weakening of below ground structures.

### 3.0 Responses of roof and pillars

The roof of the belowground working vibrates with higher amplitudes of vibrations compared to pillars. The attenuation of vibration in roof is fast than that in pillars. This indicates that the pillars of below ground working experiences vibration for a longer period compared to the roof.

### 4.0 Measurement of blast induced vibrations

### 4.1 Instrumentation

The seismograph selected for monitoring blast-induced vibration shall be simple, light, compact, easily portable, battery operated, digital output, triggering by geophone etc. Triaxial transducers for recording blast vibrations shall have a linear frequency range from 2 Hz to 250 Hz and capable of recording particle velocity upto 250 mm/s.

## 4.2 Methodology

The transducer of seismograph shall be placed in the junction of the roof with the help of attachment provided by the manufacturer of the seismograph. It may also be placed in the pillars at 1-2 m below the roof at a depth of 0.5-0.6 m inside the pillar. A minimum of a 20 observations corresponding to a minimum of 10 blasts shall be made for better prediction with a high index of determination.

## 4.3 Predictor Equation

The least mean square method of regression analysis shall be used for interpreting the data. Since, the blasting has been performed on surface and the measurements are taken in belowground, the square root scaling law shall be used for analysis and interpretation of data.

# 5.0 Guidelines on experimental blasting

## 5.1 Factors

Major factors affecting particle velocity of ground vibration are type and amount of explosives charge used, distance from the blast site to the location of belowground workings, geological, structural and physical properties of the rock that transmits the vibration and blast geometry. Use of safe maximum explosives per delay, in-hole delays with Nonel systems, proper burden, spacing and proper stemming of holes reduces blast induced ground vibrations.

## 5.2 Plan

A plan showing the opencast workings above the belowground coal mine in different prominent shades shall be prepared. The plan shall incorporate all the belowground structures including isolation/ventilation stoppings, different working faces, water dams etc. Plan should also show the place of and location of vibration monitoring transducers in roof and pillars.

## 5.3 Study/Observations

In a particular mining area where opencast blasting is to be performed above the belowground structures, experimental blasting shall be carried out, prior to commencement of drilling and blasting operations by any research/Academic Institute for optimizing the blast design parameters to restrict the vibrations in belowground workings within safe limit. The type of instruments, the methodology and predictor norms as recommended in para 4.0 shall be followed in measurement of blast induced vibrations. Based on the study, the safe charges for the safety of belowground structures shall be determined and recommendations should be made in the report.

## 5.4 Monitoring

In order to ensure effective control over the vibration and related damage there is a need of regular in-house monitoring and the management should train the blasting personnel during the experimental study and start observations on their own during the regular blasting operations.

## 6.0 Recommended permissible standards of vibrations

### 6.1 Technical considerations

The degree of damage observed in the belowground openings is influenced by the RMR of the roof rock. Thus, the damage criterion for belowground coal mine workings is based on RMR, because it includes the parameters like layer thickness, structural features, rock weatherability, and strength of the roof rock and groundwater seepage.

### 6.2 Permissible standards

The junctions of the belowground coal mine workings are more susceptible to blast produced cracking than the galleries away from the junctions. The threshold values of vibration at the junctions in terms of peak particle velocity has been given in **Table 1** for different RMR of roof rocks for the safety of belowground coal mine workings. The limiting values of vibration in the pillar are also given below in **Table 2.**

**Table 1.** ***Threshold values of vibration for the safety of roof in the below ground workings for different RMR***

| RMR of roof rock | Threshold values of vibration in peak particle velocity [mm/s] |
|---|---|
| 20-30 | 50 |
| 30-40 | 50-70 |
| 40-50 | 70-100 |
| 50-60 | 100-120 |
| 60-80 | 120 |

**Table 2.** ***Threshold values of vibration for the safety of pillar in the belowground workings for different RMR***

| RMR of roof rock | Threshold values of vibration in peak particle velocity [mm/s] |
|---|---|
| 20-30 | 20 |
| 30-40 | 20-30 |
| 40-50 | 30-40 |
| 50-60 | 40-50 |
| 60-80 | 50 |

In view of complexities of the problems it its hoped that mine management would take adequate measures as recommended above to ensure that the blasts performed near the belowground workings are carried out with utmost care and precautions. The blast induced ground vibrations should be within the permissible limits as specified above.

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