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# Empirical approach for estimation of rock load in development workings of room and pillar mining

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This study has developed relationship between rock loads of galleries and junctions in coalmines. Study was extended further to infer relation between CMRI RMR and rock load of galleries and junctions for formulation of optimum design of support system for stability of openings in Indian coalmines.

**Keywords**: Empirical approach, Rock load, Room and pillar mining

## Introduction

For stability of any excavation proper design of support is essential[1]. Rock mass rating (RMR) and rock load plays very vital role in design of support system for underground mines and tunnels. Proper design of support system is essential part while excavation in rocks based on Central Mining Research Institute Rock Mass Rating (CMRI RMR). Productivity and safety of mine is dependent on overall stability of openings.

This study presents rock load estimation in development workings of room and pillar mining of Tata Steel Ltd mines situated in Jharia region, Dhanbad, Jharkhand.

## CMRI Geomechanical Classification System (GCS)

CMRI RMR[2,3] determined by CMRI Geomechanical Classification System (GCS) is summation of ratings of following parameters: layer thickness, 30; structural features, 25; weatherability (1st cycle slake durability index), 20; compressive strength, 15; and groundwater condition, 10. For determining layer thickness, frequency of bedding planes per meter is measured for sandstone roof. In case of shale, frequency of prominent lamination or layers is measured. In case of coal roof, frequency of prominent bands is measured. Other important structural features are major faults, slips, joints and other sedimentary features (sandstone channel, plant impression etc.). For quantification of geological features, an approach was developed to determine index of structural features, based on experience and nature and magnitude of influence of different features.

Susceptibility to weathering is measured by slake durability index (SDI), determined by slake durability apparatus (BIS/IS-1981[4]). In this test, 10 pieces (roughly of same size; wt, approx. 500 g) of broken rock are placed in test drum, which is partially immersed in water and is rotated at 20 rpm for 10 min. Material broken (< 2 mm) will pass through mesh of drum. After first 10 min cycle, drums are put in an oven for about 6 h so that samples are totally dried and it is then weighed. Weight percent of material retained in drum is taken as first cycle SDI ($I_{sd-1}$). If test is repeated for another 10 min cycle, weight percent of material retained will give second cycle SDI ($I_{sd-2}$). However, for determination of susceptibility to weathering only $I_{sd-1}$ is required.

Compressive strength of rock is determined in laboratory as per BIS/IS-1979[5] and can be determined in field using point load tester on irregular samples or by Schmidt Hammer. Rate of groundwater seepage is measured by drilling a hole (1.5-1.8 m long) in roof, thereafter collecting water percolation through it. Percolation rate is expressed in ml/min. CMRI RMR so determined is further adjusted for various geomining conditions [depth, lateral stress, influence of adjacent and overlying workings, and mode of drivage (solid blasting/ blasting with undercut/mechanical drivage)]. Adjusted CMRI RMR is used for estimation of rock load at galleries and junctions as

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Table 1—List of CMRI RMR and rock load for gallery and junctions for various mines of Tata Iron & Steel Company

| Mine | Seam | CMRI RMR | Rock load, gallery $T/m^2$ | Rock load, junction $T/m^2$ |
|---|---|---|---|---|
| Bhelatand | XVI Seam | 48.6 | 3.82 | 4.5 |
| 6 & 7 Pit | XI Seam bottom | 40.5 | 3.55 | 3.96 |
| 6 & 7 Pit | XI Top seam | 50.22 | 3.84 | 4.58 |
| Jamadoba | XIV Bottom seam | 40.8 | 3.59 | 4 |
| Digwadih | XI Seam | 41.31 | 3.36 | 4.13 |
| Bhelatand | XIII Seam | 37.26 | 3.29 | 3.96 |
| Jamadoba | XIV Top seam | 39.6 | 6.08 | 6.74 |
| 6 & 7 Pit | XIV Top seam | 48.89 | 3.94 | 5 |

Rock load in gallery ($t/m^2$) = B D (1.7 - 0.037 CMRI RMR + 0.0002CMRI $RMR^2$) …(1)

Rock load at junction ($t/m^2$) = 5 $B^{0.3}$ D (1 - CMRI RMR/100)$^2$ …(2)

where, B = Roadway width (m), and D = Dry density ($t/m^3$).This classification is applicable only in development districts in Indian underground coalmines for maximum roadway width of 4.8 m.

Enhancement of stability increases overall productivity of mine. In this study, 6 collieries of Tata Steel Ltd in Jharia coalfield has been selected and CMRI RMR and rock load for different coal seam has been determined. From CMRI RMR and rock load, a relationship has been developed between rock load of galleries and rock load for junctions. Rock load of galleries is always less than that of junctions due to more area of exposure[6]. It is observed that rock load of junctions is 1.16 H"1.2 times of rock load of galleries [Eq (3)]. Best-fit equation is obtained for CMRI RMR & rock load of galleries and between CMRI RMR & rock load of junctions respectively. Correlation between existing rock load values, calculated from best-fit equations, is relatively good for galleries (0.87) and junctions (0.80). Hence, relationship obtained between CMRI RMR and rock load for galleries & CMRI RMR and rock load for junctions would be used for determination of rock loads for galleries and junctions by substituting CMRI RMR value only.

**Estimation of Rock Load for Galleries & Junctions**

Rock load for galleries and junctions has been calculated based on CMRI RMR[2,3,7] in various mines of Tata Steel Ltd. Rock loads[8] were estimated using Eq. (1) for galleries and Eq. (2) for junctions (Table 1).

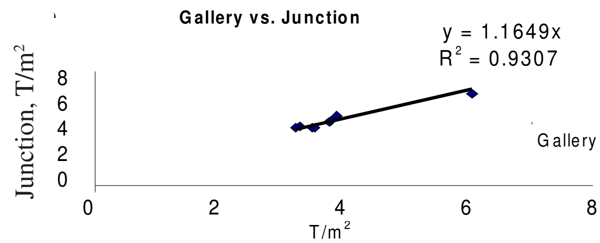


Fig. 1—Correlation between rock loads of gallery and junction

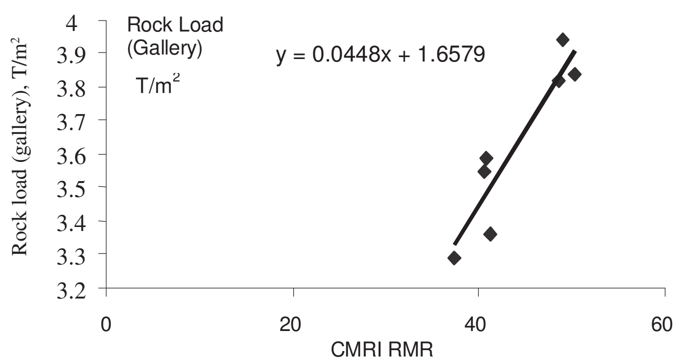


Fig. 2—Establishment of best-fit equation between CMRI RMR and Rock load of gallery

Relationship (Fig. 1) obtained after correlation between rock load of galleries and rock load junctions is:

Rock Load of Junction = 1.2 times of Rock load of Gallery …(3)

Best-fit equation obtained between CMRI RMR and Rock load of galleries (Fig. 2) is:

Rock Load of Gallery = 0.0448 CMRI RMR +1.6579 …(4)

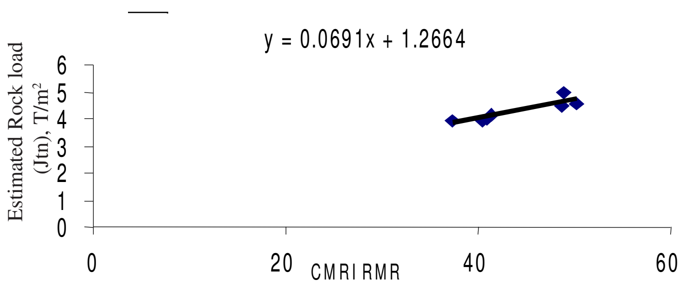


Fig. 3-Establishment of best-fit equation between CMRI RMR and Rock load of junction

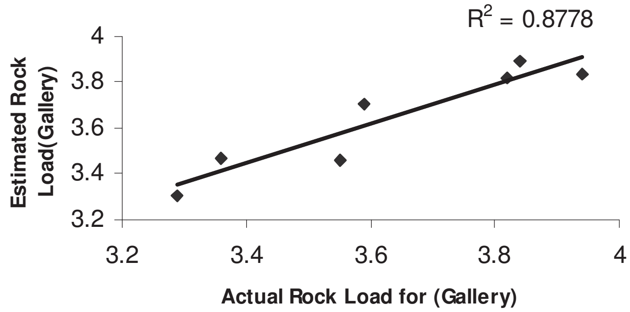


Fig. 4—Correlation between actual and estimated values of rock load values for galleries

Best-fit equation obtained between CMRI RMR and Rock load of junctions (Fig. 3) is:

Rock Load of Junction = 0.0691 CMRI RMR +1.2664 …(5)

**Correlation between Existing Rock Load Values And Newly Estimated Rock Load Values**

Using Eq. (4) for galleries (Fig. 4), obtained $r^2$ value is 0.8778 between existing and estimated rock load of gallery. Thus best-fit Eq. (4) could be used for calculation of rock of gallery directly after substituting CMRI RMR value. Using Eq. (5) for junctions (Fig. 5), obtained $r^2$ value is 0.8092 between existing and estimated rock load of junction. Thus best-fit Eq. (5) could be used for calculation of rock of junction directly after substituting CMRI RMR value.

## Conclusions

Rock Load of Junction is 1.2 times of rock load of gallery. Correlation between CMRI RMR & rock load of galleries and junctions it is observed that relationship between existing rock load value and new rock load value for galleries and junctions are 0.8778 and 0.8092 respectively. This shows that Eqs (4) & (5), which are obtained between CMRI RMR and rock load of galleries and rock load of junctions would be used for calculation of rock load of gallery and junction directly after substituting CMRI RMR value.

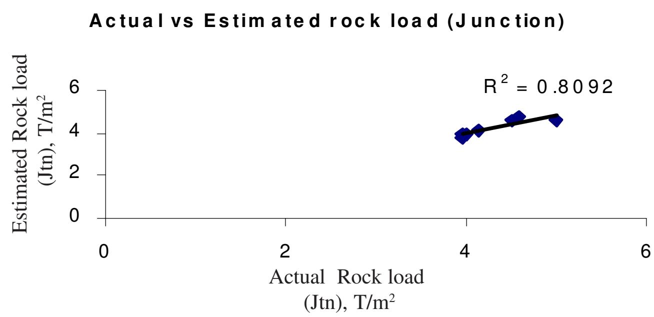


Fig. 5—Correlation between actual and estimated values of rock load values for junctions

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