

Variation of RMR for different rock types as immediate roof in Jharia Coalfield of India.

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ABSTRACT

In India, CMRI-RMR (Central Mining Research Institute-Rock Mass Rating) is an empirical approach, used mostly for formulating design of support system for roadways in underground coalmines. RMR plays important role in selection and design of roof support [1]. For stability assessment of rock mass it is very important to know the amount of rock load coming around the openings which is estimated using RMR [4, 7, 11, & 12]. The result revealed that sandstone as immediate roof is more stable compared to shale and coal. Attempt has been made to delineate the variation of RMR for different roof rocks in mines of Jharia coalfield. This would also help as useful guidelines in design of support system for roadways in other underground coalmines of Lower Gondwana Formations having more or less similar geo-mining conditions.

General Terms

Rock Mass Rating, Bharat Coking Coal Limited, TATA Steel Limited, Sandstone, Shale, Coal

Keywords

CMRI- RMR, Jharia coalfield

1. INTRODUCTION

Roof /side falls in underground mines constitutes one of the major causes for underground accidents and fatalities [8]. Over the years steps have been taken to reduce such accidents. But statistical analysis have revealed that the share of roof/side falls contributes around 28% since nationalization of Indian coal mines. CMRI-RMR, an empirical approach for design of support system of Indian underground coalmines roadways have been developed which has contributed in reducing the roof fall accidents considerably [13]. This has since been very common term amongst the mining fraternity. The RMR reflects the quality of roof in quantitative terms.

2. STUDY AREA

The case studies incorporated in this paper are taken from different mines of Bharat Coking Coal Limited and Tata Steel Limited situated in Jharia Coalfield (Table 2 to 7).

3. GEOLOGY OF THE AREA

Jharia coalfield is one of the most important coalfields in India [16]. This is the major source of the prime coking coal in the country. This coalfield is situated about 260 km

North West of Kolkata in the heart of Damodar River Valley mainly along the north of this river. The coalfield lies within the district of Dhanbad. The field is roughly sickle shaped. The coal basin extends for about 38 km in an East-West direction and maximum of 18 km in North – South direction and covers an area of about 456 sq km.

The major coal bearing horizons are in the Lower Gondwana Formation of Permian age. The general stratigraphic succession of the area is that the basement Metamorphic rocks are overlain by Talchir formation followed upward by Barakar formation which is the main coal bearing horizon. Above Barakar is the Barren Measures which is devoid of coal. The Barren Measures are overlain by Raniganj formation which is another coal bearing horizon. The Raniganj formation is the uppermost coal formation in the Jharia coalfield. The coal of Barakar formation is comparatively better in quality than coal of Raniganj formation.

4. ROCK MASS RATING

Rock Mass Rating (CMRI-RMR) [2, 3, 5,6,14, and 15] determined by *CMRI Geomechanical Classification System* is the summation of the ratings of five individual parameters. The individual parameters and their maximum rating are as follows (Table no.1).

Table 1. Parameters for Rock Mass Rating

Parameter	Maximum Rating
Layer thickness	30
Structural features	25
Weatherability (1 st cycle slake durability index)	20
Compressive strength	15
Groundwater	10

Layer thickness is most important, as delamination is the major causative factor for deterioration of roof condition [3]. For determining layer thickness, thickness of bedding planes is measured if roof is sandstone. In case of shale, thickness of prominent lamination or layers is measured. In case of coal, thickness of prominent bands is measured. This is an indirect representation of RQD and is related to it by

$$RQD = 100(0.1\lambda + 1)e^{-0.1\lambda}$$

where λ is the frequency of bedding planes per meter of thickness

Structural features are geological structures which causes roof deterioration and are faults, slips, joints, slickensides and other sedimentary features like sandstone channel, plant impression etc.

Weatherability is important because many coal measure rocks are either become weak or disintegrate due to weathering, especially in presence of water. The measure for this parameter is 1st cycle *Slake Durability Index* (SDI) determined by slake durability apparatus [9].

Compressive strength of rock is determined in the laboratory as per Bureau of Indian Standard [10]. It can also be determined in the field using point load tester on irregular samples.

Groundwater seepage is measured by drilling a 1.5 to 1.8 m long hole in roof and thereafter collecting the water

percolation through it. The rate of percolation is expressed in ml/minute.

After proper adjustment, CMRI RMR is used for estimation of Rock Load for galleries and junctions from the following equations:

$$\text{Rock load in roadways (t/m}^2\text{)} = \text{B.D. (1.7 - 0.037 RMR + 0.0002 RMR}^2\text{) ... (1)}$$

where, RMR = Rock Mass Rating,

B = Roadway width (m),

and D = Density (t/m³).

5. CASE STUDIES

Case studies have been selected from coalmines of Jharia coalfields mainly from mines of Bharat Coking Coal Limited (BCCL) and TATA Steel Limited, comprising of different roof rocks namely Sandstone, Coal and Shale (Table 2 TO 7).

Table 2. List of Case studies showing variation in RMR for Coal roof in TATA group of mines

Sl. No	Mine	Coal Seam	Thickness (cm)	Immediate Roof Rock	Gallery Width (m)	RMR	Compressive Strength (kg/cm ²).	Slake Index (%)	Density (t/m ³)
1	Jamadoba	XIV middle	8.5	Coal	4.8	41.31	307	96.74	1.64
2	Digwadih	XI	7.3	Coal	4.2	41.31	141	95.25	1.56
3	Sijua	X	6.71	Coal	4.2	45.9	190	95.65	1.55
4	Sijua	X	6.71	Coal	4.2	45	105	98.5	1.51
5	Sijua	XI	3.65-5.0	Coal	4.2	44.5	153	98.9	1.31
6	Sijua	XIII	5.79	Coal	4.2	42.12	157	98.01	1.38
7	Sijua	XIV	8.4	Coal	4.2	40.5	138	96.5	1.37
8	Digwadih	XI Bottom	7.31	Coal	4.2	34.83	145	96.53	1.23
9	6 & 7 Pit	XI Bottom	7.31	Coal	4.2	42.12	175	98.47	1.45
10	6 & 7 Pit	XIV Bottom	8.1-8.3	Coal	4.2	38.88	98	95.52	1.33
11	Jamadoba	XIV Bottom	8.52	Coal	4.2	35.19	232	96.2	1.36

Table 3. List of Case studies showing variation in RMR for Combined roof in TATA group of mines

Sl. No	Mine	Seam	Thickness	Immediate Roof	Gallery Width	RMR	Compressive Strength.	Slake Index	Density
1	Bhelatand	XII	3.6	Coal & Shale	4.2	40.4	195&228	97.83&98.84	1.9
2	Bhelatand	XIV	4	Coal & Sh.sst	4.2	39.69	170&401	96.79&98.82`	1.51

3	Sijua	XII	3.45	Coal & Shale	4.2	49.95	221&515	98.01&98.6	1.38&2.29
4	Bhelatand	XII	3.65	Sandy Shale	4.8	39.78	438	97.2	2.32
5	Sijua	XII	3.45	Coal & Shale	4.2	36.59	106&326	94.10&97.93	1.2&2.21
6	Bhelatand	XII	3.65	Coal & Sh.sst	4.2	39.9	147&247	98.23&97.6	1.58&2.1
7	Bhelatand	XIV	2.43-3.0	Shale & Sh.sst	4.2	49	441&597	98.35&98.50	2.14&2.45
8	Bhelatand	XV Top	2.6	Coal & Shale	4.2	42	225&300	98.9&98.5	1.5&1.8
9	Bhelatande	XVII	2.43	Shale & Sst	4.2	53.55	340&580	97.50&98.50	2.2&2.54
10	Malkera	XV Bottom	1.22-1.83	Shaly Sst.	3.6	46.98	405	99.35	2.46
11	Malkera	XV Top	2.42-2.7	Shaly Sst.	3.6	44.55	383	97.5	2.19
12	Malkera	XII	1.6	Shale & Sst.	4.2	50.7	470&660	99.05&99.44	2.42&2.82
13	Digwadih	XIV Top	1.8	Shale & Sst.	4.2	48.2	324&465	98.36&98.37	2.08&2.47

Table 4. List of Case Studies showing variation in RMR for Sandstone roof in TATA group of mines

Sl No.	Mine	Seam	Thickness	Immediate Roof	Gallery Width	RMR	Compressive Strength	Slake Index	Density
1	Jamadoba	XIV Top	8.5	Sandy Sh.	4.8	39.6	341	98.6	2.31
2	Bhelatand	XIV	4	Sh. Sst.	4.2	46.17	401	98.82	2.35
3	Malkera	XV Bottom	1.22-1.83	Shaly Sst.	3.6	46.98	405	99.35	2.46
4	Malkera	XV Top	2.42-2.7	Shaly Sst.	3.6	44.55	383	97.5	2.19
5	Digwadih	XI Top	7.31	Sandstone	4.2	50.22	200	96.55	2.28
6	6 & 7 Pit	XI Top	7.31	Sandy Shale	4.2	48.6	368	98.91	2.17
7	Jamadoba	XIV Top	8.52	Sandy Shale	4.2	44.37	782	95.66	2.31
8	Jamadoba	XVA	1.67	Shaly Sst	3.6	46.17	507	98.1	2.44
9	Jamadoba	XVI	3.35	Sandstone	4.8	43.74	482	96.2	2.48

Table 5. List of Case studies showing variation in RMR for Sandstone roof in BCCL Mines.

Sl. No	Name of The mine	Seam	Immediate Roof rock	Compressive strength	Slake Index	RMR	Layer Thickness	Gallery Width	Density
1	Basantimata	Gopinath(Top)	Coarse grained Sst	200.67	92.60	50.40	8.50	4.8	2.21
2	Angarpathra	IX Bot	Fine grained Sst	488.38	96.24	31.20	4.00	4.2	2.53
3	Bagdighi	XIII	Fine grained Sst	491.00	99.30	62.05	17.00	4.2	2.55
4	Dahibari	Kalimati (Top)	Fine to med gr. Sst	262.16	97.57	61.20	10.20	4.8	2.42

5	East Busseriya	III	Sandstone	296.98	97.96	60.30	5.70	4.2	2.76
6	Bararee	VIII	Massive Sst	603.83	97.23	52.00	7.00	4.2	2.48
7	Jogidih	III	Massive Sst	214.53	95.89	61.20	28.00	4.2	2.38
8	Block IV	II	Massive Sst	174.39	93.22	60.30	14.50	3.6	2.21
9	Khas Kusunda	II	Massive Sst	295.78	98.13	58.70	8.30	4.2	2.18
10	Kha Kusunda	III	Massive Sst	364.40	95.19	63.00	12.10	4.2	2.32
11	Damoda	I	Med grained Sst	310.49	95.30	61.20	12.00	4.2	2.40
12	Jogidih	IX (Bot)	Med to cg Sst	215.86	96.49	57.00	11.50	4.2	2.25
13	Mudidih (Pit # 2)	XA	Med to fin gr. Sst.	426.00	98.60	52.00	11.00	4.2	2.62
14	Bera	I	Med to fin gr SSt.	246.54	96.21	45.90	9.50	4.2	2.26
15	Angarpathra	V	Med to fin gr. Sst.	386.30	95.90	51.90	7.00	3.6	2.37
16	Sendra Bansjora	VI Bot	Sst	226.82	96.29	55.80	20.00	4.2	2.05
17	Sudamdih	VIIIA	Sst	352.91	96.53	42.40	3.00	3.8	2.53
18	Sendra Bansjora	VII	Sst	481.15	96.99	52.20	2.50	3.6	2.40
19	Angarpathra	IX (Top)	Sst	313.80	96.63	37.80	2.10	3.6	2.45
20	Bararee	IX	Sst	461.22	97.06	50.40	6.10	4.2	2.51
21	Kharkharee	XII (local)	Sst	224.50	88.24	47.70	8.70	4.2	2.18
22	Basantimata	Kalimati	Sst	113.50	89.52	40.80	15.00	4.2	2.21
23	Madhuband	XV (Top)	Sst	492.05	97.80	48.0	8.70	3.6	2.47
24	East Busseriya	II	Sst	195.57	66.67	43.40	9.20	4.2	2.36
25	Bhagaband	XVII (Bot)	Sst	314.78	97.17	40.80	6.00	4.2	2.18
26	Govindpur	IV	Sst	168.00	93.16	55.20	14.00	4.2	2.34
27	Govindpur	I	Sst	301.40	97.26	57.80	15.00	4.2	2.54
28	Dobari	O	Sst	151.92	95.42	60.40	25.00	4.2	1.82
29	Keshalpur	II	Sst	247.39	95.54	58.50	10.00	3.6	2.35
30	Dahibari	Kalimati (Bot)	SSt	253.81	98.52	54.40	10.20	4.8	2.34
31	Bhowrah North	VI	Sst	281.73	96.30	44.00	4.50	4.8	2.41
32	Huriladih	XVI A	Sst	184.60	87.26	57.60	17.50	3.6	2.19
33	Nichitpur	II (Top Sect)	Sst	284.83	94.80	56.10	18.30	4.2	2.32
34	Tetulmari	IV (Top Sec)	Sst	380.02	94.48	60.80	27.50	4.2	2.37
35	Ramkanali	V (Bot)	SSt	189.85	97.66	44.10	4.40	3.6	1.48
36	Lohapati	Pathorga B	Sst	293.52	97.85	52.70	6.50	4.2	2.33
37	Sudamdih	VIII	Sst	429.23	99.10	61.20	8.80	3.6	2.40
38	Sudamdih	VII	Sst	473.28	98.48	46.70	6.70	3.6	2.64

	Incline								
39	Salanpur	III	Sst	140.77	87.10	53.10	11.30	3.6	2.17
40	North Tisra	VI	Sst	416.31	94.70	52.20	8.10	4.2	2.31
41	Kuya (5/6 incline)	O	Sst	188.49	87.30	46.80	42.10	4.2	2.10
42	Amlabad	XV	Shaly Sst	554.82	99.18	56.70	7.00	4.2	2.44
43	Est Bhugatdih	XI/XII Comb	Shaly Sst	437.40	97.59	51.30	5.00	3.6	2.17
44	Bastacola	O	Shaly Sst	238.11	92.04	44.20	8.00	4.8	2.52
45	Lodna	IX/X Comb	Shaly Sst	229.72	99.04	42.40	2.60	NA	NA
46	Busserya	IX (Spl)	Shaly Sst	537.01	98.38	56.70	8.00	4.2	2.63
47	Kuya	III	Shaly Sst	152.49	89.41	42.50	10.00	4.2	1.80
48	Lohapati	Pathorga A	Shaly Sst	140.77	87.10	45.90	5.70	3.6	2.17
49	Mudidih (7/8 incl)	IX (Top)	Sandy shale	380.00	96.29	53.10	12.00	4.2	2.51

Table 6. List of Case studies showing variation in RMR for Shale roof in BCCL Mines.

Sl. No	Name of The mine	Seam	Immediate Roof rock	Compressive Strength	Slake Index	RMR	Layer Thick	Gallery Width	Density
1	Kharkharee	XVI (Top)	Carb. Shale	455.18	97.70	50.40	5.90	4.2	2.38
2	Mudidih (Pit #3)	VIII	Shale	214.00	99.00	45.36	4.80	4.2	2.31
3	Sudamdih	VI	Sst	486.78	98.80	48.80	7.00	3.8	2.85
4	Bararee	IX	Shale	372.77	97.88	40.00	3.70	4.2	2.27
5	Block IV	I	Shale	281.27	97.76	38.40	5.20	4.2	2.38
6	Kharkharee	XII (Local seam)	Shale	591.10	95.50	54.90	8.40	4.2	2.23
7	Basantimata	Gopinathpur(Top)	Shale	203.50	97.65	42.40	7.00	4.8	2.21
8	Salanpur	V	Shale	246.57	98.00	46.40	8.00	4.2	2.22
9	Bagdighi	X	Shale	461.80	98.60	52.00	10.80	4.2	2.33
10	Joyrampur	VI	Shale	286.70	97.50	44.10	4.80	4.2	1.63
11	Godhur	VI	Shale	318.48	99.50	46.80	2.60	4.8	2.15
12	Murlidih	Mahuda Bot	Shale	447.26	97.30	41.40	5.50	4.2	2.37
13	Simlabahal	X (Top)	Shale	344.52	98.30	53.55	7.00	4.2	2.13

14	Madhuband	XV (Top)	Shale	290.27	98.80	44.80	5.80	3.6	2.00
15	Damoda (BJ Pit)	X	Shale	256.83	98.13	38.70	6.10	4.0	2.06
16	South Govindpur	X Top	Shale	286.88	99.11	38.40	3.80	3.6	2.32
17	Bhagaband	XVII (Bot)	Shale	346.85	99.44	44.80	6.00	4.2	2.21
18	Govindpur	I	Shale	454.54	94.70	46.75	6.50	4.2	2.39
19	Bhowrah North	VI	Shale	393.93	98.48	44.80	4.80	4.2	2.33
20	Huriladih	XVI A	Shale	204.65	96.70	55.80	14.00	3.6	2.23
21	Nichitpur	II (Top Sect)	Shale	158.28	99.02	45.05	4.00	4.2	1.56
22	Godhur (30 inc)	VI	Shale	310.42	99.40	49.60	4.70	3.6	2.15
23	Tetulmari	IV (Top Sec)	Shale	351.46	99.18	52.00	5.10	4.2	2.17
24	Lohapati	Pathorga B	Shale	218.83	97.15	41.65	3.00	4.2	1.93

Table 7. List of Case studies showing variation in RMR for Coal roof in BCCL Mines.

Sl. No	Name of The mine	Seam	Immediate Roof rock	Compressive. Strength	Slake Index	RMR	Layer Thick	Gallery Width(m	Density
1	Sendra-Bansjora (Bot)	VI Bot	Coal	123.72	92.02	38.07	10.00	4.2	1.43
2	Sendra-Bansjora (Top)	VI Bot	Coal	123.72	92.02	42.30	10.00	4.2	1.41
3	Sudamdih	VIIIA	coal	153.74	98.05	47.20	6.60	3.8	1.48
4	Sendra Bansjora	VII	Coal	150.29	97.94	47.70	5.00	3.6	1.61
5	Angarpathra	IX (Top)	Coal	151.21	98.50	39.20	4.00	3.6	1.40
6	East Bhuggatdih	XI/XII Comb	Coal	292.95	97.38	54.00	5.00	3.6	1.55
7	Basantimata	Kalimati	Coal	284.60	97.57	44.80	10.50	4.2	1.52
8	Gopalichack	XIV	Coal	192.94	93.25	41.60	7.00	4.2	1.25

9	Gopalichack	IX	Coal	137.34	98.16	43.30	5.50	4.2	1.48
10	Kusunda	V/VI/VII/VIII	Coal	145.65	96.27	36.70	6.00	4.2	1.36
11	Balihari	XV	Coal	137.29	97.10	36.90	5.30	4.2	1.35
12	Dhansar	III	Coal	128.26	97.23	32.30	4.90	4.2	1.45
13	Salanpur	V	Coal	201.45	96.90	41.60	5.50	4.2	1.42
14	Bagdighi	X	Coal	174.70	94.90	40.80	6.10	4.2	1.36
15	Joyrampur	VI	Coal	148.60	96.90	45.00	8.50	4.2	1.43
16	Godhur	VI	Coal	172.33	97.30	45.00	5.70	4.8	1.48
17	South Balihari	XI	Coal	233.66	97.90	42.40	6.00	4.8	1.39
18	Simlabahal	X Top	Coal	163.83	97.10	41.65	4.50	4.2	1.34
19	East Bhuggatdih	II (Bot)	Coal	135.43	95.32	42.40	10.10	4.2	1.52
20	Damoda (BJ Pit)	X	Coal	218.64	99.60	39.60	5.30	4.0	1.55
21	Bhagaband	XVII (Bot)	Coal	121.85	97.77	36.00	4.50	4.2	1.27
22	Pootkee	XI	Coal	138.84	96.00	31.50	4.00	3.0	1.43
23	Govindpur	I	Coal	138.70	97.45	44.20	4.50	4.2	1.34
24	Dobari	II	Coal	145.94	98.03	41.70	7.00	3.6	1.50
25	Keshalpur	II	Coal	130.91	97.98	51.30	5.20	3.6	1.50
26	Gondudih	III	Coal	113.71	98.78	45.00	3.50	3.6	1.56
27	Gondudih	II	Coal	125.90	97.27	47.70	4.00	3.6	1.48
28	West Mudidih	II (Bot)	Coal	154.57	97.09	50.40	10.50	4.2	1.45

29	Bhowrah North	VI	Coal	123.32	94.70	34.40	4.20	4.2	1.53
30	Amlabad	XIII	Coal	145.54	95.52	41.60	9.50	4.2	1.44
31	Huriladih	XI	Coal	114.26	97.40	41.60	7.00	4.8	1.35
32	Alkusha	IX	Coal	115.99	98.41	43.20	4.10	4.2	1.49
33	Nichitpur	II (Bot Sect)	Coal	119.18	97.75	42.40	8.30	4.2	1.54
34	East Bhuggatdih	VII/VIII	Coal	152.11	95.63	38.40	4.20	3.6	1.36
35	Industry	IV	Coal	151.50	85.82	36.90	6.30	4.2	1.41
36	Godhur (27 incl)	V	Coal	209.31	98.44	43.20	6.60	4.8	1.47
37	Godhur (30 incl)	VI	Coal	125.21	98.50	44.80	4.60	3.6	1.55
38	Bhowrah North	XI	Coal	129.30	96.14	41.60	5.50	4.2	1.35
39	Tetulmari	IV (Top Sec)	Coal	341.43	94.45	48.80	6.30	4.2	1.43
40	Sendra Bansjora	VII	Coal	168.13	98.73	48.00	5.80	4.2	1.40
41	Ramkanali	IV (Top)	Coal	329.37	98.59	50.40	4.60	4.2	1.58
42	Pootkee	X	Coal	122.54	96.50	40.80	6.90	4.2	1.46
43	Sudamdih	VIII	Coal	177.63	90.30	45.90	6.30	3.6	1.37
44	Sudamdih Shaft	VIII A	Coal	110.51	96.18	36.80	8.00	3.6	1.30
45	Lodna (Pit 8)	Vii	Coal	244.68	95.81	47.20	10.00	4.6	1.43
46	Ramkanali	II (Bot)	Coal	160.42	98.10	41.60	5.10	4.2	1.44
47	Salanpur	III	Coal	143.31	98.80	49.50	4.20	3.6	1.42
48	Gopalichuck	X	Coal	151.69	97.77	45.90	5.10	4.2	1.33

49	Sudamdih Shaft	XI/XII Comb	Coal	98.69	95.10	37.60	5.90	4.7	1.18
50	Ramkanali	III	Coal	110.73	97.40	35.10	4.00	3.6	1.50
51	Kuchi Balihari	XI	Coal	153.90	98.10	45.90	4.60	4.2	1.34
52	Mudidih (Pit # 3)	VIII	Coal	195.00	96.79	43.74	7.60	4.2	1.51

6. GRAPHICAL REPRESENTATION OF VARIATION OF RMR

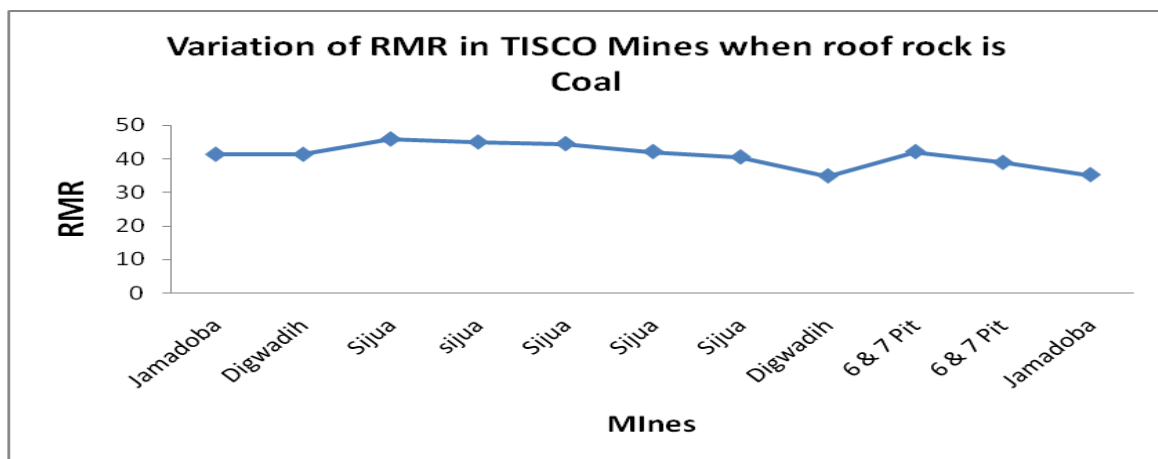


Fig 1: Graphical representation of variation in RMR when immediate roof is composed of Coal for TISCO group of mines.

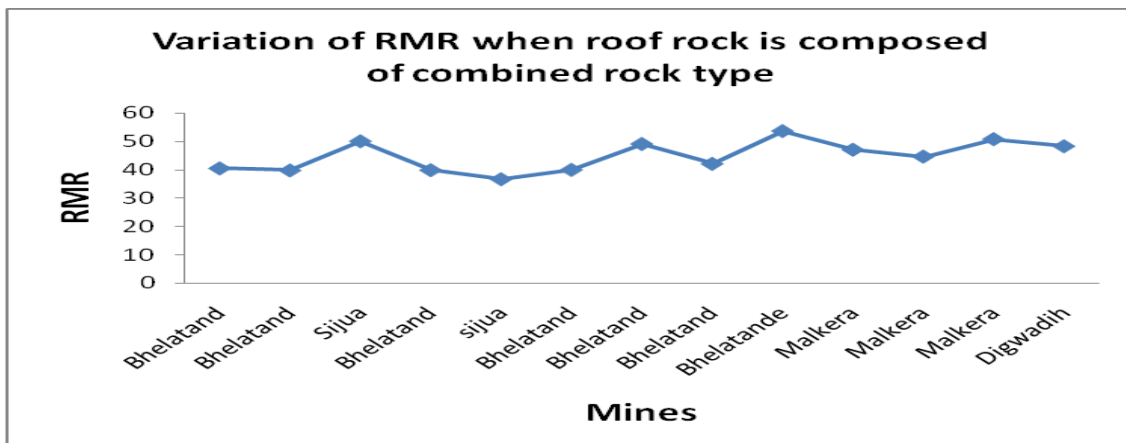


Fig 2: Graphical representation of variation in RMR when immediate roof is composed of combined roof for TISCO group of mines

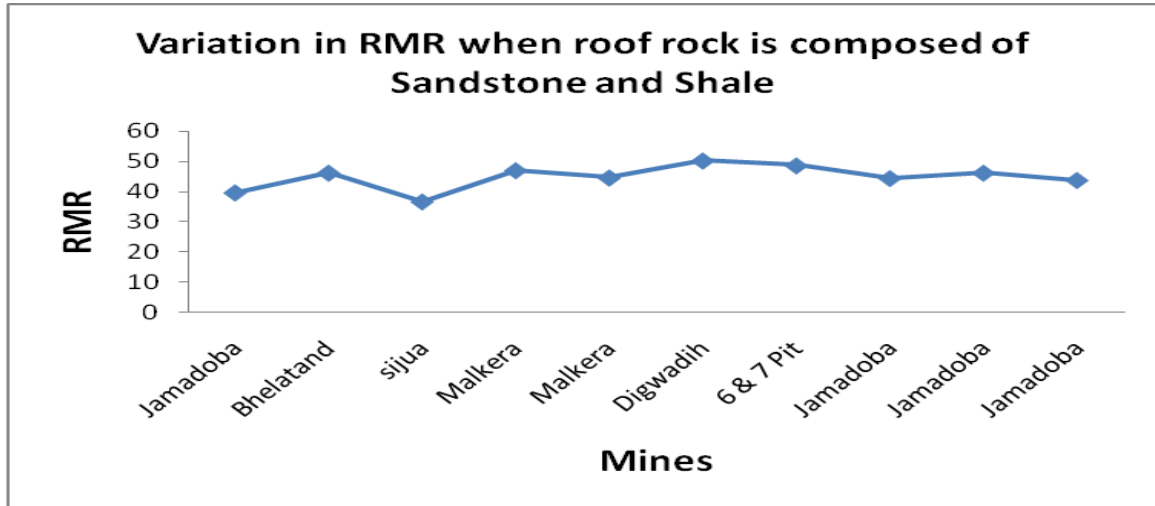


Fig 3: Graphical representation of variation in RMR when immediate roof is Shale & Sand Stone roof for TISCO group of mines.

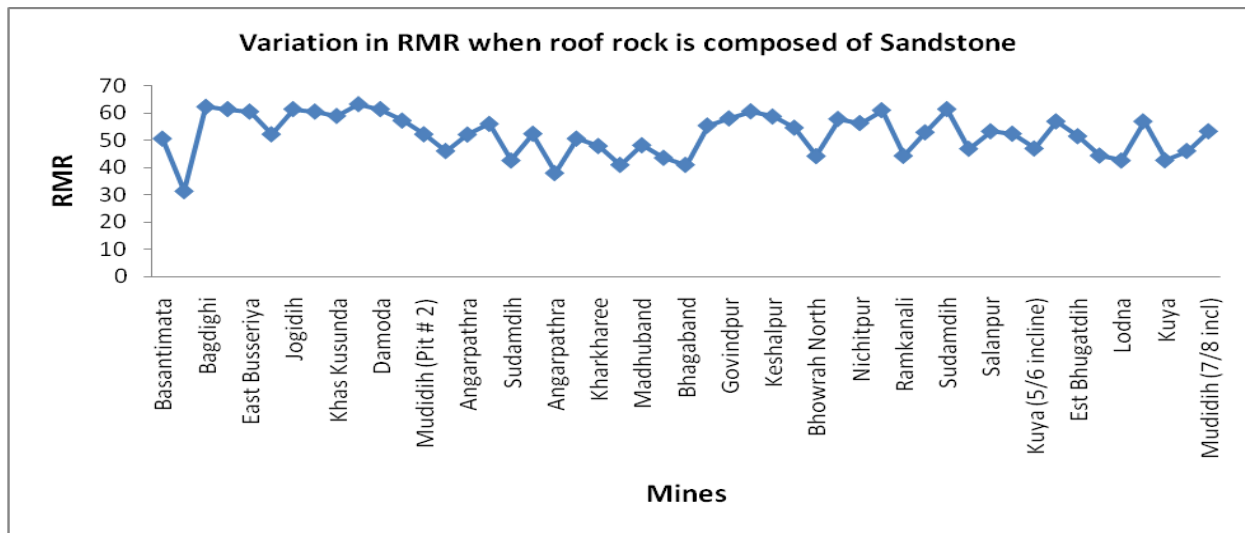


Fig 4: Graphical representation of variation in RMR when immediate roof is composed of Sand stone for BCCL mines

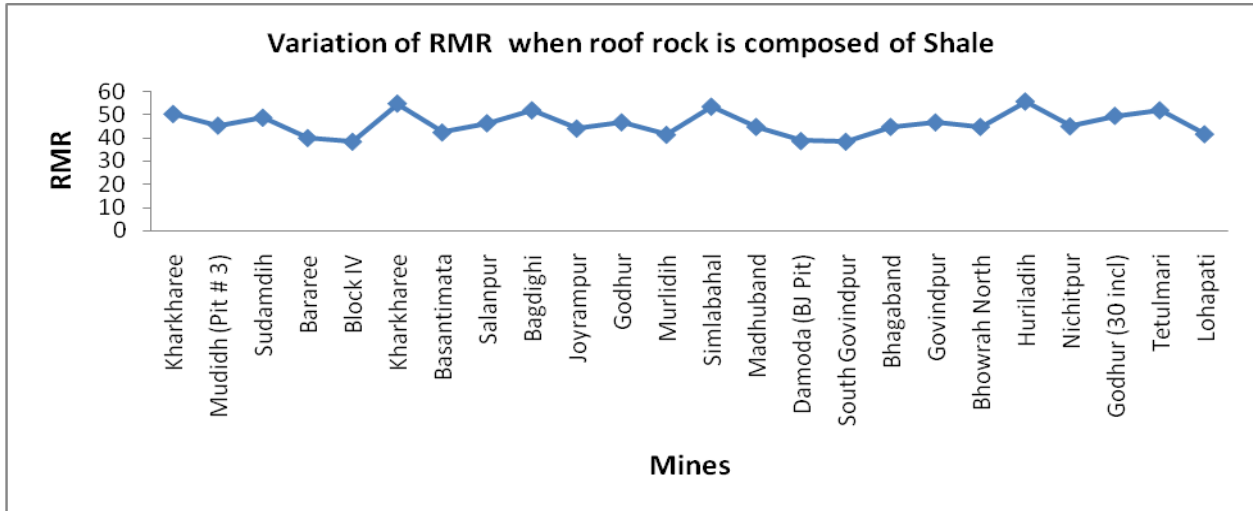


Fig 5: Graphical representation of variation in RMR when immediate roof is composed of Shale for BCCL mines

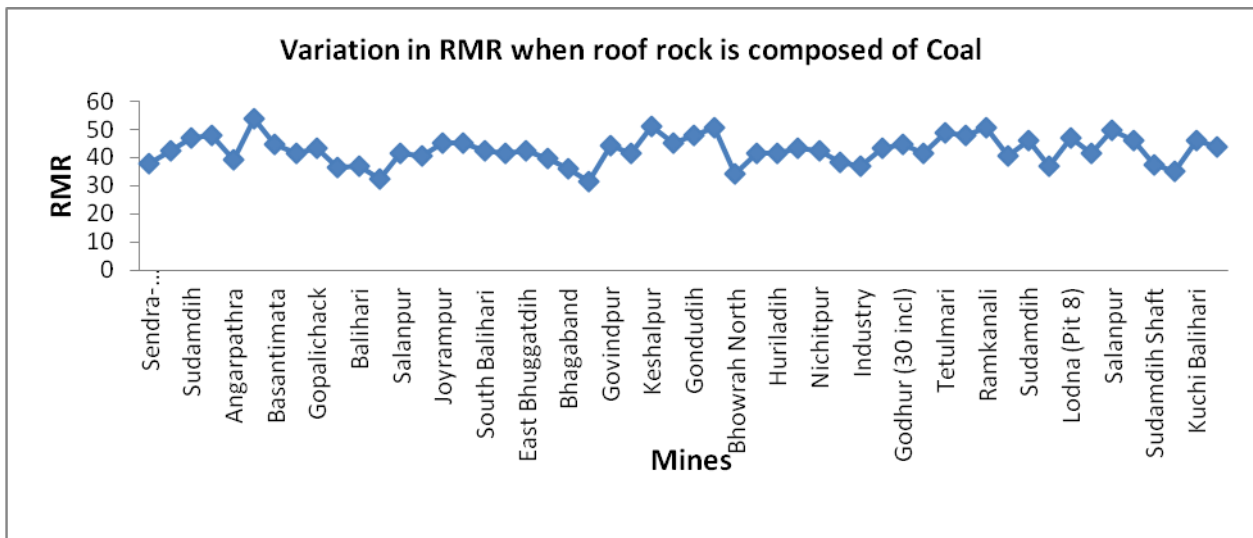


Fig 6: Graphical representation of variation in RMR when immediate roof is composed of Coal for BCCL mines

7. RMR VARIATIONS FOR DIFFERENT ROOF ROCKS

Table 8. Table showing RMR for different roof rocks in mines of Tata steel Ltd & BCCL.

S.No	Location/Company	Immediate Roof Rocks			
		Coal (RMR)	Sandstone (RMR)	Shale (RMR)	Combined roof (RMR)
1.	Tata Steel Limited	34.83 – 45.9	43.74 – 50.22	39.6 – 48.6	36.59-53.55
2.	Bharat Coking Coal Limited	31.50 - 54	31.20 - 63	38.40 – 55.80	36.59-50.22

8. CONCLUSIONS

1. The coal measure rocks encountered as immediate roof in coalmines are mainly sandstone, shale and coal and their combinations.
2. The study revealed that the mines with sandstone as immediate roof, 18% are having Good roof with RMR between 60 to 80, 78% are in Fair roof with RMR between 40 to 60 and only 4% are in Poor category with RMR 20 to 40. The variation in RMR is 31.20 to 63
3. In shale roof 15% are Poor and rest 85% are Fair roof. The RMR varies between 38.40 to 55.80
4. The mines with coal roof, 25% are in Poor category and rest 75% are Fair roof. The RMR varies between 31.50 to 54.
5. The results revealed that sandstone as immediate roof rock is having better roof conditions, compared to coal and shale. It is observed that shale deteriorates with time especially in presence of water due to its weathering properties and should be avoided leaving in the roof.
6. In this study almost all the mines of Jharia coalfield of India has been included covering most of the coal seams. It would be helpful for the industries to have an idea about the quality of the roof they are encountering while going for extraction of coal. This study would also help as a guideline for RMR with different roof rocks which would further helpful for the mine management to frame their design of support system (Systematic Support Rule - SSR) till the actual determination of RMR is done.

9. ACKNOWLEDGMENTS

Authors would like to thank Director, CSIR-CIMFR (erstwhile CMRI), Dhanbad, for his guidance and help in this research work.

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