Geotechnical studies in short wall mining - a case study of RK Tech mine, SCCL

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Abstract

The Singareni Collieries Co. Ltd (SCCL) recognized for success full operation of short wall technology in RKNT-Mine Srirampur area Adilabad district in Telangana State. For this purpose the geo technical studies were conducted in main gate to tail gate of all the panels. The forecasting and interpretation of stable roof strata needs to generate data viz., Geo-Engineering properties of roof rocks, rock quality designation, caving parameters of roof rocks, geo technical logs and underground mapping. Detailed Geotechnical mapping carried out in 1 to 6 panels helped the Mine Management in all respects and DGMS also considered the data for necessary approvals.

1. Introduction:

RK NEW TECH incline is located in Somagudem - Indaram coal belt of North Godavari Valley coal field. The area of mine block is 2.64sq.km. The block is lying between N latitude 18^0 46' to 19^0 05' and E longitude 79^0 26' to 79^0 35' and falls in survey of India topo sheet no.56 M/8, N/5, N/9.

SCCL availed services of CODCO, China to study the Short wall potential mines and assess the status of Chinese equipment existing in SCCL. CODCO team visited six mines in SCCL and recommended initially RKNT Mine. Accordingly, Short wall mining is introduced in RKNT in IA seam. Initially six panels were identified on north side property for extraction by this method. Three panels (1, 2 & 3) were successfully completed and presently, Panel-4 is in progress. Geotechnical studies were conducted in 1 to 6 panels for continuous technical support to mine management and to provide higher safety, faster rate of extraction and productivity.

1.1. Status of mining:

Two top most seams IA and I are being worked by RK-NT and the lower four seams are being worked by RK-7. Both the seams are mined by Board and Pillar method. The average thickness of the IA seam is 5.80m having roof of thin pyretic layer and sandstone

(top section is 1.7m and bottom section is 3.5m, In between the seams 0.6m of clay).The top section and the bottom section of the coal seams mostly comprises of coal and shaly coal. The grade of IA seam (Top and bottom sections) varies from C- E grade.

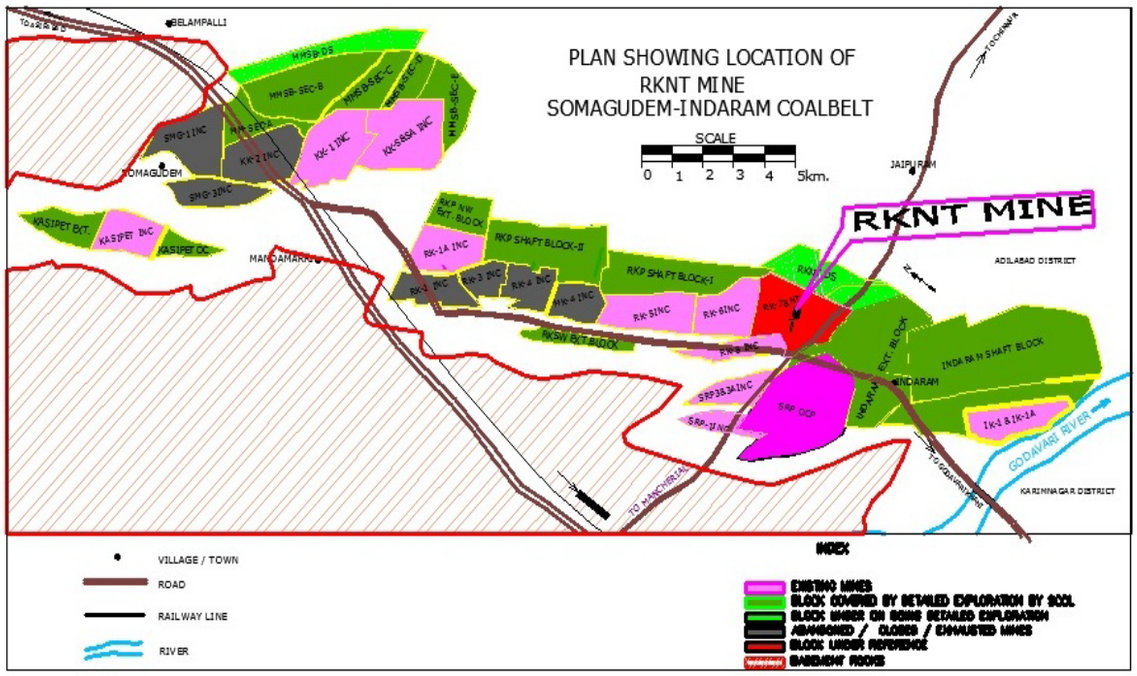


Figure 1 Location plan of RKNT mine

2. Geology and structure of RK New Tech mine:

The block is covered by the soil with few exposures of barren measures, while the strata of the Barakar formation constitute a narrow strip. In This formation only top most part of the sequence is exposed in this block. A maximum thickness of the Barakar formation around 234.00m. This strata predominantly consists of medium to coarse grained grey white feldspathic sandstones, with few shale bands and 8 regionally persistent of coal seams of 0.30m to 6.84m thickness.

The local strike and dip data as well as the stratum contour map of the coal seams prepared on the basis of the subsurface data have been used to interpret the structure. The western and southern boundary is limited by faults. The western boundary is defined by sub parallel strike faults trending approximately in a NW-SE direction with a considerable down throw to the south west, thus advantageously in bringing up the coal measures to minable depths in this block.

3. Underground geotechnical mapping:

A detailed underground geotechnical mapping has been carried out in IA Seam (Top Section) to pick up the trends of Slips, Joints, Cleats, Sedimentary structures etc All the mapping features are demarcated on underground working plan of IA seam on RF 1:

2000(Fig-1), Mapping is carried out from 7 Dip to 30 Dip and 7L to 28L (SHORT WALL PANEL No's.4, 5&6). In the study area, as many as 43 Joints, 68 Cleats, 08 faults / slips have been picked up besides various lithological characters of Roof strata and sedimentary depositional structures observed during the Geo Technical mapping. A thin (about 5cm to 10cm) pyretic layer forms the immediate roof of IA seam and it is a characteristic feature in Somagudem - Indaram coal belt. The overlying strata above the pyretic layer is Medium grained grey white sand stone and no roof fall is observed in the study area. During the mapping, sedimentary structures viz. Sandstone dykes, Cut & Fill structures, pinch out of sandstone bands in the coal seam, cross bedding and plant impressions were observed. Details of all these features are discussed hereunder-

3.1. Joints:

The rose diagram drawn for 43 joints reveals two distinct direction of joints viz. J_1 and J_2. The most prominent joint set J_1 is in the direction of $N35^0W$, joint set J2 trends in $N25^0E$ and along the J_1 joints, calcite fillings are observed. Spacing of these joints varies from 0.2m to 0.50m. J_2 joints are closely spaced joints in the sense; the spacing varies from 10 cm to 20 cm and is tight joints (Figure 2).

Nelson and Bauer (1987) opined that in the Illinois basin, the predominant direction of jointing in the roof is parallel with the major stress axis. Sharma and Chandra (1988) reported based on their observations that the greatest principal stress direction σH is oriented parallel to the most prominent joint set J1.

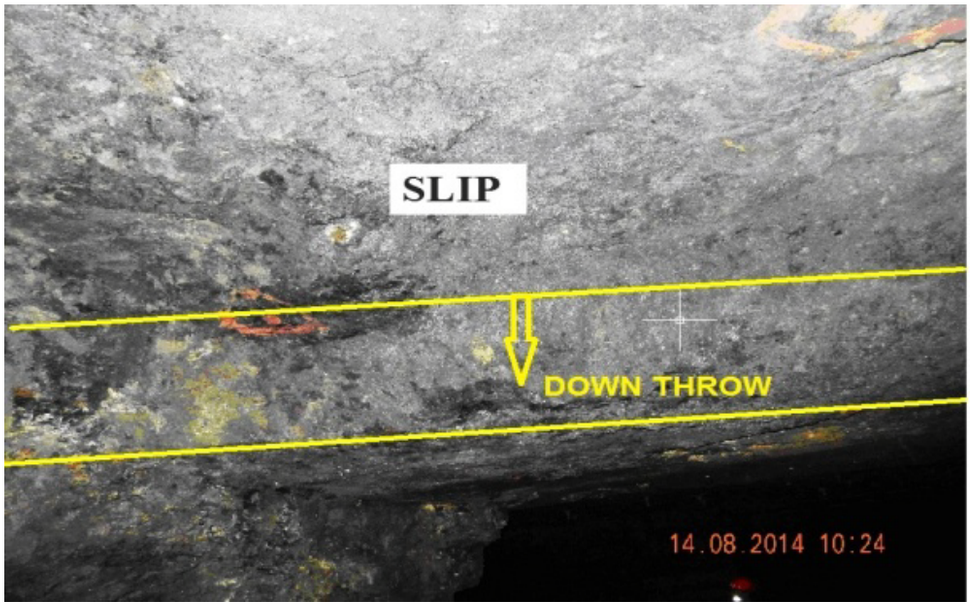
3.2. Sandstone dykes/ intrusions:

Clay veins, clay stone dykes or sandstone filings are wedge shaped masses that occur in crevice of a coal bed. The common feature is that of the “Sandstone Dyke” or “Stone intrusions” or “Stone eye” (irregular masses of sandstone) that occur within the seam or penetrating into the seam. These generally range up to 1m to 2m in width. The pattern and character of these structures suggest that they formed as tension fissures in coal which later filled with clayey/sandy material and then were compacted after burial. The details noticed in the location in panel area and observed feature are listed below.

Photograph 1 Sandstone intrusion in coal pillar

3.3. Faults/ minor slips:

About 8 slips are mapped. It is inferred from the rose diagram (Figure 2) drawn for the slips that the most prominent slip trend in $N40^0W$. Down throw of the slips are mostly trending in $N50^0E$. In most of the cases, the slip angle is 65^0. Slickensides are observed along the slip planes.The effects of faults always undesirable in coal mining. These effects are physical displacement of coal seams, reducing the stability of roof and ribs in underground workings, opening of path ways for the influx of water into underground workings and introduction of impurities and various forms of mineral matter in to coal seam.



Photograph 1 Minor slip with down throw in dip gallery

3.4. Clean pattern:

A distinct cleat pattern is developed in the coal bands of IA seam. About 68 readings of Face cleat and Butt cleat are taken. The trend of cleat pattern is mapped constructed a Rose diagram and depicted in Fig-2. Face cleat trends in and $N15^0E$ and Butt cleat trends in $N75^0W$. The frequency of both Face cleat and Butt cleat are 30cm and 20cm respectively. In general, the cleat is well defined in vitrain bands and fusain bands. Since roof of working section is sandstone, no influence of Cleat on roof stability is observed. However it helps for easy cutting of seam with shearer.

Photograph 3 Face Cleat & Butt Cleat in Coal Pillar

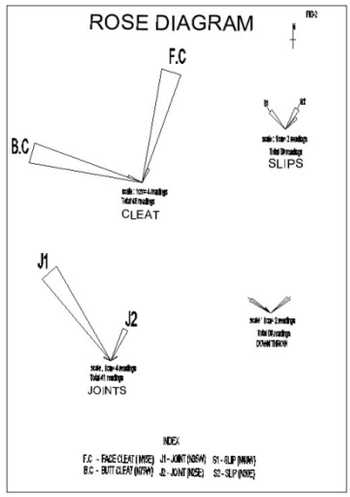


Figure 2 Rose Diagrams of Joint, Slips & Cleat.

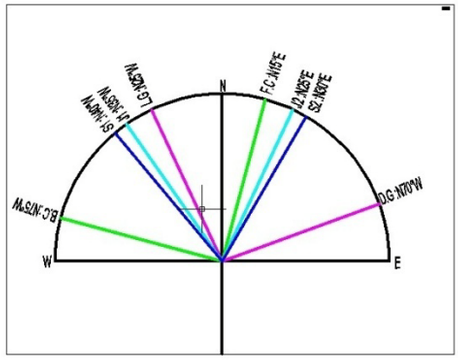
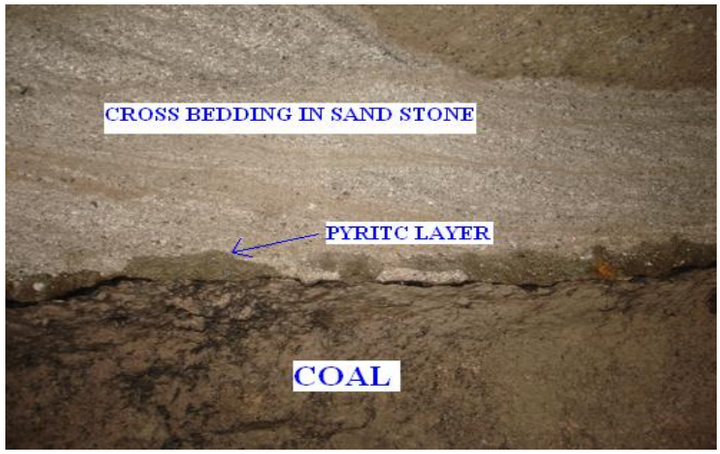


Figure 3 Orientation of galleries, joints, slips and cleat.

F. C: N15^{0}E J1:N35^{0}W S1:N40^{0}W L.G:N25^{0}W
B. C: N75^{0}W J2:N25^{0}E S2:N30^{0}E D.G:N70^{0}E

3.5. Cross stratification:

Layers oblique to bedding surfaces are referred to as cross stratification and is a weak surfaces along which, thin beds of strata separates. Cross stratification is observed in the exposed roof strata and noticed that layers are separated from the main roof along the cross stratification.



Photograph 4 Cross bedding in 8L/18D

3.6. Plant impressions:

Leaf impressions are discontinuous planes. Roof strata separate easily along such planes. In the area under reference, roof strata is medium to coarse grained sandstone consisting of leaf impressions. Along the leaf impressions due to weak bonding between over lying and under lying strata, it leads to separation and failure.

Photograph 5 Plant impression (Trunk structure) in roof sandstone

4. Geo engineering properties:

To assess the strength of roof strata of working section of IA seam, different geo-engineering properties viz. Compressive Strength, Tensile Strength, Shear Strength, Young's modulus, Impact Strength Index and Protodyaknov strength Index are essential. Core samples collected from the roof strata of bore hole no. RKBH-589 was subjected to all the above tests in the Regional laboratory, SCCL, Kothagudem. Range of different strength parameters is provided in table1 indicating Compressive strength of the strata ranges from 82 to 439Kgs/cm^2 classifying into "Medium Strength to High Strength". The Geo technical log of the borehole is depicted in the Figure 5.

Table 1
Summarised data on Physico-mechanical properties of Bore hole no. RKBH-589 in the roof strata of working section of IA seam

Parameters	**Roof of IA seam**
Density (gm / cc)	1.93 - 2.41
Tensile strength(Kg/cm^2)	8.15 - 59.66
Compressive Strength (Kg/Cm^2)	82 - 439
Young's Modulus-Dry x 10^5(Kg/Cm^2)	0.23 - 0.93
Shear Strength (Kg/Cm^2)	16.82 - 88.78
Impact Strength Index	46.85 - 53.45
Protodyaknov Strength Index	0.20 - 1.95
Slake Durability Index	82 - 91
RQD %	31-91

4. Rock quality designation (RQD):

Rock Quality Designation (RQD) is determined for the roof strata of IA seam pertaining to BH.No.RKBH-589. RQD ranges from 53 to 100%, classifying the roof as "FAIR to VERY GOOD".

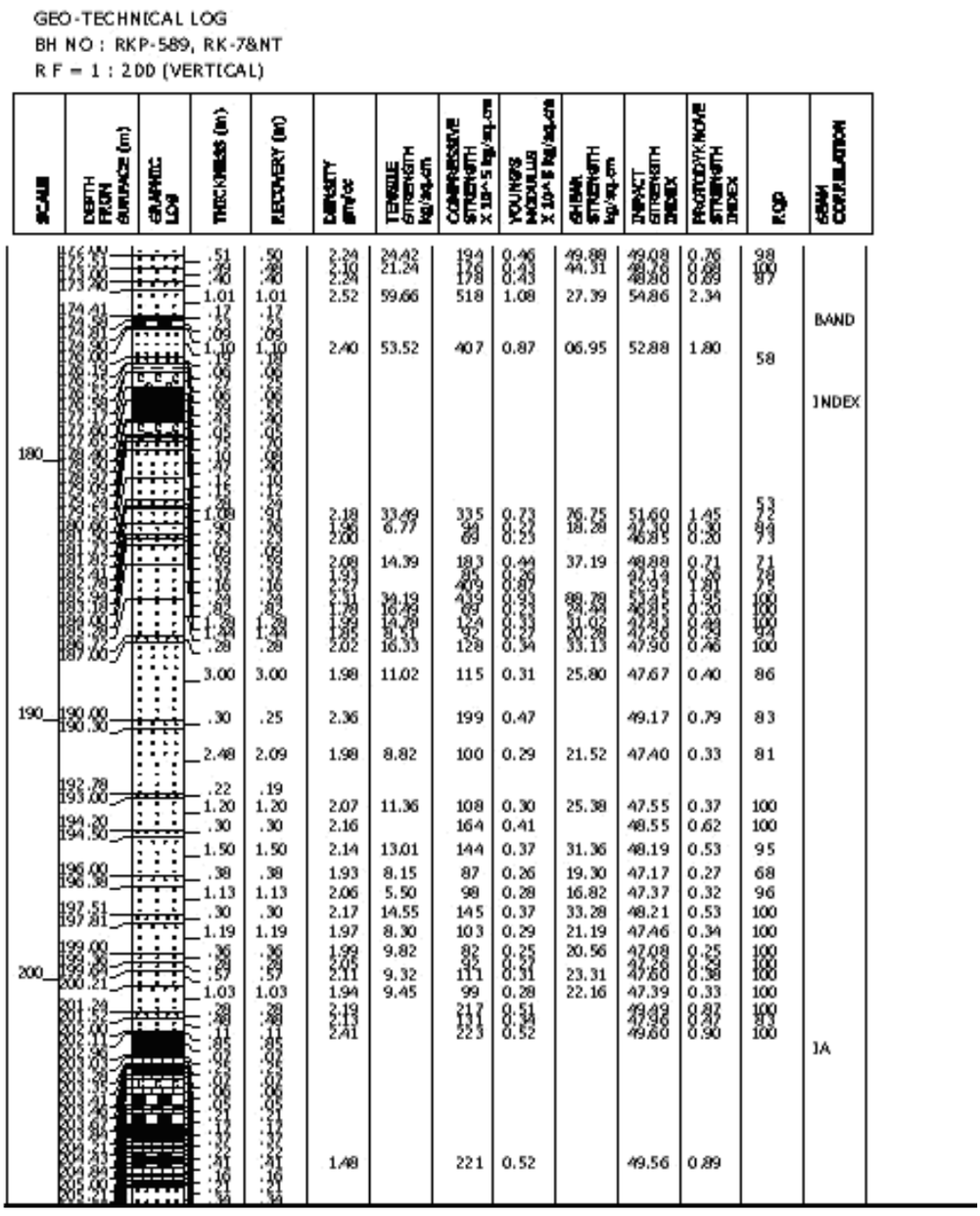


Figure 5 Geo technical log of BH. No. RKBH-589

6. Caving Index:

Caving behavior of roof rocks is the most important to assess the estimation of cavability of overlying rocks. CIMFR, Dhanbad has developed a method for the Cavability of roof rocks, involving three factors i.e. compressive strength (Sc in Kg/cm^2), average length of core (l cm) and thickness of bed (t in m). Cavability Index is expressed as follows:

$$I = S_C \, L^n \, t^{0.5} / 5$$

Where

I = Cavability Index
Sc = Compressive strength (kg/cm^2)
T = Thickness of bed (m)
L = Average length of core (cm)
N = 1.2 in case of uniformly massive rocks with weighted average of RQD of 80% and above while in all other cases 'n' is equal to unit.

Table 2
Classification of Caving Index

Classification	**Caving Index Number(I)**
Weak Roof	<500
Easily caveable	500-1000
Moderately difficult in caving	1000-2000
Roof caveable with difficulty	2000-4000
Roof caveable with considerable difficulty	>4000

For the roof of IA Seam, considering the PMP data of BH.No.RKBH-589, Cavability Index is assessed. The data thus generated is furnished in Table -2 and depicted in fig-4. As per the caving Index, total eight beds are identified and classified the Bed No's 2, 3, 4, 5, 7 & 8 as “Roof caveable with difficulty", whereas Bed No.6 is classified as “Roof caveable with considerable difficulty". Bed No.1 is categorized as "Moderately difficult in caving".

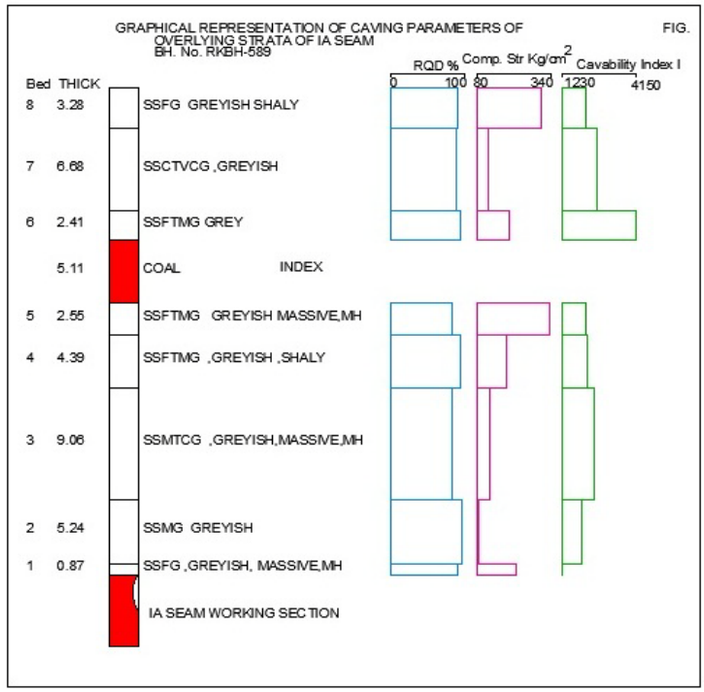


Figure 4 Graphical representation of caving parameters of overlying strata of BH.No.RKBH-589

Table 2
Physico-mechanical properties of overlying roof rocks above IA seam of RKNT block.
(BH.NO. RKBH 589.)

BED NO.	Depth (m)		STRATA	Thickness of the bed	Avg. length, L (cm)	Weighted Mean Sc	Cavability Index
	From	To		(m)			I
8	161.95	162.34	SSFG GREYISH SHALY, LAMINATED < 30 MM,MH	3.28	21	154	2139
7	165.32	166.00	SSCTVCG ,GREYISH ALL OVER,PEBBLY	6.68	21	134	2601
6	172.00	172.51	SSFTMG GREY,MICACEOUS,LAMINATED < 30 MM	2.41	22	325	4147
	174.41	179.52	COAL	5.11			
5	179.52	180.60	SSFTMG GREYISH MASSIVE,MH	2.55	19	201	2162
4	182.33	182.41	SSFTMG ,GREYISH ,SHALY,MICA,LAMINATED < 30 MM,MH	4.39	22	129	2215
3	186.72	187.00	SSMTCG ,GREYISH,MASSIVE,MH	9.06	19	120	2462
2	196.00	196.38	SSMG GREYISH,MICACEOUS,LAMINATED < 30 MM,MH	5.24	23	101	2008
1	201.24	201.52	SSFG ,GREYISH, MASSIVE,MH	0.87	21	170	1234
	202.1	207.93	COAL				

7. Summary and Conclusions:

The following conclusions are drawn based on the consideration of Geotechnical data generated in the present area of interest: –

a. Sandstone channels are observed within the seam. These generally range from 1m to 3m in width. The pattern and character of these structures suggest that they formed as tension fissures in coal which later filled with sandy material and then were compacted after burial.
b. In 4,5&6 panels, 43 joints are observed. The most prominent joint set J_1 is in the direction of $N35^0W$ and next prominent joint set J2 trends in $N25^0E$. Along the J_1 joints, calcite fillings are observed. Spacing of these joints varies from 0.2m to 0.5m. J_2 joints are closely spaced in the sense; the spacing varies from 10 cm to 15 cm and is tight.
c. Cleat pattern is well developed in the coal bands of IA Seam. About 68 readings of Face cleat and Butt cleat each are taken. Face cleat trends in $N15^0E$ and Butt cleat trends in $N75^0W$. Since roof of working section is sandstone, no influence of cleat on roof instability is observed.

d. About 8 slips are mapped. In general slips trend in $N40^0W$. Down throw of the slips are mostly in $N50^0E$. In most of the cases, the slip angle is 65^0. Slicken sides are observed along the slip planes.
e. Compressive strength of the strata ranges from 82 to 439kgs/Cm^2 indicating that the roof strata is "Medium Strength to High Strength". RQD ranges from 53 to 100%, classifying the roof as "Fair to Very Good".
f. As per the caving Index, total 8 beds are identified and classified in general as “Roof caveable with difficulty" whereas Bed No.6 is classified as” Roof caveable with considerable difficulty" and Bed No.1 is "Moderately difficult in caving".
g. Based on the above findings, it is concluded that roof conditions of Panel no-4, 5& 6 in general are moderately stable.

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