ANALYSIS OF STRENGTH PROPERTIES — AN APPROACH FOR DETERMINATION OF UNSTABLE ROOF CONDITIONS IN THE VENKATESH KHANI 7 INCLINE OF KOTHAGUDEM COAL BELT

D. N. SHARMA
Exploration Division, The Singareni Collieries Co Ltd, Godavarikhani 505 209, India.

ABSTRACT

An attempt was made to study the physico-mechanical properties of roof rocks and their significance in the determination of roof stability. Investigations were carried out to find out if there is a trend in the variation of strength properties with depth and if any correlation exist among them. It was concluded that sandstone forms a better roof than carbonaceous shale and carbonaceous clay. In the present study no definite relation was found with respect to depth and among the various strength properties.

INTRODUCTION

STRENGTH properties of rocks have a direct bearing on strata control. The physico-mechanical properties of rocks depend on mineral composition, structure, textural features, etc. Roof-falls in underground coal mines occur because of the low strength of roof strata. The strength of rock diminishes as a result of swelling and slaking of clay minerals and weathering of shale and clay bands. To avoid roof-falls it is, therefore, essential to know the physico-mechanical properties of rocks.

The strata mostly fail in compression, tension, shear and bending around excavations and in structures[1]. It is necessary to observe the type of failure in order to take precautionary measure. For example, roof fails in the middle of the gallery owing to development of tensile cracks; the precautionary measure for such a case is to have closely spaced channels supported with roof bolts and rigid props.

METHOD OF STUDY

The Queen Seam in Venkatesh Khani 7 Incline of Kothagudem coal belt has been developed with a three metre-high working section keeping sandstone as floor. In the roof, part of the seam, consisting of carbonaceous clay, carbonaceous shale and a few coal bands, was left to a thickness of 7 or 8 m and is referred to as 'immediate roof'.

In order to standardize the method of expressing the separation of bending planes, rock quality designation (RQD) was chosen as the index. Compressive strength, tensile strength, shear strength, impact strength index and protodyaknov index were determined as per the International Standards of Rock Mechanics.

RESULTS AND DISCUSSION

The samples of the immediate roof display a wide range of compressive strength (57 to 277 kg/cm^2) and density (1.30 to 2.25 g/cc). Immediate roof associated with bands of carbonaceous shale might account for the lower compressive strength (57, 63 and 88 kg/cm^2). The tensile strength varies from 17.25 to 25.83 kg/cm^2. The shear strength ranges from 25.39 to 58.77 kg/cm^2 and the impact strength index from 46.64 to 50.56 respectively. In general, the immediate roof samples have indicated unstable roof conditions. The average RQD (45%) also discloses that unstable roof conditions have developed due to low-strength rocks in the immediate roof.

The main roof consists of fine-to coarse-grained grey sandstones. Compressive strength varies from 79 to 155 kg/cm^2 and density from 1.99 to 2.18 g/cc. Tensile strength varies from 13.397 to 24.22 kg/cm^2, shear strength from 23.27 to 39.26 kg/cm^2, and impact strength index from 46.99 to 48.79. The average RQD for the main roof is 97%.

Taken together, the physico-mechanical properties indicate poor strength of the roof rocks. Figure 1 shows the percentage of core recovery and RQD curves. The two curves follow the same pattern, perhaps due to the variation in RQD values with core recovery. There is a decreasing trend in the

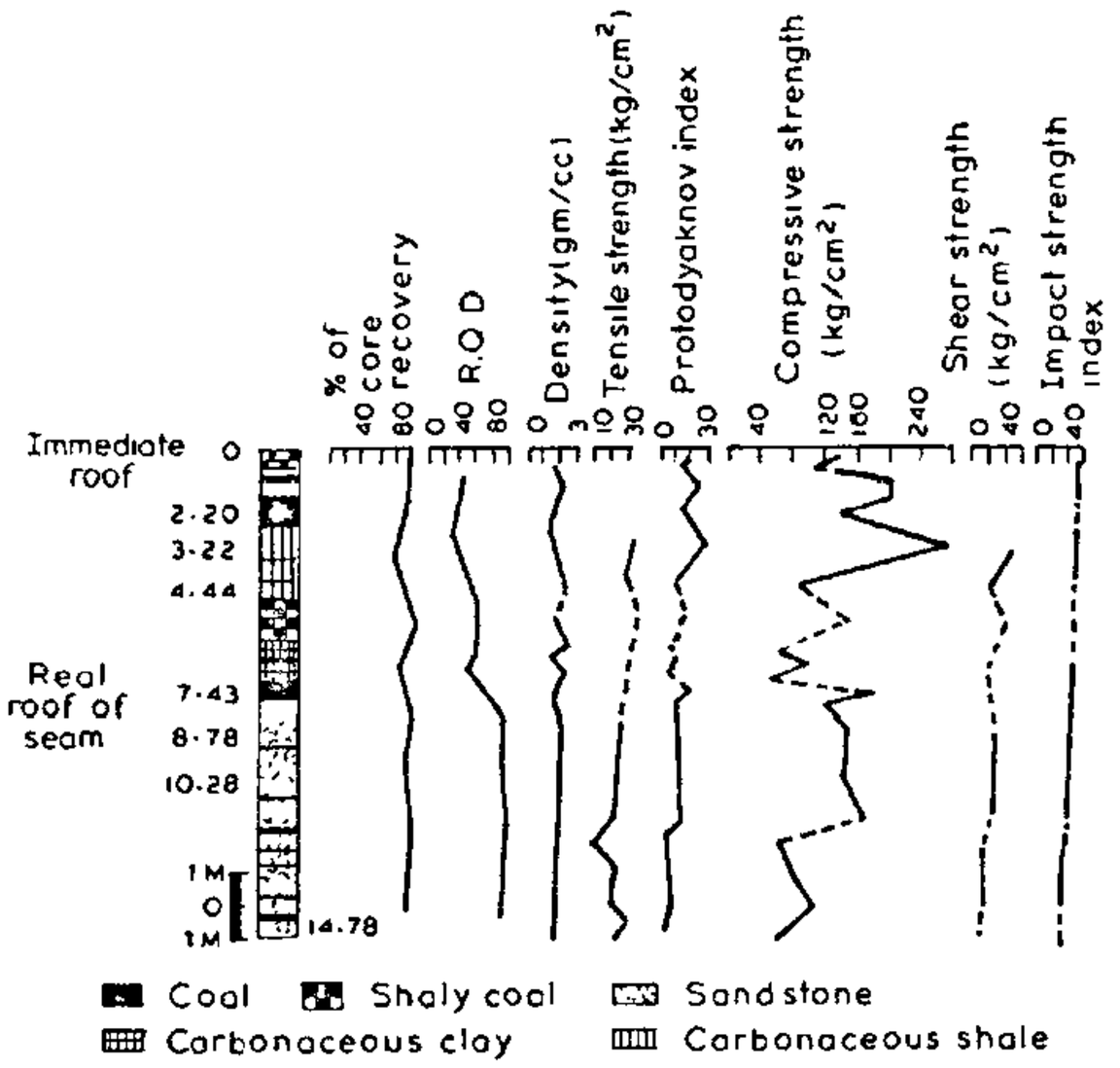

Figure 1. Trend of mechanical properties with depth.

compressive strength of sandstones with increasing depth from the seam contact.

CORRELATION BETWEEN ROCK PROPERTIES

Different physico-mechanical parameters have been correlated. Various workers[2–5] have concluded that physical properties of rocks are correlated with each other.

Compressive strength vs percentage of core recovery

The relation between compressive strength and percentage of core recovery shows no definite trend (figure 2a). Rocks with compressive strength above 57 kg/cm^2 gave good core recovery. There were no samples with compressive strength less than 57 kg/cm^2. It was found that rocks with more than a certain strength gave good core recovery. Singh and Singh[3] have stated that above compressive strength of 40 kg/cm^2 core recovery percentage varies from 70 to 100% and this is also indicated by the present findings.

Compressive strength vs RQD

Figure 2b is a plot of compressive strength vs RQD and shows that the RQD increases with compressive strength up to a value of the latter of 90 kg/cm^2. The RQD varies from 14 to 100%. These data further confirm that strength is directly proportional to core recovery and RQD. Beyond compressive strength of 90 kg/cm^2 and RQD varies from 90 to 100%.

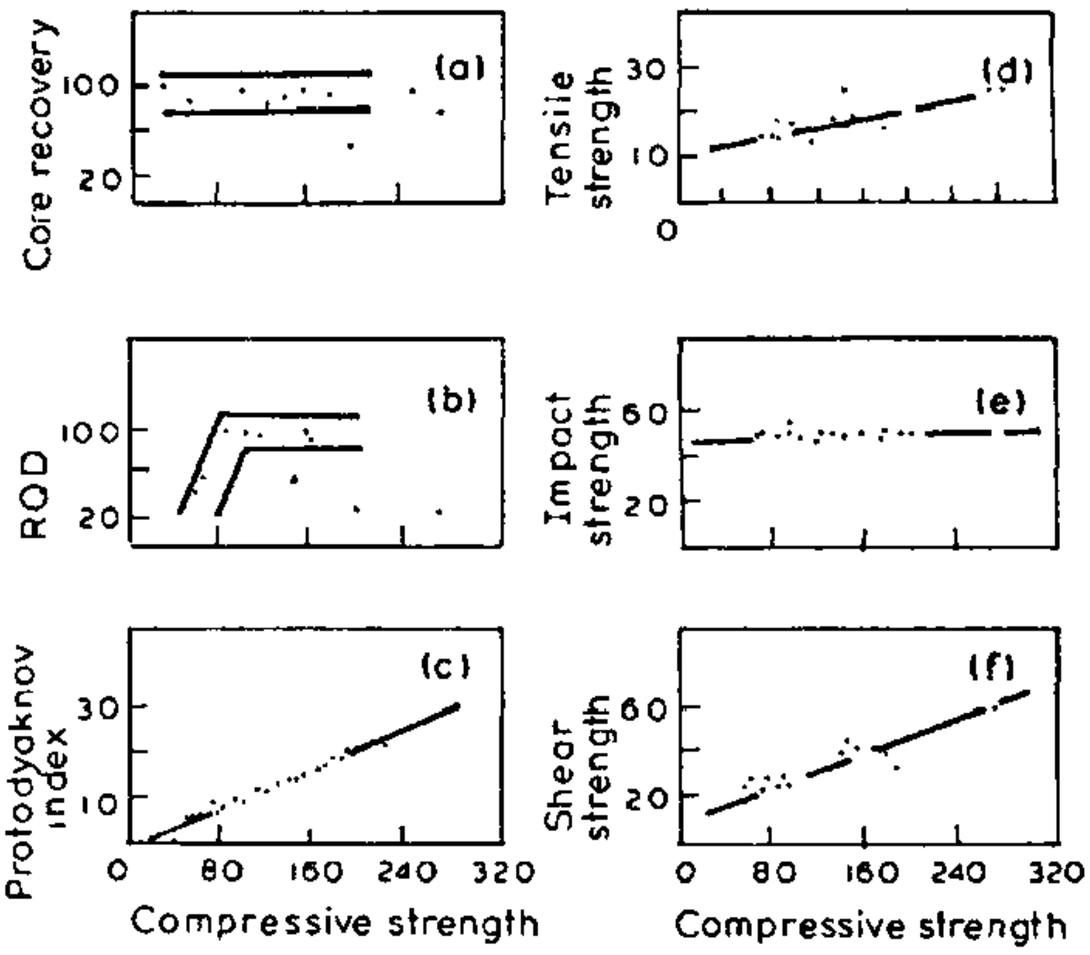

Figure 2. The relation between compressive strength and other strength parameters.

The RQD values for the test samples can be divided into three groups. Most roof problems are created by the immediate roof which consists of carbonaceous shale, carbonaceous clay, shaly coal and a few coal bands to a thickness of 7.43 m. In the immediate roof three bands are in the 'poor' class (25 to 50% RQD) and the other three bands are in the 'fair' class with an RQD range of 50 to 75%. In the main roof all the bands have RQD of 90 to 100%, which places the main roof in the 'very good' class (table 1).

Compressive strength vs other strength parameters

Figure 2(c–f) shows the relationships of compressive strength versus protodyäknov index, tensile strength, impact strength index and shear strength. Except in the case of impact strength index, a trend of increase with compressive strength was observed.

Table 1. *Classification of rock quality designation* (after Deere[6] 1968)

Description	RQD%
Very poor	< 25
Poor	25–50
Fair	50–75
Good	75–90
Very good	90–100

In the case of impact strength index only a slight increase was observed

As sandstone has low compressive strength, the protodyaknov index number, tensile strength and shear strength also were low. The immediate roof had high of protodyaknov index, tensile strength and shear strength. Impact strength index did not vary much from sandstones to other bands.

CONCLUSIONS

The results indicate that the 'immediate roof' rocks are poor in 'soundness'. The strength characteristics of 'main roof' indicate that good roof conditions can be attained by keeping sandstone as immediate roof. It is also concluded that roof-falls in the area under reference are the result of tension cracks.

ACKNOWLEDGEMENTS

The author is grateful to Prof. D. Chandra, Indian School of Mines, Dhanbad, to Dr B. V. Ramana Murty, the Singareni Collieries Co Ltd, and to Dr T. Sirish Chander, PG Centre in Geology, Kothagudem for their constant encouragement and help received in the preparation of this paper.

18 August 1987; Revised 26 July ' 88

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