Effect of Water on Coal Strength

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ABSTRACT

Water content is one of the most important factors influencing the rock strength. The present study has been conducted to see how coal strength changes under dry and water saturated conditions. The study reveals that the strength of coal decreases with increasing moisture. For rock mechanics and rock engineering projects, it is strongly recommended that the dry uniaxial compressive strength is used for the purposes of strength classification, while for the actual engineering design it is essential to establish the wet strength and ideally the water sensitivity of the rock, in order to assess their potential change in strength and deformability. It has been observed that there is a significant reduction in strength when water is absorbed by coal. It has also been observed that the strength is higher in case the loading is done perpendicular to cleats as compared to when loading is done parallel to cleats. So, the orientation of cleats also plays a major role in the strength of coal. The specimen loaded parallel to cleats has a reduction in strength by 32.48% whereas the specimens loaded perpendicular to cleat has a reduction in strength by 29.29%.

Keywords: Coal Strength, Cleats, Loading Direction, Coal Saturation, Compressive Strength.

1. INTRODUCTION

The knowledge of the mechanisms of the interaction of water with rock and its effects on rock properties is of paramount importance in geotechnical engineering. The presence of water at site of large projects such as dams, canals, caverns, highways and underground reservoirs are always a significant problem and therefore, appreciable research work has been done in this respect. The authors have emphasized that water reduces the strength and it is quite difficult to understand the effect of water on different rocks. Considering the classifications presented for intact rocks, it is observed that most of them are based on the strength parameters of rocks and not on moisture effects; however, presence of water in many rocks may change their behavior from strong to weak.

An attempt has been made to investigate the strength of coal under both dry and water saturated conditions. It is one of the most important factors to understand the strength reduction in water saturated condition to design engineers for rock mechanics and rock engineering projects. It is very important for underground mine planning and design purposes. The dry uni-axial

compressive strength is used for the purpose of strength classification and rock mass classification system while for the actual engineering design it is essential to study the wet strength and ideally the water sensitivity of the rock, in order to assess their potential change in strength and deformability.

The structural discontinuities like joints are very common in sedimentary rocks. Joints present in coal are known as cleats which strongly affects its strength. The loading direction too plays an important role in determination of strength. A study has also been made to know the percent reduction in strength with respect to loading direction.

2. METHODOLOGY

The aim of this study is to analyze the effect of water on the strength of coal. Dry and wet coal specimens have been tested under Servo Controlled Stiff Testing Machine (MTS) to observe the effect of water on the Uniaxial Compressive Strength and to deduce a relation between dry and wet compressive strengths.

2.1. Experimental Work

The investigation undertaken in the laboratory includes experiments to find out the strength of dry and wet coal specimen and to plot a graph between axial force and axial displacement for them. Out of ninety specimens, test on a few specimens are presented here. All the specimens are prepared from lump using rock cutters. At the time of measuring uniaxial compressive strength under MTS, care has been taken that the face of the specimen is uniform throughout its area so that while applying the load it is equally distributed. The specimen size is measured by using Vernier Caliper to get exact length and width. It is important to measure these as both the stress and coefficients of strain curve are dependent on them. The average length and width is calculated taking four readings for each specimen, and the actual area of the face on which loading is done is calculated.

After measuring the dimensions of specimens, few specimens are immersed in water for 1, 2 or 3 days although few have been kept dry. Dry and wet weights for specimens have been recorded to estimate the percent increase in weight of specimens.

For the determination of uniaxial compressive strength of coal specimens, the MPT software is used for loading of the specimen using MTS in Rock Mechanics Laboratory of Indian Institute of Technology (Banaras Hindu University), India. The loading of specimen is done in such a way

that there is no gap between the surface of the specimen and the loading plates. The specimen is sandwiched between the two platens and MTS starts loading gradually. The instrument is simple to operate and the compressive strength is computed. The uniaxial compressive strength is determined as per the norms of International Society for Rock Mechanics (I.S.R.M.).

3. RESULTS AND DISCUSSION

The size of some of the coal specimens and increase in weight percent after saturation is presented in table 1. Loading direction with respect to cleats has also been indicated in table 1.

Table 1. Size of coal specimens and increase in weight percent.

Specimen No	***Av. Length (cm)***	***Av. Width (cm)***	***Area (cm^2)***	***Testing Direction parallel / perpendicular to cleats***	***Dry Wt. (gm)***	***Wet Wt. gm)***	***Increase in weight (%)***
1	5.6	5.314	29.758	Parallel	191.2	---	---
2	5.32	5.45	28.994	Perpendicular (2 days in water)	190.5	216	13.38
3	5.412	5.214	28.218	Parallel	193.5	---	---
4	5.5	5.608	33.538	Perpendicular (3 days in water)	193.0	218.5	13.21
5	5.6	5.1	28.56	Perpendicular	198.9	---	---
6	5.74	5.41	31.05	Parallel (3 days in water)	184	206.5	12.23
7	5.8	4.80	27.851	Perpendicular (3 days in water)	240.5	266	10.60
8	6.3	5.4	34.02	Parallel (3 days in water)	269.5	298	10.57

Specimen 1: This specimen is loaded in dry condition and parallel to cleats.

The relationship of axial force versus axial displacement is shown in Figure 1. This dry coal specimen loaded parallel to cleats. Load bearing capacity of coal specimen is 22 kN. It has been observed that initially it did not take much load as the micro granules got crushed and then gradually started taking load before reaching the peak value and then failed. Finally, the maximum load at failure is divided by the load bearing area of the specimen to determine the uniaxial compressive strength of the specimen.

Uniaxial compressive Strength of specimen 1 is 7.392 MPa.

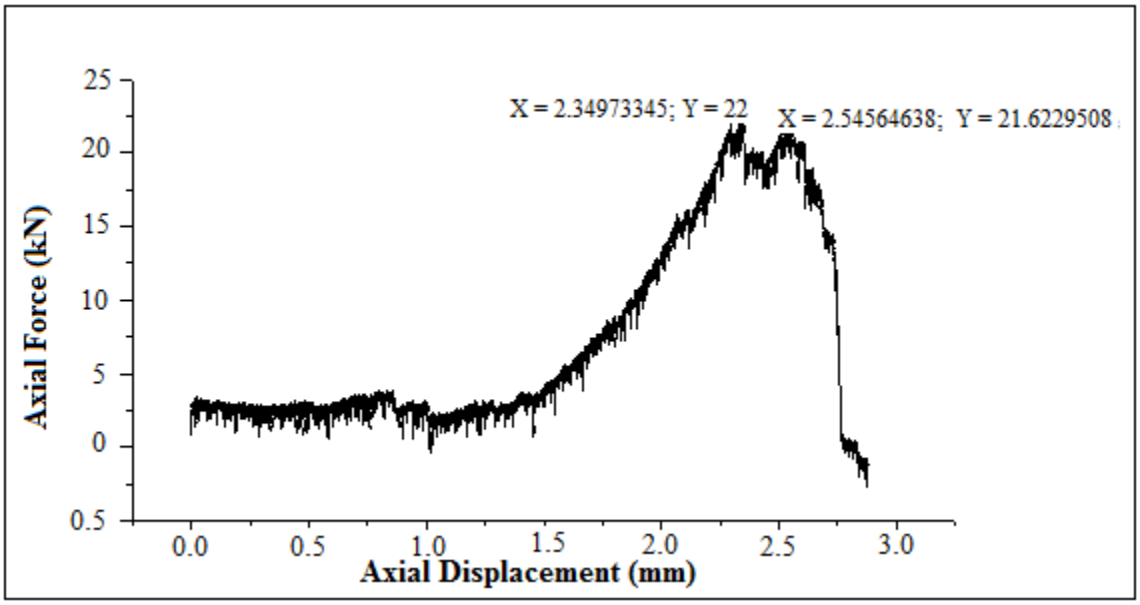

Figure 1. Plot of Axial Force vs Axial Displacement for specimen 1.

Specimen 3: This is loaded in dry condition and parallel to cleats.

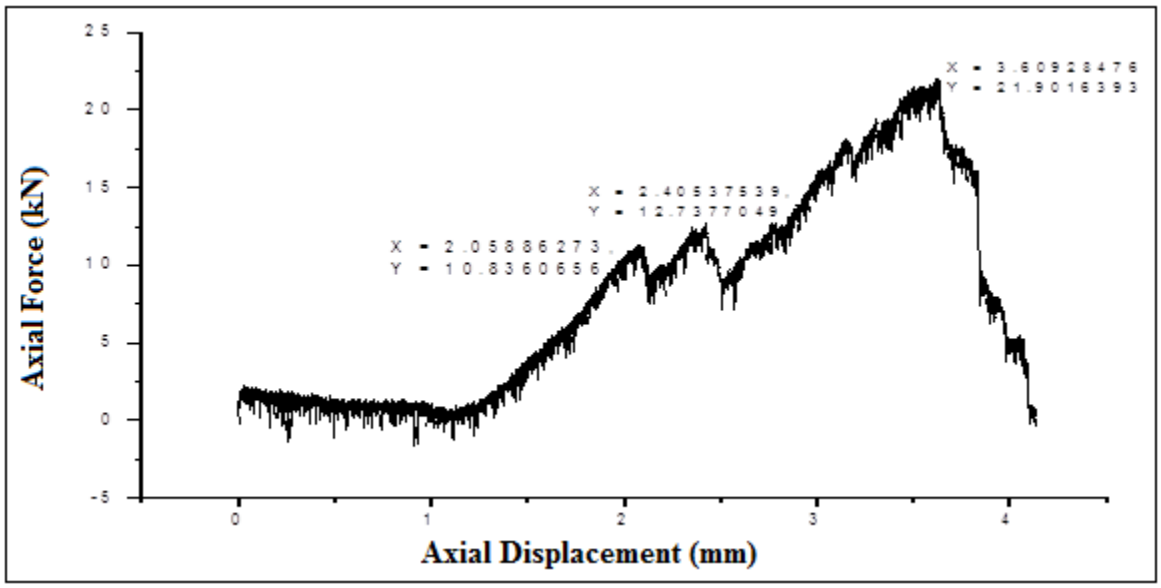

Figure 2. Plot of Axial Force vs Axial Displacement for specimen 3.

Similarly, the relationship of the axial force versus axial displacement for specimen no. 3 is depicted in Figure 2. The dry coal specimen was loaded parallel to cleats and observed that initially it did not take much load as the micro granules got crushed and then gradually started

taking load before reaching the peak value and then failed. The maximum load at failure has been recorded as 21.9 kN.

Uniaxial Compressive Strength of Specimen no. 3 is 7.76 MPa.

Specimen 5: The sample has been loaded in dry condition and perpendicular to cleats.

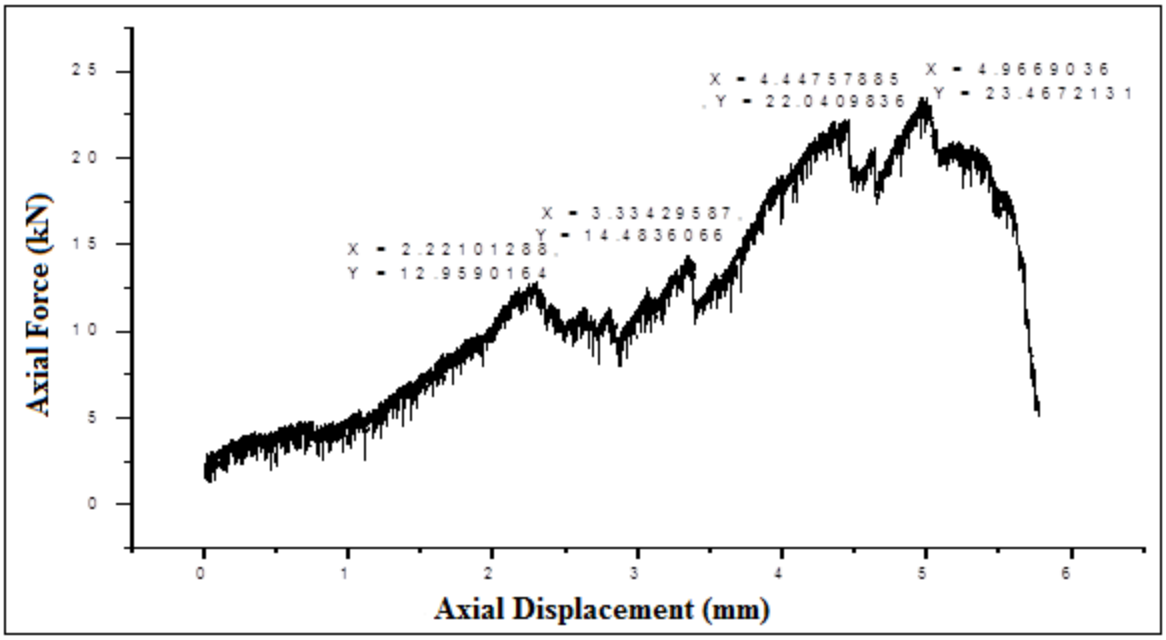

Figure 3. Plot of Axial Force vs Axial Displacement for specimen 5.

The relationship of axial force versus axial displacement of specimen no. 5 has been shown in Figure 3. The coal specimen has been loaded perpendicular to cleats in dry condition. The specimen initially started taking load due to the orientation of cleats and then reached the peak load before failure. The maximum load at failure of the specimen is 23.46 kN.

Uniaxial compressive strength of Specimen no. 5 is 8.214 MPa.

Following tests were done on specimens that were kept in water from 1 to 3 days.

Specimen 6: This specimen has been immersed in water for 3 days and loaded parallel to cleats. This wet coal has been loaded parallel to cleats. Initially it did not take much load as the micro-granules got crushed and then gradually started taking load upto 17.82 kN and then failed.

Uniaxial compressive strength of specimen no. 6 is 5.73 MPa.

Specimen 7: The specimen has been immersed in water for 3 days and loaded perpendicular to cleats.

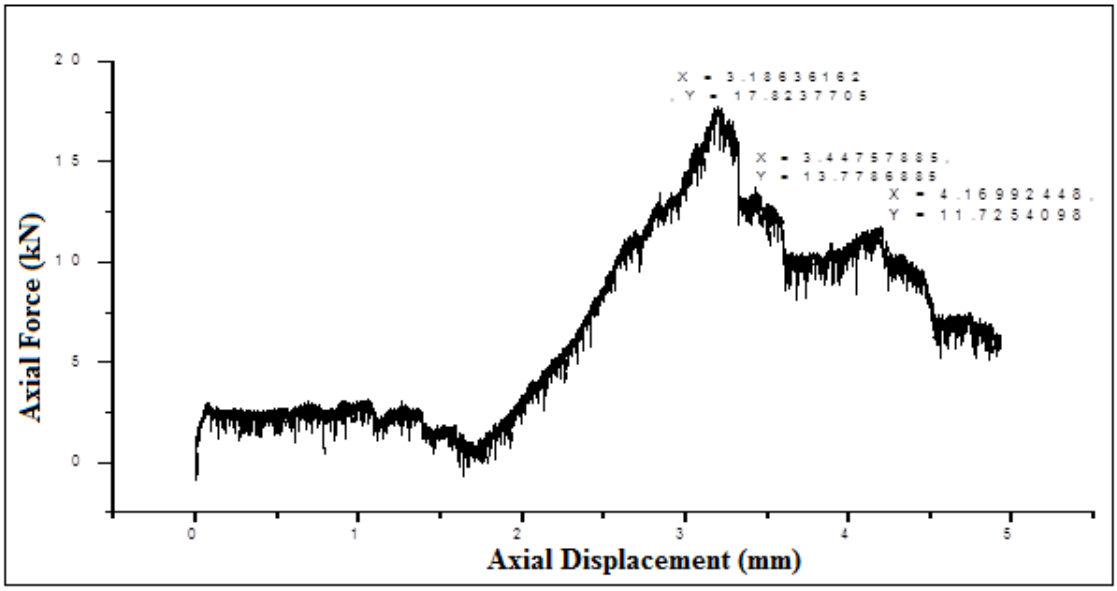

Figure 4. Plot of Axial Force vs Axial Displacement for specimen 6.

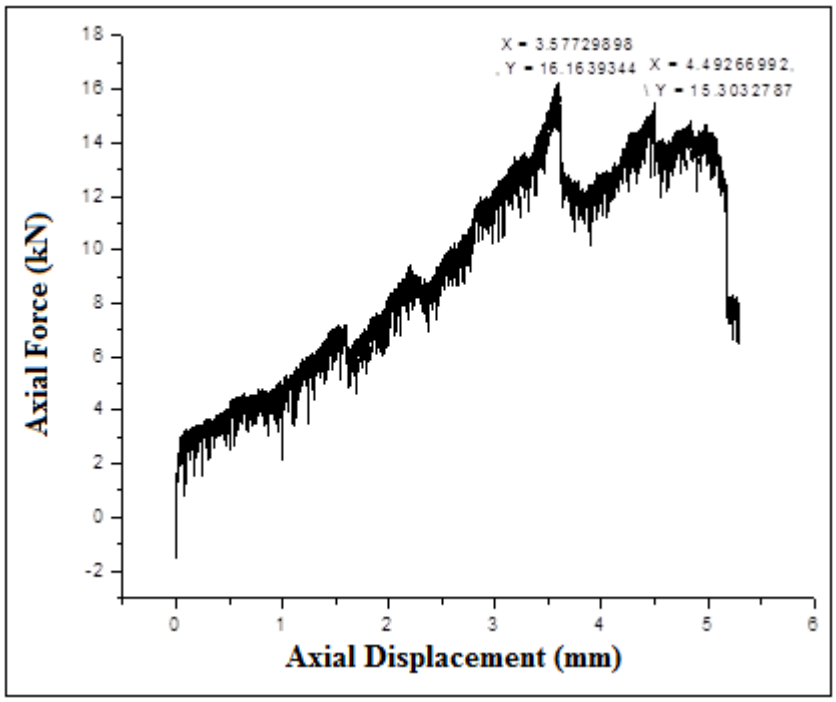

Figure 5. Plot of Axial Force vs Axial Displacement for specimen 7.

The coal specimen has been loaded perpendicular to cleats so the sample initially started taking load due to the orientation of cleats and then reached the peak load before failing. The maximum load at failure of the specimen is 16.16 kN.

Uniaxial compressive strength of the specimen is 5.8 MPa.

Specimen 8: The coal specimen has been immersed in water for 3 days and loaded parallel to cleats.

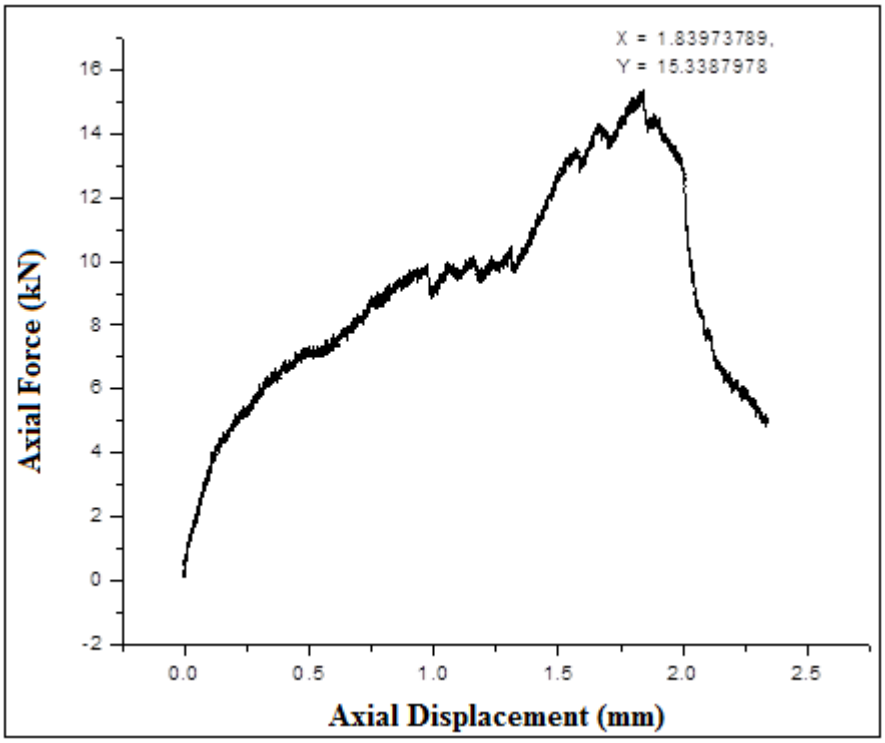

Figure 6. Plot of Axial Force vs Axial Displacement for specimen 8.

This coal specimen has been immersed in water for 3 days. This wet coal specimen was loaded parallel to cleats. The specimen started taking load from the start and then gradually reached the peak value before failure. The maximum load at failure of the specimen is 15.33 kN.

Uniaxial compressive strength of the specimen no. 8 is 4.5 MPa.

4. CONCLUSION

From the above tests it has been observed that the average strength of wet coal, when loaded parallel to cleats is found to be 5.115 MPa and when performed perpendicular to cleats it is 5.8MPa. Similarly for dry coal when loaded parallel to cleats, the average strength was found to be 7.576 MPa whereas the average strength of specimen when loaded perpendicular to cleats was 8.214 MPa. Therefore, it can be concluded that there is a significant reduction in strength when water is absorbed by coal.

It has also been observed that the strength of specimen is less when loaded parallel to cleats as compared with the strength of specimen loaded perpendicular to cleats. So, the orientation of cleats also plays a major role in the strength of coal. For parallel orientation, percentage reduction in strength is 32.48 and for perpendicular orientation, the percentage reduction in strength is 29.29.

5. REFERENCE

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