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LOADS ON FRICTION PROPS ON A LONGWALL FACE

H. ZORYCHTA
FUELS AND MINING PRACTICE DIVISION

G. S. MERRILL
DOMINION COAL COMPANY LIMITED

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H. A. MARSHALL, *President* R. F. MACKINNON, *Secretary*

H. Zorychta

Mining Engineer, Fuels and Mining Practice Division, Mines Branch, Department of Mines and Technical Surveys, Glace Bay, Nova Scotia.

G. S. Merrill

Field Engineer, Mining Engineering Department, Dominion Coal Company Limited, Sydney, Nova Scotia.

Loads on Friction Props on a Longwall Face

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ABSTRACT

Based on underground measurements made at the Nova Scotia coal mines of the Dominion Coal Company, Limited, this paper presents a comparison between the physical properties of hardwood packs and steel friction props when used for longwall support. The probable loads supported by steel friction props on a longwall face at both the Dominion No. 20 Colliery and the Princess Colliery are delineated, and the results of the tests are presented in graphical form. It is concluded that the steel friction props are more efficient than the hardwood packs that they replaced as roof supports.

Introduction

AN evolution in the methods of longwall face support is taking place in the Sydney coalfield. Longwall face support had consisted primarily of timber props and hardwood packs. In 1957, however, at the Princess Colliery, Sydney Mines, Nova Scotia, the first longwall was equipped with steel friction props. At the present time, eleven longwall faces are supported on wood and sixteen faces are carried on steel friction props.

The loading characteristics observed on the artificial supports erected underground will vary from those obtained by standard test procedures in a laboratory. This is understandable — the procedures in the laboratory for erection, rate of loading, etc., will conform to a standard; loading patterns observed underground, on the other hand, vary with the physical conditions encountered, the method and rate of mining, and the efficiency of the workmen erecting the supports.

As part of the rock pressure investigations carried out by the Mines Branch, Department of Mines and Technical Surveys, in co-operation with the Nova Scotia Research Foundation, the Department of Mines, Province of Nova Scotia, and the Dominion Coal Company, Limited, many measurements of yield and the loads imposed on the artificial supports on longwall faces have been obtained.

This paper will present a comparison between the physical properties, as measured underground, of hardwood packs and steel friction props, and the probable loads supported by steel friction props over sections observed on two longwall faces.

Observations on Face Supports

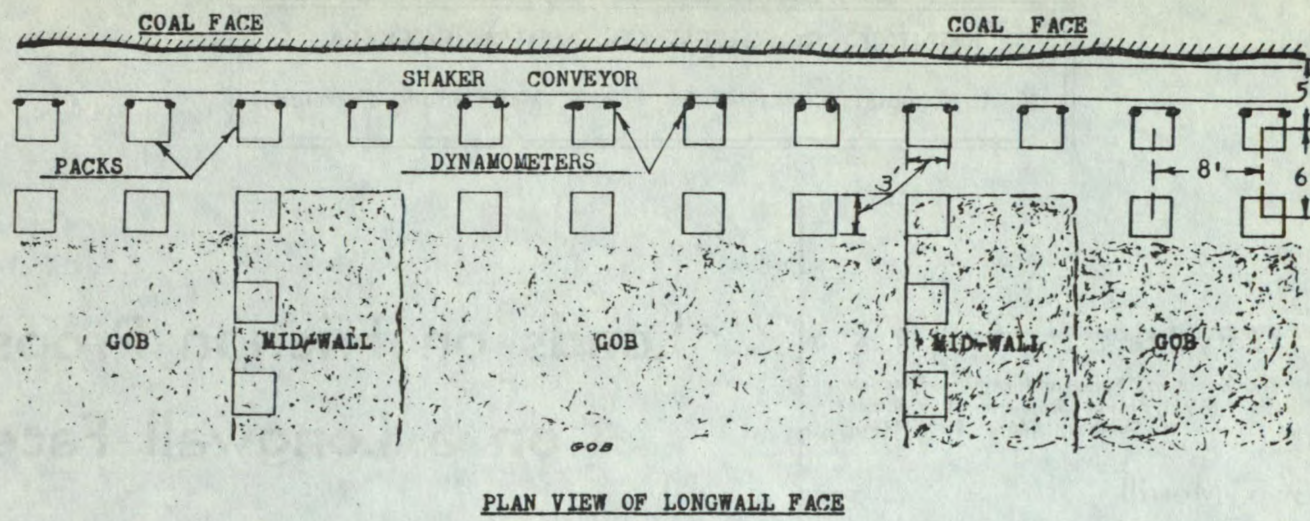
Hardwood Packs

The steel friction props usually replaced packs made from hardwood blocks 6 inches square and 2½ to 3 feet long.

As part of regular studies, observations on packs of this size were made on an advancing machine-cut, hand-loaded face, at a depth of cover of approximately 2,500 feet on the 5700 East wall, No. 4 mine, Springhill, Nova Scotia. This seam was 5 feet in height and dipped about 12 degrees. Mining operations were conducted on a three-shift-daily cycle of cutting, loading and caving. The coal was undercut to a depth of 6 feet, shot down by explosives, and hand loaded onto a shaker conveyor. The usual practice was to carry three lines of packs, with the rear line being drawn off daily during the caving shift and re-built at the face during the loading shift.

Hydraulic dynamometers were used to measure the loads imposed on the corners of the packs. Davis convergence recorders and simple telescopic rods were installed adjacent to the instrumented corners to measure the yields of the packs.

Figure 1 illustrates the construction and spacing of such face supports, the positioning of the hydraulic dynamometers in the packs and the location of the convergence measuring units. Measurements of load and yield were conducted continuously, on a



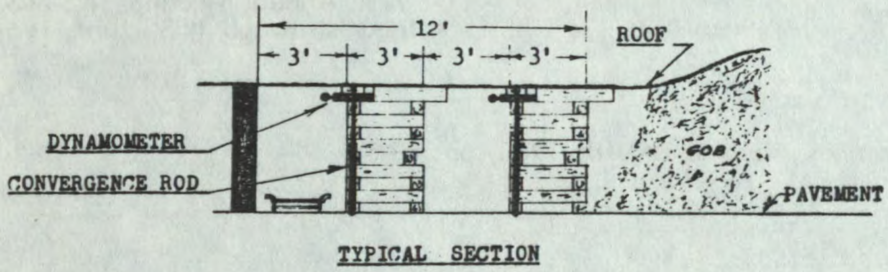


Figure 1.—No. 4 Mine, Springhill. Hardwood Pack Supports on 5700 East Longwall.

three-shift basis, from the time the dynamometers were built into the packs at the face until the packs were drawn in the gob line. Load and yield data were obtained on approximately 150 pack corners.

Steel Friction Props

Observations on four surface-type steel friction props were carried out on a longwall face in Dominion No. 20 Colliery, Glace Bay, Nova Scotia, and in Princess Colliery, Sydney Mines, Nova Scotia.

To observe the loads on the steel props, a load cell was designed to fit securely on top of the friction props. The load cell is illustrated in Figure 2. The load-bearing component is a thin-walled cylinder of high-tensile steel, and the deformations occurring in the cylinder, when loaded, are observed by means of electrical-resistance strain gauges which are bonded to the inside wall of the cylinder. The strain gauges are connected so as to minimize the errors caused by eccentric loading. The cell has a loading capacity of 40 tons. The Baldwin strain indicator used to measure the deformations of the load cell was modified and certified as safe for use in a coal mine. The load cells were calibrated in the laboratories of the Fuels and Mining Practice Division, Ottawa, and calibration curves were obtained for each load cell.

Prop yields were measured, with a steel tape, from the top of the inner sliding member to the top of the outer member of the prop. Prop yields were noted as zero when the props had been erected and pre-loaded. The friction props were fitted with floor plates with an area of 140 square inches to prevent pavement penetration.

During the observation periods, records were kept of working operations, wall face and gob conditions, and the position of the coal face relative to the steel friction pumps.

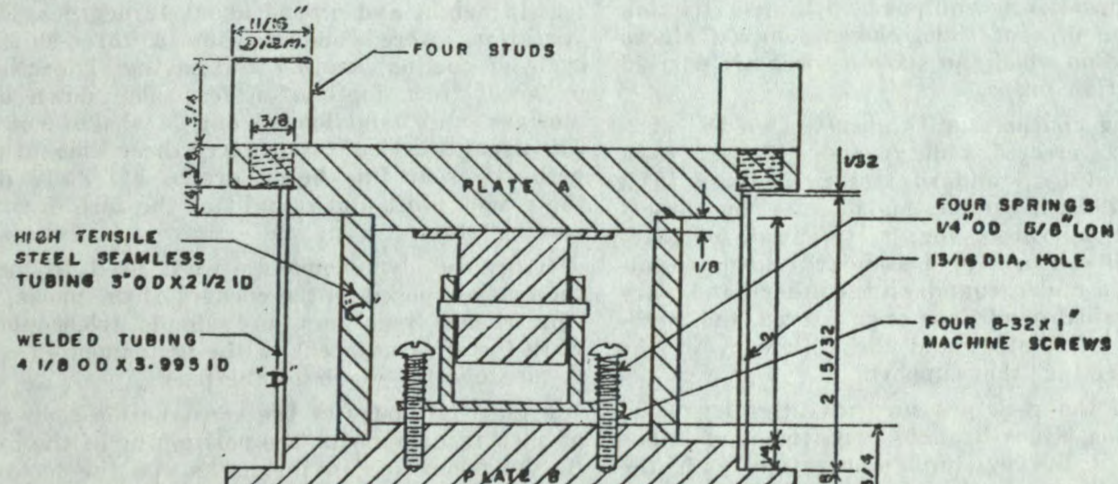


Figure 2.—The Load Cell.

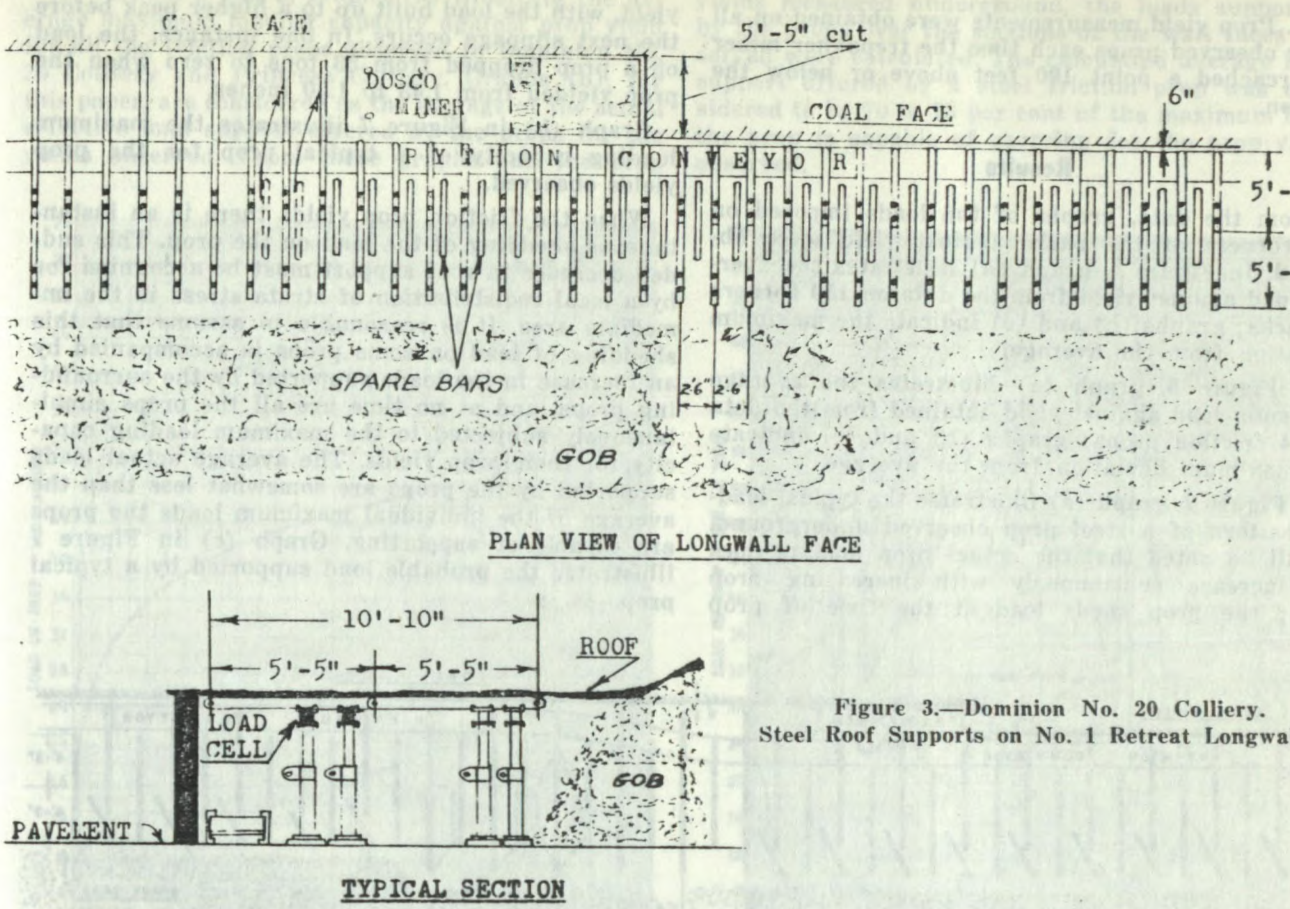


Figure 3.—Dominion No. 20 Colliery. Steel Roof Supports on No. 1 Retreat Longwall.

Dominion No. 20 Colliery, Glace Bay, Nova Scotia

Observations were made on the steel friction props on the No. 1 retreat longwall, No. 2 North Deeps, Dominion No. 20 Colliery. This Dosco-Miner longwall face was 400 feet long at a depth of cover of approximately 1,050 feet. The section observed extended from 150 to 250 feet above the bottom of the wall. The coal seam was 5 to 5½ feet high and dipped about 6 degrees. The immediate roof was comprised of shale and sandy shales. The coal was underlain by a 6-in. band of clay, 6 inches of coal, sandy shale and shales.

Mining operations were conducted on a three-shift-daily cycle of cutting, flitting and caving. The usual practice was to carry three lines of roof bars: the prop-free bar installed at the face during the cutting shift and the two props under the rear line drawn off and re-built under the face bars during the caving shift. One 12-foot stone mid-wall, located at the center of the longwall, was maintained as the longwall face retreated.

Programs of measurements were conducted with the prop load cells to determine the loads borne by the props during a complete operational cycle. The load cells were fitted on the front two rows of props under three consecutive roof bars. These cells were then observed until the props were withdrawn at the caving line. Prop yield measurements were obtained on the props under every third row of roof bars during two of the programs.

Figure 3 illustrates the construction and spacing of the face supports, and the positioning of the load cells on top of the props.

Princess Colliery, Sydney Mines, Nova Scotia

The location observed was on the No. 16 North trepanner longwall, Princess Colliery, Sydney Mines, Nova Scotia. This longwall is approximately 900 feet long; the section observed extends from 300 to 500 feet above the bottom level. In this location, the seam averages 57 inches in thickness at a depth of cover of approximately 1,700 feet. The dip is 10 per cent. The immediate roof is comprised of sandstone, but a band of shale caprock underlies the sandstone on some sections of the wall. The pavement strata are shales. Mid-walls, 10 to 12 feet wide, located at approximately 100-foot intervals, are maintained as the face advances.

The system of roof support is illustrated in Figure 4. This staggered system requires the installation of every second roof bar under the newly exposed roof. The daily work cycle consisted of two successive coal-loading shifts followed by a maintenance shift. Gob caving was carried out behind the miner on the loading shifts; the third bar was drawn and the two props re-installed under the face bar after the conveyor had been advanced to the coal face.

Load cells were installed in the center of the observed area on top of the props erected under the roof bars, which were linked in a line as the face advanced. The loads and yields were measured on the props under four consecutive interlocking roof bars. Prop yield measurements were made on the props, in every second row, in line with the first and third interlocking roof bars that were supported by the props fitted with cells.

Load cell readings and prop yield measurements were taken ten to twelve times per coal-cutting shift. Prop yield measurements were obtained on all other observed props each time the trepanner miner had reached a point 100 feet above or below the section.

Results

From the data, graphs of the loads imposed on the corners of the packs against yield were obtained. In Figure 5, graph (a) illustrates the average load against yield from the data on 150 corners of packs; graphs (b) and (c) indicate the maximum deviation from the average.

In Figure 6, graph (a) illustrates the average maximum load against yield obtained from the data on 34 friction props; graphs (b) and (c) indicate the maximum deviation from the average.

In Figure 7, graph (a) illustrates the typical loading pattern of a steel prop observed underground. It will be noted that the actual prop loading does not increase continuously with increasing prop yield; the prop sheds load at the time of prop yield, with the load built up to a higher peak before the next slippage occurs. In one instance, the load on a prop dropped from 33 tons to zero when the prop yielded from 1.43 to 1.50 inches.

Graph (b) in Figure 7 illustrates the maximum loading capacity of a typical prop for the prop yields observed.

When the friction prop yields there is an instantaneous shedding of the load on the prop. This sudden decrease in roof support must be accounted for by a local redistribution of strata stress in the immediate area. It is reasonable to assume that this shedding of load on some props is accompanied by an increase in the loads supported by the surrounding props, and at no time are all the props simultaneously subjected to the maximum loading capacity for their prop yields. The average actual loads supported by the props are somewhat less than the average of the individual maximum loads the props are capable of supporting. Graph (c) in Figure 7 illustrates the probable load supported by a typical prop.

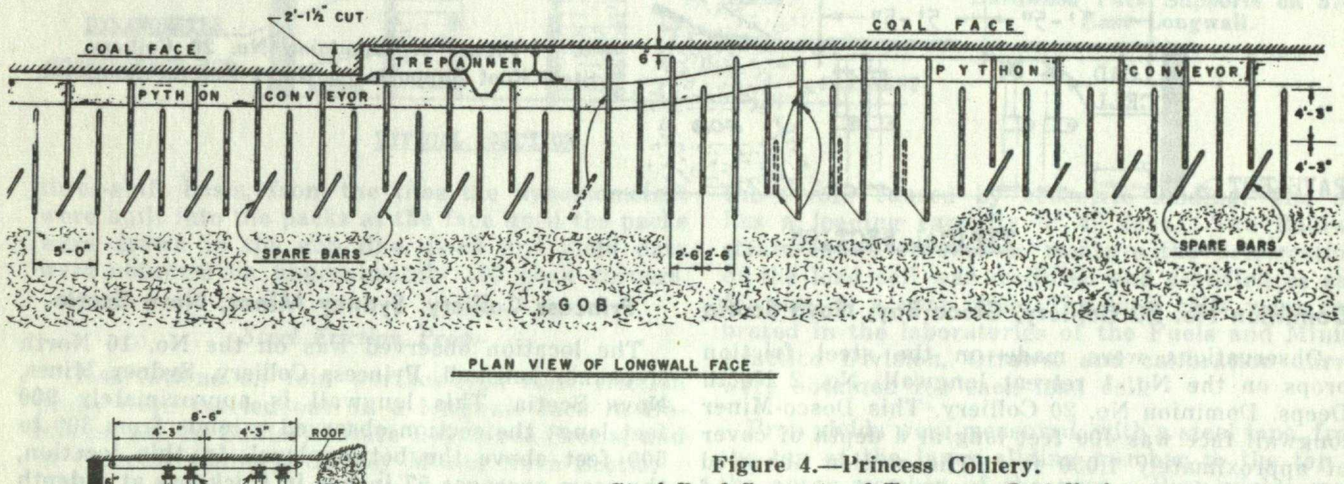


Figure 4.—Princess Colliery.
Steel Roof Supports of Trepanner Installation.

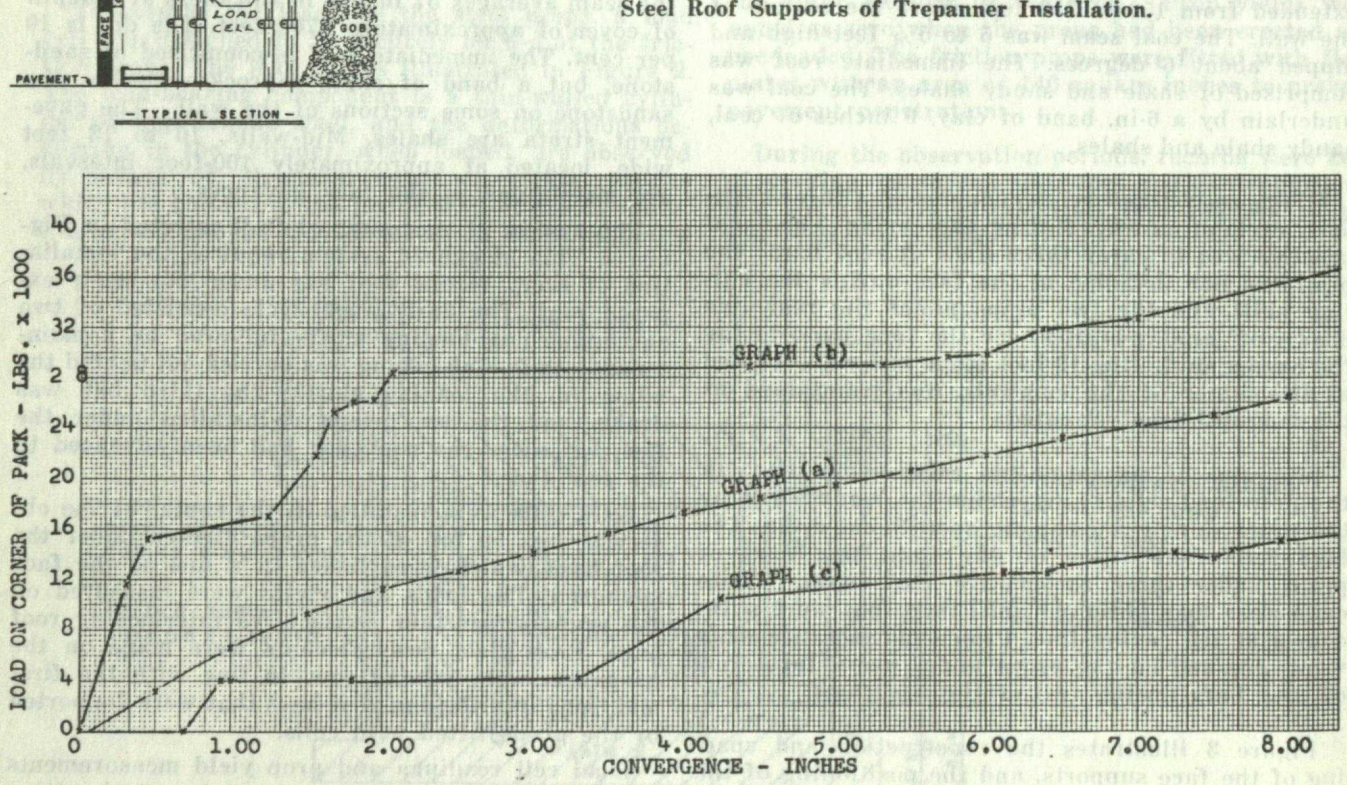


Figure 5.—Loads on Corner of Hardwood Pack — 5700 East Longwall, No. 4 Mine, Springhill, N.S.

In Figures 8 and 9, graphs (a) illustrate the average maximum loading capacity against prop yield for all the friction props observed in Dominion No. 20 Colliery and Princess Colliery. Graphs (b), for this paper, are considered as the average of the actual effective load support offered by the props for the yields observed. From these graphs and the prop yields measured underground, the loads supported by the props over the sections of the wall faces observed were calculated. The calculated average load support offered by a steel friction prop was considered to be 70 to 75 per cent of the maximum load the prop is capable of carrying for the prop yield observed.

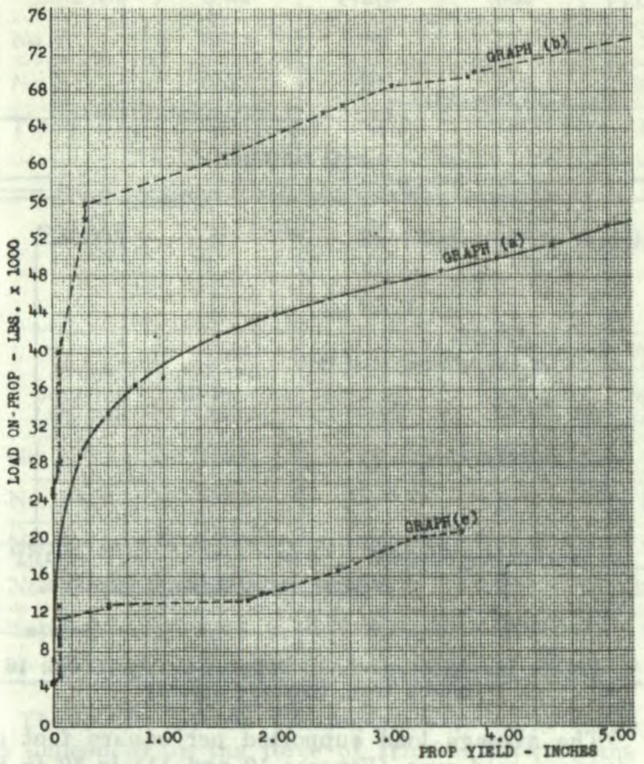


Figure 6.—Loads on Steel Friction Prop. No. 1 Retreat Wall, Dominion No. 20 Colliery.

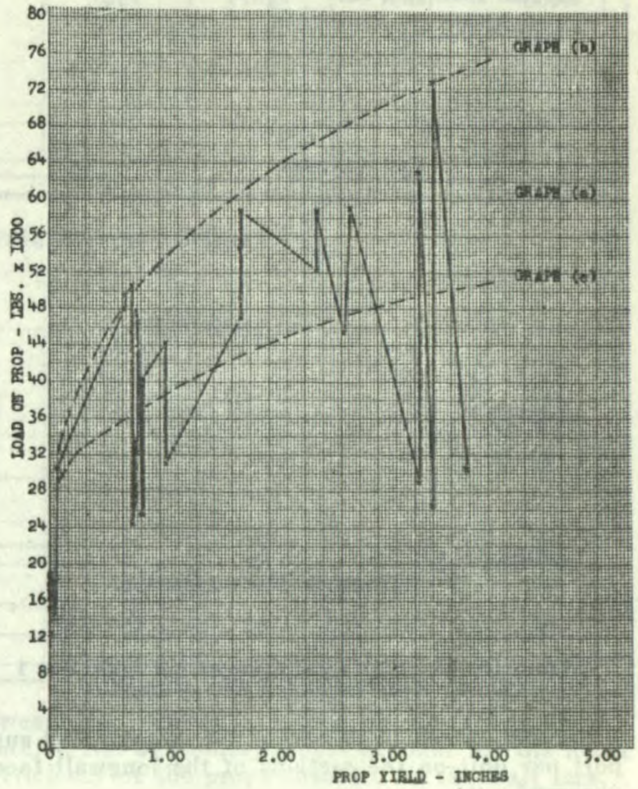


Figure 7.—Loads Observed on a Typical Prop. No. 16 North Wall, Princess Colliery.

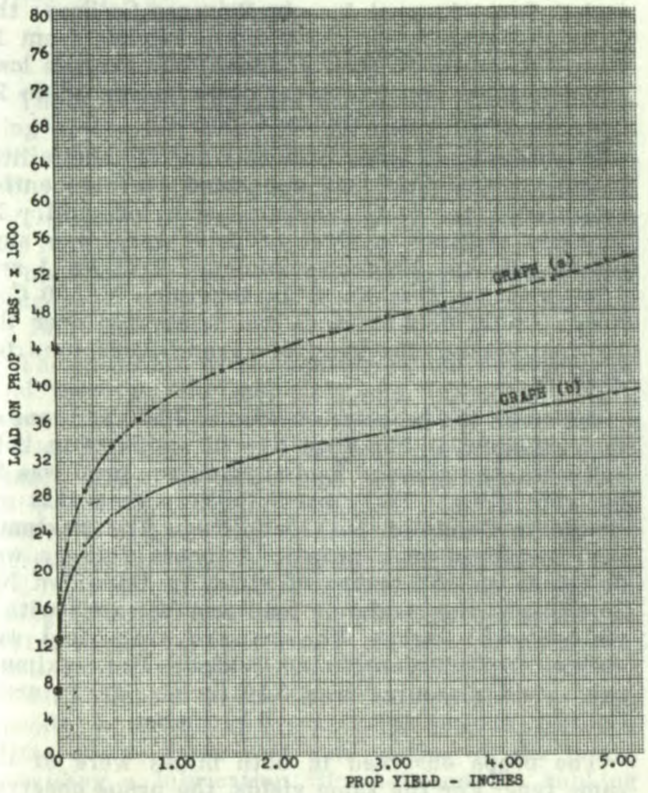


Figure 8.—Average Loads on Prop. No. 1 Retreat Wall, Dominion No. 20 Colliery.

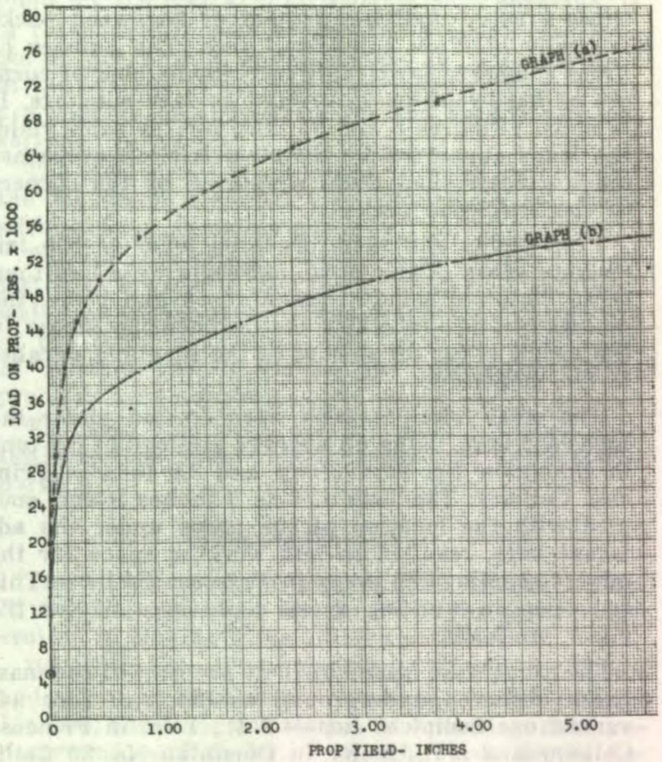


Figure 9.—Average Loads on Prop. No. 16 North Wall, Princess Colliery.

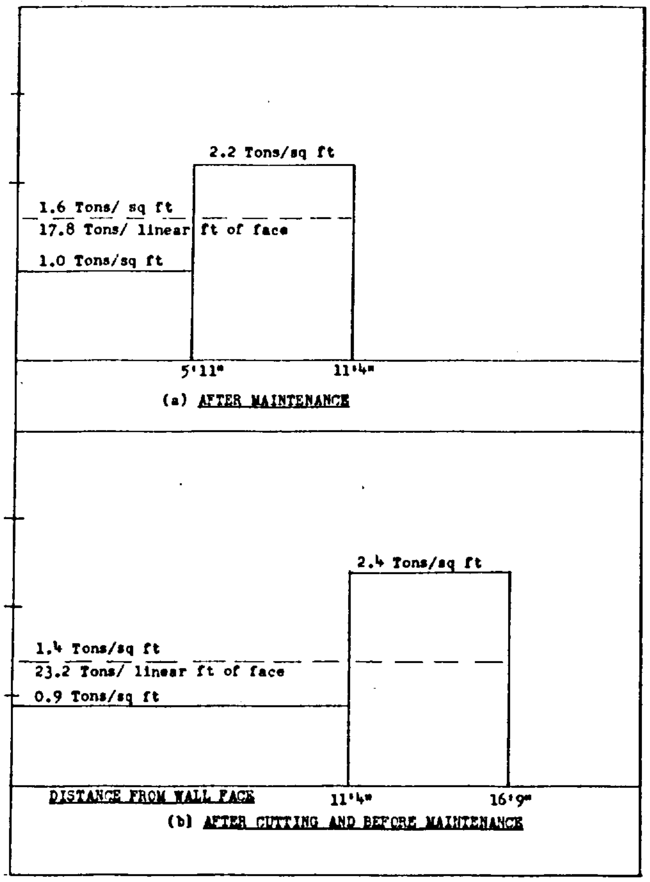


Figure 10.—Average Load Support per Unit. No. 1 Retreat Wall, Dominion No. 20 Colliery.

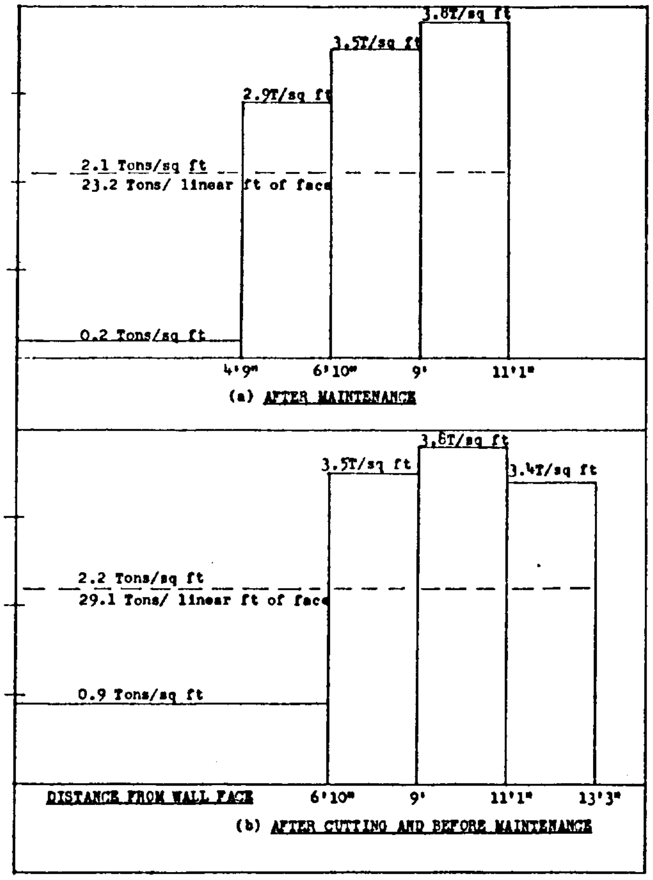


Figure 11.—Average Load Support per Unit. No. 16 North Wall, Princess Colliery.

Figures 10 and 11 illustrate the average load support per unit on the sections of the longwall faces observed.

Discussion of Results

The number of steel friction props is four to six times greater than the number of hardwood packs normally built on a longwall face. The number of props compares favourably with the number of corners of hardwood packs erected as face supports. It is noted (Figures 5 and 6) that, for the same yield, the loads supported by the steel friction props are much greater than those supported by the corners of the hardwood packs.

Prop yields and therefore prop loads in the immediate areas of the stone mid-walls were less than those observed some distance above and below the mid-walls; this indicates that a shearing stress in the strata is set up normal to the face and parallel to the mid-walls.

The steel friction props were erected under the face roof bars, using an average pre-load of 3.6 tons in Dominion No. 20 Colliery and 2.6 tons in Princess Colliery. The height, 6 to 9 inches lower, coupled with the location of the props under the adjacent bars, resulted in less working space for the miners erecting the props in Princess Colliery. This reduction in working space could account for the lower pre-loads.

The props were loaded to 70-80 per cent of the maximum observed underground as the wall face advanced one complete cut — 2 ft., 1 in. in Princess Colliery and 5 ft., 5 ins. in Dominion No. 20 Colliery. The average maximum load supported per prop was attained when the prop was in the gob line.

The average load supported per square foot of exposed roof area (Figures 10 and 11) is 30 to 55 per cent greater on the section of the longwall face observed in Princess Colliery. The span of the supported area ranges from 11 feet, 1 inch to 13 feet, 3 inches from the coal face in Princess Colliery; the span in Dominion No. 20 Colliery extends from 11 feet, 4 inches to 16 feet, 9 inches. The average load supported per linear foot of wall face is 25 to 20 per cent greater in Princess Colliery.

The calculated loads (Tables I and II) show little change in the total load supported over the entire section for the tests made on each longwall. In Princess Colliery, a total of 5,961 tons was supported over the 200-foot section for Test No. 1 and 5,708 tons for Test No. 2. In Dominion No. 20 Colliery, a total of 2,311 tons was supported over the 100-foot section for Test No. 1 and 2,327 tons for Test No. 2.

Although the props are loaded to 70-80 per cent of the maximum in the first line of supports in both collieries, the average load support per prop was 30 per cent greater in Princess Colliery than that observed in Dominion No. 20 Colliery. The maximum load measured on a prop in Princess Colliery was 39.3 tons at 2.83 inches of yield. In Dominion No. 20 Colliery, the maximum load was 36.9 tons with a yield of 5.31 inches. The average prop yield was greater in Dominion No. 20 Colliery. The maximum prop yield measured was 6.10 inches; in Princess Colliery, the maximum was 5.10 inches.

The props observed in both mines were of the same type. For the same yields, the props observed in Princess Colliery were capable of supporting approximately 40 per cent more load.

Table I—No. 1 Retreat Wall, Dominion No. 20 Colliery

	Test No. 1				Test No. 2			
Props Location Line No.	Total Load All Props, tons	No. of Props	Avg. Load/ Prop, tons	Per Cent Max. Load	Total Load All Props, tons	No. of Props	Avg. Load/ Prop, tons	Per Cent Max. Load
No. 1........	1,074	86	12.5	77	1,104	85	13.0	80
No. 2........	1,237	76	16.3	100	1,223	76	16.3	100
Totals.......	2,311	162	14.3	88	2,327	161	14.4	88

Table II—No. 16 North Wall, Princess Colliery

	Test No. 1				Test No. 2			
Props Location Line No.	Total Load All Props, tons	No. of Props	Avg. Load/ Prop, tons	Per Cent Max. Load	Total Load All Props, tons	No. of Props	Avg. Load/ Prop, tons	Per Cent Max. Load
No. 1........	1,329	78	17.0	77	1,159	80	14.5	72
No. 2........	1,505	80	18.8	85	1,510	80	18.9	93
No. 3........	1,644	76	21.6	98	1,615	80	20.2	99
No. 4........	1,482	67	22.1	100	1,423	70	20.3	100
Totals......	5,961	301	19.8	88	5,708	310	18.4	90

The ability of the friction prop to carry loads is dependent on the force of friction between the contact surfaces of the sliding member and the friction plates.

Where $L = fF$
L = load of the prop
f = coefficient of friction between the rubbing surfaces
F = the normal pressure between the contact surfaces

There will be some differences in the initial setting of the friction lock and therefore some small variations in the initial normal pressure between the contact surfaces.

The value of the coefficient of friction between the rubbing surfaces depends very much on the type of material, the nature of the rubbing surfaces, their roughness, whether the rubbing surfaces are dry or lubricated, etc.

The props are of the same type and manufacture, and therefore the materials and degree of roughness of the contact surfaces are of the same order.

The condition of the longwall faces may appreciably affect the degree of dryness and/or lubrication of the rubbing surfaces. The relative humidity is slightly higher in Dominion No. 20 Colliery than in Princess Colliery. In Princess Colliery, a 2-ft., 1-in. cut is mined with the trepanner miner, using relatively few cutting picks at low speed; no water sprays are necessary for dust suppression. In Dominion No. 20 Colliery, the Dosco Miner mines a 5-ft., 5-in. cut, using many cutting picks at high speeds; water sprays are used for dust suppression. Some of the damp coal dust settles on the props, providing a lubrication film between the rubbing surfaces and thereby reducing the coefficient of friction.

This decrease in the coefficient of friction between the rubbing surfaces on the props in Dominion No. 20 Colliery would account for the lower efficiency of the props observed on the wall face.

Conclusions

Prop loads do not increase continuously with prop yield for the type of steel friction prop observed. It is reasonable to assume that the average load supported per prop is approximately 70 to 75 per cent of the average of the maximum loads that the props are capable of supporting for the prop yields observed.

The steel props were loaded to 70-80 per cent of the maximum observed underground as the faces advanced one complete cut.

The capacity of the friction props seems to be affected to a great extent by conditions on the longwall face. Those factors that can change the nature of the rubbing surfaces and lower the coefficient of friction greatly reduce the efficiency of the props as roof supports.

The steel friction props are more efficient than the hardwood packs that they replaced as roof supports.

Acknowledgments

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