Measurement of prop Loads on Longwall Faces

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Abstract

In longwall working face, it is essential to maintain roof strata in good condition, which is closely connected to safety and productivity of the face. Since the condition of the roof strata is greatly influenced by the resistance of the face props, it is important for strata control to use proper types of props in the proper way.

From this point of view, underground investigations in order to confirm the resistance displayed by the face props were carried out. The resistance of a steel prop was obtained by measuring the strain of the prop, for which a couple of strain gauges were cemented onto the prop. This method of measuring the prop load proved to be pertinent in order to obtain the magnitude of the load acting on friction props and Dowty hydraulic props.

In longwall face, high stresses occur in the coal seam, immediately before the cutting face, by which the seam and the roof strata are fissured, lowering the strength and rigidity of the roof strata. The roof strata, supported by coal seam which has not been crushed, sink down by their own weight, loading the face props. When roof props yield or penetrate into the floor under such loads, the roof strata subside, increasing the fissures in the roof strata, lowering the strength of the strata more and more, and the roof tends to cave.

Therefore, when partial cavings of roof strata occur, it is necessary to prevent the closure of the roof, by using rigid props, increasing the prop density, setting loads and clamping loads. In case that the roof strata do not cave in into goaf by drawing out the rearmost props, the span of the suspended roof increases, the strata suddenly cave in when the span reaches a certain limit, resulting in heavy load on the face props. It is important to support the roof strongly by the rearmost props in order to maintain the roof in a good condition to prevent the caving in of the immediate roof.

However, the resistance of face props is influenced, by the type and state of the roof strata, height of working face, dip of face, prop density, and the rate of advance. Therefore, the author has investigated the influences of these various conditions by the measurment of the prop load on the longwall faces.

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Research on the longwall faces

In addition to the measurement of prop loads, the following researches were conducted on the longwall faces.

Research on the geologic columnar section

The columnar section and the strength of strata were investigated within the extent of 20 m on the upper side and 2 m on the lower side of the seam.

Macroscopic observation

The state of fissure within the immediate roof, partial caving of the roof, hanging roof on goaf, deformation of laggings placed between steel bars and roof, inclination of props, penetration of props into the floor, cracking of cutting face, seepage of water out of roof strata, and the size of caved waste into the goaf were investigated by macroscopic observation.

Measurement of convergence

The convergence between roof and floor was measured by a steel tape, driving in one nail into the roof and the other nail into the floor adjacent to the face prop the load acting on which was measured.

Measurement of the penetration of the prop into the floor

The penetration of the prop into the floor was investigated by measuring the distance between a base point on the upper part of the lower shaft and a nail driven into the floor.

Measurement of the yield of the prop

In order to examine the performance of face props, the load acting on it was investigated, and the yield of the upper shaft was measured.

Measurement of convergence rate

The convergence rate was measured by apparatus consisting of a steel pipe, 14 mm in inner diameter, a coil spring, and a dial-gauge. The convergence rates, after blasting the coal face, before and after cutting by means of a coal-cutter, after withdrawal of the prop and during the rest time, were measured.

Observation of deformation of lagging on the steel bars

Since the laggings placed on the steel bars influence the resistance of props, the state of contact between the roof surface and the steel bars was sketched.

Method of measuring the prop load

In order to obtain the magnitude of resistance, various types of load cells which are set under the prop have, hitherto, been devised. These prop load cells are classified into oil pressure dynamometer type[1),2)], strain gauge dynamometer type[3),4)], steel frame dynamometer, the elastic deformation of which is measured by a dial gauge[5)], and steel vessel dynamometer, the change in volume of which is measured by mercury.

Prop load measurements using load cells mentioned above include the following objectionable points.

a) In the case where the bottom surface of the load cell is larger than the bottom of the face prop, the load acting on the prop set on the load cell tends to become larger than that acting on other props.

b) Prop load cells employing the dial gauge or Burdon's tube pressure gauge tend to go out of order by rough handling.

c) The setting of the prop tends to be unstable when the prop is erected on the load cell.

d) The height of the prop erected on the load cell is shorter than other props.

e) The load cells set under rear raw props tend to get buried by waste caved into goaf.

f) Most types of prop load cells are considerably heavy, and are inconvenient for treatment at the face.

g) Sensitivity of load is in most cases relatively low.

h) It is difficult to measure a load which acts on many props simultaneously.

In order to eliminate the above mentioned objections, the author has designed a miniature load cell which is set between prop and steel bar. It was found that this type of load cell was difficult to set stably.

It is desirable that the number of props, whose loads are measured are as large as possible, because the distribution of the load acting on the face props is by no means uniform, and in most cases differ greatly.

The load acting on hydraulic props, on which pressure gauges for measuring inner pressure is set up, can be obtained by this pressure gauge. The load acting on friction type steel props or Dowty hydraulic props cannot be obtained by such a method. Therefore the author has investigated a method for measuring load acting on friction type steel props and Dowty hydraulic props using strain gauges, in which a couple of strain gauges are cemented onto the steel prop, and the load acting on this prop is obtained from the magnitude of strain of the steel prop.

By this means, the magnitude of load acting on props which are placed at regular service in face can be measured, and it is a point of advantage of this method that measurements can be taken at any time even after the props have been erected.

Since the lower shaft of a friction type steel prop is a hollow cylinder or a hollow rectangular prism made of high strength steel materials, and the cross-sectional area of the lower shaft is uniform except the cotter box part, a couple of strain gauges were cemented on two points at which the outer profile of a cross section and the axis of symmetry intersect, and the load acting on this prop was obtained by multiplying the mean value of strain, which was obtained by connecting these gauges in series, the magnitude of cross-sectional area and the longitudinal modulus of elasticity for steel.

As the position on the lower shaft of friction type prop, on which the gauges are cemented, the middle part of the lower shaft was selected taking the structure of the lower shaft into account, avoiding, welded portions, holes, cotter box, the base plate. The penetration of the prop into the floor and being buried by the caved waste were also taken into account.

The surface of the steel prop to which the gauges are cemented, was ground slightly by a miniature air grinder, polished by abrasive cloths, and after removing stains with carbon tetrachloride, the gauges were cemented by glue of α-cyanoacrylate type.

In order to cement the gauges to steel props in the working face, the strain gauges and a couple of short lead wires were soldered to foil terminals. After the gauges were cemented, damp-proofing paste was spread on the gages, and a cover plate was fixed for protection.

As the instrument for strain measurement, PS7/H Static Strain Indicator manufactured by Shinkotsushin Kogyo was used after taking necessary precautions against shock and high humidity in the working face. The lead wires of two strain gauges cemented on the prop were connected with lead wires, to which the terminals were soldered, in series.

Compression test of the steel prop

In order to investigate the accuracy of the method of measuring the load mentioned above and the influence of the position on which the gauges are cemented, the relationship between load and strain was obtained by loading a Daido S2 prop, on the lower shaft of which strain gauges were cemented, using a compression testing machine for long column.

Fig.1 illustrates the relationship between load and strain obtained by cementing 8 gauges on the lower shaft of a S2 prop as shown in Fig. 2.

Fig. 3 illustrates the relationship between load and strain obtained by connecting 2 gauges cemented on opposite points of same height in series.

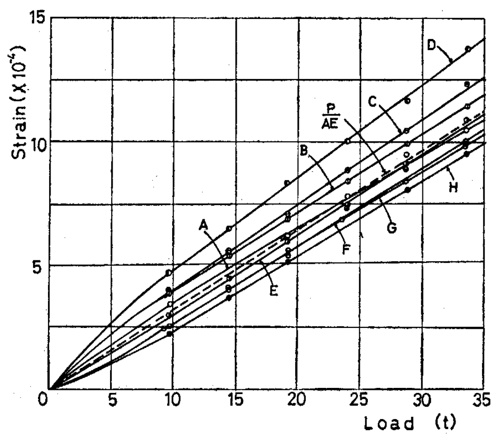

Fig. 1. Relationship between load and strain by gauges shown in Fig. 2.

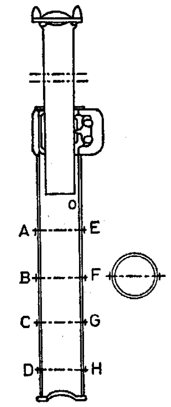

Fig. 2. Posisions of gauges on a S2 prop, which was loaded by a long column compression testing machine.

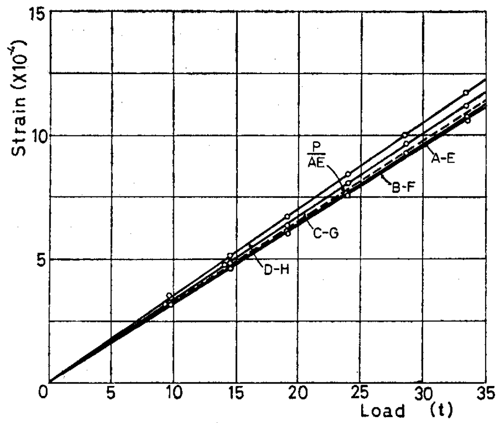

Fig. 3. Relationship between load and strain obtained by connecting 2 gauges cemented on opposite points of same height in series.

It is evident from Fig. 3 that average values of strain which arises on the opposite points show comparatively small variation, although magnitudes of strain measured by the individual gauges shows fairly large fluctuation.

It is recognized that the magnitudes of strain obtained by gauges D and H, cemented on the positions near base plane of the lower shaft show the largest deviation.

The straight lines shown in Fig. 1 and Fig. 2 by broken lines indicate theoretical strain obtained by dividing the load p by the product of cross-sectional area of the lower shaft A and longitudinal modulus of elasticity E.

Error of the results of measurement obtained by connecting two gauges in series was approximately 3.5% of the theoretical value mentioned above, except the values obtained by gauges D and H.

Accuracy and applicability of the method of measuring the prop load

Since the minimum graduation of the strain indicator used corresponds to strain of 1×10^{-5}, the minimum graduation of the instrument is equivalent to load of approximately 1/3 tons, when the cross-sectional area of the lower shaft of a prop, the load acting on which is measured is about 15 cm^2 as would usually be used.

It is desiarable that the relationship between the load and the strain is previously obtained by compression test of props on which strain gauges are cemented, and that thereafter those props are used for underground measurement.

Since it takes considerable labor and a compression testing machine is necessary for the procedure mentioned above, however, it is possible to measure the prop load using the props on which gauges are cemented at the face.

In such case probable cause of error would be as follows:

a) Imperfect cementing of gauges.
b) Inaccurate estimation of the cross-sectional area of the lower shaft.
c) Temparature change of the active and the dummy gauges.
d) Poor insulation of the gauges.

Influence of the temparature would be rare as the temparature change of working faces are usually small. Accuracy of prop load measurement by this method would be lower in some degree than that of measurement using load cells. It would be the merit of this method of measurement that prop load can be obtained comparatively easily, on the props used in the working faces in normal condition.

Results of underground investigation

Measurements of prop loads were carried out at longwall faces of collieries in various places. Typical examples of results of these measurements are as follows:

Investigation at face A

a) General situation of the face
average dip of seam: 23°, average height of coal face: 1.6 m
face length: 100 m, immediate roof: sandstone
method of getting coal: blasting (3 shifts)
steel prop: friction prop (Nitto GTRH)
steel bar: steel shoe joint bar (1.25 m in length)
treatment of goaf: caved goaf with roadside pack

b) Results of measurement

The site of props, the load acting on which was measured, was approximately 35 m from the gate road. The results obtained are shown in Fig. 4.

c) Discussion

From the results of prop load measurement, it was found that the maximum load acting on the props was 26.5 tons. Magnitude of maximum setting load was 6.8 tons and minimum setting load was 2.8 tons. Load acting on first row props was 18.0 tons in maximum and 2.8 tons in minimum. For the

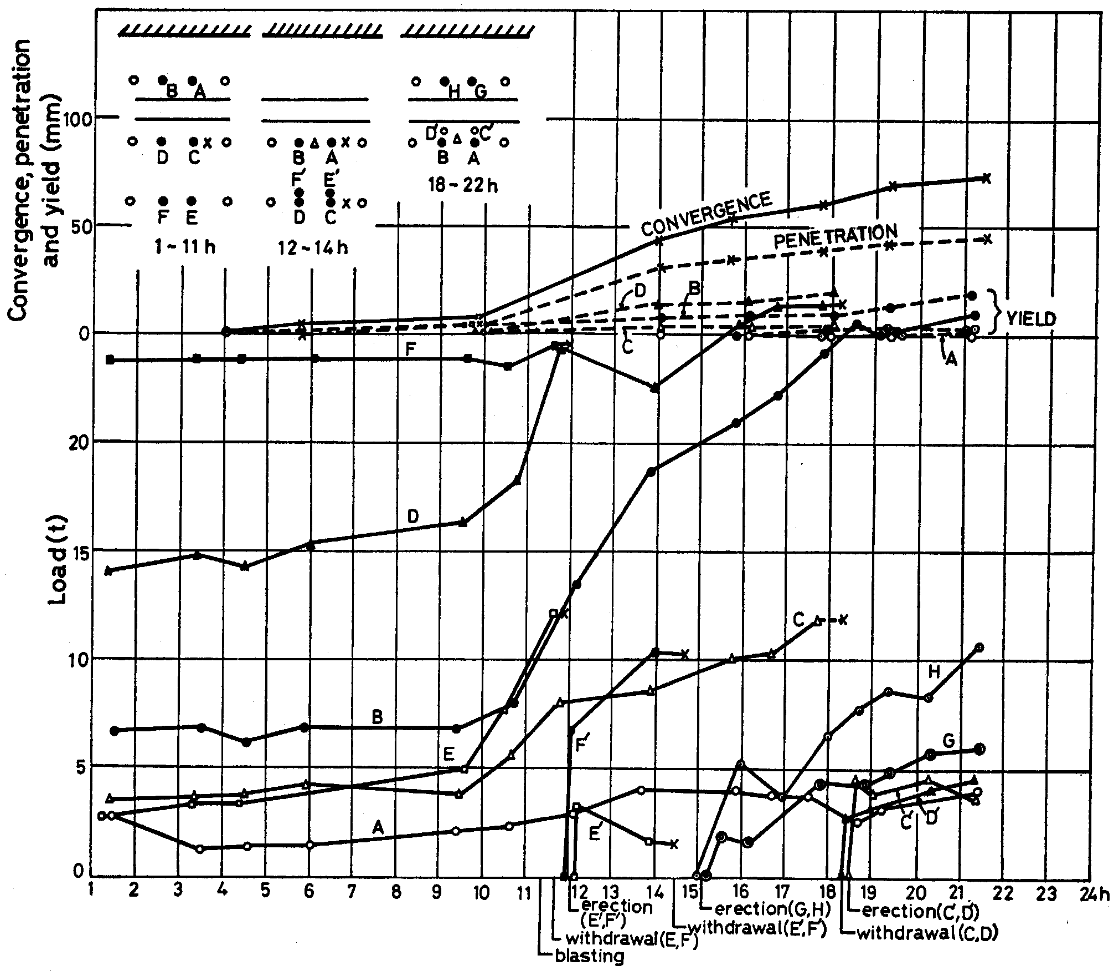

Fig. 4. Results of underground investigation (face A).

second row props, the maximum load was 26.5 tons and the minimum load was 12.4 tons. For the third row props, the maximum load was 26.5 tons and the minimum load was 13.3 tons. Load acting on a prop immediately before drawing was 26.0 tons at maximum and 12.5 tons at minimum.

The average convergence rate was 1.0 mm/h, the average penetration rate was 0.6 mm/h and the average yield rate was 2.1 mm/h. The average load intensity was 17.4 t/m^2. Since the setting load of friction type props used on this face was lower than 6.8 tons, the resistance offered by these props was not sufficient, so that partial caving of the immediate roof occured.

The roof was supported by thick laggings or planks on steel bars, so that, owing to the yield of these, the resistance of props was smaller than 10 tons except B, D and F. Though the yield of the upper shaft was small, penetration of the lower shaft would be a cause of insufficient resistance, so that it would be necessary to use a base plate to prevent the penetration of the lower shaft. Since the resistance of the third row props is very small, a hanging roof was observed on the goaf at the site of measurement.

Investigation at face B

a) General situation of the face

average dip of seam: 38°, average height of coal face: 1.8 m
face length: 90 m, immediate roof: sandstone
method of getting coal: blasting (2 shifts work, 1 shift rest)
steel prop: Dowty hydraulic prop
steel bar: steel shoe joint bar (1.4 m in length)
treatment of goaf: caved goaf with roadside pack
note: There was goaf of previously mined seam 1.5 m above the roof of the face.

b) Results of measurement

The site of props, the load acting on which was measured, was approximately 68 m from the gate road. The results obtained are shown in Fig. 5.

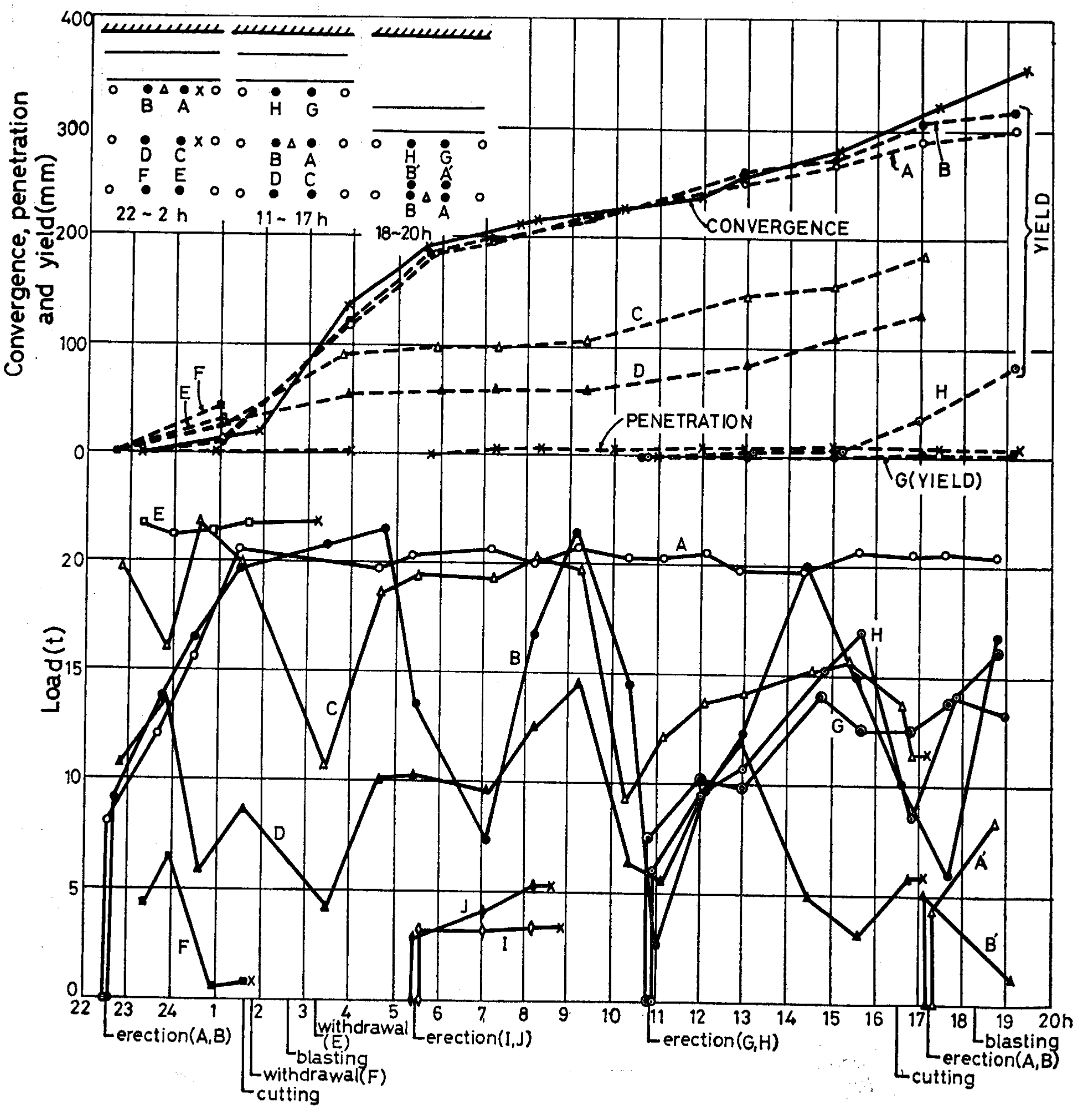

Fig. 5. Results of underground investigation (face B).

c) Discussion

From the results of the prop load measurement, it was found that the maximum load acting on the prop was 21.8 tons. Maximum setting load was 9.2 tons at maximum and 2.8 tons at minimum. The load acting on a prop immediately before drawing was 21.8 tons at maximum and 3.3 tons at minimum.

The average congergence rate was 18 mm/h, the average penetration rate was 2.3 mm/h, and the average yield rate was 0.4 mm/h. The average load intensity was 12.1 t/m^2.

Since the depth of cover of this face is so small that the magnitude of initial vertical stresses is approximately 10 kg/cm^2, no fissure occures ahead of coal face by increased stresses. There being goaf of previously mined seam 1.5 m above the roof of this face, and the roof bed of this face was shale, no danger of heavy caving of roof strata exists. This shale bed is broken by bending above the opening of this longwall face, so that the weight of this bed and caved wastes in the goaf above this face are supported by face props as dead load. Consequently, props A, B, C, and D show a large yield, being subjected to loads over the clamping load of the prop, and the roof also sinks down about the same amount as the yield of the prop.

Conclusions

By means of measuring strain using strain gauges cemented on steel props, magnitude of setting load and load histories after setting of the props were obtained.

It was found that in many cases, face props do not exhibit sufficient resistance. The main reasons for this would be as follows:

Deterioration of performance of props

In friction props, wear of friction plates, deformation of cotter box and insufficiency in clamping the cotter are causes of yield by loads smaller than the clamping load of the prop.

In hydraulic props, defects in valves or packing are causes of yield by loads smaller than the clamping load.

Penetration of prop into floor

In the case where the floor is weak by nature or weakend by immersion or where some depth of coal is left in the floor, the prop resistance goes down owing to penetration into the floor. In such cases, the use of base plates for props is desirable.

Compressive deformation of laggings on steel bars

When laggings or cribs are placed on steel bars, sufficient resistance cannot be exhibited owing to their yield. It is desirable, therefore, to use no laggings on the bar. If it is necessary to use laggings, use of thin planks or rectangular blocks of wood, placed above the prop, are recommended.

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References

1) D. O. Kühn: Glückauf, **88,** 625 (1952)
2) H. W. Woehlbier: "International conference about rock pressure and support in the workings", Liége, 1951, p. 194
3) R. Shepherd: "International conference on strata control and rock mechanics", New York, (1964), p. 230
4) I. Storey: Colliery Engineering, **36,** 435 (1959)
5) A. Abe: J. Mining and Metallg. Inst. Japan, **56,** 388 (1940) (in Japanese)