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FUEL RESEARCH INSTITUTE OF SOUTH AFRICA.

TECHNICAL MEMORANDUM NO. 3 OF 1964.

A STUDY OF THE STATIC DRAINAGE OF WET FINE COAL.

BY:

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INTRODUCTION:

The application of mechanical mining methods in the coal industry tends to increase fines production and decrease the selectivity in mining. The decrease in selectivity makes cleaning of the run-of-mine coal more imperative. One result thereof is that the fine coal recovered at colliery washeries frequently has such a high moisture content that marketing becomes virtually impossible.

In order to alleviate this position, some collieries have installed dewatering centrifuges. This solution cannot, however, always be applied and, therefore, it was decided to determine the static drainage characteristics of such fines. This report deals with experiments done on fines procured from a Natal colliery.

THE COAL:

The coal, kindly made available by Messrs. Natal Navigation Collieries, had a nominal size grading -5mm to zero. A screen analysis done at the Institute yielded the results given in Table 1.

THE TESTS:

To simulate drainage in trucks or bunkers the static drainage tests were carried out in a cylindrical drum 8 ft high and 18 inches in diameter, fitted with a 0.5 mm screen bottom, reinforced sufficiently to support the coal. This apparatus is shown in Figure 1A. The tests were carried out in the following manner:

Enough .../

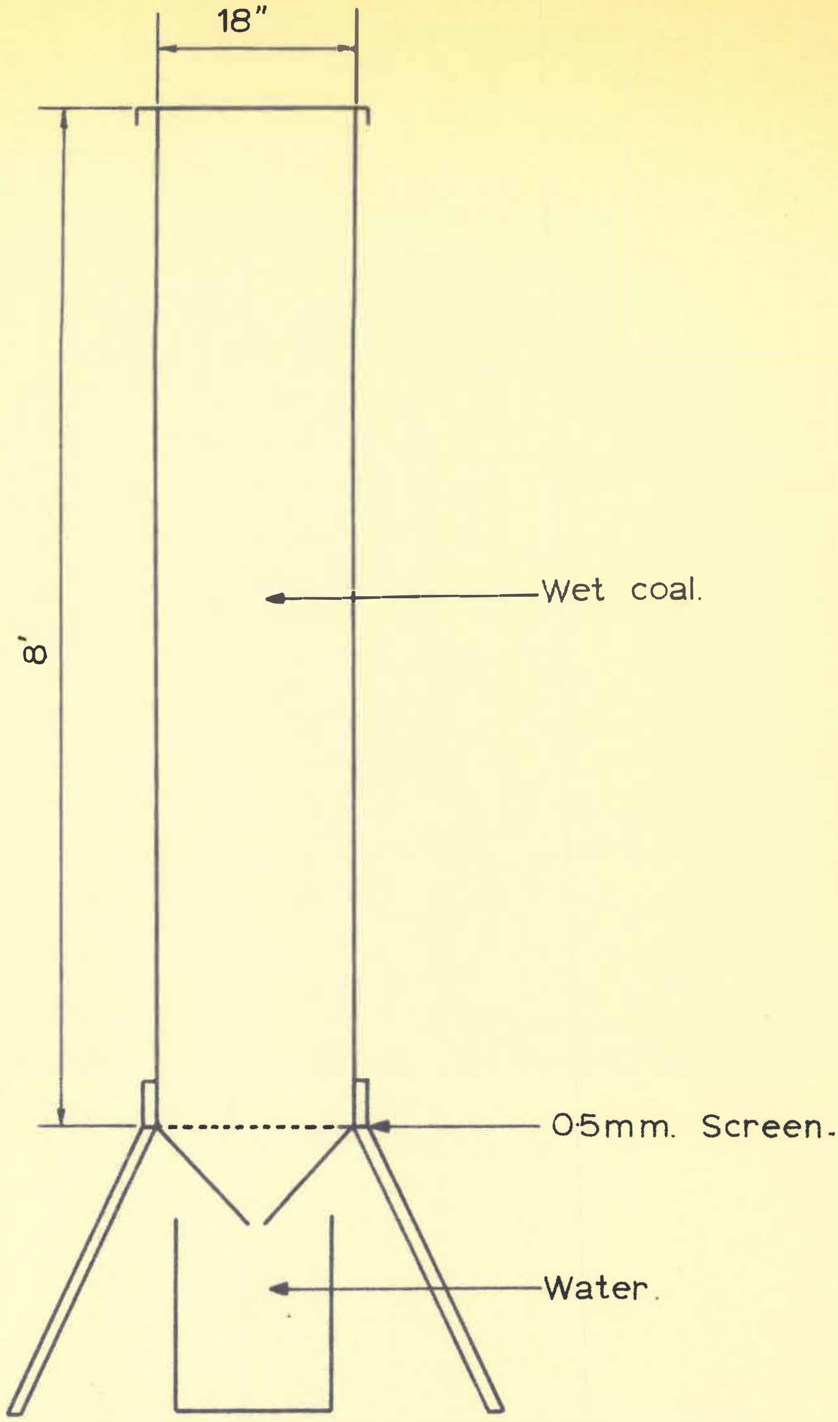

Fig. 1A Apparatus used for drainage experiments.

Enough water was added to the coal to be tested to bring the moisture content of the product to about 30%, and it was left to saturate overnight. The following morning the sample was stirred to form a homogeneous mixture of coal and water and was loaded into the apparatus to a height of 8 feet.

Water which was drained off through the wire-mesh screen-bottom was collected and was weighed at regular intervals.

After 96 hours of drainage, the coal was taken out and the residual free moisture content of the coal was determined by air-drying. From the moisture content of the coal at the conclusion of the experiment and the weight of water collected during the experiment, the moisture content of the sample, at the different time intervals, was calculated.

The loss of water due to evaporation during the experiment was not taken into account, but this should not be significant because the top of the column was always covered by a lid, and the experiments were carried out during autumn and winter when maximum temperatures seldom exceeded 20°C.

RESULTS OF EXPERIMENTS:

It has long been known that the moisture holding capacity of a wetted coal mixture is dependent on the size grading of the material. The following three series of experiments were carried out to obtain more exact data on the effect of size grading.

SERIES A.

To determine the effect of the elimination of the lower size ranges on the drainage characteristics of the coal, three experiments were carried out on:

(a) 5 mm × 0 (natural product);
(b) 5 mm × 0.5mm;
(c) 5 mm × 1.6 mm;

Results ..../

Results of these experiments are reported in Table 2, and are graphically illustrated in Figure 1.

SERIES B.

To determine, separately, the drainage characteristics of closely graded size fractions, tests were done on the following size fractions:

(a) 5 mm × 3.2 mm;
(b) 3.2 mm × 1.6 mm;
(c) 1.6 mm × 0.5 mm.

To extend the range in this series a fourth test was carried out on a 22 mm x 5 mm size fraction of Brakfontein coal. The results of these experiments are reported in Table 3 and illustrated in Figure 2.

SERIES C.

To determine the effect of different amounts of -0.5 mm material in a mixture on its drainage characteristics. Four tests were carried out on coal containing:

(a) 0% of -0.5 mm material;
(b) 10% of -0.5 mm material;
(c) 16.5% of -0.5 mm material;
(d) 23.1% of -0.5 mm material (natural product).

These results are reported in Table 4 and illustrated in Figure 3.

DISCUSSION:

Before assessing the value of static drainage as a means of reducing the moisture content of a fine coal it is necessary to consider some of the difficulties experienced when the moisture content of fine coal is too high:

(a) Coal produced at collieries has to be transported to its ultimate point of utilisation. Distances vary from a few miles to thousands of miles in the case of coal for export. Moisture adhering to the coal, therefore, represents additional tonnages to be tramsported and paid for at ruling coal freightage rates. At the same time excess moisture results in the loss of valuable shipping space in seagoing vessels.

(b) ..../

(b) The transportation of coal to its destination invariably necessitates the handling of the product at different stages by mechanical means such as conveyors, chutes etc. It is here that the greatest difficulty is experienced, through blockages and the lack of fluidity if coal fines have too high a moisture content.

It has been stated that for easy handling, the moisture content of a fine coal should not exceed 12%. In some cases this figure has been set as low as 8 - 10%.

(c) With coking coals a number of difficulties connected with the moisture content of the coal products are encountered. The major ones are concerned with handling, mixing and the reduction of output of carbonisation plants due both to decreased bulk density and to the heat necessary to drive off additional moisture in the ovens.

TIME FACTOR:

When considering the reduction of the moisture content of coal through drainage, an important factor is the time taken to effect the required reduction in moisture content. After preparation, coal cannot be left indefinitely in bunkers or trucks due to perpetual shortages of storage space and rolling stock.

The maximum static drainage time permissible under conditions of continuous production would depend on the availability of storage facilities, but it would normally not exceed 8 - 12 hours even where ample storage facilities exist.

To make static drainage practicable, the drainage characteristics of the coal should, therefore, be such that a moisture content of less than 12% could be attained in about 10 hours. Results of the experiments in Series A show that the 5 mm x 0 fines cannot be drained to a satisfactory level in any practicable time.

Results on the 5 mm x 0.5 mm and 5 mm x 1.6 mm size fractions indicate that the -0.5 mm size fraction is mainly responsible for the moisture retaining characteristics of the coal.

The .../

The fact that the curves in Figure 2 run virtually parallel and that they are vertically displaced according to the size of the particles, suggests that the moisture holding capacity of a coal is a function of particle diameter or the total surface area of the sample.

The results of the experiments in Series C again emphasise the influence of the -0.5 mm size fraction on the drainage characteristics of the coal and show that drastic reduction of this size fraction in the mixture is necessary to improve the drainage characteristics of the fines.

ESTIMATING MOISTURE CONTENTS:

The question now arises whether one could estimate the residual moisture content after a given time, say 24 hours, for an arbitrary size distribution.

As a first rough approximation one might assume that each size fraction drains to its final moisture content unaffected by the presence of other sizes. While this is probably not quite true, the calculations in this case are very simple and consist only of a number of linear combinations.

The experimental results obtained in this study, unfortunately, do not include figures for the -0.5 mm material which obviously contains most of the moisture. It would be somewhat difficult to obtain the information experimentally, but an estimate of the residual moisture content may be made from the data contained in Table 4.

Material without the -0.5 mm fraction drains to 10.8% in 24 hours. The additional moisture contained in the other samples tested,may thus be assigned to the presence of the -0.5 mm fraction.

One thus obtains:

Case:	Percentage of -0.5 mm coal.	Additional Moisture	Total Moisture
(a)	0	-	10.8
(b)	10	1.9	12.7
(c)	16.5	4.3	15.1
(d)	23.1	4.2	15.0

Let .../

Let the residual moisture content of the -0.5 mm coal be x%. Then the moisture content in the series is given by the contribution of individual size fractions, as follows:

case (b)	$0.9 \times 10.8 + 0.1x = 12.7$	Hence $x = 29.8\%$
(c)	$0.835 \times 10.8 + 0.165x = 15.1$	" $x = 36.9\%$
(d)	$0.769 \times 10.8 + 0.231x = 15.0$	" $x = 29.0\%$
		Average $x = 31.9\%$

One may now calculate the moisture content of a coal having the composition given in Table 1.

TABLE: Calculation of moisture content of small coal after 12 hours static drainage.

	(a)	(b)	(a) × (b)
Size range	Fractional Weight %	Residual Moisture %	Fractional contribution to moisture content of sample (a × b)
> 5mm	3.2	5.4	0.017
5mm × 3mm	10.0	6.3	0.63
3mm × 1.6mm	25.6	9.3	2.38
1.6 mm × 0.5mm	38.1	14.0	5.33
-0.5mm	23.1	31.9	7.37
TOTAL	100.0		15.7 %

This calculated total should be compared with the 15.0% of Table 2 and is, therefore, 5% high. In view of the rather anomalous result (c) found above this deviation is not surprising. If the calculated residual moisture content of 31.9% is replaced by the 29.0% of case (d) a figure of 15.1% total moisture is obtained.

This method could probably be used for a rough assessment of the moisture content of a coal, differing in size grading from the material investigated.

The correspondence is sufficiently good to indicate that such a method might be useful to obtain an indication of the .../

of the probable residual moisture content of mixed smalls after a given static drainage period.

A closer assessment of its value can, obviously, only be obtained by continuing with experimental work so as to cover all the important size ranges, and to obtain more reliable average values for use in such calculations.

(SIGNED) S. F. STREICHER.
SENIOR TECHNICAL OFFICER.

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TABLE 1.

Screen Analysis of Elandsberg 5mm × 0 Fines.

Size Fraction	Yield	
	Fract. %	Cum. %
+ 5mm	3.2	3.2
-5mm + 3mm	10.0	13.2
-3mm + 1.6mm	25.6	38.8
-1.6mm + 0.5mm	38.1	76.9
-0.5mm + 0.25mm	14.1	91.0
-0.25mm+ 0.15mm	2.6	93.6
- 0.15mm	6.4	
TOTAL:	100.0	100.0

TABLE 2.

SERIES A.

Effect of the Elimination of Lower Size Ranges on Drainage Characteristics.

Drainage Time Hours	Calculated Moisture Content (%)		
	5mm × 0	5mm × 0.5mm	5mm × 1.6mm
0.5	25.2	15.9	11.1
1.0	23.4	14.3	10.8
2.0	20.6	13.2	10.7
3.0	19.7	12.7	10.7
4.0	19.0	12.4	10.6
5.0	18.5	12.1	10.6
6.0	18.0	11.9	10.6
7.0	17.6	11.8	10.6
24.0	15.0	10.8	10.2
32.0	14.3	10.5	10.0
48.0	13.5	10.2	9.9
72.0	12.9	9.6	9.8
96.0	12.4	9.4	9.7

TABLE 3.

SERIES B.

Drainage Characteristics of Closely Graded Size Fractions.

Drainage Time Hours	Calculated Moisture Content of Size (%)			Fractions
	1.6mm×0.5mm	3.2mm×1.6mm	5mm × 3.2mm	22mm × 5mm
0.5	19.5	13.3	8.6	-
1.0	18.0	12.7	7.5	6.7
2.0	17.0	11.8	7.4	6.5
3.0	16.5	11.2	7.2	6.3
4.0	16.1	10.9	7.2	6.2
5.0	15.8	10.7	7.1	6.1
6.0	15.6	10.5	7.0	6.0
7.0	15.4	10.4	6.9	5.9
24.0	14.0	9.3	6.3	5.4
32.0	13.7	9.2	6.1	5.4
48.0	13.3	8.9	5.7	-
72.0	12.9	8.5	5.6	-
96.0	12.5	8.3	5.5	-

TABLE 4.

SERIES C.

The Effect of the Percentage -0.5mm Material on the Drainage Characteristics.

Drainage Time Hours	Calculated Moisture Content of Coal Containing			
	23.1% -0.5mm Mat.	16.5% -0.5mm Mat.	10% -0.5mm Mat.	0% -0.5mm Mat.
0.5	25.2	23.8	20.2	15.9
1.0	23.4	22.2	18.4	14.3
2.0	20.6	20.5	16.9	13.2
3.0	19.7	19.4	16.5	12.7
4.0	19.0	18.7	16.0	12.4
5.0	18.5	18.2	15.6	12.1
6.0	18.0	17.8	15.2	11.9
7.0	17.6	17.7	14.8	11.8
24.0	15.0	15.1	12.7	10.8
32.0	14.3	14.6	12.3	10.5
48.0	13.5	14.0	11.9	10.2
72.0	12.9	13.3	11.5	9.6
96.0	12.4	12.8	11.0	9.4

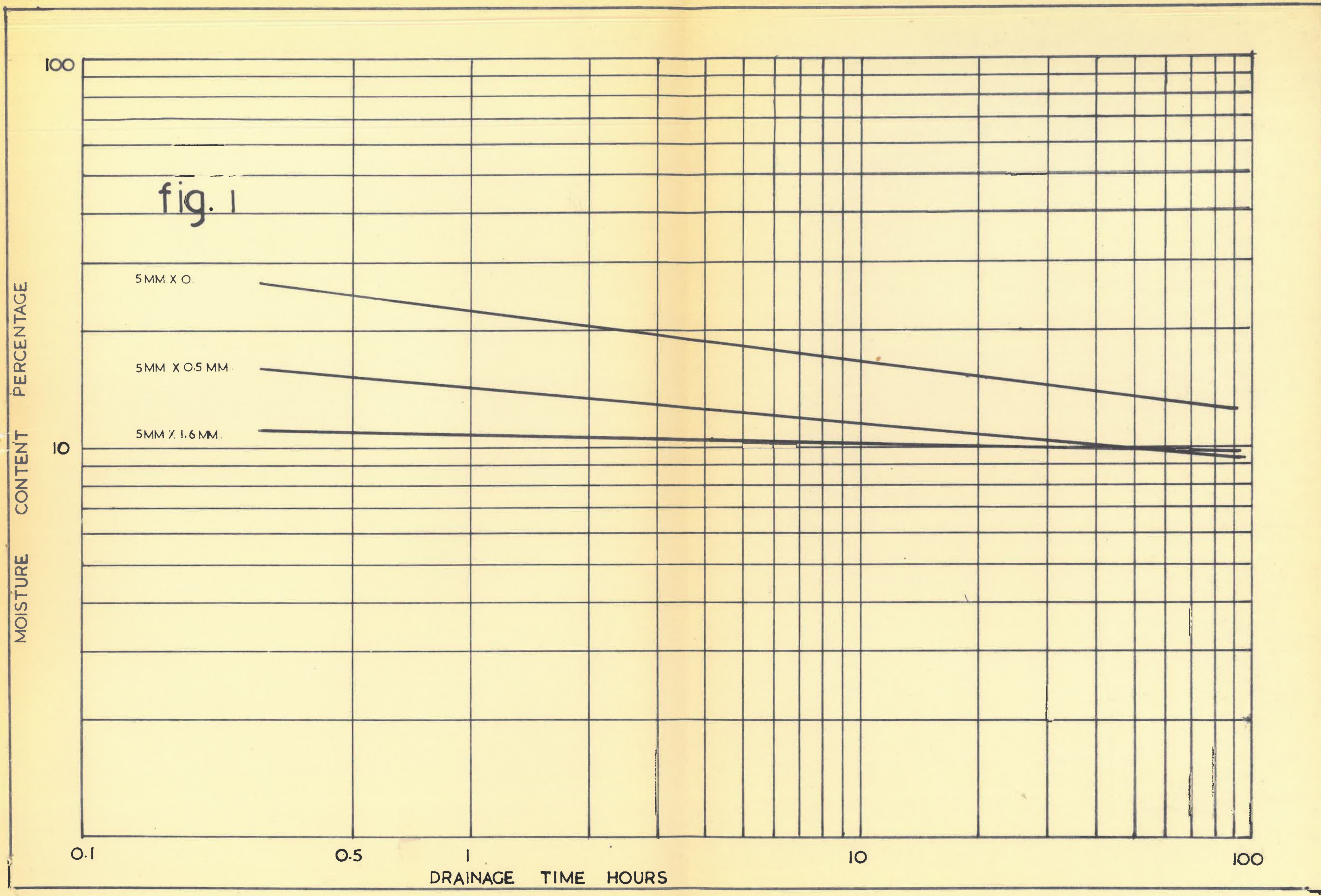


fig. 1
5 MM X O.
5 MM X O.5 MM
5 MM X 1.6 MM
MOISTURE CONTENT PERCENTAGE
100
10
0.1
0.5
1
10
100
DRAINAGE TIME HOURS

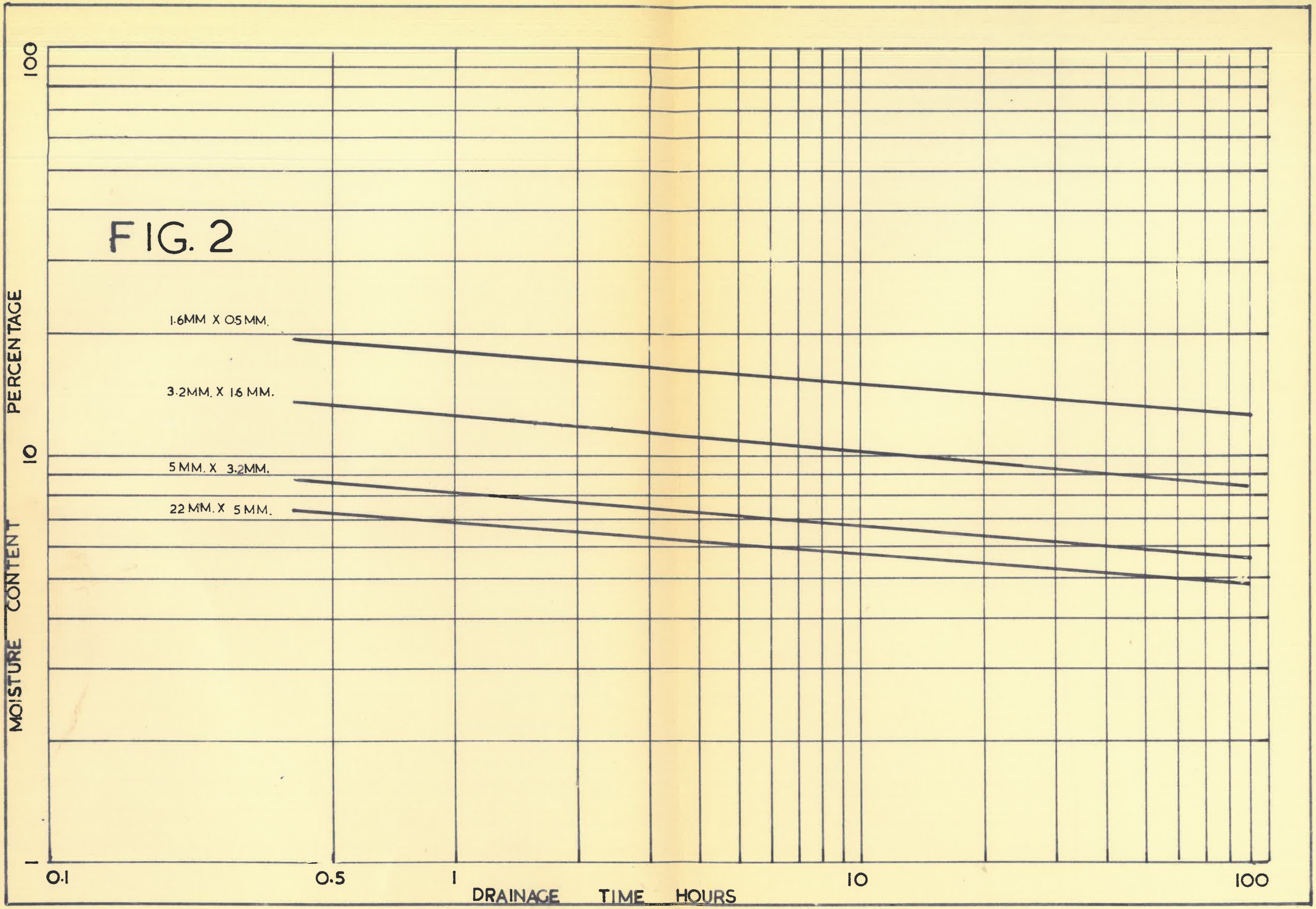
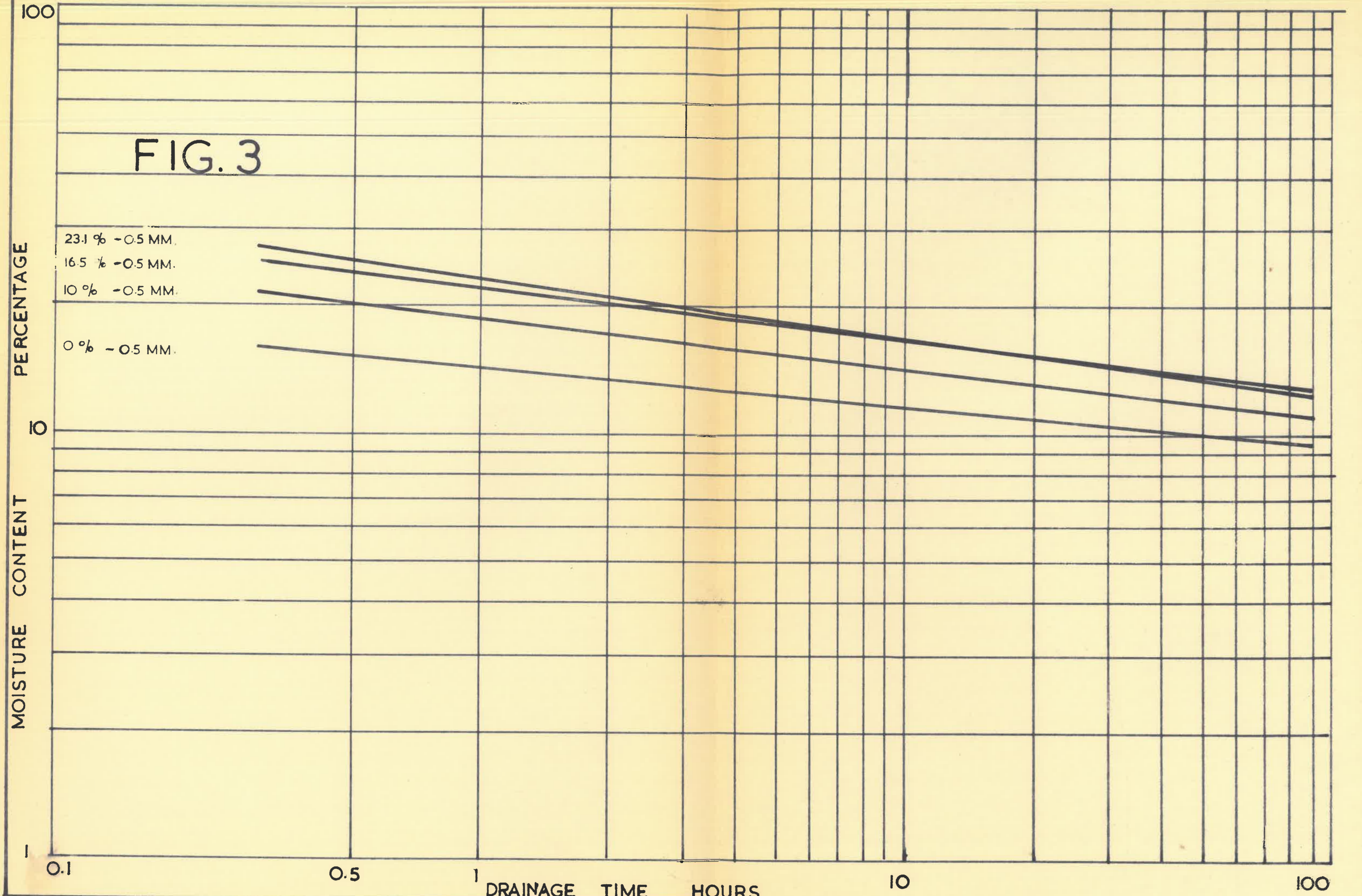


FIG. 2
1.6MM X 0.5MM.
3.2MM. X 1.6 MM.
5 MM. X 3.2MM.
22 MM. X 5 MM.
MOISTURE CONTENT PERCENTAGE
100
10
1
0.1
0.5
1
10
100
DRAINAGE TIME HOURS

FIG. 3


100
10
1
0.1
0.5
1
10
100
MOISTURE CONTENT PERCENTAGE
DRAINAGE TIME HOURS
23.1 % -0.5 MM.
16.5 % -0.5 MM.
10 % -0.5 MM.
0 % -0.5 MM.