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DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH AND FIRE OFFICES' COMMITTEE
JOINT FIRE RESEARCH ORGANIZATION

THE RELATION BETWEEN CRITICAL SHEAR STRESS AND "25 PER CENT DRAINAGE TIME" OF AIR-FOAM

by

Nicola Savage

Summary

In this report it is shown that a relation exists between "25 per cent drainage time" and critical shear stress. This relation differs for different foam compounds and for different batches of the same compound, but for any one batch it is shown to be independent of expansion and compound concentration.

March 1958

Fire Research Station,
Boreham Wood,
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1. Introduction

A fire-fighting foam can be defined for most applications by its expansion and its fluidity.

Fluidity can be expressed in terms of the critical shear stress, but the apparatus used to measure the latter is unsuitable for field use. It has been suggested that there is a relation between critical shear stress and "25 per cent drainage time" as measured in the N.R.L. test, and this relation is examined in this report.

2. Apparatus

For the measurement of "critical shear stress" the viscometer in Plate 1 is used. The stationary bowl is filled to the brim with foam, and the vane ($1\frac{1}{4}$ inch square) is immersed in the foam by depressing the instrument head against a spring. This causes the electric motor to rotate and drive the torsion head and scale at 8 r.p.m. The vane is first held back by the foam, but the increasing torsion in the wire ultimately overcomes the foam resistance, and a cylinder of foam of which the vane is a diametral plane shears from the body of the foam. The reading shown by the pointer on the scale at this stage is multiplied by a constant depending on the torsional rigidity of the wire used. This gives the "critical shear stress" of the foam in lb/ft^2 ($1 lb/ft^2$ = 480 $dynes/cm^2$). The "25 per cent drainage time" is measured using the apparatus in Plate 2 (1). The drainage pans are 2 inches deep and $7\frac{3}{8}$ inches in diameter (having a capacity of 1400 cc) and the small drainage tube is $\frac{1}{8}$ inch in diameter. The pans are placed on a stand which is inclined at an angle of 1 in 14 to the horizontal (i.e. $4^{o}5'$ of arc). The *"25 per cent drainage time" is measured.

3. Details of foam compound used

Table 1

Identification	Type	Remarks
A	Hydrolised keratin	No longer in large scale use.
B	Hydrolised keratin	Has replaced compound A in most applications. From same manufacturer.
E	Wetting agent	Not generally accepted as suitable for fire fighting.
P	Hydrolised keratin	Made as compound B but stabilising salt has been subsequently removed.

*The"25 per cent drainage time" is defined as the time for 25 per cent of the liquid content of the foam to drain in the test apparatus.

4. Experimental

For most of this work the foam was produced by a laboratory foam generator (2) but some tests were made with foam produced from foam-making branchpipes. Various concentrations of compound were used in the range $\frac{3}{4}$ per cent to 10 per cent, to produce foams with expansions of 7 or 14 and a range of fluidities. The critical shear stress and 25 per cent drainage time were measured for each foam. Three measurements of critical shear stress and two measurements of 25 per cent drainage time were made for each foam, the critical shear stress being measured one minute after the sample of foam was taken.

5. Results

The results obtained in the above experiments are shown on the curves in Figs. 1 and 2. Fig. 1 shows the results obtained for one of the compounds and fig. 2 compares the relations obtained for the various compounds.

6. Discussion of Results

The results shown on the curves in figs. 1 and 2 indicate a well defined relation between the critical shear stress of a foam and its 25 per cent drainage time. This relation differs for different foam compounds and for different batches of the same compound, but expansion and concentration do not appear to have an effect. The relation between these two characteristics is the same for foam produced by the laboratory generator and by foam-making branchpipes, and it is evident that the two characteristics are a measure of the same property. The 25 per cent drainage test is more convenient for field use, and a knowledge of the drainage time - critical shear stress relation for the particular compound used should enable the critical shear stress to be calculated.

It has been shown elsewhere (3) that the 25 per cent drainage time cannot be used as a direct indication of how a foam will drain on a burning or hot flammable liquid, particularly when comparing compounds, although for a given compound a higher 25 per cent drainage time means a more stable foam.

References

1. Tuve, R. L. and Peterson, H. B. A study of some mechanical foams and their use for extinguishing tank fires. U.S. Naval Research Laboratory Report No. 3725, Aug. 1950.

2. Fry, J. F. and French, R. J. A mechanical foam generator for use in laboratories. Journal of Applied Chemistry 1951, 1 425-429.

3. French, R. J. Characteristics of air-foams and their performance in controlling and extinguishing petrol fires. F. R. Note No. /1958.

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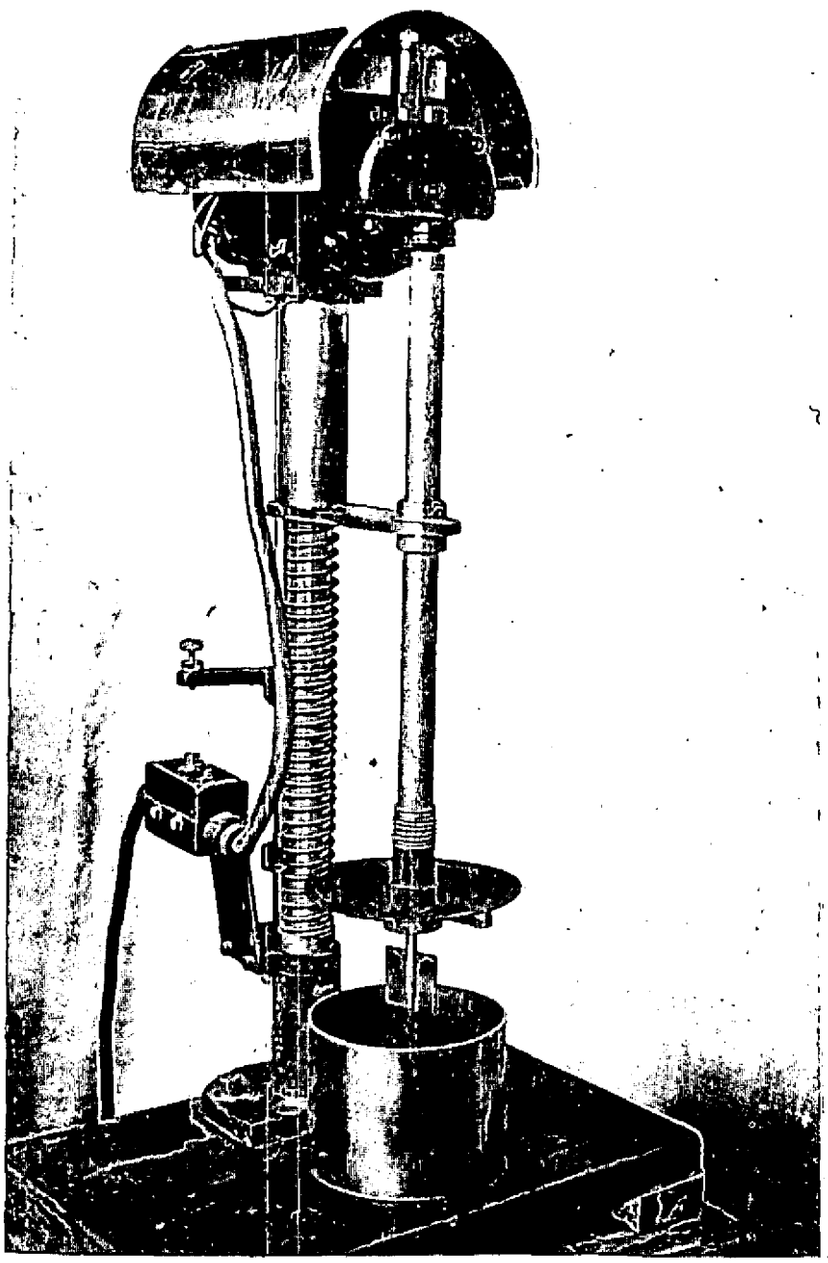

PLATE.I. VISCOMETER USED FOR THE MEASUREMENT OF CRITICAL SHEAR STRESS

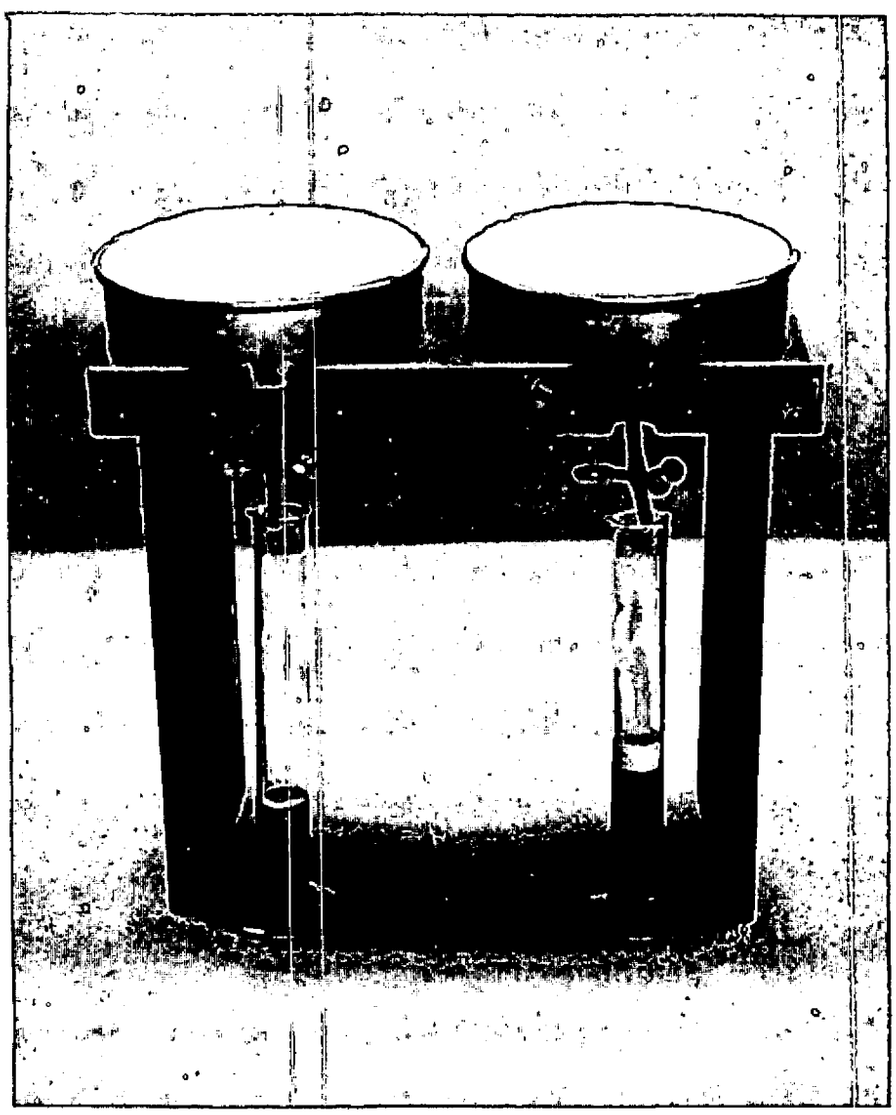

PLATE. 2. APPARATUS USED FOR THE MEASUREMENT OF 25 PER CENT DRAINAGE TIME

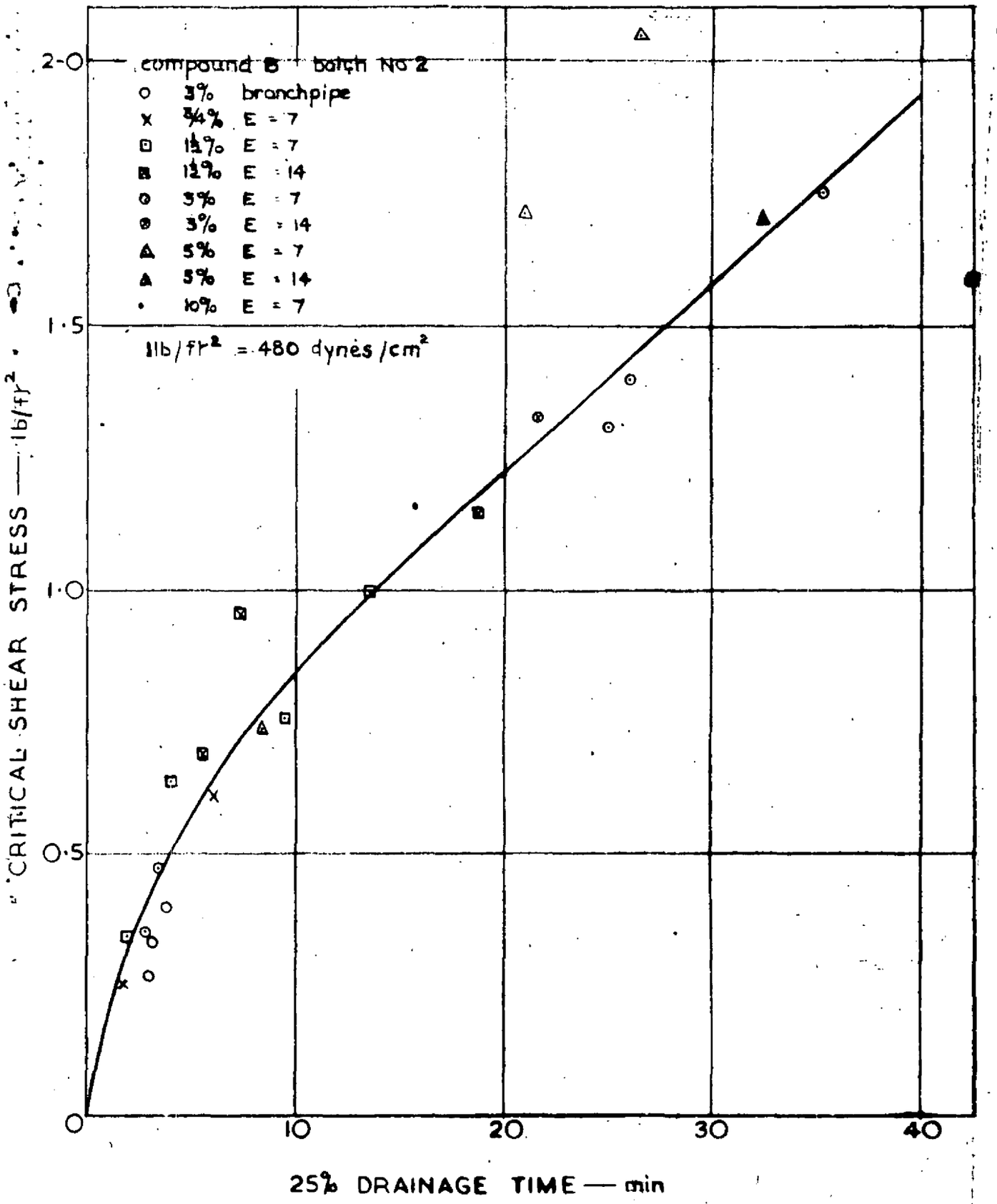

FIG. 1. RELATION BETWEEN CRITICAL SHEAR STRESS AND 25 PER CENT DRAINAGE TIME FOR COMPOUND B (BATCH 2)

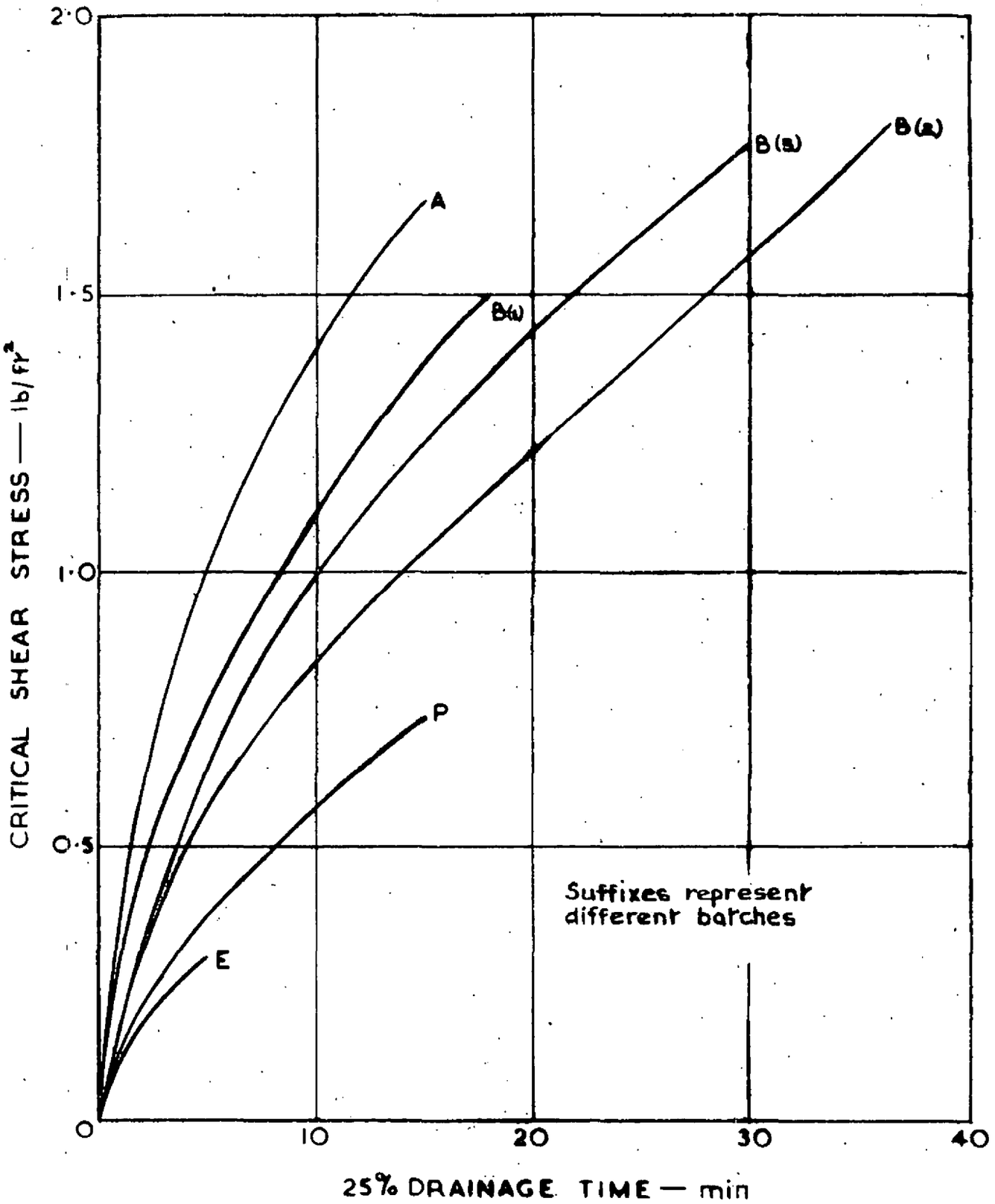

FIG. 2. COMPARISON OF THE RELATION OBTAINED FOR DIFFERENT COMPOUNDS