Mechanical Properties of Some Jute Fabrics and Fibre Drains

M. H. Kabir
Bangladesh University of Engineering and Technology, Dhaka, Bangladesh
K. U. Ahmed
Roads and Highways Department, Dhaka, Bangladesh
S. S. Hossain
Bangladesh Water Development Board, Dhaka, Bangladesh

ABSTRACT: A number of grades of jute fabrics and fibre drains were tested to establish some of their hydraulic and mechanical behaviour. Test results of four grades of jute fabrics are presented enabling establishment of their hydraulic conductivity and filter behaviour. Inplane hydraulic conductivity results of two types of jute fibre drains are presented. Static creep behaviour of one grade of jute fabric is also presented.

1 INTRODUCTION

Historical evidence show that jute fabric soaked in bitumen was used in military road construction in Burma front of South East Asia during the Second World War (Slim ,1955). Traditionally soil filled Jute bags have been extensively used in military application and in erosion and flood related civil engineering applications. " Geojute" in the form of coarse Jute mesh is being used for a long time in protecting soils from wind and rain erosions. Dastidar (1969) reported use of jute sand wicks in vertical drain application. Kabir et. al (1988) presented laboratory studies on repeated loading and filter behaviour on some grades of Jute fabrics.Recently Lee et. al (1989) reported use of jute fibre drains using coconut coir cores in vertical drain application. Nevertheless, studies on jute and other natural fibers lagged behind enormously in comparison with those one geosynthetics. The reason is that, the natural materials being biodegradable, are not suitable for application in permanent structures. However these materials can be conveniently used in a number of applications. These include application as transitional layers, complete performance application where working life is short, as construction expedients and in repair of structures during emergencies. Although there exists enormous potential of use of jute and natural materials , very little has been reported so far on their engineering properties. These paper reports some index test data, hydraulic and mechanical properties of four grads of jute fabrics and two types of fibre wick drains. Understanding of fundamental behaviour of these materials will lead to their widespread use.

2 FABRIC GRADES TESTED

The fabric grades used in this study are canvas, CBC (Carpet Backing Cloth) Twill and Felt. Some physical and index properties of these fabrics are presented in Table. 1. None of these grades of fabrics are purpose constructed for civil engineering application. These grades are selected for this study for inclusion of materials having varied physical and structural properties. The canvas is a very densely woven fabric, woven by round twisted yarns. This was the least porous out

Table 1 Characteristic Properties of Jute Fabrics.

Jute Fabrics / Properties	1	2	3	4
Trade Name	Canvas	CBC	Twill	Felt
Unit Wt. (gsm)	540	240	610	620
Thickness (mm)	1.36	1.13	1.82	4.22
O_{95} (mm)	0.06	2.0	0.6	0.3
Grab Tensile Strength (N)	840	410	410	240
Grab Tensile Elongation (%)	22	10	8	24
Burst Strength (kPa)	2500	1760	1960	1760
Index Puncture Resistance (N)	600	160	400	250
m*	0.93	2.08	1.28	1.27
v_{1g}* (10^{-3}m/sec)	0.014	27	4.3	6.8

* Equation 1
Note : All tests are according to ASTM standards.

of the four types. The CBC on the other hand was the most porous. This fabric was also woven by using round twisted yarns. The twill fabric is woven by using relatively flat type yarns. The felt is a fabric of composite construction. Jute fibers from carpet industry wastes are needled on a open web woven base fabric.

3 HYDRAULIC CONDUCTIVITY TESTS

For all the grades of fabrics in-isolation hydraulic conductivity tests were performed using an apparatus as prescribed in ASTM D4491. Additionally the felt fabric was tested using an apparatus similar to that used by McGown, Kabir and Murray (1982).The ASTM apparatus was used to establish the hydraulic conductivity behaviour under a range of hydraulic gradients.

The results are presented in Fig. 1. As Jute fabrics, like geotextiles, normally exhibit non Darcy behaviour, the method of characterisation of hydraulic conductivity suggested by McGown, Kabir and Murray (1982) was used. Their suggested flow law is of the form

$$i_g = (v/v_{1g})^m \quad (1)$$

where, i_g is the hydraulic gradient through the geotextile, v is the velocity, v_{1g} is the velocity at a hydraulic gradient of unity and m is the exponent defining the degree of non-Darcy behaviour. For Darcy flow condition m becomes equal to unity and v_{1g} represent Darcys coefficient of permeability. The flow parameters of the four grades of Jute fabrics are presented in Table 1. These show the canvas to follow Darcy´s law and the highly porous CBC showing the most shift (m=2.08) from Darcy behaviour.

The felt fabric was tested to establish its hydraulic conductivity characteristics under pressure. An apparatus similar to that proposed by McGown, Kabir and Murray (1982) was used. The specialty of the BUET apparatus is that it is a modified version of a triaxial cell in which flow is allowed in the upward direction, through layers of geotextile. Two layers of uniform sized glass balls were used on either face of the test specimen, which acted as load transferring media without interfering with the flow.

The test results are presented in Fig. 2. Fig. 3 shows the variation of on and v_{1g} as a function of confining pressure at a hydraulic gradient of unity. The material exhibits non-Darcy behaviour and there is a four fold reduction in hydraulic conductivity due to increase in pressure from 2 kPa to 35 kPa.

4 GRADIENT RATIO TESTS

To establish the filterability of canvas, twill and felt fabrics, gradient ratio tests were performed. This test was suggested by the U.S. Army waterways experiment station. Overall hydraulic gradients of approximately 2 was maintained in these tests. The soil used is a sandy silt river sediment, which is abundant in Bangladesh. The soil parameters are, D_{50}= 0.065 mm, U_s=10 and k_s=2.0x10^{-5} m/sec. The soil was used in a very soft state

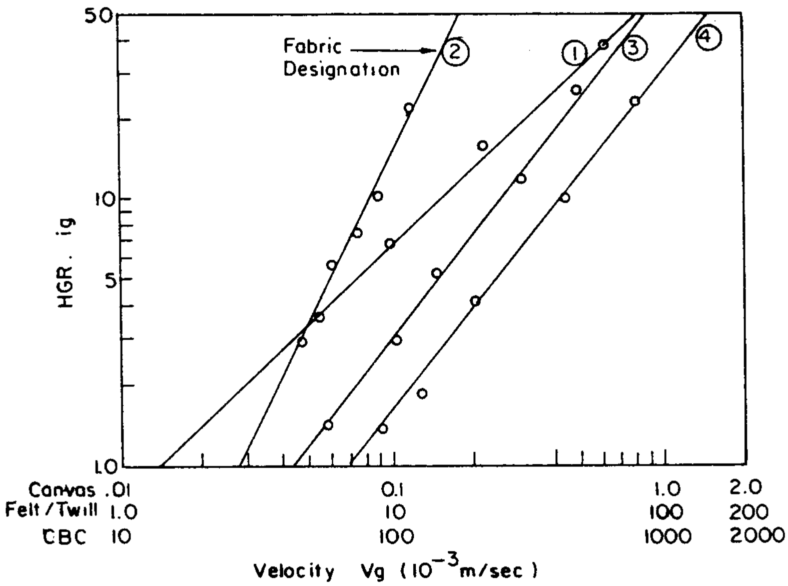

Fig. 1 Hydraulic gradient versus velocity plots for four grades of jute fabrics

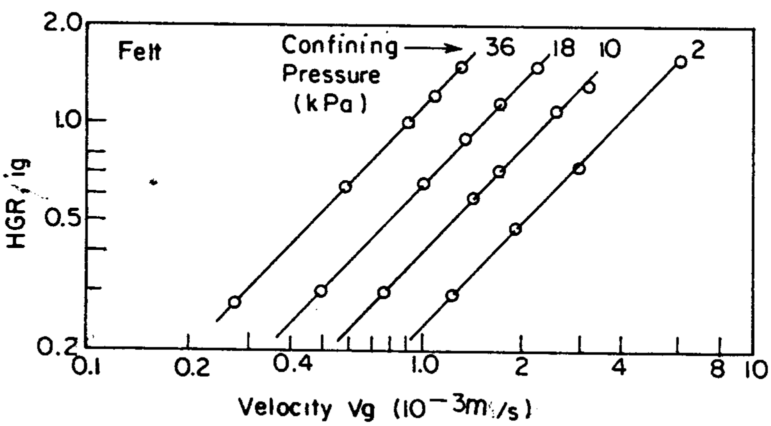

Fig. 2 Hydraulic gradient versus velocity plots as functions of confining pressure (felt fabric)

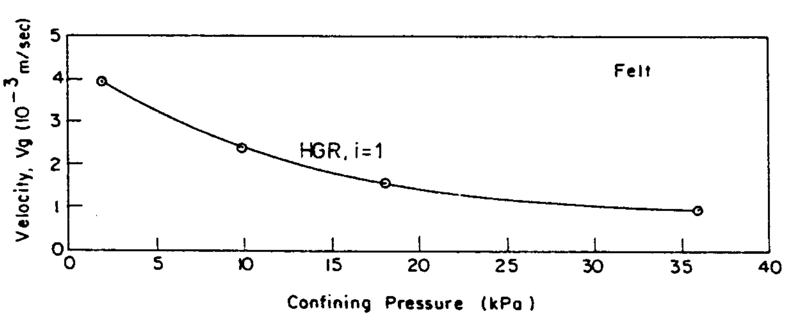

Fig. 3 Reduction of velocity due to confining pressure (HGR = 1, Felt fabric)

having a moisture content of 40 percent which is the liquid limit.

The test data for the three fabrics are presented in Fig. 4. These show the gradient ratio as a function of time. At the end of 90 hrs the stabilised gradient ratios are between 1.8 and 2.2 for all the fabrics. A value of gradient ratio GR < 3 is accepted as satisfactory filter performance. An inspection of the downstream face of the fabrics after test indicated no evidence of piping through.

5 DRAIN TEST

Two types of Jute fibre wick drains were used in this study. These drains have similar geometrical features to those developed at the National University of Singapore (Lee et. al., 1989). Both the types have a couple of layers of twill fabric filter jackets. In one type twisted coconut coir rope was used. The other type have twisted jute fibre ropes. The drains are 100 mm wide and 10 mm thick, each having four rope channel for hydraulic conveyance.

An apparatus conforming the in plane hydraulic conductivity test of ASTM D4716 was used for this purpose. The drains were tested under out of plane pressure to simulate their operational condition in the field . Drain specimens were enclosed in rubber membrane and two thin layers (5mm each) of sand was used on either face of the wrapped drains. This was done to transmit the pressure in the space between the rope channels. The tests were performed under three hydraulic gradients.The flow conditions were repeated for five levels of confining pressures.

The test data showing discharge as a function of hydraulic gradient for each confining pressure is shown in Figs. 5 and 6 respectively for drains with jute rope core and coconut coir rope core respectively. Figs. 7 and 8 shows respectively the reduction in discharge due to increase in confining pressure for different hydraulic gradients. A comparison of reduction in discharge ratio due to confining pressure for the two types of fibre drains is presented in Fig. 9. The results revealed the following, which is true for both the drain types.

a) There is, in general, reduction in discharge rate due to increase in pressure between 2 kPa and 90 kPa.

b) The discharge ratio, defined by discharge rate at any pressure divided by that at 2 kPa

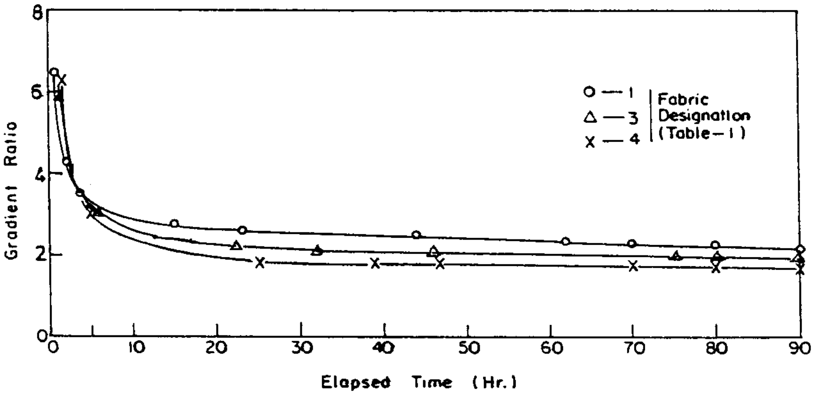

Fig. 4 Gradient ratio as a function of elapsed time for three fabrics

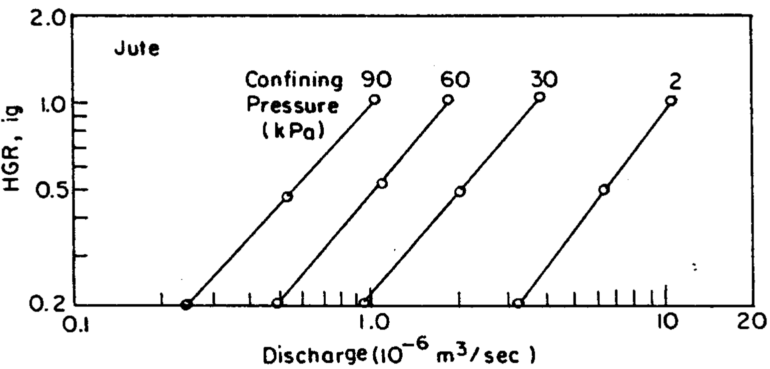

Fig. 5 Hydraulic gradient versus discharge plots as function of confining pressure for fibre drain (jute rope core)

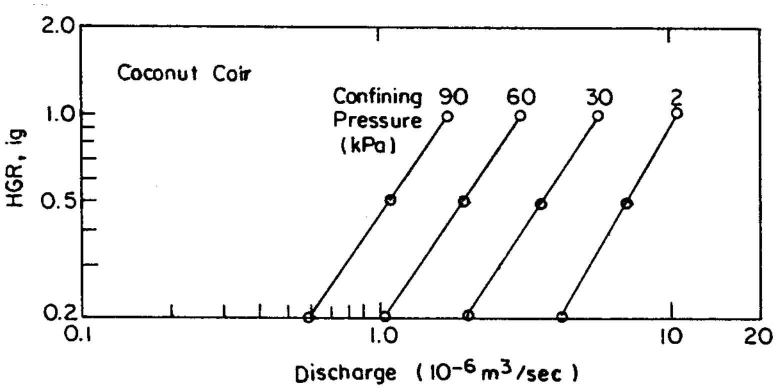

Fig. 6 Hydraulic gradient versus discharge plots as function of confining pressure for fibre drain (coconut coir core)

pressure, is almost independent of the imposed gradient.

c) The discharge ratio for wick drain with jute rope core at all pressures is lower than that with coconut coir. The difference was the maximum between 30 and 50 kPa pressure range.

6 CREEP TEST

Creep tests were performed on the canvas fabric under four different loading condition. The test procedure and data analyses presented by Kabir (1988) was followed.

The test data in dot form is presented in Fig. 10. The creep response equation may be written as

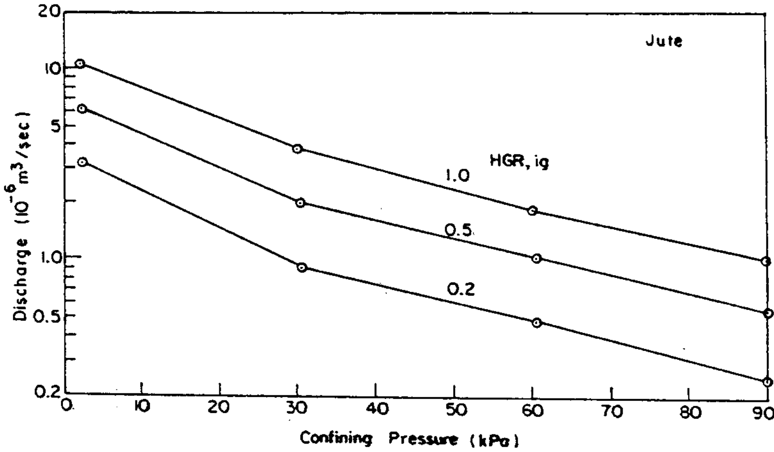

Fig. 7 Discharge rate as function of confining pressure for different hydraulic gradients (fibre drain with jute rope core)

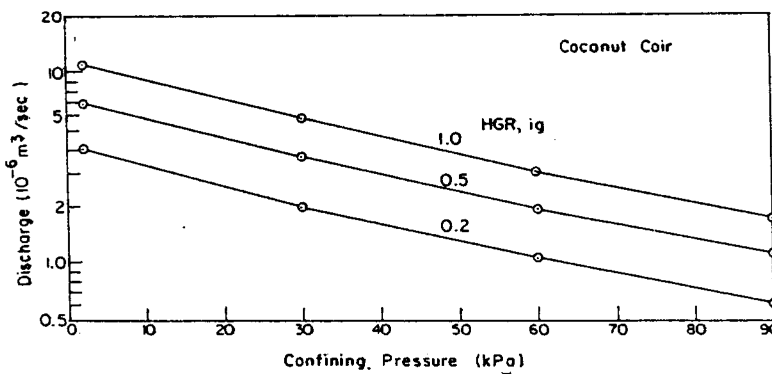

Fig. 8 Discharge rate as function of confining pressure for different hydraulic gradients (fibre drain with coconut coir core)

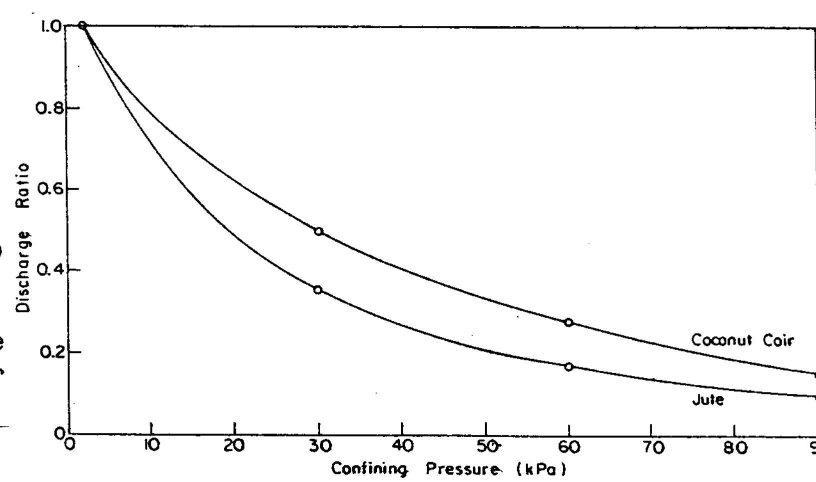

Fig. 9 Comparison of reduction of discharge ratio with confining pressure for two types of fibre drains

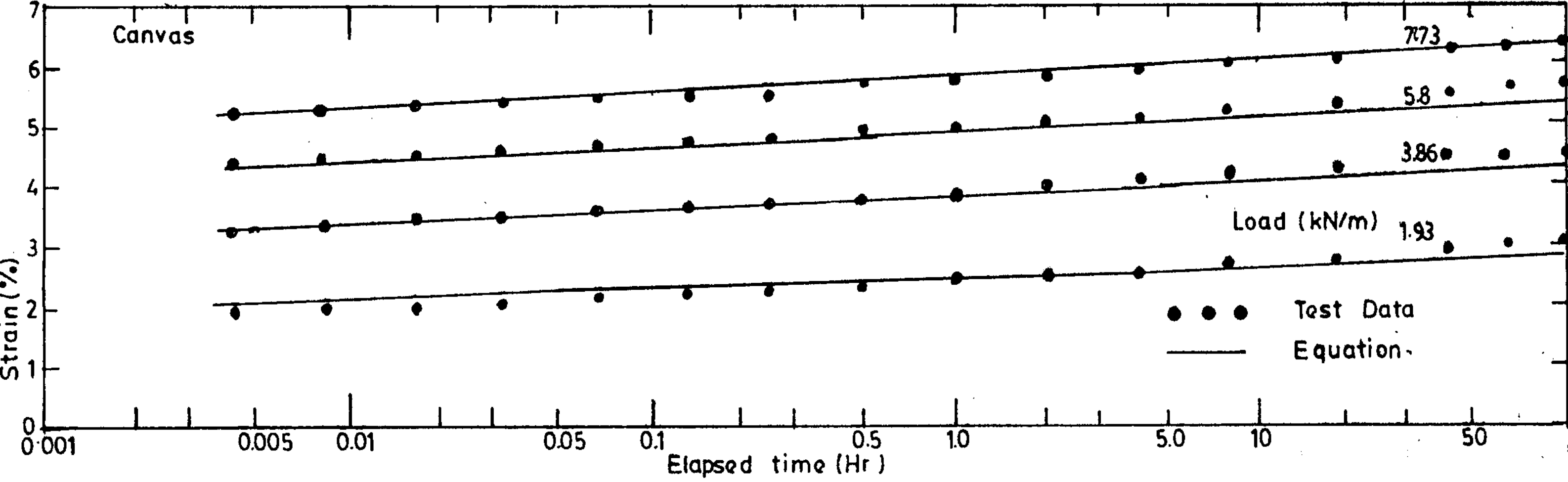

Fig. 10 Creep strain versus log time plots for canvas

$$\epsilon = \epsilon_o + \epsilon_t . t^n \qquad (2)$$

Where, ϵ is total strain
t is elapsed time
n is a material constant usually independent of load and time
ϵ_o is a function of load
ϵ_t is also a function of load

These are determined by using curve fitting technique forwarded by Kabir (1988).

Figs. 11 and 12 show the method of calculation of creep parameters n, ϵ_o and ϵ_t . For canvas fabric these parameters were obtained as:
$n = 0.0203$; $\epsilon_o = -2.752 + 0.822\ P - 0.099\ P^2 + 0.005\ P^3$; $\epsilon_t = 3.32 + 0.321\ P$; where P is the load. These values are valid only between load levels of 2 kN/m and 8 kN/m. The isochronous load versus strain diagrams are presented in Fig. 13.

The creep test results obtained from Eq. 2 are superimposed as continuous lines on Fig. 10 showing good agreement with the test data. The canvas fabric shows less susceptibility to creep, even less than polyester geosynthetics (Kabir, 1988).

7 CONCLUDING REMARKS

The hydraulic conductivity and creep tests on the grades of jute fabrics revealed the following.

a) Jute fabrics generally show non Darcy flow behaviour with the degree increasing as the porosity increases. The canvas fabric having small pores obeyed Darcys law.

b) The felt fabric suffered reduction in hydraulic conductivity due to increase in confining pressure. The order of magnitude is similar to those for nonwoven needle punched geosynthetics.

c) The canvas, twill and felt fabrics showed excellent hydraulic and mechanical filter effectiveness in filtering a very soft silty soil under a hydraulic gradient of about 2.

d) Creep behaviour of canvas fabric revealed the material to be less susceptible to creep, even less than polyester geosynthetics.

e) The curve fitting technique reported by Kabir (1988) has been proved to be a very versatile tool, which could produce satisfactory representation of creep behaviour of canvas fabric.

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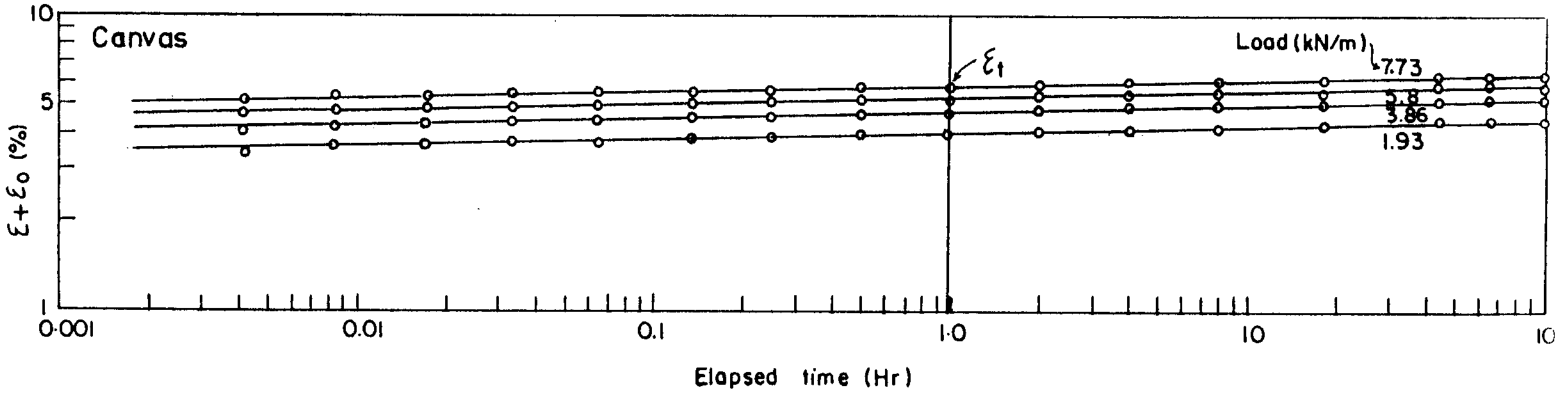

Fig. 11 Curve fitting of creep data of canvas to establish creep parameters

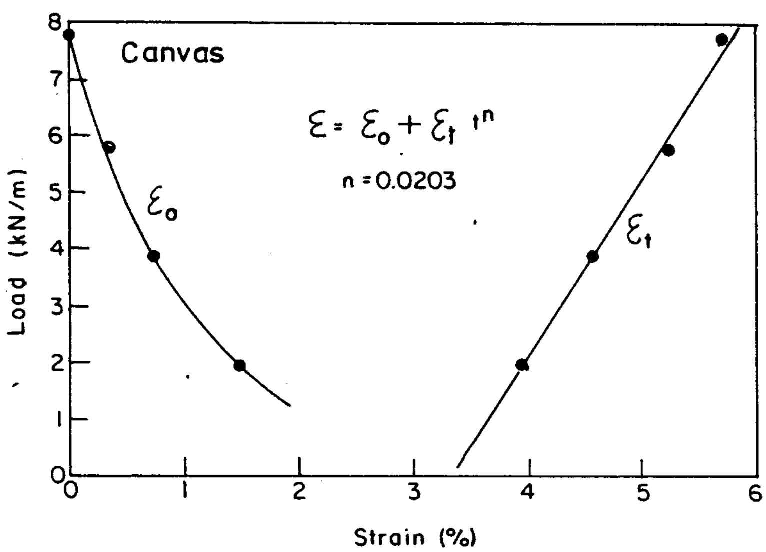

Fig. 12 Calculation of creep parameters of canvas

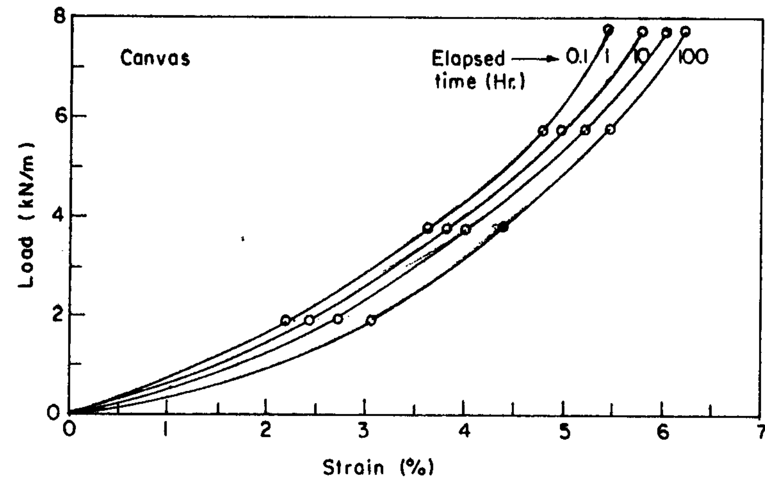

Fig. 13 Isochronous load versus strain diagrams for canvas

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