STRENGTH CHARACTERISTICS OF HOSTALEN GUR

By

AHMED GALAL EL-SAKKA

Department of Applied Mathematics, Faculty of Science,
Ain Shams University, Cairo

I. *Introduction :*

Hostalen GUR is a high-density polyethelene which is much denser, stiffer and more rigid than the soft polyethylenes and is suitable for application in plastic's industry. Here the strength properties of Hostalen GUR will be determined using the method suggested in I for determination of the elastic limit. The obtained results will be compaired with that obtained by the method used in references II. and III. In reference I the stress-strain curves are obtained from creep curves and therefore the strength characteristics of plastic may be obtained for any duration (say 1 ; 5 ; 10 ; ... minutes) of load application. The stress-strain curves which are so obtained are called stress-strain-creep curves.

II. *Stress-strain-creep curves for Hostalen GUR :*

The stress-strain creep curves will be constructed in the coordinates of true stress-true (or logarithmic) strain which are more meaningful and adequate specially in case of large strain. Therefore the creep curves must be obtained at constant true stress. The load applied to produce certain stress must be varied in proportion with the variation of the croos-sectional area of the tested specimen which undergoes large strain (more than 5%).

The modified 5 ton creep testing machine in Assiut Faculty of Engineering laboratory (see IV) is used to get the creep curves in case of constant true stress. The elongation is mesured by dial type extensometer (see Fig. 4 in I) which gives readings with accuracy up to 0,005 mm.

The creep test of Hostalen GUR at 0,5 ; 0,75 ; 1.0 ; 1, 25 ; 1, 5 ; 1, 75 ; 1, 85 Kp/mm^2 was carried out, the results of this creep test are represented on the strain time plane (Fig. 1), the strain axis

contains two scales to suit the different strain ranges. The tested Hostalen blocks are ordered from the Egyptian company of plastics and electricity in Alexandria. The specimens are produced from these blocks by turning and polishing. The specimen is of 10 mm. diameter and 60 mm. long, the guge length is 40 mm. The ends of the specimen are threaded according to M 16 to be fixed in the clamping rods of the machine (through a joint M 16/M20). The stress acting on he specimen has a constant true value.

After enough strain the load is removed gradually by the same velocity by which it is applied, the strain begins to decrease by different velocities in dependence of the value and duration of the stress σ_i . After complete removal of load the strain continues to decrease with time. The process of strain reduction with time due to removal of load is called recovery process.

Creep and Recovery of Hostalen GUR :

The stress strain creep curves will be constructed for Hostalen GUR at : 1 ; 5 ; 10 ; 20 ; 30 ; 45 ; 60 ; 90 ; 120 minutes after load application. For this purpose at the required instant (say at 20 mins) we draw on the strain-time plane a line paralled to the strain axis (see Fig. 1). This line will intersect the creep curves, at each intersection we can find the stress and the strain induced in the specimen after he considered period (20 mins). The relation between stress and strain induced in Hostalen GUR after certain period may be then determined.

The true strain $\bar{\varepsilon}$ is calculated from the ordinary one ϵ by the relation :

$$\bar{\varepsilon} = \text{In} (1 + \varepsilon)$$

The true stress-strain relations at different durations are represented graphically in Fig. 2).

III. *Study of the Stress-Strain Creep Curves of Hostalen GUR :*

To compair the suggested in I stress-strain creep curves which are obtained here fore Hostalen GUR and are shown in Fig. 2 with the recommended in II and III stress-strain curves obtained from an ordinary tension test, the last test was carried out on a Hostalen GUR specimen 10 mm. diameter and 55 mm. length. This ordinary tension test was carried out on the 500 Kp. tensile testing machine in Assiut Laboratory with a straining velocity equal to 20 mm. per minute. The load is measured by a pendulum mechanism, the least suitable weight of the pendulum was used.

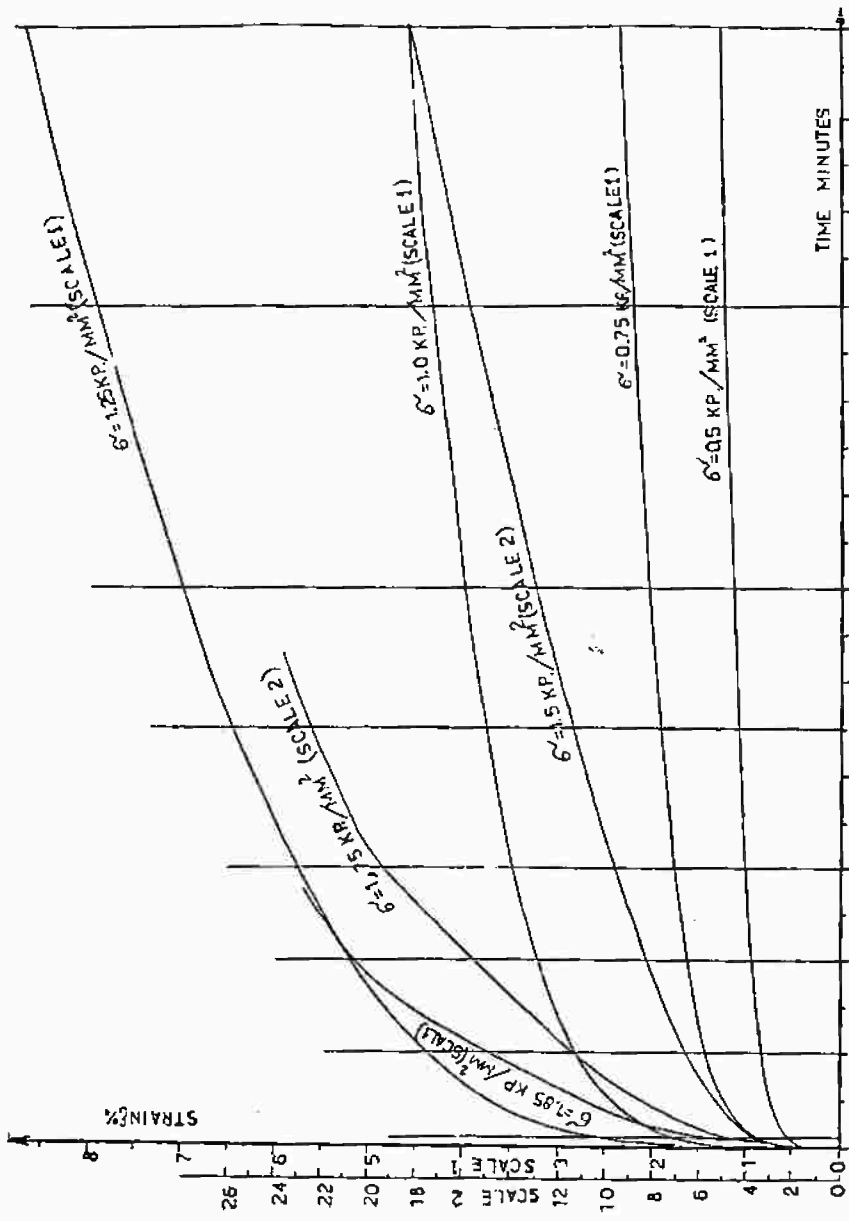

fig 1: CREEP CURVES OF HOSTALEN GUR

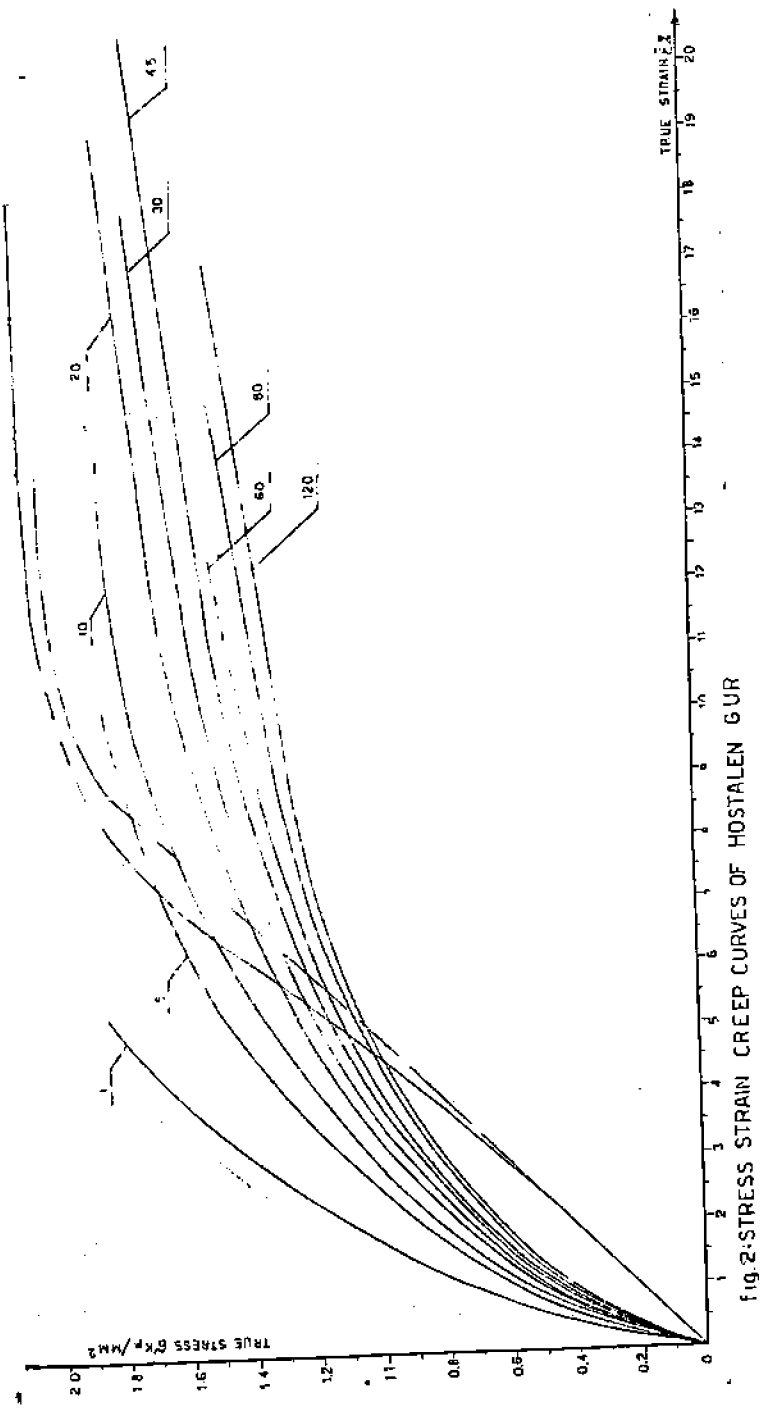

fig.2:STRESS STRAIN CREEP CURVES OF HOSTALEN GUR

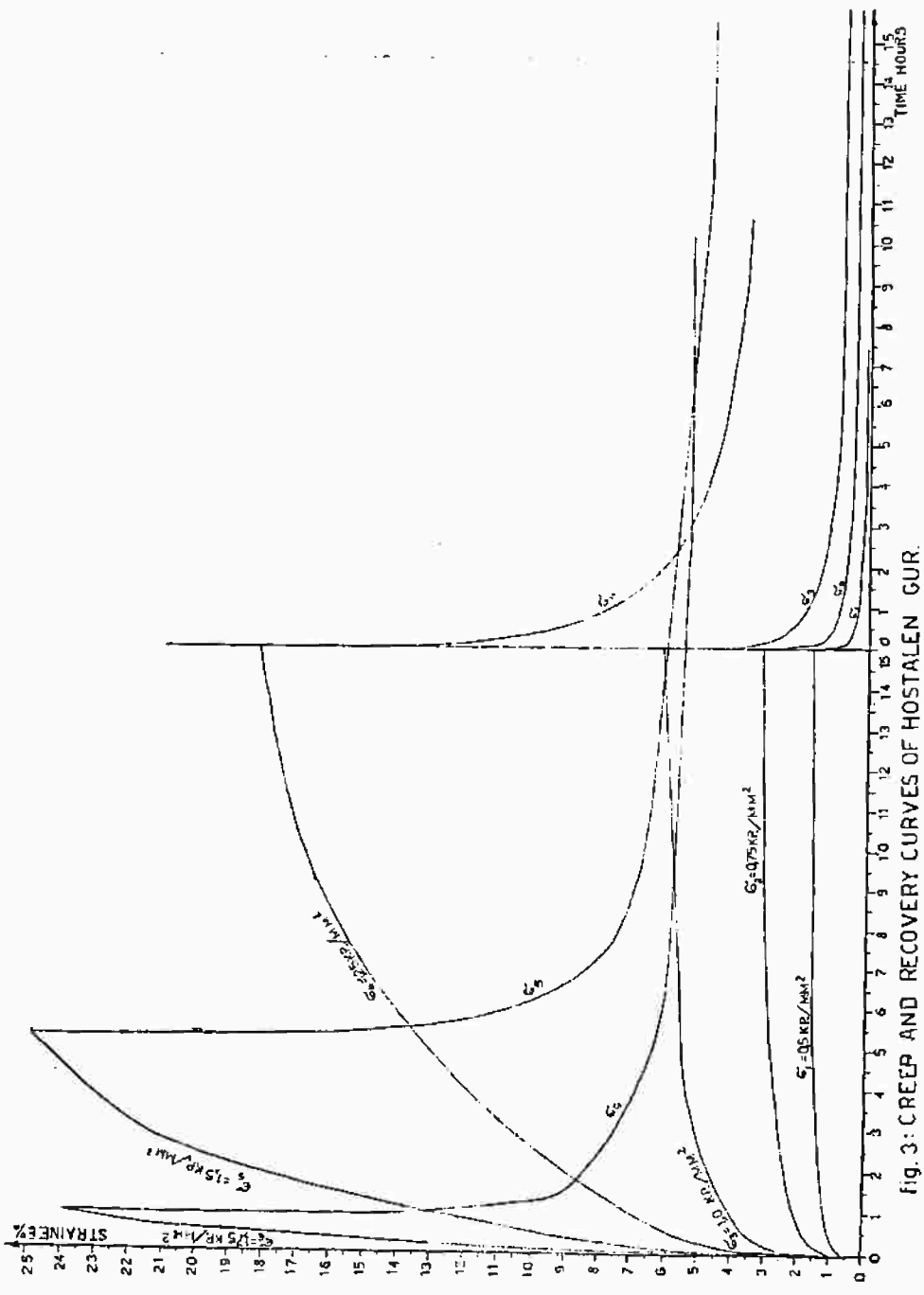

fig. 3: CREEP AND RECOVERY CURVES OF HOSTALEN GUR.

The true stress σ is calculated from the ordinary one σ_0 by the formula :

$$\sigma = \sigma_0 (1 - \mu \varepsilon)^2$$

where the value of Poisson's ratio μ is taken from the results of the test carried out for its determination for Hostalen GUR. The true values of Poisson's ratio $\bar{\mu} = \varepsilon_2 / \varepsilon_1$ are calculated.

It was found that Poisson's ratio μ depends very slightly on the strain and a mean value of μ for Hostalen GUR may be taken equal to $\mu = 0{,}47$. Even to 0,5 Kp/mm². A residual strain is noticed after load removal by a long enough period (about 7,5 hrs.), therefore the proportional limit 1,8 is devoid of physical meaning. Complete recovery of the origimal dimensions occurs after load removal by 30 minutes if Hostalen GUR is stressed only to a stress $\sigma = 0{,}25$ Kp/mm².

Let us now discuss the stress-strain creep curves (continuous curves in Fig. (2)) obtained for Hostalen GUR in comparison with the stress-strain curves obtained from an ordinary tension test (dash-dotted curves).

If the limit of proportionality is determined from dashed curve it will be approximately 1,8 Kp/mm². The stress-strain creep curves show no linear proportionality between stress and strain for all durations of load application. The proportional limit must determine to what extent the polymer behaves linearly and to what extent its deformation is elastic. As it is clear from creep and recovery curves (Fig. 3) if a Hostalen GUR specimen is stressed even to 0,5 Kp/mm², a residual strain is noticed after load removal by a long enough period (labout 7,5 hours).

A proportional limit with the explained above meaning (i.e. at which the load removal will cause absence of strain almost directly) if determined from the true stress-true strain curves will be less than 0,25 Kp/mm² (approximately 0,20) which is justified by the results.

Hostalen GUR in comparison with PVC (see. I) is 10 times weaker (in regard to the proportional limit), therefore it is not recommended to use Hostalen GUR in production of machine parts which are designed on strength or rigidity criterions.

IV. *Linear Superprosition Principle :*

Some relations between stress and strain for viscoelastic bodies are based on the principle of linear superposition (see I), therefore it

is important to check whether the material fulfils this principle. For this principle a test with stepped stress program was carried out on a Hostalen GUR specimen of 10 mm diameter, 55 mm length and 40 mm gauge length ; the steps of stress are 0,5 ; 0,75 and 1,0 Kp/mm².

The results of test are given where ε_s (t) is the strain calculated according to the libear superposition principle by the formula. :

$$\varepsilon_s (t) = \varepsilon_{0,5} (t) + \varepsilon_{0,25} (t - t_1) + \varepsilon_{0,25} (t - t_2)$$

where $\varepsilon_{0,5}$ (t) and $\varepsilon_{0,25}$ (t) are the strains at any time t due to a stress 0,5 (the strains obtained in this test will be extrapolated guided by the test and curve σ = 0,5 Fig. (1) and 0,25 Kp/mm². respectively, t_1 is the time at which the stress is increased from 0,5 to 0,75 Kp/mm² and t_2 is the time at which the stress is increased from 0,75 to 1,0 Kp/mm² ; $\bar{\varepsilon}$ % is the true strain as found from test. It was found that there is a large difference between the true strain values as found from test and strain values calculated on the bases of libear superposition principle.

ABSTRACT :

The suggested in I stress-strain-creep curves for determination of the strength properties of plastic are constructed for Hostalen GUR. It was noticed that stress-strain-creep curves differ sharply from stress-strain curves which are obtained from ordinary tension test as suggested in II and III.

It was found that the proportional limit determined by the method given in II and III is devoid of physical meaning since if a specimen of this Hostalen is stressed to this limit (σ = 1,8 Kp/mm²) it will not recover its original dimensions after load removal.

The stress-strain-creep curves show no linear proportionality between stress and strain expect for small stress values (less than 0,2 Kp/mm²). To check whether a Hostalen GUR specimen recovers its original dimensions if stressed to values higher than the limit obtained above (0,2 Kp/mm²), a creep and recovery test was carried out at a stress σ = 0,25 Kp/mm² and complete recovery is noticed only after 30 minutes which verifies that the proportional limit is still smaller as noticed from the stress-strain-creep curves.

As seen from item IV Hostalen GUR does not fulfil the linear superprosition principle.

RESUME

The suggested in I stress-strain creep curves for determination of the strength properties of plastecs are constructed for Hostalen GUR. It was found that the obtained stress-strain-creep curves differ sharply from stress-strain curves which are obtained from ordinary tension test as suggested in II and III. It was found also that Hostalen GUR does not fulfil the linear superposition principle.

References

I. Strength characteristics of plastics PVC. By Dr. Farouk Badran. Assiut Faculty of Engineering December 1971.

II. Designing with plastics : R.N. Peterson and R.H. Gender. Machine design sep. 20, 1962.

III. Design Fundamentals : Staff of technical servics laboratory. Machine Design 12, 1968.

IV. Modification of the creep testing machine Dst 5 ton to suit plastic testing. Dr. Farouk Badran, Assuit Faculty of Engineering. December 1971.