The study of properties in consideration of the structure of the material due to their profound interrelationships is one of the fundamental problems in the modern study of materials. The combination of physical and mechanical approaches in studying the failure and deformation of different classes of materials has recently been characteristic. An example of the combination of structural and phenomenological approaches in the study of failure of metals is [1].

The carrying capacity of articles made of polymers and polymeric composites is tested with two limit states: the limit strength and the limit deformability. The physical aspect of failure of polymeric materials has been the subject of many studies, and the recent advances in this area are summarized in [2]. Some success has been attained in understanding the molecular mechanism of the deformation of glassy polymers [3]. The combination of the two approaches noted in studying the mechanical behavior of polymeric materials has been used to a lesser degree [4].

In the examination of the deformational properties of solid cross-linked polymers, the physical approach is complicated by the difficulty of selecting the structural parameters. Actually, the basic parameter of the structure of a cross-linked polymer—the molecular weight of the chain segment between points $M_g$—characterizing the features of the structure is determined in the highly elastic state. An assessment of the mechanical behavior is required for the glassy state as the most characteristic with respect to the practical application of solid polymers.

It is pertinent to note here that the deformational properties of polymers are sometimes examined based on concepts of the different levels of structural organization of amorphous polymers. However, in most cases, this approach is used without the quantitative characterization of the parameters of the supermolecular structure, and a reliable correlation of this structure with the strains has not been established. For this reason, we will use the generally accepted characteristics of the structure of the condensed state in the present study: the thermal motion of the structural units, the intermolecular interaction (IMI) between them, and their packing density [5]. This approach corresponds to the results of studies [6] in which the deformational properties of densely cross-linked polymers in the final analysis are determined by the molecular structure. However, there are still very few data which reveal this correlation.

In consideration of the above, the question is examined on the example of two epoxy polymers (binders) with significantly different values of $M_g$. The structure of the polymers was regulated by using curing agents with a different structure with the same composition of the resin (ÉD-20 epoxy resin). An attempt was made to examine the effect of the value of $M_g$ on the structural parameters of the glassy state. The structural parameters were estimated based on the simplest tests of the same type: taking the strain diagrams in a wide range of rates of deformation and temperatures. All tests were performed on an Instron universal machine. For brevity, designating the binder with the more widely spaced network as polymer 1 and the binder with the more closely spaced network as polymer 2, let us turn to a discussion of the data.

The thermomechanical curves of the polymers examined, which qualitatively give a representation of the difference in the density of the chemical network, are shown in Fig. 1a. The values of $M_g$, determined from the equilibrium values of the viscoelastic modulus, differed by approximately two times [7]. We note one feature here: Similar values of the softening point and glass transition temperature are possible with a different density of the chemical network (Fig. 1f), which indicates the significant role of the IMI in the formation of the

*Presented at the Sixth All-Union Conference on the Mechanics of Polymer and Composite Materials (Riga, November, 1986).
physical properties of cross-linked polymers. The measurements show that significantly higher values of the proportionality and creep limits correspond to polymer 1 (Fig. 1b).

The quantitative analysis of the $\sigma - \varepsilon$ diagram is usually completed with its segment before the creep limit (induced elasticity) $\sigma_1$ is attained, and the segment of the diagram after the maximum, characterized by a decrease in the stress, is examined very little with respect to the structure, although the conclusion concerning the determining effect of structural factors in its appearance raises no doubts [8].

On the example of cross-linked polymers, it was shown in [9] that a decrease in the stress $\Delta \sigma$ in the $\sigma - \varepsilon$ diagram characterizes the mobility of the network under the effect of stress. The subsequent examination showed [10] that the dependence $\Delta \sigma / \sigma_1 - T$ exhibits certain features: its character is similar to the dependence $\tan \delta - T$, and the maximum corresponds to some characteristic temperature $T_2$ in the dependence $\sigma_1 - T$ (see Fig. 1c). The data indicate that the height and shape of the peak of $\Delta \sigma / \sigma_1 - T$ (Fig. 1c) correlate with the character of the thermomechanical curve: the narrow temperature range of the transition in the dependence $\varepsilon - T$ corresponds to the narrower and higher peak of the curve of $\Delta \sigma / \sigma_1 - T$. A similar correlation is also observed with the creep curves (Fig. 1d). This suggests that the usual $\sigma - \varepsilon$ diagram contains information on the molecular mobility which can be quantitatively expressed by parameter $(\Delta \sigma / \sigma_1)_{\text{max}}$. It is characteristic that the order of magnitude of $(\Delta \sigma / \sigma_1)_{\text{max}}$ corresponds to the value of $\tan \delta_{\text{max}}$ for the given class of polymers, and there is a proportional correlation between the resistance to deformation, where the value of $\sigma_1$ can be an index, and parameter $(\Delta \sigma / \sigma_1)_{\text{max}}$ (Fig. 2).

The widely known equation which correlates the creep rate $\dot{\varepsilon}$ in the conditions in which it was established with the stress $\sigma$ and temperature $T$ will be used for the quantitative characterization of the IMI in polymers

$$\dot{\varepsilon} = \dot{\varepsilon}_0 \exp \left( - \frac{Q_0 - \alpha \sigma}{RT} \right). \quad (1)$$

The creep limit $\sigma_1$ corresponds to the stress at which a given rate of deformation becomes equal to the "flow" rate $\dot{\varepsilon}$; thus, based on (1)

$$\sigma_1 = \frac{Q_0}{\alpha} - \frac{2.3RT}{\alpha} \lg \frac{\dot{\varepsilon}_0}{\dot{\varepsilon}}. \quad (2)$$

A profound physical meaning can be given to activation parameters $Q_0$ and $\alpha$, determined from the data on creep [3]. We will show that a similar analysis is also possible from the results of tests with a constant loading rate.