A method of primers is elaborated which allows one to calculate the distribution function of durability of a composite material in tension in the reinforcement direction. Integral and differential equations for calculating the probabilities of formation of primers and destruction of a material caused by their formation are presented. Distribution functions of material strength for the parameter of Weibull distribution of fiber strength on the interval $2.1 \leq \beta_f \leq 50.1$ are calculated. From the functions, the average values and root-mean-square deviations of material strength are found. The results obtained agree well with calculations by using the structural-imitation simulation. The distribution functions of material strength with a high precision are approximated by the three-parameter Weibull distributions. The distribution parameters are approximated by the linear functions of $\ln(\beta_f)$.

Models of destruction of a unidirectional composite material (CM) in tension along the reinforcement direction, as a rule, have a probabilistic character. Such an approach is possible because the structure of this material is rather simple, and the probabilistic characteristics of the fibers taking up the basic part of a load are known.

It is usually assumed that a CM fails as soon as some of its parameters reach a critical value [1-6]. As a rule, it is impossible to present a rigorous substantiation of the validity of such a criterion. The agreement with experiments is achieved only in a narrow range of parameters of CM components.

In the present study, an attempt was made to directly calculate the probability of destruction of the material. For calculations, we adopted the model elaborated by H. E. Daniels, B. W. Rosen, and C. Zweben, according to which a CM in tension can be imagined as a chain whose links are material layers (cut perpendicularly to the reinforcement direction) of length $\delta$ equal to two inefficient lengths of the fiber. The destruction of fibers in this layer is considered. Upon break of a fiber, the latter is loaded again at its ends by the shear stresses of matrix on a total length $\delta$. As a result of the break, the neighboring fibers become overloaded on the same length $\delta$, which, with increasing stress, can cause their rupture. At some loading stage, this leads to an avalanche-type destruction. Outside the layer $\delta$, these breaks of fibers do not affect the destruction of the layer considered. The material fails if at least one link (layer) is broken.

As in [5], the problem was solved with the following assumptions.

1. The hexagonal arrangement of fibers is accepted. The six fibers neighboring to a considered one are regarded as the nearest to it.
2. The overloads associated with the dynamic effects arising in the destruction of fibers and with their separations from the matrix are excluded from consideration.

3. For solving the problem, we must know, for any group of broken fibers, how the loads from them are redistributed on the surrounding ones. But this is known only for some, most simple, cases; therefore, in our calculations, the simplified scheme suggested in [7] is adopted. According to it, the load from a broken fiber is uniformly redistributed on its six neighbors. If some of them are broken, they do not take up the load, and it is redistributed on the adjacent fibers. The process proceeds until the loads from the broken fibers get redistributed on the unbroken ones and those remaining in the broken fibers become negligibly small. Contrary to [7], in the present study, it is assumed that all the load is transferred from the broken fiber to the neighboring ones, i.e., each fiber takes up a load \( P/6 \), where \( P \) is the load on the broken fiber. At a great number of broken fibers, this assumption seems more valid.

4. The probability of failure of a fiber of length \( l \), at stresses smaller or equal to \( \sigma \), is described by the two-parametric Weibull distribution

\[
F(\sigma) = 1 - \exp \left(-\lambda(\sigma) \cdot L\right) \quad \lambda(\sigma) = \frac{1}{\bar{\sigma}_L} \left(\frac{\sigma}{\bar{\sigma}_L}\right)^{\beta_f} \Gamma\left(1+\frac{1}{\beta_f}\right),
\]

where \( \sigma \) is the stress in the fiber; \( \bar{\sigma}_L \) is the average value of fiber strength on the length \( L \); \( \beta_f \) is the parameter of Weibull distribution.

The results obtained by calculating the probability of failure were compared with those obtained by the method of structural-imitation simulation (SIS), in which precisely the same model of destruction of the material was used. The SIS method is described in a great number of studies. The existing models are adequately covered in [7, 8]. In each SIS computer experiment, defects in constituents of the material are arbitrarily specified, and then the stress growth in the material, the corresponding initiation and accumulation of damages, and the subsequent avalanche-type destruction are simulated. By performing a sufficiently great numbers of experiments, the statistical characteristics of material strength can be obtained. The SIS allows one to check the reliability of analytical calculation methods.

1. Calculating the Probability of Destruction of a CM

Let us consider groups of broken fibers forming a joint break in a layer \( \delta \). Each of the fibers borders on at least one fiber from this group. The joint break of \( r \) fibers at which the break of one of the fibers occurs on a given section of length \( \Delta l \ll \delta \) is called the primer of multiplicity \( r \). We may say that the primer is related to this section. Primers of the same multiplicity differ in fiber arrangement (configuration) and in the sequence of breaks in them.

For convenience, we introduce the parameter \( t = \lambda(\sigma)\delta \). Then, the distribution of the probability of break of an \( \bar{\sigma}_l \) fiber with a constant overload factor \( k \), at \( t \geq 0 (\sigma \geq 0) \), is given by

\[
F_i(t) = 1 - \exp \left(-k^0 t \right) \quad \sigma_i = k \sigma,
\]

where \( \sigma_i \) is the stress in the \( \bar{\sigma}_l \)th fiber and \( \sigma \) is the stress in nonoverloaded sections of this fiber.

The destruction of a material caused by different primers relating to a given section of length \( \Delta l \) are inconsistent events; therefore, the probability of material failure \( P_m(t, \Delta l) \) from the primers related to \( \Delta l \), at a stress in the fibers smaller or equal to \( \sigma \) (and the value of \( t \) corresponding to it), is

\[
P_m(t, \Delta l) = \sum_{r=1}^\infty P_m^{(r)}(t, \Delta l), \quad P_m^{(r)}(t, \Delta l) = \sum_{s=1}^{nrs} P_{m,s}^{(r)}(t, \Delta l), \quad nrs = ns(r) \cdot r!.
\]

Here, \( P_m^{(r)}(t, \Delta l) \) is the probability of destruction of the material from the formation of various possible primers of multiplicity \( r \); \( P_{m,s}^{(r)}(t, \Delta l) \) is the probability of destruction of the material in an \( \bar{\sigma}_l \)th realization of a primer of multiplicity \( r \); \( nrs \) is the number