INTERACTION BETWEEN TWO NEIGHBORING CIRCULAR HOLES IN A PRESTRETCHED SIMPLY SUPPORTED ORTHOTROPIC STRIP UNDER BENDING

S. D. Akbarov,*,** N. Yahnioglu,* and U. Babuscu Yesil\

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In this work, the influence of initial stretching of a simply supported plate-strip containing two circular holes on the stress concentration around the holes caused by bending of the strip is examined using the finite-element method. The mathematical formulation of the corresponding boundary-value problem is presented within the framework of the three-dimensional linearized theory of elasticity (TDLT) under a plane strain state. The material of the plate-strip is linearly elastic, homogeneous, and orthotropic. The numerical results obtained in investigating the influence of the initial stretching and the location of holes on the stress concentration are presented. In particular, it is established that the initial stretching significantly decreases the stress concentration at some characteristic points on the contour of the holes.

Introduction

Investigations into stress concentrations around holes have many applications in almost all branches of engineering. There are many monographs, such as [1], that contain results of these investigations. Reviews of the above-mentioned research are given in [2-7], from which it follows that there are no studies on the influence of initial stresses arising as a result of initial stretching or another type of initial loading on the stress concentration caused by an additional loading in the case where the superposition principle is inapplicable. Here, the inapplicability of the principle means that the stress field caused by the additional loading significantly depends on the initial loading. The theoretical investigation of the phenomenon requires the use of complicated geometrically nonlinear equations of the mechanics of deformable bodies. However, according to the well-known mechanical considerations, in the cases where the magnitude of the initial loading is greater than that of the additional one, these investigations can be carried out within the framework of the three-dimensional linearized theory (TDLT) [8, 9] of deformable bodies. In [10], an attempt was made in this field, and the influence of initial tension of a simply supported strip, containing a rectangular hole with rounded-off corners, on the stress concentration around the hole caused by bending of the strip under the action of uniformly distributed normal forces on its upper face was examined. In the present paper, this investigation

is developed for the case where a strip contains two circular holes, and the material of the strip is orthotropic. It should also be noted that, for example, in monograph [11], similar problems were investigated for cracked elastic bodies. Therefore, in a certain sense, the present investigation can also be viewed as a development of the investigations reported in [11], where the initial stress state was assumed to be homogeneous, and an infinite medium containing cracks was considered. However, in the present investigation, the initial stress state is inhomogeneous, and the region containing the holes is bounded. The corresponding boundary-value problems are solved numerically by employing the finite-element method (FEM) [12]. For this purpose, the version of FEM developed in monograph [13] is used.

**Formulation of the Problem**

Consider a plate-strip containing two circular holes. The geometry of the strip is shown in Fig. 1. The Cartesian coordinate system $Ox_1x_2x_3$ is associated with the strip so as to give Lagrange coordinates in the initial state. Assume that the plate-strip occupies the region shown in Fig. 1, and the $Ox_3$ axis is directed along the normal to the $Ox_1x_2$ plane.

Suppose that the material of the strip is orthotropic with symmetry axes $Ox_1$, $Ox_2$, and $Ox_3$. The strip is simply supported at its ends, and, in the initial state, uniformly distributed normal tensile forces of intensity $q$ act on these ends. Additional uniformly distributed normal forces of intensity $p (<< q)$ act on its upper face. The influence of the initial stretching on the stress concentration around the holes caused by the additional forces is investigated below. Henceforth, all quantities referring to the initial state will be labelled by the superscript $(0)$.

According to the above-stated, the initial stress state can be determined by solving the following boundary value-problem: