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DEVELOPMENT AND OPTIMIZATION OF A DEPTH SENSOR FOR MONITORING THE STRESS-STRAIN STATE OF BUILDING STRUCTURES

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This article describes ideas for developing and optimizing a depth sensor for monitoring the stress-strain state of building structures. Models of depth sensor housings in Ansys are presented. Simulation results are presented. A disk-shaped depth sensor will produce the smallest stress concentrator.

Concrete failure is known to be associated with the formation and development of micro- and macro-cracks under load. The initial microcracks are caused by stress concentrations near structural defects such as pores, inclusions, and dislocations. Concrete failure begins with the development of cracks in the matrix-aggregate contact zone, which then extend into the matrix. Contact cracks develop under the influence of shear displacements, while matrix cracks develop under tensile displacements. In low-strength concrete, cracks bend around the aggregate grains, oriented at an angle to the compressive forces at the contact, and parallel to them in the matrix. In high-strength concrete, cracks cut through the aggregate grains and are directed parallel to the compressive forces [1].

Based on the above, it is necessary to determine how to control crack growth, including main cracks. A main crack is a crack whose length exceeds the dimensions of the structural components of the materials and the areas of self-equilibrated stress, and along the surfaces of which the specimen will be divided into parts [2].

There are two methods for monitoring main crack growth: destructive and indirect. The disadvantages of the destructive method include the requirement to take a sample from an already operating building, which may not always have a positive impact on the structure itself. This method is also quite expensive. An advantage is that testing the sample will yield a more accurate result.

The disadvantages of these research methods include the fact that the data may differ from the actual readings, but there are methods that provide accurate readings. One such method is the use of depth sensors.

Currently, a composite strain gauge for embedding in concrete is known. Its operation is based on the principle of strain gauges. Its housing contains two strain gauges. The sensor itself has a two-layer, sealed housing. The first layer covers the strain gauges, and the second layer surrounds the rod and the layers. The layers are composed of silicone [3].

This work also uses a strain gauge. This type of sensor operates using various types of strain gauges. A strain gauge is an element whose resistance changes depending on the strain [4].

The main problem with a depth gauge is that it acts as a stress concentrator, which in turn leads to deformation and compromises the integrity of the object. The issue of corrosion resistance also arises. A steel or iron sensor in a concrete environment will initiate corrosion.

A 3D-printed depth gauge housing made from recycled PET bottles will solve all the above problems.

The ANSYS Workbench software helped optimize the sensor housing, which acts as a stress concentrator. Ansys Workbench is an integration and workflow platform that connects Ansys products. The project framework allows users to customize simulation processes, optimize studies using parametric control, submit tasks to the solver both locally and remotely, and add APIs that enable the use of third-party software [4].

Ansys uses the finite element method. A disadvantage of this method is that, due to ANSYS's matrix-based solution, it requires a powerful computer, even for older versions of the software. This product has previously been used for testing asphalt concrete cores and other applications [5]. This software was used to optimize three geometric shapes: a sphere, a disk, and a cylinder.

To test the geometric shapes for the depth sensor, the "Static Structural" graph was selected (Figure 1). Three housing models were pre-built for testing.

After opening “Static structure”, I was asked to select a material (Figure 2) and create a “body” (Figure 3), and the material for it was selected – concrete, which is included in the basic ANSYS Workbench package.

After testing, the following stress results were obtained: disk – 0.0066466 MPa; cylinder – 0.0071466 MPa; ball – 0.0097554 MPa. Thus, the disk will be the smallest stress concentrator.

Figure 1. – Ansys software interface

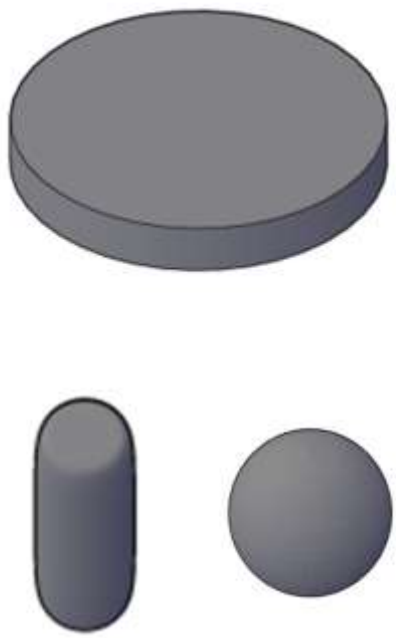

Figure 3. – Types of sensor housing models

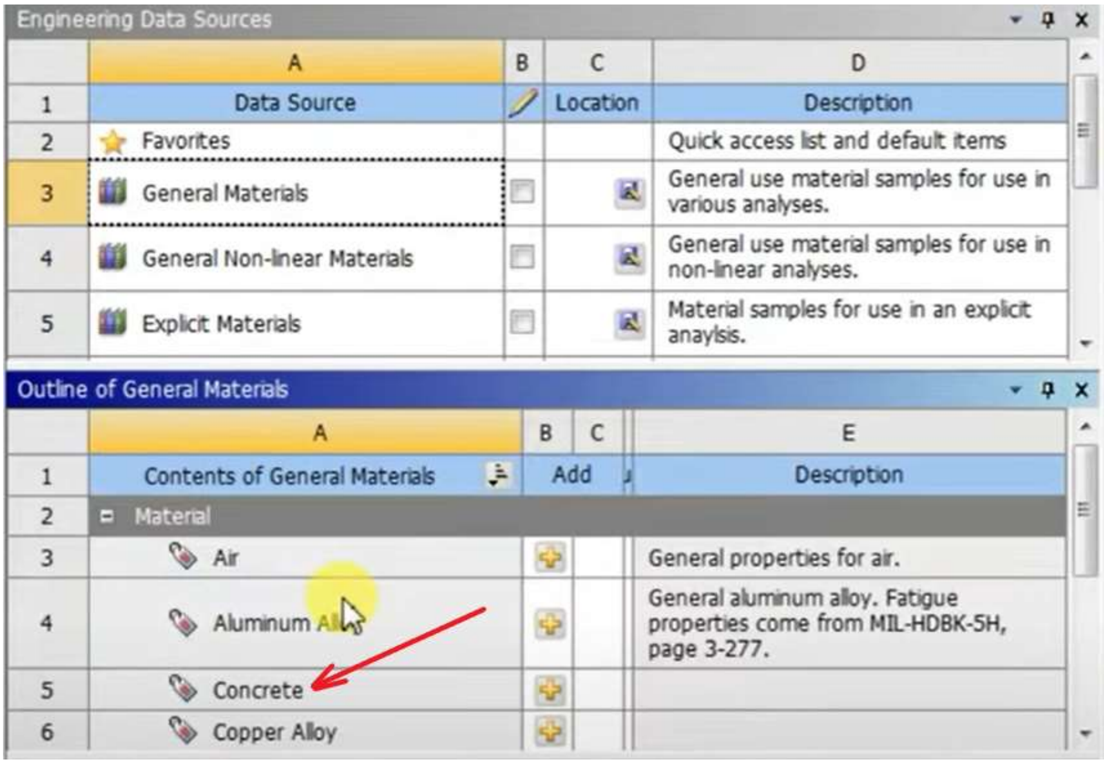

Figure 2. – Ansys Product Material Selection Interface

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