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Two Dimensional Stress Analysis by Photoviscoelasticity

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The photoviscoelastic materials such as the polyurethane rubber have a significant time- and temperature dependence mechanically as well as optically. Therefore, in order to perform the practical analysis of viscoelastic stress or strain optically, mechanical and optical characterizations of the materials are required. In other words, it is necessary to determine the time- and temperature dependent visco- and photoviscoelastic coefficients.

On the basis of the consideration that the "Correspondence Rule" concerning the mechanical behavior of viscoelastic materials originally proposed by Alfrey may be also applicable to their optical behaviors if the materials are linearviscoelastic, the reseach group of several viscoelastic materials by mathematical interconversion of the experimental data obtained from the constant strain rate testing.

In the experiments, the polyurethane rubber was employed as the material specimens which is linearly viscoelastic, thermorheologicalsimple, incompressible and fairly transparent.

Mechanical and optical characterizations of this material essential to the practical photoviscoelastic analysis have already been carried out by two different kinds of experiments: i.e. constant strain rate- and creep testings. It was found that the both results from these experiments agreed fairly well with each other. This teaches us that the polyurethane rubber employed here has linearly photoviscoelastic properties, because the methematical interconversion from one to another can be allowed under the condition of existence of its linearity. Thus, the performance of the photoviscoelastic analysis is possible by using this material after the experimental determination of its various characterization coefficients. Also, a new collocation method somewhat different from that by Schapery was proposed in the mathematical interconversion.

In this thesis the practical photoviscoelastic analysis was carried out on two problems, employing the polyurethane rubber mentioned above. The first problem was a static two-dimensional strain analysis, that is, a square plate with a central hole was loaded non-proportionally* on the adjacent side under a condition of a constant temperature at which the material showed fair viscoelastic behavior. Generally speaking, the axes of principal stress, principal strain and polarization of light do not always agree with one another for the photoviscoelasticity. The variations of

* Non-proportional loading means that the distribution pattern of the load varies with time.

the fringe patterns of isoclinics and isochromatics with time were recorded by a camera used for the ordinary photoelastic techniques. Thus, the principal stress difference, and the axes were obtained from experimental data. It was found that these results agreed quite well with the theoretically calculated results.

The second problem was concerned with the analysis of stress wave propagation. Dynamic stress concentration due to viscoelastic wave was analyzed for a prismatic bar with a hole. Also the analysis of the stress wave through a simple prismatic bar having no hole was preformed for the purpose of their comparison. The bars were loaded impactly by shock waves at various constant temperatures. The fringe patterns of the specimens were recorded by a camera at various time intervals from the impact, using „Delayed Synchro Flash" and the ordinary photoelastic equipment. The time-varying stress was calculated from the experimental data and photoviscoelastic coefficients. From these results, it is found experimentally that the dynamic stress concentration due to a hole is smaller than the corresponding static stress concentration for a small initial period of time immediately following impact, and the former tends to approach the latter as time increases. Furthermore, such a tendency comes to occur more quickly as the temperature falls down.