I-88 NEW PHOTOELASTIC METHOD FOR ANALYSIS OF STRESS AND STRAIN IN MASSIVE STRUCTURE MODELS USING LASER-LIGHT-SHEET

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1. INTRODUCTION

The earthquake resistant design of massive structures such as fill-type dams, tunnels in soft soil deposits, and so on, requires the full comprehension of their dynamic behavior. Although conventional photoelastic methods can provide us with useful information on the analysis of these kind of structure models, this information is not enough to determine completely stress distribution in a model. Here, a new photoelastic method developed by the authors using a Laser-Light-Sheet (LLS), which yields further information about stress condition, is described.

2. PROCEDURE OF EXPERIMENT

In the method a LLS can be passed through the model at any arbitrary section, without destroying the model, thus slicing is done optically, (Fig. 1). This laser light is scattered by the fine particles on the cross section of the model. Since the scattered light is plane-polarized, it can be used to produce a plane-polarized source of light inside the model. This scattered light is resolved into two components along the directions of the principal stresses. These two components emerge from the model with a relative phase retardation proportional to the cumulation of $\sigma_2-\sigma_3$ over the distance (x_0-x_a). This phase retardation can be observed as a photoelastic fringe pattern through a polarizing element (analyzer) put outside the model. If the LLS is moved a small distance Δx, the change in retardation determines the state of stress between the plate element sliced optically by the two planes of scattering.

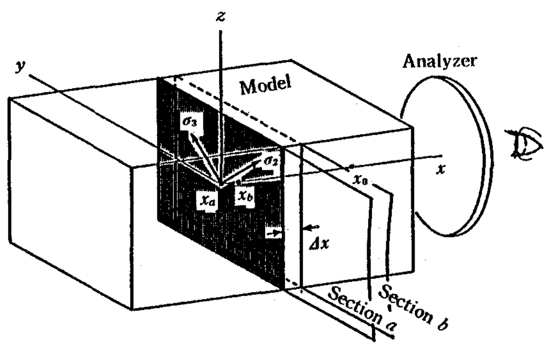


Fig. 1 Proposed Method Using LLS

3. VERIFICATION OF THE PROPOSED METHOD

Fig. 2 shows the optical system used for the experiment. Polarized light source for a conventional photo-elastic method is replaced by LLS. Thus, the observed fringe pattern must coincide with that by the conventional method if the LLS passes through a 2-dimensional model sweeping its backside. The model for the verification is a block (20cmx20cmx12.5cm), made of gelatin with a 10-percent concentration. This model was deformed by its own weight. The observed fringe pattern by the conventional 2-dimensional technique, together with that by the proposed method, are shown in Fig. 3. Good agreement between these fringe patterns validates the present technique. Crossed isoclinic lines, associated

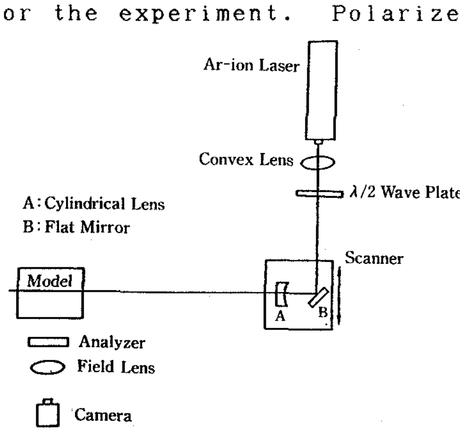
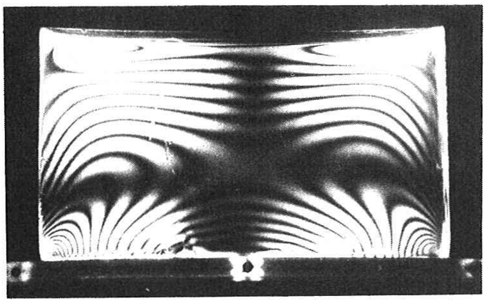
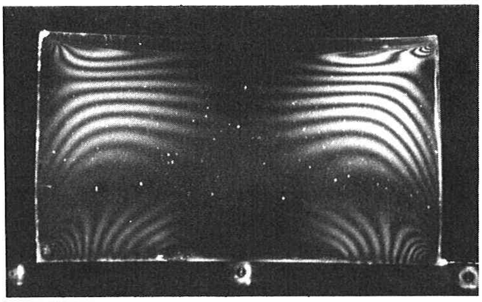


Fig.2 Optical Elements Array



(a) Conventional Photoelasticity



(b) Proposed Method

Fig.3 Verification of the Proposed Method

with the direction of the principal stress, are superimposed in both pictures. Fig. 4, shows the change of fringe pattern with the change of position of the incident LLS. Fringe order is gradually decreasing as the distance from the LLS to the surface facing the analyzer decreases. As was noted before, this change of fringe order is proportional to the principal stress difference in this optically-sliced model.

For the sake of comparison, the fringe pattern produced when a rigid disk (r=3cm, W=425grf) was put on the surface of the model, is shown in Fig. 5(a), while Fig. 5(b) shows the fringe pattern obtained by using the conventional scattered light method.

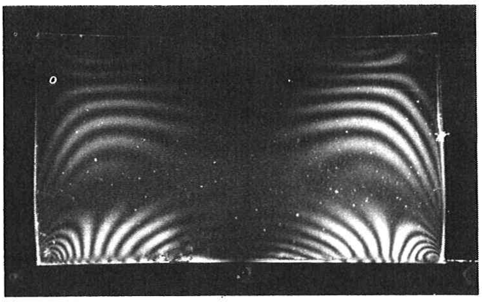
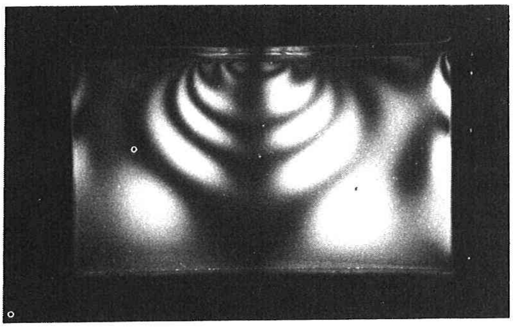
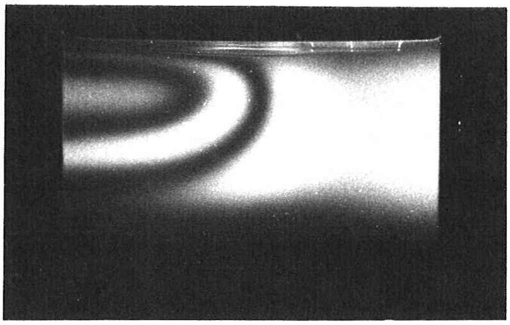


Fig.4 Fringe Pattern at a Different Position of the LLS for block of Fig. 3



(a) Proposed Method



(b) Conventional Scattered-light Method

Fig.5 Fringe Pattern Appareance

4. REMARKS

The procedure has the advantage of giving the same stress information as in the conventional stress freezing method without destroying the model (optical slicing). Contrary to the scattered-light method, this technique yields stress information in a plane parallel to the LLS, so the use of both methods will be powerful in studying 3-dimensional stresses in massive models.