SELECTING THE OPTIMUM LOADING CONDITIONS FOR GLASSES AND LIGHT-SENSITIVE GLASSES WHEN TESTING THEM IN COMPRESSION

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At the present glasses having high strength in compression [1] are used mostly in lightly loaded structures, where the high strength is only utilized in part. This is explained by the small amount of investigation devoted to questions of the strengths of both glasses and also light-sensitive glasses based on them, and also by the absence of a practical test for the use of these materials in highly stressed articles.

It has been shown in [1] that, with the proper measures for reducing the contact stresses during testing in compression (in particular the preliminary cementing of the glass testpiece ends into the sockets of the metal yokes) it is possible to approach closely the true compressive strength, which in this case depends only slightly on the concentration and high contact stresses in contrast to loading by plane metal bearings [1, 2]. In addition to this the selected cement composition and cementing parameters have an important bearing on the results obtained in achieving comparable optimum strengths which are independent of the compressive effect of the yoke.

The purpose of this work was to conduct tests with the aim of selecting the optimum edge conditions during the transmission of compressive loads to glass and light-sensitive glass testpieces, and also to determine the effects of end cementing depths in the yoke, the length of the working section and its shape, on the breaking point during compression.

Tests were carried out on cylindrical, tubular, and prismatic testpieces of type 23 lithium light-sensitive glass, type STM-1 magnesium light-sensitive glass, type 13v glass, and transparent quartz tubes (wall thickness 3 mm), in which the diameters or the side of the base were equal to 10 mm and were one third of the height, and also plate testpieces of type 23 lithium light-sensitive glass, window glass, and epoxy resin models of dimensions 5 × 22 × 22 mm. The cylindrical and tubular testpieces of type 13v glass and transparent quartz tubes had fire-polished side surfaces, whilst the remainder of the testpieces were machined with a diamond tool over all surfaces to give a surface finish not less than V7. Sharp edges of faces were not rounded off.

The support faces of the testpieces were parallel to within 0.05-0.10 mm on a length of 100 mm. Loading was carried out with a rapid increase of the major stress (2-3 kgf/mm² · sec) on equipment described earlier [3]. Noncoincidence of the line of action of the compressive load to the geometric axis of the testpiece was not more than ±0.15 mm, whilst the negative influence on the strength due to the deviation from parallel of the loaded faces was eliminated by transmitting the loads through a 25 mm ball bearing.

The effects of the edge conditions on the stress distribution in the testpiece during compression were estimated qualitatively by a polarization optical method on the plate testpieces of window glass and epoxy resin. The instrument used for this purpose was a type FP "Meopta" photoelasticity meter (Czechoslovakia) with a special attachment for biaxial compression [3]. The band patterns for various edge conditions and load levels were recorded by a reflecting camera.

The investigations were carried out with contact loading of the glass and epoxy resin testpieces by dies of VK-8 hard alloy, the loading surfaces of which had a surface finish of V8, and also whilst loading
Fig. 1. Band patterns during biaxial compression of the testpieces: a) glass testpiece during loading by hard alloy dies; b, c) same testpiece during loading through paper and rubber packings, respectively; d) epoxy-resin testpiece during loading by hard alloy dies.

Fig. 2. Relation between the compressive strength of a transparent quartz glass tube and the bearing condition: i) smooth bearings of type ShKh-15 steel; 2) bearings cemented with sealing wax; 3, 4) bearings cemented with cold cured and hot cured epoxy cement, respectively. (Here and in Fig. 3 the crosshatched region is the scatter zone for $\sigma_3$-values.)

For the case of the testpiece ends cemented in the sockets of the metal yokes the effects were determined of the edge conditions on the maximum failure stresses in the working part of the testpieces, identified with compressive strengths. Tests were made on transparent quartz tube testpieces, the ends of which were cemented to a depth of 8 mm by means of sealing wax, cold cured epoxy cement based on type ED-6 resin, and also resin hot cured at a temperature of 150 $\pm$ 5°C for 7 h. The stated cement was composed of the following components (wt. %): ED-6 epoxy resin 74; dibutylphthalate 14.8; polyethylenepolyamine 11.2. For the preparation of the cement they were weighed on a type VTK-500 electrical balance to an accuracy of $\pm$1.5%. The technique of actual sample preparation, and also the cementing of the ends in the yokes have been given in [1]. The results of the investigations are given in the form of a diagram in Fig. 2.

The effects of testpiece and cementing depth in the metal yoke on the compression strength were studied on cylindrical testpieces of type 23 lithium light-sensitive glass and of type STM-1 magnesium light-sensitive glass, the compressive strengths of which according to the data in [4, 5] are, respectively, 150 and 45 kgf/mm$^2$. The testpieces of type STM-1 light-sensitive glass had a constant cross section working area of length equal to two and a half diameters and end cementing depths $h$ of 0.25, 0.5, 0.75, and 1.0 diameters. For the type 23 light-sensitive glass investigations were made for cementing depths of 0.40, 0.65, and 1.00 of the testpiece diameter. The test results are given in Fig. 3.

In order to determine the influence of the edge effects on the compressive strength as a function of the length of the working section these were 0.3, 1.0, 1.7, and 2.2 times the testpiece diameter for cylindrical testpieces of type 23 light-sensitive glass with a cementing depth of 10 mm. In this case, as in the preceding cases (see Figs. 2 and 3), the tests on smooth bearings were carried out on testpieces having heights of three times the external diameter (Fig. 4).

The relations between the compressive strength and the testpiece shape were investigated on cylindrical, prismatic, and plate testpieces of types 23 and STM-1 light sensitive glasses, and also of type 13v glass (Fig. 5). Testpieces of type STM-1 light-sensitive glass were tested on plane metal bearings.