Technical glasses and sitals have high specific compressive strengths [1, 2] and therefore constitute promising materials for use in objects subject to compression under service conditions. Shells loaded with an external hydrostatic pressure provide one such example.

However, the use of glasses and sitals in highly-stressed construction elements is severely restricted by the fact that the structural strength of these materials has been insufficiently studied. The mechanical properties of glasses and sitals under biaxial compression are of particular interest. Certain special properties of these materials make it almost impossible to determine their mechanical characteristics by conventional plane-compression test methods, as used for brittle materials such as gypsum, concrete, and cast iron [3-5]. These special properties include their extreme brittleness, manifesting itself as an extremely low impact strength, their tensile and bending strength [6] (negligible compared with the compressive strength in the absence of appreciable surface defects), and also the absence of appreciable macro-plastic deformations, right up to the rupture point [7]. Glasses and sitals are characterized by a high sensitivity to contact stresses [2] and stress concentrators (raisers), and also by the practical absence of any stress and strain redistribution with time.

Owing to their high compressive strength $\sigma_c$ and comparatively low Young's modulus $E$, the compressive elastic deformations of glasses and sitals are 1.4-3.0 times greater than those of steels and titanium alloys [1, 2, 8].

The aim of the present investigation was to set up a special method for testing brittle materials such as glasses and sitals under conditions of biaxial compression, allowing for the special aspects of their physico-mechanical properties just indicated. The method had to satisfy the following requirements.

1. A high accuracy of centering the applied load and a great rigidity of the loading systems, so as to ensure the achievement of the prespecified stress distribution in the working zone of the test sample right up to the point of rupture.

2. The creation of optimum conditions for transmitting the load to the supporting surfaces of the sample, so as to minimize the influence of contact stresses on the compressive strength characteristics of the material, and to maintain the original support conditions up to the point of rupture.

3. Prevention of the loss of stability by the test sample or construction element during the compression test, right up to the point of rupture (owing to the high strength and limited elastic modulus, the breaking loads may be higher than the critical loads producing loss of sample stability).

4. The possibility of carrying out tests with large loads and small displacements of the loading supports, at the same time ensuring the prespecified relationship between the principal stresses.

5. The possibility of measuring large (1.5-3.0%) elastic compressive strains and small (0.03-0.12%) tensile strains in the working zone of the sample.

6. The possibility of observing and recording the rupture mechanism in the working zone of the samples (determination of the sources of failure, together with the points of origin and sequence of development.
Fig. 1. Samples for compression tests: a) Cylindrical; b) prismatic; c)-f) lamellar monolithic, containing an aperture, containing a butt glued joint, and three-layered samples, respectively.

of the rupture process); this facility is important because on compression glass and sital samples rupture instantaneously into a large number of fragments, and it is practically impossible to study the failure mechanism by means of ordinary fractograms.

The method thus developed is based on an apparatus specially designed for studying the strength of glasses and sital under biaxial compression \[9\].

For studying the strength of brittle materials under biaxial compression, cubic and prismatic samples are the most widely used types of sample for practical tests. Remembering that in a cubic sample it is almost impossible to ensure a plane-stressed state \[10, 11\], we decided for present purposes to use prismatic, plate-type samples (Fig. 1c).

In choosing the dimensional relationships for the lamellar sample (Fig. 1c) we allowed for the well-known condition governing the maintenance of stability up to the point of rupture \[12\]

\[
\frac{\pi^2}{8} \frac{d}{h} \left( \frac{q_1}{a} + \frac{q_2}{h} \right) = 0.258 \frac{1}{1 - \mu^2} E \frac{a d (a^2 + h^2)^2}{\pi h^3},
\]

where \( q_1 \) and \( q_2 \) are the permissible values of the specific pressures on the loaded faces of the sample and \( \mu \) is the Poisson coefficient.

Putting \( \mu = 0.23 \) \[13\] and \( a = h \) in Eq. (1) we obtain the dimensional ratio for a lamellar sample

\[
\frac{d}{h} \geq 0.94 \sqrt{\frac{q_1 + q_2}{E}}.
\]

If we put \( q_1 = q_2 = q_C = 270 \text{ kg/mm}^2 \) \[2\], \( E = 0.8 \times 10^4 \text{ kg/mm}^2 \) \[8\] in inequality (2) we find that the inequality is satisfied for \( d/h \geq 0.244 \).

In certain cases in which cylindrical and prismatic samples were additionally tested under axial compression in order to determine the influence of sample shape on the ultimate strength (Fig. 1a, b) the sample dimensions were chosen with due allowance for the following relationships (based on Euler's equations for hinged supports) so as to ensure stability: for a cylindrical sample the ratio of the diameter \( d \) to the half height \( h \) was

\[
\frac{d}{h} \geq \frac{1}{\pi} \sqrt{\frac{64q_C}{E}};
\]

for a prismatic sample the ratio of the side of the base \( d \) to the half height \( h \) was

\[
\frac{d}{h} \geq \frac{1}{\pi} \sqrt{\frac{48q_C}{E}}.
\]

We note that inequality (2) cannot be used in the form indicated above for the case of axial compression \( q_2 = 0 \). Accordingly we must put \( q_2 = 0, a = \infty \) in Eq. (1); after evaluating the indeterminacy of the form \( \infty / \infty \) we obtain an expression which, apart from a factor of \( (1 - \mu^2)^{-1} \), produces results in exact agreement with the Euler formula \[14\].

A comparison between the heights of the samples recommended by conditions (1), (3), and (4) showed that, for the same base \( d \), prismatic and cylindrical glass and sital samples might have heights four to five times greater than lamellar samples. This additional height offers certain conveniences when measuring deformations and studying the character of the fracture, and also increases the zone of uniform stress in the