MODEL INVESTIGATION OF THE STATIC BEHAVIOR
OF A NEW TYPE OF TRUSSED CELLULAR FRAME

A. I. Svetilov and B. V. Orlov

Experimental and design work carried out in 1965 and 1966 has made it possible to develop a new type of retaining structure consisting of prismatic blocks (Fig. 1), which permit making effective use of high-grade concrete.* The structure is made up of blocks in the form of a hollow triangular prism and a section similar to that of a dam or a retaining wall. Each block consists of three trussed slabs erection-welded at the corners. After erection, the blocks form a rigid reinforced concrete frame, which in a sectional view may be considered as a highly indeterminate truss. In order to provide stability, the hollows of the structure are filled with earth.

This new type of structure is noted for its industrial advantages and economy, for it permits reducing the volume of concrete by a factor of 2, as compared to the existing types of light structures. Moreover, it permits reducing the construction costs by 15-45%, the overall labor volume by 20-30%, and the labor volume during construction by 30-50%.

The main tasks in the investigation of the structure here discussed were the following: a) preliminary evaluation of the technical adequacy of the procedures adopted for manufacturing the blocks and for erecting them in the structure; b) evaluation of the reliability, strength, and operating characteristics of the structure (including the determination of the factors of safety); c) development and justification of practical methods of analyzing this new type of trussed cellular structure, by using the data from model investigations. The investigations included tests and design-theoretical work. This article presents some of the results of these investigations.

For preliminary evaluation of the operating characteristics of the structure, the investigators built a reinforced-concrete model of a portion of a 27-m high dam to scale 1:10.

The model (Fig. 2) was assembled on a reinforced-concrete foundation by using blocks similar to those previously designed for the actual structure, and by applying the method contemplated in the project for joining these blocks, that is, by placing one layer of cast-in-place concrete in the space between two adjoining blocks. The model was built to scale 1:10, by applying geometrical and structural similitude. This scale was selected after examining the conditions of ease of erection and testing of the model at the experimental shop.

In order to satisfy the structural similitude of the section, it was necessary to fulfill the condition \( \sigma_m = \sigma_a \), where \( \sigma \) is the stress in the elements of the model and of the actual structure.

Disregarding the possible eccentricities of the bars, we may write the equation

\[
\sigma_m = \frac{P_m}{F_m} \quad \text{and} \quad \sigma_a = \frac{P_a}{F_a}
\]

where \( P \) is the force in the element, and \( F \) is the cross-sectional area.

For conversion from model to the actual structure and vice versa, we use the following relations:

\[
\frac{P_m}{P_a} = \frac{1}{\lambda^2}
\]

In the structural analysis of the dam, the following assumptions were made: a) all loads in the structure are transmitted through the joints; b) the bars are not eccentric; c) the moduli of elasticity of the materials in the model and in the structure are equal.

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The first assumption is entirely admissible, since in the analysis of the general strength of the structure almost all the loads on the highly stressed lower zone are transmitted precisely through the joints, whereas the bending moments produced in the elements as a result of the soil action are considered additionally in the analysis of the local strength. The second and third assumptions lead to errors in the tests, but they do not exert an appreciable effect on the final conclusions.

Based on these assumptions, the investigators calculated all the external loads on the model, and from them they calculated the forces acting on the elements of the structure. The analysis was carried out by using an exact method as well as an approximate method. The exact analysis was made on the basis of the method of forces for a highly indeterminate truss, by applying well-known formulas, and with the aid of "Ural" and "Minsk" electronic computers. In the basic system employed, the horizontal joints were replaced by unknown forces.

In the approximate method, by analogy with the solution of a triangular dam section by the theory of elasticity, a linear decrease of the horizontal forces transmitted by the joints from the water-bearing face to the overflow face was assumed. After the horizontal forces were determined, the analysis was carried out in the same manner as for a statically determinate system.

Special difficulties in the experimental investigation of the type of structure here discussed were involved in the modelling of the foundation. However, in the first stage of the investigation of this trussed cellular structure, the foundation may be regarded as rigid, from the following considerations. The total area of the bars is equivalent to not more than 10% of the bearing area of the entire structure on the foundation. Taking into account the fact that the modulus of elasticity of the rock foundation is not larger than the modulus of elasticity of the elements of the structure, we may, by allowing a certain degree of error in the experiment, consider that the foundation is rigid.

After establishing the characteristics of the behavior of the structure and adopting the methods of analyzing it in the case of a rigid foundation, we may, by introducing the contour conditions (deformability of the foundation, nature of the contact with the foundation, etc.) in the relations previously obtained, solve the problems pertaining to a more exact analysis.