BASIC METHODS OF MONITORING AND PRINCIPLES OF QUALITY ASSESSMENT FOR THE MONOLITHIZING OF CONCRETE DAMS

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CONTROL PROBLEMS

The majority of high-head concrete dams are built by a method, which includes sectioning of the structure into individually placed columnar masses (columns, sections), and its subsequent monolithizing by grouting of temporary (intercolumn) joints via a system of tubes with discharges for the injection of grout, which are embedded in the body of the dam during concreting [1]. Monolithizing is the final step in the building of the dam, and determines its readiness to receive a head, and for subsequent service.

The method of building a dam with joints left between the columns for subsequent concreting, which is also occasionally used in construction, is not considered here. We will address only contact joints that remain when columns are concreted “flush against” one another. By their nature, operations involving the grouting of joints are performed out-of-sight, and direct monitoring of their quality during production and acceptance is difficult; to evaluate the quality of joint grouting, therefore, it is necessary to carry out special monitoring operations to:

— ascertain measures whereby the joints are filled with cement stone over the area, and the thickness of the layer of cement stone in the joint is determined; and,
— determine the physico-mechanical properties of the cement stone filling the joints – the strength and deformation characteristics, and adhesion to the walls of the joint.

Quality control of joint grouting includes both analytical, and also instrument methods. It is more convenient, however, to divide them into two groups: direct methods that permit direct solution of the indicated problems, and indirect methods that make it possible to evaluate the quality of joint filling, and the characteristics of the material with which they are filled without coming into direct contact with them.

DIRECT METHODS

Drilling of holes that intersect grouted joints with extraction and subsequent testing of the core from the zone of intersection is one of the direct methods employed for the control. These holes are drilled by the column method, although a greater part of the hole extending to within 0.5 – 1 m of the joint, can be opened using air-percussion-drilling rigs. The arrangement of holes is adopted such that the maximum number of intersections with joints is obtained during drilling (Fig. 1).

Diamond bits, which ensure better core integrity, are used in the zone where the joint is intersected (0.5 m on both sides of the joint) [3]. No inspection holes are drilled in the vicinity of the thrust face of the dam to avoid damaging the permanent seals of the intersectional joints situated in this zone.

To determine the properties of the cement stone in the joint, all cores extracted during drilling are examined, and described with respect to a special procedure [4]. Information on the inspection hole and the procedure used for its drilling, as well as characteristics of the cores are entered in a core-description journal:

— the designation and location of the hole, the elevation and angle of its intersection with the joint, and the diameter and type of drill bit;
— the percent ratio of the areas of core fracture through the concrete, through the cement stone filling the joints, and along the concrete/cement-stone contact (Fig. 2); characteristics of the cement stone – average layer thickness, color, and surface condition; and,
— a visual estimate of the strength of, and the adherence with the concrete.

Cylindrical specimens for laboratory strength tests and determination of the compression modulus of the cement
stone are made from the cores retained. Some of the cores are tested for shear along the joint. It should be pointed out that preparation of specimens from small-diameter cores presents major difficulties.

The quality of the cement stone is considered acceptable, if strength and deformation characteristics, and the adhesion to the walls of the joint, which are close to those computed values called for in the design, are obtained during its testing. When there are no such indications in the design, these characteristics can be compared with indicators obtained during the investigation of similar specimens (cores) or monolithic concrete under other conditions.

The above-described method makes it possible to evaluate directly the opening $\delta_{ji}$ of the joint and the thickness $d_{csi}$ of the cement-stone layer, the relative extent to which the joint is filled $S_{rel}$ over the area of the grouting chart, as well as the deformation-strength characteristics $\sigma_{cst}$ and $E_{cst}$ of the cement stone in the zone where the joint intersects the inspection hole. This method is time-consuming, and the degree of reliance of the results relative to the area of the joint within the limits of the grouting chart will depend on the quality of the intersections with the joint and the uniformity of their arrangement over the area of the chart.

Hydraulic sampling, i.e., hydraulic testing — the injection of water into a grouted joint via holes that intersect it, for which holes drilled for the extraction of cores can be used, is another direct method of control. Hydraulic testing is carried out in descending (from the mouth to the face of the hole) zones to ascertain the ratio of the flow rates of the water passing through the grouted joint, and the water that runs off through low-density areas in the concrete. The injection pressure is increased in steps. The flow $Q_i$ absorbed is recorded at each pressure step $P_i$. The specific water absorption $q_i$, i.e., the flow of water absorbed in 1 m of hole under a head of 1 m of water, is calculated from results of the hydraulic testing:

$$q_i = \frac{Q_i}{P_i l_i}$$

where $l_i$ is the length of the interval of the hole into which water is injected, i.e., the section of the hole between the seal (plug) and face, or between two seals.

The average $q_{avg}$ from values of specific water absorption $q_i$ obtained for all injection points in the grouting chart