FOREIGN EXPERIENCE AND TECHNIQUES

METHODS AND PRACTICE OF TREATING HORIZONTAL CONSTRUCTION JOINTS
WHEN CONSTRUCTING CONCRETE DAMS ABROAD

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To make concrete dams suitably monolithic it is necessary to link the earlier-placed concrete with the fresh concrete mix placed in subsequent concreted blocks. The necessary strength of the horizontal construction joints is obtained both by using rational concreting methods (reduction of the time interval between placing the concrete mix in the blocks, provision of an optimal temperature regime in the concrete masonry, proper curing of the placed concrete) and by appropriate treatment of the horizontal surface of the blocks. The latter is one of the significant items of expense in concreting and, therefore, to reduce the cost of constructing large concrete dams the proper choice of the means and the rational mechanization of treating horizontal surfaces of concreted blocks acquire special importance.

The composition and extent of measures for treating joint surfaces and preparing the blocks for concreting are determined in many respects by two processes occurring in the concrete mix immediately after placing it in a block and having a substantial effect on the formation of the horizontal block surface — separation of water and emergence of laitance on the surface. Separation of water is the spontaneous flow of water caused by settling of the solid material in the concrete mass or draining of the mixing water and can have favorable effect on the strength characteristics of concrete, since it leads to a decrease in the water/cement ratio. However, water separation disturbs the internal homogeneity of concrete and leads to other quite undesirable disturbances of its quality.

As a consequence of water separation, freshly placed concrete is less strong and more porous in the upper part, which reduces its resistance to disintegration during varying freeze-thaw cycles. Water rising to the surface of the concrete carries small unset particles of cement, which weakens the concrete and forms a cement scum on the surface. Channels are formed during the upward water movement in a concrete mass and water accumulates under coarse aggregates and under horizontal reinforcement bars, which also leads to weakening of the structure owing to the production of an unsuitable bond between the cement and particles of coarse aggregate and reinforcement steel. Therefore, concrete experiencing considerable water separation is more permeable, and corrosion of the reinforcement steel is possible.

Water separation can be controlled to a considerable extent by the appropriate selection of the components and proportions of the concrete mix. Water separation in concrete mixes is reduced by using a high cement content in the mix, a fine-ground cement with a normal setting rate, natural smooth-surfaced sands, appropriate proportions of fine particles, and air-entraining agents or additives containing fine particles. Some improvement in the properties of concrete which experiences a noticeable water separation is achieved by vibrating or tamping the placed concrete mix at the end of the water separation process and at the start of setting. In order to noticeably decrease water separation in a concrete mix containing entrained air it is necessary to treat it much more rapidly than a concrete mix without air-entraining agents.

As investigation by American specialists has shown, water separation affects the formation of microcracks and the presence of weakened zones with sedimentation pores adversely affects stress and durability of the concrete. This is confirmed by testing its frost resistance. After 1 week of continuous cycles of wetting, freezing, and thawing microcracks were found in all specimens: the majority formed in porous zones under the coarse aggregate particles and at the boundary between the weak cement mortar and aggregate.

The emergence of laitance occurs during the first several hours after placing the concrete mix, laitance is a layer of weak material containing cement and fine aggregate particles carried by water emerging onto the surface of overwetted concrete. The volume of this
layer increases mainly following recom pacting or reworking the concrete whose surface is not being finished suitably or is subjected to the effects of travel of heavy-duty machines. Laitance is observed almost always when con creting the blocks of dams and, since this process occurs simultaneously with the separation of water, it can be limited by the same method as the water separation. The removal of laitance before placing concrete in the next block is mandatory. The main reason for the undesirableness of laitance on the surface of the block lies in the formation of a weak zone with which the layer of concrete mix in the new block will not bond well, a thick layer of laitance forms a horizontal band with low strength, and fracture of concrete usually begins from this band.

Treatment of the surfaces of horizontal construction joints to eliminate water separation and laitance can be avoided by using in the concrete mix cements which do not lead to the indicated phenomena. Since the problem of preparing blocks for concreting is thus eased considerably, many foreign specialists are inclined to favor the use of such cements and to develop the technology of mass production of cements of this type.

Laboratory and full-scale investigations under construction conditions by the planning department of the Tennessee Valley Authority (U.S.A) indicate a considerable decrease in the separation of water and emergence of laitance when stiff concrete mixes of optimal design with a zero cone slump (less than 2.5 mm) are used. In this case there is no need to remove the laitance and specially treat the horizontal construction joints. The average shear strength of the untreated construction joint in these investigations was 21 kg/cm² for concrete with an average cube strength of 220 kg/cm².

Since a suitable joint quality and good cohesion between the concrete layers can be achieved by covering the surface of the blocks with insulating compositions and mastics, specialists in a number of countries in recent years have developed such compositions. The general research division of the U.S. Bureau of Reclamation (Denver) carried out extensive investigations under laboratory and field conditions in 1972-1974.

Various factors influencing the quality of horizontal construction joints using a special binding material were examined in the investigation. Age of the concrete, change in the moisture content of concrete, method of removing laitance from the block surfaces, durability and abradability of the film of binding material, and the effect of the method of final cleaning of the block surface before placing the concrete mix can all affect the quality of the joint. Three binding materials were tested in three different joints and with different curing regimes and the quality of the joints was evaluated at age 28 days and 2 years by tensile, splitting, axial tensile, and shear tests of cores (d = 76 mm and d = 152 mm) bored from a concrete slab 0.6-0.75 m thick. Each block of the slab was 11.5 cm high; subsequent blocks were placed at 5-day intervals. Aggregates with a maximum size of 19 mm and sand in an amount of 50% of the total weight of the aggregates and type II cement as the binder (with a moderate specific heat of hydration) with a water/cement ratio of 0.47 were used for the concrete mix of all test slabs. The cone slump was kept within 7.5-10 cm, the air content 6%.

Results of the laboratory tests established that insulating compositions on a base of synthetic resins are suitable for use as binding materials, providing a reliable joining of concrete layers in interblock construction joints. Tests of 79 core specimens bored from horizontal joints indicated that joints from whose surface the laitance was removed before applying the resin-base insulating compositions had a higher tensile strength than mass concrete. All horizontal joints whose surfaces were treated by metal brushes and which were covered by one of the three tested resin-based insulating compositions proved to be stronger or just as strong as the joints treated by a hydraulic sandblaster. The tensile strength of all joints was higher than the strength of the mass concrete. Tests of the joints 2 years later established that the joints, during curing of which materials on a base of chlorinated rubber resin were used, lose some of their shear strength with time: averaging 1% when dry cured, 17% when cured underwater, and 5% when cured in the environment.

Testing of the joints was continued under field conditions during construction of the dam for the third powerhouse of the Grand Coulee hydroelectric station of Pueblo dam. Horizontal construction joints were investigated in three sections of the Grand Coulee dam. Insulating pigment compositions on a base of synthetic resins with a specific consumption of