is the case when the deposits are allowed to accumulate. The emptying and cleaning of a basin is a costly operation, especially in winter time, and is to a very great extent avoided even if only a portion of the basin is properly underdrained.

Water Required in Cleaning.—The amount of water that passes off with the sludge in the system just described for Muskogee, it is estimated, will not exceed one-sixth of 1 per cent. of the water treated.

Discussion of Reinforced Concrete.—The basin is being constructed of reinforced concrete. It is possible to construct a monolith of considerable proportions of plain concrete. However, it is but a question of time when the unequal settlement of the foundation, always possible except when the foundation is solid rock, and the shrinkage and temperature stresses set up in the mass, destroy the continuity of the structure. On the other hand, it is possible to construct and maintain as such, a reinforced concrete monolith of very large proportions.

There appears to be some doubt that thin sections of reinforced concrete are suitable for water-tight structures. There need be no fear whatever that there will be any trouble if the work is carried out as it should be. The water-tightness of concrete depends principally upon the amount of cement present, provided the sand and stone or gravel are properly proportioned. Six bags of cement per cubic yard of concrete is ordinarily sufficient to produce a water-tight mixture. This amount, however, should be increased when the hydro-static head is considerable.

The author is opposed to the use of waterproofing ingredients or waterproofing applications. Both increase the cost of the concrete work considerably. It is far better to put the value of the waterproofing materials into the concrete itself by adding more cement. The use of a waterproofing ingredient or application tends to poor construction work, the contractor counting upon the waterproofing to help out careless construction.

The author, from his study and experience in the construction of tanks and reservoirs, has reached the conclusion that leakage may be due to any one of the following causes:

(1) Faulty construction, (a) Lean and porous concrete work. (b) Inexperience and carelessness in carrying out the construction.

(2) Faulty design. (a) Weak details at the connections. (b) Excessive secondary stresses at connections. (c) The use of too high unit stresses in steel and concrete.

Faulty construction can be rectified to some extent, but often only at a considerable cost, by waterproofing the structure from the inside. Leaks developing through faulty design are, on the other hand, always difficult to master, and in many cases very little can be done to remedy the unsatisfactory condition of the completed structure. To guard against the production of lean concrete work, the author's specifications provide that all cement used in the work should be paid for separately.

As 10 ft. of the basin is constructed below the original surface of the ground, it was decided to use counterforts instead of buttresses to save excavation. The counterforts are 15 ins. thick, spaced 13 ft. 4 ins. on centres. The side walls of the basin are 12 ins. thick on the top, widening out to 18 ins. at the bottom. The floor of the basin is 6 ins. thick in the larger compartment, and in the smaller and underdrained one, 9 ins. The basin, including the floor, is constructed and reinforced as a monolith. No expansion joints whatever are provided. There will, however, be an expansion joint between the present basin and future extension.

The author would like to get the opinion of the members on their experience with extensive monolithic construction, both plain and reinforced, especially with reference to the conditions under which such construction has given more or less trouble.

Details of Design of Basin.—The success of a reinforced concrete structure of any magnitude depends primarily upon the thoroughness with which the various structural details, especially the connections, are worked out. The connections should receive the same careful attention that is given them in structural work. The author, therefore, thinks it advisable to dwell as some length upon the design of the structure.

The Muskogee basin is being constructed of gravel concrete. The gravel is washed river gravel obtained from the bed of the Arkansas River. Its size is limited to 1 in. in the side walls and counterforts, and to 2 ins. in the bottom. The sand is a very coarse river sand, obtained from the same river. It is clean, coarse and sharp, and makes a splendid concrete sand. The concrete is being mixed approximately in the proportion of one part of Portland cement, two parts of sand, four parts of gravel. The mixture is changed slightly from time to time to meet slight changes in the quality of the aggregate.

In the design of the structure, the unit stresses were assumed as follows:

$fc =$ The maximum allowable working compression in the concrete in flexure, 650 lbs. per sq. in.

$fs =$ The maximum allowable tension is the steel, 14,000 lbs. per sq. in.

$v =$ The maximum intensity of transverse shear in concrete (assuming a uniform distribution of the shear) 50 lbs. per sq. in.

$u =$ The maximum working adhesion or bond stress between the concrete and deformed bars, 80 lbs. per sq. in.

$e =$ The ratio of the modulus of elasticity of steel to concrete, 12.

These values are conservative. They limit the percentage of the steel to be used in the structure to 0.83 per cent. of the area of the concrete above the steel.

The following equations, with numerical constants, have been developed in accordance with the now universally recognized theory:

$$q = \sqrt{\frac{M}{8.54}} \qquad \text{(Equation 1)}$$

$$As = \frac{M}{1020 \times q} \qquad \text{(Equation 2)}$$

Where q is the distance from the compression side of the beam to the steel, known commonly as the effective depth of the beam; M is the bending moment in foot-pounds per inch width of beam, and As is the area of the steel required.

Equation 1 gives the effective depth of the beam when the bending moment is known and the reinforcement is fixed at 0.83 per cent. of the area of the concrete above the steel.

Equation 2 gives the amount of the steel reinforcement when the bending moment is known and the depth of the beam (q) is fixed. It can only be used when the percentage of steel reinforcement is 0.83 per cent. or less.

Design of Side Walls.—The reinforcement in the side walls and their construction makes them partially continuous. The common theory of flexure as we know it is applicable to this case, but not with the numerical constants familiar to us. The allowance that is usually made in reinforced concrete construction for the increase in strength due to the partial continuity is a reduction of from 25 to 50 per cent. in the bending moment computed on the basis of a simple beam. The exact amount of the increase in strength due to partial continuity can be computed in any one case when all the factors are known. The process, however, is a very tedious one, and entirely unnecessary. A