

inate the core altogether and to substitute drainage even though no other precautions are taken to strengthen the dam.

The idea of draining an earth dam is not new, but it has not been given sufficient attention. It is manifest that some plan should be evolved and put in practice whereby the dam may be protected from the water and the rate of percolation reduced to the minimum. When this is accomplished the necessity for extensive drainage is lessened. Not only is it necessary to prevent water entering and remaining in the dam in large volumes, but it is essential that the water face of the dam be protected from wave action and erosion due to the rise and fall of the water surface. It has been customary to riprap the water face of the dam with hand-laid stone paving. This may protect the dam from the action of the water, but it is expensive compared with the beneficial function performed. The riprapping does not tend to make the dam more waterproof. It does not always prevent erosion on the water face, for often during high winds the wave action will wear away the fine material of the dam back of the paving and permit a stone to settle here and there. This brings about settlement in other places and before many months the face of the dam consists of ridges of paving material and broad stretches of unprotected earth. It is plain that it would be impossible to maintain a facing of clay on the water slope of the dam, even though it were protected by the best kind of riprapping. Clay when wet will run and it will pass away in suspension in water that is almost quiet. It seemed necessary, therefore, if clay is to be used for this purpose, that it be placed in the body of the dam where it will be protected from the action of the water. This clay core doubtless had its birth in reasoning of this kind. We would not have high regard for a rain coat that would have to be worn under other clothing to protect it against injury from water.

Reinforced concrete laid on the water surface of an earth dam furnishes a surface which not only retards percolation into the dam, but it makes an admirable protection against wave action. The concrete need not be laid in a heavy course. From 3 to 6 in. in thickness will answer for any dam.

It is advisable to carry the concrete of the face to the extreme toe of the dam and from there vertically until it enters some impervious material, such as rock or shale. Sheet-steel piling can be substituted for the concrete below the toe of the dam where conditions are favorable for pile driving. The steel reinforcing of the concrete facing above can be attached to the top of the sheet piling. By bringing the concrete wall down over the top of the sheet piling a very satisfactory union of the two materials can be made. Fig. 6 shows a dam constructed in this way. The water slope of the dam has been reduced to 2 to 1. This is often permissible where the concrete face is employed. The dam shown in cross-section in Fig. 6 is paved on both the dry and wet slopes. This furnishes a spillway over the dam. A water cushion is provided at the toe of the dry slope. The drainage tile, the outlet pipes and the spillway all discharge into this cushion. The controlling device for the outlet pipes is located under the facing on the dry slope of the dam and it is reached by a protected entry from one side of the depression in which the dam rests.

The intention has been to show general types of construction and not to enter into details. Concrete may be employed to advantage in building the box at the lower toe which provides the water cushion, in constructing collars about the iron pipe to prevent percolation along them and in the construction of the valve house and approach thereto.

It is well to permit an earth dam to stand for a year or longer before the concrete facing is applied. This gives the

earth an opportunity to settle. The surface of the concrete can be protected by an application of coal tar and maintained by similar applications from year to year.

SPECIFICATIONS FOR FUEL OIL.

The United States Bureau of Mines has recently issued a bulletin discussing specifications for fuel oil. In view of the fact that this type of fuel is becoming more and more popular, suggestions such as embodied in this report are very welcome. An abstract of the specifications is given below:—

In determining the award of a contract, consideration will be given to the quality of the fuel offered by the bidders, as well as the price, and should it appear to be to the best interest of the government to award a contract at a higher price than that named in the lowest bid or bids received, the contract will be so awarded.

Fuel oil should be either a natural homogeneous oil or a homogeneous residue from a natural oil; if the latter, all constituents having a low flash point should have been removed by distillation; it should not be composed of a light oil and a heavy residue mixed in such proportions as to give the density desired.

It should not have been distilled at a temperature high enough to burn it, nor at a temperature so high that flecks of carbonaceous matter began to separate.

It should not flash below 60° C. (140° F.) in a closed Abel-Pensky or Pensky-Martens tester.

Its specific gravity should range from 0.85 to 0.96 at 15° C. (59° F.); the oil should be rejected if its specific gravity is above 0.97 at that temperature.

It should be mobile, free from solid or semi-solid bodies, and should flow readily, at ordinary atmospheric temperatures and under a head of 1 foot of oil through a 4-in. pipe 10 ft. in length.

It should not congeal nor become too sluggish to flow at 0° C. (32° F.).

It should have a calorific value of not less than 10,000 calories per gram (18,000 British thermal units per pound); 10,250 calories to be the standard. A bonus is to be paid or a penalty deducted according to the method stated under section 21, as the fuel oil delivered is above or below this standard.

It should be rejected if it contains more than 2 per cent. water.

It should be rejected if it contains more than one per cent. sulphur.

It should not contain more than a trace of sand, clay or dirt.

Each bidder must submit an accurate statement regarding the fuel oil he proposes to furnish. This statement should show: The commercial name of the oil; the name or designation of the field from which the oil is obtained; whether the oil is crude, a refinery residue, or a distillate; the name and the location of the refinery, if the oil has been refined at all.

The fuel oil is to be delivered f.o.b. cars or vessel, according to the manner of shipment, at such places, at such times, and in such quantities as may be required.

Should the contractor, for any reason, fail to comply with a written order to make delivery, the government is to be at liberty to buy oil in the open market and charge against the contractor any excess of price above the contract price of the fuel oil so purchased.

Copies of this Technical Paper may be obtained by addressing, the Director of the Bureau of Mines, Washington, D.C.