were not due to poor explosives, but to carelessness and ignorance on the part of those handling the explosives.

MAKING CONCRETE WATERPROOF.*

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Concrete is very largely employed in many building constructions, and in some situations it is very important that it should be at least practically waterproof. There are several methods of rendering concrete more or less impermeable to water, some of which are simple and free to anyone, and some of which consist in using secret or patented compounds. Of the former, the simplest method consists in mixing hydrated lime or finely divided clay with the concrete, thus at least partially filling the voids or interstices in the concrete and decreasing the percolation of water. Another simple method consists in mixing powdered alum with the cement and dissolving ordinary soap in the water to be used in mixing the concrete. Although the latter materials have been used for more than sixty years as a wash for rendering masonry impervious to water, and although in recent years they have frequently been employed as ingredients of concrete to make the entire mass impermeable, the proportions to be employed, and the reason for the effect seems to have had little or no scientific consideration, at least the proportions used in practice vary very widely. For the purpose of securing data for use in the revised edition of the writer's "Treatise on Masonry Construction," now in preparation, certain investigations and experiments have been made; and it is the object of this article to present these results more fully than can be done in the book mentioned.

Alum and Soap Waterproofing Compound.

To use the alum and soap method of decreasing the permeability of mortar or concrete, the alum in powdered form may be mixed with the dry cement or the sand, and the soap may be dissolved in the water employed in mixing the concrete, or both the alum and the soap may be dissolved in the water. The former is probably the safer method in practice, since with the latter method the water must be thoroughly stirred while the two are being mixed or the precipitate may form in large masses, which it is practically impossible to break up; and further, the water must be kept stirred to prevent the compound from accumulating on the surface. These are conditions that it is not always easy to be certain of securing. However, the alum is more easily dissolved than the soap; and hence the alum may be dissolved in, say, one-fifth of the water and the soap in the remaining four-fifths, and then the two portions may be mixed together, being careful to stir them as the mixing progresses. The alum and the soap combine and form a finely-divided, flocculent, insoluble, water-repelling compound, which fills the pores of the concrete and decreases its permeability.

The best proportions are: alum 1 part and hard soap 2 parts, both by weight. Soap varies in its chemical composition, and hence a single proportion cannot be stated which will be chemically exact for all cases. The above proportion is in round numbers the relative combining weights of alum and average hard soap; and hence it is the best proportion to use, although widely different proportions have been used in practice with success. Any reasonably pure soap will do; but if soft soap is employed, a greater amount should be used in proportion to the amount of water in it.

It is difficult to dissolve more than about 3 per cent. of hard soap in cold water; and hence this practically limits the amount of alum to 1.5 per cent. and of the soap to 3 per cent. These amounts will give a precipitate equal to about 3 per cent. of the weight of the total water. The amount of precipitate formed in the pores of the mortar or concrete will depend upon the amount of water used in the mixing. Of course, if it were desired to use a greater quantity of soap and alum, the soap could be first dissolved in a smaller quantity of hot water, which is afterwards mixed with the water used in making the mortar; but this is hardly practicable, nor necessary, as will appear presently.

An excess of alum does no harm, since alum alone is a fair waterproofing material. An excess of soap does no harm; and an excess is better than a deficiency, since the excess will unite with the free lime of the cement and form calcium soap—a finely-divided, water-repelling compound, which is apparently the essential element of several of the proprietary waterproofing compounds. The above is the explanation why such diverse proportions of alum and soap give reasonably successful results in actual practice.

Effect of Water-Repelling Compound.

A film of oil on the wires of a moderately fine sieve makes it nearly, if not quite, water-tight. The question then naturally occurs: Can a water-repelling compound in the concrete act in the same way as oil on a sieve? Or, in other words, can a volume of water-repelling compound less than the volume of the voids in the concrete decrease the permeability of the concrete in a greater ratio than the per cent. of the voids filled? If so, then a water-repelling compound is more efficient in decreasing the permeability of a concrete than a mere void-filling material.

To test the effect of a water-repelling ingredient upon the permeability of concrete, a series of experiments were made under the writer's direction by Mr. B. L. Bowling in the cement laboratory of the University of Illinois. The experiments consisted in moulding a series of Portland cement mortar disks in short lengths of 6-in. pipe, subjecting these disks to water under pressure, and measuring the amount of percolation. For convenience in making the experiments, mortar was used instead of concrete. The mortar for the treated and the untreated disks was alike except for the alum and soap compound. However, the mortars containing the alum and the soap were invariably drier than those made without these ingredients; but this probably has no significance in this connection. An annulus, 1-in. wide at the circumference of both the top and the bottom faces of the disk was coated with hot asphalt, and also covered with a rubber gasket against which a flat casting was pressed by bolts through an external flange; and consequently the flow was through a disk 4 ins. in diameter and 2 ins. thick. The percolating water was caught in a tin funnel, the top of which fitted closely against the lower casting and the neck of which passed through a perforated rubber stopper into a bottle. The water pressure varied from 40 to 45 pounds per square inch. The date and the results of the experiments are given in the accompanying table. Tests 1 and 2 were made together, as also tests 3 to 6, and 7 to 9. The intention was to have four tests in each series, but through one reason or another some of the tests were of doubtful value or were useless, and hence are not reported.

The mortar used in making the disks was 1:6, which is unusually lean and porous, but it was purposely made porous the better to test the effect of the alum and soap

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