IMPERMEABLE CONCRETE.

One of the most desired characteristics of concrete at the present time in connection with its physical resistance to the results of loading is impermeability to water. Although the ultimate compressive resistance of the strongest concrete is far below that of the best natural building stones, it is high enough to meet the exacting requirements of masonry in most engineering structures, and its lack of tensile resistance is effectively cured by steel reinforcement. In spite of the fact that its real merits, intrinsically of a high order, have at times been greatly exaggerated and grossly overworked by ignorant and ill-judged advocates, concrete is rapidly becoming one of the most valuable of all our structural materials for engineering purposes, if, indeed, it has not already reached that position. It is employed in many cases where its main function is that of carrying loads, but at the same time where the quality of real impermeability would add greatly to its value. This is not only true in an extended range of engineering structures, such as dams and aqueducts, but also in its application to buildings both en masse and in blocks. If concrete could be given a truly impermeable character its value would be greatly enhanced and its field of usefulness would be even more rapidly extended than at present.

The great obstacle heretofore experienced in making concrete waterproof has been its highly porous character. With the dry mixtures used in times past, the porosity of concrete was excessive and not the least of the many advantages accruing to the use of wet mixtures is the greater solidity or density conferred upon the mass. A wet mixture not only causes all portions of the mass to run together in greater solidity but it enables the finer materials of the aggregate to flow freely and thoroughly into the spaces between the coarser particles, thus producing a much more nearly continuous and dense interior mass. This means obviously a greatly reduced permeability to water or a much enhanced capacity to resist seepage through it. In fact, if the cement were ground sufficiently fine to enable it and the finest parts of the sand to enter freely into all the interior spaces of the aggregate, a waterproof material under high intensities of pressure would result; but the wettest mixtures which it is possible to use neither eliminate all the air bubbles nor fill all the interior spaces. However, much care may be taken in securing a thorough and intimate admixture of the component parts, all porosity is not eliminated and some seepage results under pressures of forty to sixty pounds per square inch or even less.

If suitably mixed concrete could be put under a high pressure before the initial set takes place, so as to squeeze out all air and surplus water, should there be any, in much the same way as molten steel is compressed, in order to produce grades of that metal of special value, it is altogether probable that the resulting density would be sufficient to secure essential impermeability under very high heads. This obviously is impossible, but some recent investigations appear to indicate that there may be other simple means of attaining the much-desired quality of impermeability. In a discussion by Mr. Richard H. Gaines of the paper presented to the American Society of Civil Engineers in April of the current year by Messrs. W. B. Fuller and S. E. Thompson, there are set forth some results of tests made to determine the effect of the addition of certain substances on ordinary concrete mixtures. In the search for materials which may enhance the waterproof character of concrete it is clear that none must be used which will prejudice the resistance or durability of the mixture. Mr. Gaines, who is the chemist of the New York Board of Water Supply, shows that the addition of small percentages of alum solution and fine clay to Portland cement mortar and concrete enhances greatly the impermeability of the mixture and that both compressive and tensile resistances were increased. Although the number of the tests was relatively small and the life of the test specimens was not long enough to settle conclusively such a question as that under consideration, the results obtained show that the line of investigation followed is worthy of being carried further in order to determine just what value may be attached to the mixtures of such materials as were employed with the usual proportions of cement, sand and gravel or broken stone in the manufacture of mortar and concrete.

It has been indicated by tests that, contrary to the former opinions of engineers, the presence of small percentages of fine clay of a suitable character and properly mixed does not necessarily injure the strength of concrete, and it has also been shown that the same mixture may aid in attaining more nearly waterproof qualities. Up to the present time, however, investigations of this kind have not been carried far enough to give quantitative results of sufficient range for practical purposes. It has generally been considered that the effect of fine clay in reducing the porosity of concrete was wholly mechanical, but the modern view of physical chemistry, so to speak, may disclose a different significance to the results of use of fine clay for such a purpose. With the modern wet concrete mixtures, the presence of the clay is asserted by Mr. Gaines to induce a colloidal action which is apparently aided by such a solution as that of alum, so that the result is a modification of the interior mass, tending to eliminate ordinary porosity.

There is nothing new in the employment of an alum solution as well as various soap solutions to afford concrete a certain degree of impermeability to water, but the purpose hitherto has been to produce an impermeable surface rather than an impermeable mass, which the results of Mr. Gaines' experimental work appear to indicate as attainable. The great advantage of securing an impermeable or waterproof mass of concrete over surperficial effects is so clear as to need no comment. This observation is especially pertinent to all reinforced concrete work, in which it is of the first importance to protect the steel reinforcement from corrosion. At the present time it is difficult to imagine any greater benefit to be conferred upon all classes of concrete work than to find some simple and effective method of making it waterproof under reasonably high pressures. An investigation should include tests with hydrated lime and the various proprietary waterproofing compounds now extensively used, some of which seem to be giving good results when added to the usual concrete mixtures.—Engineering Record.