STUDIES ON THE INFLUENCE OF INTEGRAL WATERPROOFING POWDERS ON THE PHYSICAL PROPERTIES OF CEMENT AND CONCRETE

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The influence of integral water proofing powders, particularly 'Cemto' and an imported product, on the physical properties of cement and concrete has been studied. These compounds do not have any appreciable influence on the setting properties of Portland cement which might cause any construction problem. They reduce the compressive strength of concrete but are effective water-repelling materials. Recommendations regarding the amount of 'Cemto', a composition developed by the P.C.S.I.R. for different applications are tabulated.

Introduction

Concrete cannot be made completely impermeable, no matter how much care is taken in proportioning the aggregates of different sizes, reducing the water-cement ratio and employing proper workmanship. Probably a major reason for this is that, whereas the amount of water required to hydrate the cement is about 22% by weight of cement, its amount for concrete construction is rarely less than twice the amount required for hydration. An increase in the cement content decreases the permeability, but it is uneconomical and particularly not desirable for massive structures, where it is desirable to keep the cement content low.

The commercial materials available for rendering concrete impermeable fall into two groups: (1) pore filling materials and (2) water repelling agents. The former includes chemically reactive and inert finely divided materials, which tend to reduce the pore size, but such compounds are not effective as damp-proofing materials. Water repelling agents are added to the mix to produce water repellent concrete and are helpful in reducing the capillary rise of moisture through concrete floors. The use of these repelling agents as integral water-proofers for Portland cement, first introduced around 1920, is now firmly established. Such water-proofing compositions are available, both in liquid or solid form, and operate on the principle of distributing throughout the concrete mass a repellent, which prevents water from passing through. The selection is a matter of preference and job conditions but both are equally effective in producing a water-repellent mix. These compounds are particularly suitable for use in all concrete, stucco and cement plaster mixes for basements, foundations, reservoirs, tanks, swimming pools etc. "Cemto"[1] - an integral water-proofing powder developed by the Pakistan Council of Scientific and Industrial Research and an imported product commonly used in the country were chosen for the present study.

Effect of Integral Waterproofers on Physical Properties of Portland Cement

Setting Time.—The effect of 'Cemto' on the setting properties of Portland cement is reported in Tables 1 and 2. Results in Table 1 are for the setting time based on a fixed water/cement ratio and in Table 2 for varying water/cement ratios to adjust the cement mix to a normal consistency. Corresponding results with an imported product are included for comparision.

Integral water-proofers in small quantities delay the initial setting time; otherwise generally they have the property of accelerating the setting time, but, in in any case, the setting time remains within the permissible limits for ordinary concrete contruction.

Compressive Strength.—The evaluation of the effect of these water-proofing materials on the compressive strength was carried out on 2″ mortar cubes, made with 'Dalmia' cement and Malir sand (passing through sieve No. 30) in the proportion 1:3 by weight. The integral water-proofer was mixed with cement for five minutes and then sand and water were incorporated for the preparation of the mortar mix. The moulds were filled with hand compaction and the cubes were removed from moulds after 24

TABLE 1.—INFLUENCE OF INTEGRAL WATERPROOFERS ON THE SETTING TIME OF PORTLAND CEMENT. (ROOM TEMPERATURE, 21-22°C); WATER/CEMENT RATIO, 0.25.

Integral waterproofer % by weight of cement	Setting time. Cemto Initial Hrs. Mts.	Cemto Final Hrs Mts.	Imported Initial Hrs. Mts.	Imported Final Mrs. Mts.
0.0	2—15	6—45	2—15	6—45
1.0	2—50	6—40	2—45	7—00
3.0	2—0	5—40	2—10	5—30
5.0	1—50	3—20	2—0	4—25
7.0	1—45	3—10	1—55	4—00

TABLE 2.—INFLUENCE OF INTEGRAL WATERPROOFERS ON THE SETTING TIME OF PORTLAND CEMENT. (ROOM TEMPERATURE, 25-26°C); WATER/CEMENT RATIO FOR NORMAL CONSISTENCY.

Integral water-proofer % by weight of cement		Water/cement ratio	Setting Time Hrs. Minutes Initial Hrs. Mts.	Final Hrs. Mts.
0.0		0.255	2—47	4—58
3.0	Cemto	0.270	1—58	5—08
5.0	Cemto	0.275	1—53	5—00
3.0	Imported	0.290	2—15	5—50

TABLE 3.—INFLUENCE OF 'CEMTO' ON THE COMPRESSIVE STRENGTH OF CONCRETE (MADE WITH DALMIA CEMENT).

Integral waterproofer % by weight of cement	Water/cement ratio	% Reduction in compressive strength 7 days	28 days
CEMTO			
1.0	0.5	10—12	3—4
3.0	0.5	16—18	20—22
5.0	0.5	18—20	25—27
7.0	0.5	40—42	30—32
1.0	0.6	9—10	3—4
3.0	0.6	27—29	23—25
5.0	0.6	40—42	33—35
IMPORTED			
1.0	0.6	12—14	13—15
3.0	0.6	16—18	20—22
5.0	0.6	18—20	24—24
7.0	0.6	36—38	26—28

hours for water curing. The results are shown in Table 3. Another series of measurements was made on 2" mortar cubes made with 'Zeal Pak' cement and Malir sand (passing through sieve No.8) and the results are reported in Table 4.

TABLE 4.—INFLUENCE OF 'CEMTO' ON THE COMPRESSIVE STRENGTH OF ZEAL PAK CEMENT AND MALIR SAND MORTAR USING WATER/ (CEMENT + ADDITION) RATIO AS 0.45.

Integral waterproofer % by weight of Cement	Wet compressive strength in lbs. per sq. inch at 3 days	7 days	28 days
Nil	2870	4007	5182
3.0% (Cemto)	2292	3342	4471
3.0% (Imported)	2781	3588	4603

Waterproofing Properties

The earlier method for the determination of water absorption of a dried concrete specimen to evaluate the comparative water-proofing properties of concrete is no longer considered satisfactory. The real water permeability of concrete, or the inverse function, the water tightness, must necessarily depend on the resistance to the flow of water through the specimens and this resistance to flow has been directly measured by the following two methods.

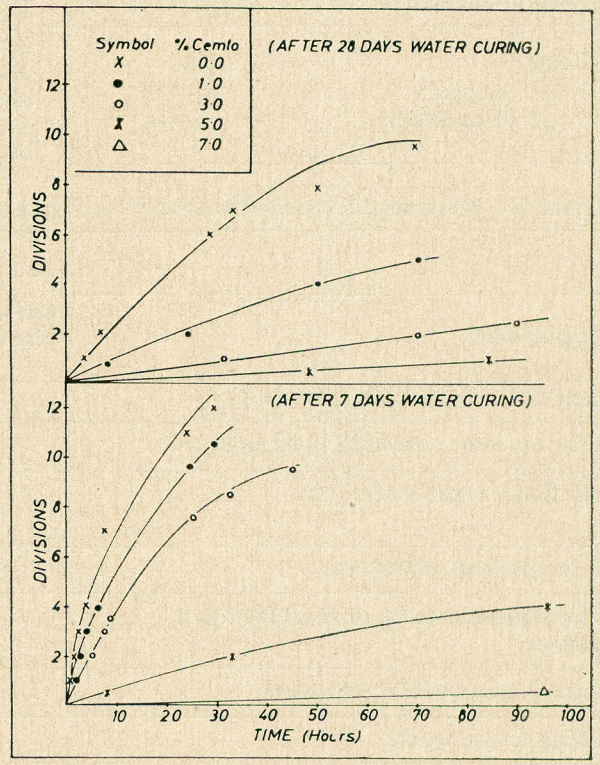

Fig.—Showing water peneteration properties of concrete by plotting fall in water level against time.

(1) The method has already been described by the authors in a previous publication on foam concrete.[2] The composition of the concrete used for the test was cement: Malir sand in the proportion of 1:3 by weight with a water/cement ratio of 0.6. The results are shown in Graph I. The curve for the imported product is not shown in this graph but results show it to be slightly inferior to 'Cemto'.

(2) The other method, used by Chotani et al.[3], comprises making slabs of 16″×12″×1″ and determining the rate of percolation through them under one feet head of water. For this test, a 3-walled steel tank fitted with water inlet and an over-flow arrangement was fabricated. The slab was fitted on the fourth side, and the internal space between the tank-walls and slab was sealed with bitumin. The composition of the concrete used for this testing was cement: Malir sand in the ratio of 1:3 by weight with a water/cement ratio of 0.45. The results of rate of percolation through the slabs are reported in Table 5.

TABLE 5.—WATERPROOFING PROPERTIES OF INTEGRAL WATERPROOFER.

Integral waterproofer % by weight of cement	Rate of percolation (cc/sq. ft./hour)
Nil	508
3.0 (Cemto)	10—12
3.0 (Imported)	12—14

Results

The integral water-proofers do not have any appreciable influence on the setting properties of Portland cement which might cause any construction problem. Abrams[4] studied the influence of many compounds on compressive strength of 1:3, 1:4 and 1:5 concrete mixtures and reported that without exception, compressive strength of the concrete was reduced by these compounds, e.g. soap solution (¼ pound per gallon of water) reduced the strength by 43%; 5% crude oil (both asphaltic and paraffin base) by 27% and propriety compounds by 13-26%. This last class of compounds is generally used in the proportion of 1-3% and the reduction in strength found in the present investigations is comparable with previously reported results. In this respect, to get best results with 'Cemto' it is preferable to use a lower water/cement ratio. The water-proofing properties of 'Cemto' are only slightly better than those of the imported type and its use in a slightly less proportion will make up for the comparatively greater loss of strength.

Applications

On the basis of the above results, recommendations for the use of 'Cemto' are given in Table 6. Precautions that must be taken in order to get satisfactory results are that (i) 'Cemto' should be well mixed with cement before the incorporation of sand and aggregate, (ii) only clean and sharp sand should be used, (iii) the aggregate should be non-porous and (iv) curing must be continuous since, once dried out, it cannot be effected.

TABLE 6.—RECOMMENDATIONS REGARDING THE AMOUNT OF 'CEMTO' FOR DIFFERENT APPLICATIONS.

Application	Proportion by Volume: Portland cement	Fine aggregate	Coarse aggregate	'Cemto' by weight of cement
Cement concrete (for ordinary use)	1	2	4	2 Percent
Cement concrete (resisting-water pressure.)	1	1½	3	3 ,,
Mosaic floors tanks, baths, etc.	1	2 (Marble Chips)	—	3 ,,
Wells (to prevent pollution.)	1	2	—	3 ,,
Ordinary mortar (brick or concrete block masonry.)	1	3	—	2 ,,
Mortars (water bearing structures)	1	2	—	3 ,,
Pointing (stone work.)	1	3	—	2 ,,
Damp-proof coarse (plinth level).	1	2	4	3 ,,

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