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Waterproof Concrete Additives and Their Effects on Concrete Properties

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***Abstract*— The use of waterproof additives in concrete for construction of some civil engineering structures founded below water table cannot be overemphasized as non-compliance to this has caused some structural failures. This study investigates some water proof additives available within south-east Nigeria, and their effect on the strength and water absorption rate of the concrete. There is a significant reduction in water absorption rate for all the concretes containing the various additives when compared with the controlled sample without additive. At 28 days, the water absorption rate of the concrete with additives varies from 1.71 – 4.65% while that of the controlled sample is 14.4%. As the curing age increased, the concretes with additives absorbed water at a slower rate than the controlled sample. In general, the additives do not have any negative effect on the compressive strength of the concrete instead some of the concretes have improved strength. The highest compressive strength obtained in this work at the end of 28 days is 29.7N/mm^2.**

Keywords*— Waterproof, concrete, additives, compressive strength, water absorption

I. INTRODUCTION

Concrete which is one of the most extensively used materials in civil engineering construction, is made of binder (cement), aggregates, water and sometimes additives/admixtures. Admixtures are materials other than the basic constituents of concrete added to the mix to vary or modify its properties. In this case, water proof additive is defined as a material other than cement, water and aggregate that is used as an ingredient of concrete and is added to the batch immediately, before or during mixing to modify the properties of concrete so as to make it more suitable for under-water conditions, thereby imparting many desirable characteristics like durability and effecting economy in construction.

Certain engineering structures such as basement, dams, waterworks, sea walls, docks, tunnels, tanks, drains, swimming pool are constructed with their foundations beneath ground water table. For these structures to stand, they need good concrete foundation that can resist ingress of water to an extent.

Water proofing is one of the basic requirements for durability of concrete. Water, on its part is essential to concrete production, placement and curing but once it fulfills its roles in the above process, it is no longer a friend to a concrete structure. Majority of concrete failures are attributed to high permeability, sorptivity / absorption of water, water penetration and ingress of some other liquids that can cause corrosion of steel reinforcement and destructive expansion of concrete.

Some investigators are of the opinion that concrete, carefully designed, efficiently executed with sound materials will be impermeable to water. The capillary pores formed during early age which allow passage of water can be blocked by further hydration during curing period if there is sufficient hydration product produced later. They also go on to assert that the use of low water-cement ratio, adequate cement and effective curing contribute significantly to reduce permeability [1]- [3]. However, since the usual design, placing, curing and in general, the various operation involved at the site of work leave not much to be desired, it is accepted that the use of a well chosen water proof additive may prove to be of some advantage in reducing permeability. The application of admixtures could reduce the amount of pores and make better dispersion of cement particles so that more dense concrete can be made [4]. Furthermore, concrete as ordinarily made is permeable to water and hence to secure the immunity of concrete structure from damaging influences of water in its discomforting, unhealthy or destructive features, some method of water proofing the concrete must be used.

In as much as the use of water proofing additives in concrete is highly recommended, the knowledge of the effect of these additives on the properties of concrete is very vital. Hence this study investigates some water proof additives available within south-east Nigeria, and their effect on the strength and water absorption rate of the concrete.

II. MATERIALS AND METHODS

The materials used in this work are cement, fine and coarse aggregates, water and water proof additives. Dangote cement brand of ordinary Portland cement with properties conforming to BS 12 was used [5]. The cement type is PC 42.5 with a specific gravity of 3.21g/cm^3. The fine and coarse aggregates were sourced from Otamiri River. The coarse aggregate has maximum size of 12.5mm. The grading and

properties of the aggregates conformed to BS 882 [6]. Potable water conforming to the specifications of EN 1008:2002 [7] was used. The water proof additives are Waterseal manufactured by MB. London ltd., Complast wp 100 manufactured by Purechem Manufacturing Ltd., J.K. Waterproof manufactured by Ujala Merchant & Trader Ltd., and Weber waterproof manufactured by Chemo Chemical Lassalle, New York.

A total of 60 concrete cubes measuring 150mm x 150mm were cast using a mix ratio of 1:2:4 and water cement ratio of 0.5. The additives were added according to the specifications of the manufacturers. Twelve (12) cubes were cast for each additive and the control without additives and three cubes were used to evaluate the water absorption property of concrete at 7, 14, 21, 28 days. The cubes were manually produced and cured in the laboratory. The cubes for this test were weighed and immersed in water for 24 hours. On removal from water, they were reweighed to determine the quantity of water absorbed. Water absorption was calculated as a measure of the difference in weight of the specimen before and after immersion in water for the specified period expressed as a percentage of weight before immersion. Three cubes were tested for each point and the average taken as the water absorption of the point.

Another set of 60 concrete cubes measuring 150mm x 150mm were cast using a mix ratio of 1:2:4 and water cement ratio of 0.5. Twelve (12) cubes were cast for each additive and the control without additives and three cubes were used to determine the compressive strength of the concrete at 7, 14, 21, 28 days. Using the universal compression testing machine, the cubes were crushed and the crushing load was recorded. The compressive strength was obtained from the following equation:

$$f_c = P/A \quad (1)$$

where f_c = the compressive strength

P = crushing load

A = cross-sectional area of the specimen

Three cubes were tested for each point and the average taken as the compressive strength of the point.

III. Results And Discussion

The result of the water absorption test and compressive strength test of the concrete with and without water proof additives is presented on Tables 1 - 4.

TABLE 1: COMPRESSIVE STRENGTH AND WATER ABSORPTION TESTS RESULT OF CONCRETE FOR 7 DAYS OF CURING

Days/age of curing (days)	**7**				
Water proof additives	A	B	C	D	E
Compressive strength (N/mm^2)	16.5	32.3	27.1	19.3	19.7
Water absorption (%)	0.76	0.57	0.81	1.36	3.5
KEY: A - D (ADDITIVES) , E-CONTROL(NO ADDITIVE)					

TABLE 2: COMPRESSIVE STRENGTH AND WATER ABSORPTION TESTS RESULT OF CONCRETE FOR 14 DAYS OF CURING

Days/age of Curing(days)	**14**				
Water proof additives	A	B	C	D	E
Compressive strength (N/mm^2)	26.6	24.7	25	23.3	22.7
Water absorption (%)	0.99	1.14	1.18	1.57	4.24
KEY: A - D (ADDITIVES) , E-CONTROL (NO ADDITIVE)					

TABLE 3: COMPRESSIVE STRENGTH AND WATER ABSORPTION TESTS RESULT OF CONCRETE FOR 21 DAYS OF CURING

Days/age of curing (days)	**21**				
Water proof additives	A	B	C	D	E
Compressive strength (N/mm^2)	19.4	22.9	16.9	23.2	24.2
Water absorption (%)	1.15	1.18	1.95	2.31	12.41
KEY: A - D (ADDITIVES) , E-CONTROL (NO ADDITIVE)					

TABLE 4: COMPRESSIVE STRENGTH AND WATER ABSORPTION TESTS RESULT OF CONCRETE FOR 28 DAYS OF CURING

Days/age of curing (days)	**28**				
Water proof additives	A	B	C	D	E
Compressive strength (N/mm^2)	29.7	27.1	21.2	25.5	26.7
Water absorption (%)	4.65	1.71	3.15	3.45	14.44
KEY: A - D (ADDITIVES) , E-CONTROL (NO ADDITIVE)					

From the results presented on Tables 1 - 4, it could be observed that the additives have a considerable effect on the properties of the concrete.

There is a significant reduction in water absorption rate for all the concrete containing the various additives when compared with the controlled sample without additive. At 28 days, the water absorption rate of the concrete with additives varies from 1.71 – 4.65% while that of the controlled sample is 14.4%. As the curing age increased, the concretes with additives absorbed water at a slower rate than the controlled sample. This is commendable as this shows that all the additives under consideration in this study are really water proof in nature.

The overall compressive strength of the concrete with additives except one at the end of 28 days falls within the range of 25 and 30N/mm^2 just like the controlled sample. The exception attained the same strength range for other curing ages. Increase in the curing age has variable effect on the strength of concrete with additives. Hence, it can be concluded that the additives do not have any negative effect on the strength of the concrete instead some of the concretes have improved strength.

It is worthy of note here that the results shown in this study are for concrete manually produced and cured in the laboratory which is prone to human errors. It is expected that better results /higher strength will be obtained for mechanized concrete.

IV. CONCLUSION

1. Concrete was produced with four different water proof additives sourced from south-east Nigeria.
2. Controlled concrete sample was also produced without the water proof additives.
3. The water absorption rate and the compressive strength were determined at 7, 14, 21, and 28 days.
4. There is a significant reduction in water absorption rate for all the concretes containing the various additives when compared with the controlled sample without additive. This is commendable as this shows that all the additives under consideration in this study are really water proof in nature.
5. In general, the additives do not have any negative effect on the strength of the concrete instead some of the concretes have improved strength.

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