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RESEARCH ARTICLE

Durability of Concrete Internally Cured with Thermostone Waste Subjected to Kerosene

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Manuscript Info ***Abstract***

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Prediction of the influence of internal curing on the final mechanical properties and its durability is an important issue in concrete researches. The concept of protected concrete has been one of the most significant theoretical approaches to internal curing. In this paper, the sustainable of thermostone waste (TW) as replacement of a volume portion of the normal weight sand to provide internal curing (IC) for a concrete is examined with respect to its. By adopting this approach (volumetric sand replacement with 7.5% and 10 % prewetted TW) internally cured mixture with 10% show additional benefits that should permit their broader application.

1.BACKGROUND

Concrete is the most commonly used material in construction industry. There are a number of reasons for using it such as high strength, ease of production, low cost, good compatibility with other materials, especially with steel, durability under aggressive conditions [1]. But, when used in the petroleum environment, concrete has some special requirements compared to the conventional concrete [2].

The oil had and still great importance in all fields of life. It is basic source of energy all over the world. Therefore, the storage of petroleum products in concrete tanks has been offered more benefits compared with other materials such as safety, serviceability and maintenance costs.

Concrete deteriorated by petroleum products such as kerosene, many studies were published approved that, study by Al-Jalawi[3], have shown that the tested specimens exposed to kerosene and gasoline showed reducing in compressive strength at all ages with compared to their corresponding reference specimens. Ayininuola[4], shows that the presence of diesel oil and bitumen of any proportion in sand resulted in concrete of lesser compressive strengths.
While, Ejeh[5], observed low development in compressive strength as the age of curing increase where the crude oil used as a curing media. Also, Ogbonna [6] was published that the ordinary Portland cement has weak resistance to crude oil attack as they displayed slow compressive strength development.

This revealed clearly that the petroleum products working as preventing agents in face of main property of concrete (compressive strength) development and in concrete production, also affected its durability.

In this paper, the workers were using internal curing to enhance the properties and durability of concrete. Principal objective of this research was to study the effects of thermostone waste (TW) as internal curing agent with percentages of (7.5%) and (10%) by volume as sand replacement, on the properties of hardened concrete i.e. compressive strength, absorption, bulk density and voids.

The concrete strength is often regarded as the most important property of concrete. The compressive strength of concrete is about ten times its tensile strength[7]. Concrete suffers from one major drawback compared with other materials like steel and timber; its strength cannot be measured prior to it being placed. Factors affecting concrete compressive strength are water cement ratio, mix ratio, degree of compaction, type of cement, the grades of aggregates, design constituents, mixing method, placement, curing method and presence of contaminants[1].

Curing is the maintenance of a satisfactory moisture concrete and temperature in concrete for a period of time immediately following placing and finishing, so that the desired properties may develop. Curing has a strong influence on the properties of hardened concrete; proper curing will increase durability, strength, water tightness, abrasion resistance, volume stability, and resistance to freezing and thawing[8].

Internal moist curing refers to methods of providing moisture from within the concrete as opposed to outside the concrete. This water should not affect the initial water to cement ratio of the fresh concrete. Lightweight fine aggregate may provide additional moisture for concretes prone to self-desiccation. lighweight fine aggregate can provide additional moisture to extend hydration, resulting in increased strength and durability. Internal moist curing must be accompanied by external curing methods.
Therefore the main objective of curing is to keep concrete saturated, or as near saturated as possible, for sufficient time for concrete hardening [9].

Philleo[10] suggested incorporation saturated lightweight fine aggregate into the concrete mixture to provide an internal source of water that consumed during hydration of the paste. A reasonable explanation of how the LWA(internal curing material) act as reservoir of water to the cementations binder.

During hydration, a system of capacity pores is formed in the cement paste. The radii of these pores are smaller than the pore of the internal curing material. As soon as the RH decreases due to hydration and drying, and a humidity gradient develops. With the internal curing material acting as a water reservoir, the pores of the cement paste absorb the water from the internal curing material by capillary suction. The unhydrated cement particles from the cement paste now have more free-water available for hydration. The new hydration prouducts grow in the pores of the cement paste thus causing them to get smaller, this continues until all the water from the internal curing material has been transported to the cement paste[11].

2. RESEARCH APPROACH

This study will evaluate a potential strategy for using TW as sustainable material for internal curing purpose as partial volumetric replacement of normal weight fine aggregate. Whereas kerosene has aggressive effect on concrete and its durability, the work will seek to improve properties of concrete by using internal curing technique, as water migrates from TW particles to cement paste sustains cement hydration toward increase hydration products. Compressive strength and tests related to durability of concrete have been conducted to study the effect of internal curing on concrete.

3. EXPERMINTAL DETAILS

3.1 MATERIALS

Materials used in this work are locally available in Iraq. Material properties are evaluated according to Iraqi Standard Specifications (I.Q.S), and compared with their limits.

Ordinary Portland Cement (OPC) confirming (I.Q.S NO.5)[12] was used in this study. The cement had a Blaine fineness of 326 m^2/kg, a compressive strength of 26.8 MPa at 7 days, a specific gravity of 3.15, and an estimated bogue composition of 56% C_3S, 21% C_2S, 7% C_3A, 9% C_4AF.

Crushed coarse aggregate has been brought from Al-Nib'aee quarry, with maximum size of (20 mm), its properties confirm requirement of (I.Q.S No. 45)[13].

Natural fine aggregate has been brought from Al-Ekhader quarry, its grading shown in Fig. (1), and confirming (I.Q.S No. 45) [13], also other properties.

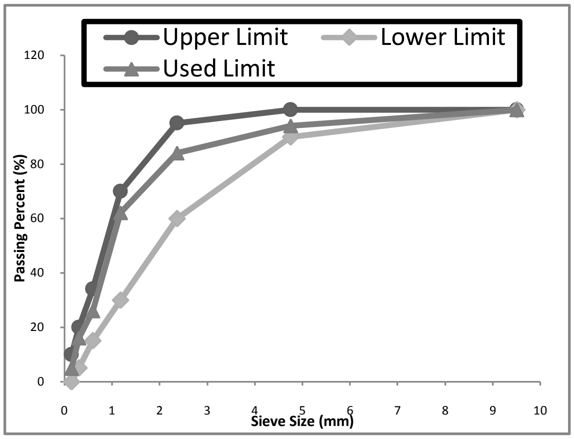

Fig. (1): Grading of Fine Aggregate

Thermostone wastes used as sustainable material have been brought from Thermostone factory in holy Kerbala government. In order to get the same grading of fine aggregate as shown in Fig. (1), Los Angeles machine and standard sieves have been used. Table (1) shows values of absorption and bulk density of TW.

Table (1): Some Physical Properties of TW.

Properties	Test results
Absorption, %	49.8
Bulk Density (Dry Loose), Kg/m3	747

3.2 MIXTURES PROPORTIONING

A three mixtures have been prepared, and all of them have the same W/C ratio and the same volume of gradients, which calculated according to ACI 211.1-21[14], mixtures proportions are listed in table (2). One of them was a plain control concrete, while the two other mixtures had a varying fraction of the fine aggregate replaced by saturated surface dry TW (24 Hrs. pre-wetted). To keep the volumetric proportioning of three mixtures, and because the density of TW is less than the density of fine aggregate, the amount of TW was used to replace the fine aggregate has been determining on the basis of volumetric replacement.

All mixtures have been cured in water for 28 days, after that, these mixture subjected to kerosene, and have been tested in periods of 30, 60 and 90 days.

Table (2): Mixtures proportion.

Mixture	Cement Kg/m^3	Water Kg/m^3	Coarse Aggregate Kg/m^3	Fine Aggregate Kg/m^3	TW Kg/m^3
C-M	570	228	768	686	0.00
K-7.5	570	228	768	635	22.4
K-10	570	228	768	617	30.6

4. CONCRETE PROPERTIES TESTING ANDEVALUATION

The hardened concrete properties such as compressive strength, density, absorption and percentage of voids have been examined in the laboratory. The results are presented along with their graphical plots and discussions.

4.1. COMPRESSIVE STRENGTH

Compressive strength for each of the 3 mixes was measured at three different ages: 30, 60 and 90 days, after have been cured with water for 28 days, depending on British standard[15]. Fig. (2)represents the graphical plot between the cubes compressive strength and period of subjected to kerosene. It is indicated that decreasing of compressive strength of control mix and (K-7.5), because the aggressive effect of kerosene on compressive strength of concrete as has been approved in many researches[3,4,5,6], and increasing of compressive strengthfor (K-10) with increasing in period of subjecting to kerosene, because the positive effect of internal curing.

The compressive strength of (K-10) was found to be highest at all ages of test, while compressive strength of (K-7.5) was lowest at all ages of test as compared with control mix. This behavior can be attributed to internal water migrates by using 10% TW is sufficient in sustain cement hydration and increase its products, that reguerdon the formation of pores as a result of using TW toward increase the compressive strength, but water migrates by using 7.5% TW is not sufficient in sustain cement hydration and the porous founded in concrete as a result of using TW.

The plot reveals the compressive strength of all mixtures after 58 days of subjected to kerosene are closer, whereas the increment of compressive strength of (K-10) was 2.5%, and the decrement was 10% of (K-7.5) compared with control mix. After 88 days of subjecting to kerosene, compressive strength of (K-10) improved 12.8% and decrease 15.4% of (K-7.5) compared with control mix. Finally at 118 days test the rate of increment of compressive strength is more up to 58 daysfor (K-10), it's 27%, but the decrement 18.9% of (K-7.5) compared with control mix.

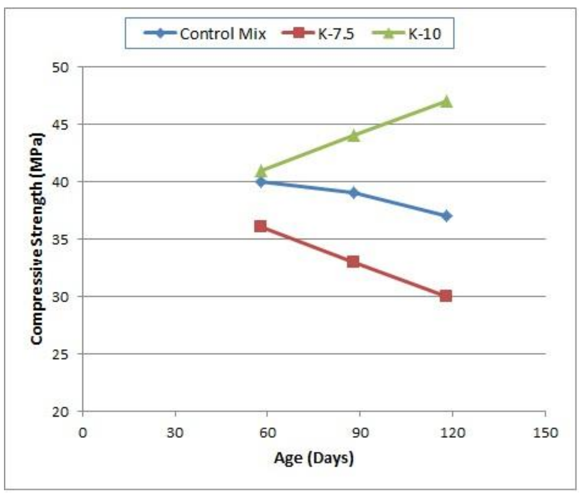

Fig. (2): Effect of TW on Compressive Strength.

4.2. DENSITY

Density of three mixtures has been calculated according to ASTM C-642[16], the results plotted as shown in Fig. (3). It is indicated that decreasing density of all mixtures with increasing period of subjecting to kerosene.

Also, indicated that the increase of TW percentage decreasing the density of concrete. The percentage of decreasing of density of (K-7.5) is (0.5%), (1.5%) and (1.05%) relative to control mix at ages of (58), (88) and (118) days, respectively. While, the percentage of decreasing of density of (K-10) is (2.5%), (4.06%) and (5.8%) relative to control mix at ages of (58), (88) and (118) days, respectively. This can be attributed to low density of TW.

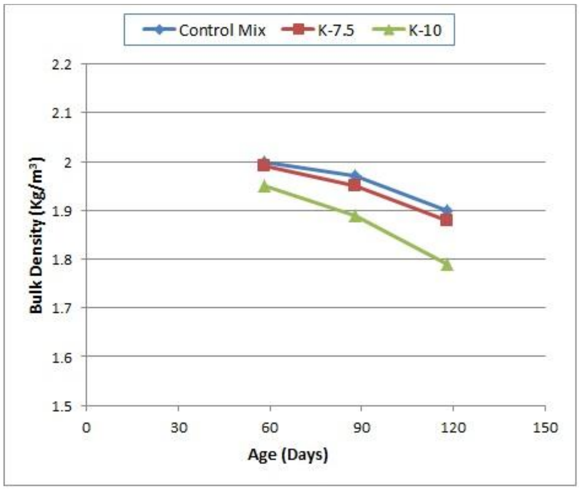

Fig. (3)Effect of TW on Bulk Density.

4.3 Voids and Absorption

The percentage of voids and absorption calculated depending on ASTM C-642 [15], Fig. (4) and Fig. (5) show the results of voids and absorption, respectively. The results reveal increasing the voids and percentage of absorption in concrete with increasing period of subjecting to kerosene, with increasing the percentage of TW increasing the voids and absorption of concrete, because high absorption of TW compared with normal weight aggregate.

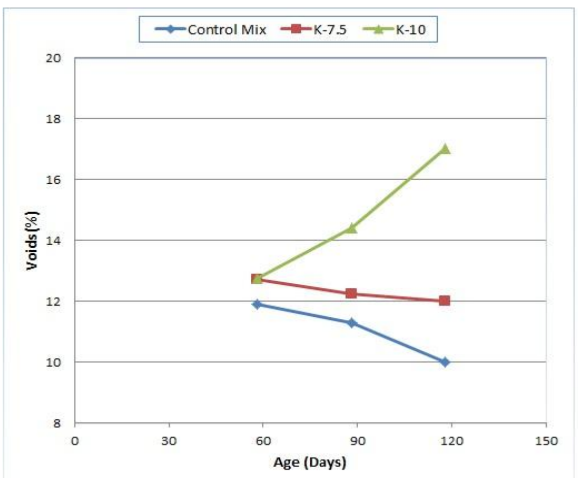

Fig. (4) Effect of TW on Voids in Concrete .

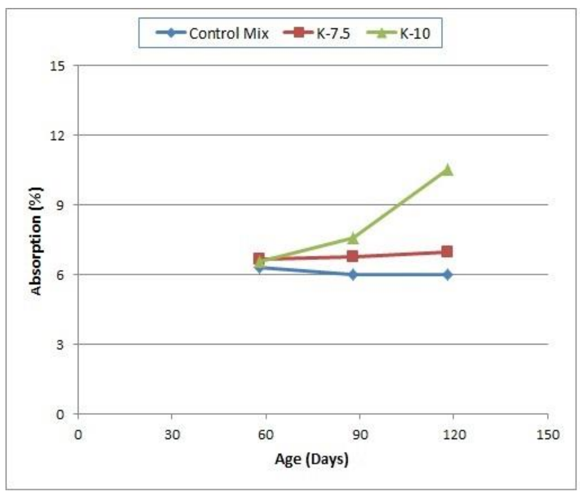

Fig. (5)Effect of TW on Absorption.

Conclusions

1. Kerosene has aggressive effect on all mixtures with increasing period of subjecting.
2. Using thermostone waste as internal curing material as volumetric replacement instead of fine aggregate lead to decrease in compressive strength with percentage of (7.5%), while with percentage (10%) the compressive strength increasing significantly.
3. Decreasing bulk density of concrete with increasing percentage of thermostone waste.
4. Increasing percentage of thermostone waste lead to increasing in voids of concrete.
5. Absorption of concrete increase with increasing percentage of thermostone waste.

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