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Re-Use of Date Palm Wastes to Improve Aging of Composite Concrete System

Falak O. Abas
Department of Chemistry, College of Since, University of Baghdad, Baghdad, Iraq

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Abstract:
The presented research aims to manipulate and improve the aging behaviors of concrete composite systems by employing ecologically safe date palm (seeds and husks) waste as a filler. In addition, optimized workability, durability, and erosion resistance properties for the new material were investigated.

The experimental work included the application of different mixing ratios (50/50, 30/70, and 70/30) of husk date/ date seeds to study the enhanced physicochemical behaviors and erosion resistant of bio-waste-concrete composite system exposed to severe temperature conditions (50 ºC) for a time period of 25 days. Optimum results were observed for samples reinforced with the natural filler with a ratio of 50/50 in comparison to the base samples.

In conclusion, good resistance to erosion and creeping thickness appeared at optimum conditions of 250 µm particle size. Also, higher reaction compatibility and less pores between particles were observed, which improved all physical and chemical properties as depicted by SEM images.

Keywords: Concrete System, Erosion Resistance, Chemical Durability.

إعادة استخدام نفايات نخيل التمر من أجل تحسين عملية الشيخوخة في نظام الخرسانة المركبة

فلك اسامه عباس
قسم الكيمياء، كلية العلوم، جامعة بغداد، بغداد، العراق

الخلاصة:
يهدف البحث المقدم إلى معالجة وتحسين سلوكيات شيخوخة الأنظمة المركبة الخرسانية من خلال استخدام نفايات النخيل (البذور والقشور) الآمنة بيئيًا ، كملء. بالإضافة إلى ذلك ، تم فحص قابلية التشغيل المثلى والمتانة ومقاومة التآكل للمواد الجديدة.

أظهر العمل التجريبي تأثير قشور التمر والبذور في نسب خلط مختلفة (50/50 ، 70/30 ، و 30/70) من بذور قشر التمر / الزمن ، لدراسة السلوكيات الفيزيائية والكيميائية المحسّنة ومقاومة التآكل في المخلفات الحيوية. نظام المركب الحيوي . عند التعرض لظروف من درجات الحرارة القاسية (50 درجة مئوية) لفترة زمنية تبلغ 25 يومًا.

وقد لوحظت النتائج المثلى للعينات المقواة بحشو طبيعي بنسبة (50/50) بالمقارنة مع العينات الأساسية.ظهرت مقاومة جيدة للتآكل وسمك الزحف في الظروف المثلى لحجم الجسيمات ميكرون 250. ثم

*Email: falak_usama@yahoo.com

أيضًا بتوفير قابلية أعلى للتفاعل وتقليل المسام بين الجزيئات التي تعمل على تحسين جميع الخصائص الفيزيائية والكيميائية كما هو موضح في صور SEM .

1. Introduction

Cementitious systems are widely employed as a supporting composite material in diverse applications. These engineered systems are composed of hydration artifacts, inert cement, pores, and water. Simple manufacturing procedures are used to enhance the freshness, hardness, and chemical durability of high performance concretes (HPCs), based largely on economical, eco-friendly and high performance natural waste materials (husk and seeds wastes) as fillers in ternary systems[1-5].

Many investigators have reported different operating routes to uphold the market demands of these sustainable systems. Aubert *et al*. [2006] employed organic solid waste fibers of bamboo, date palm, oil palm, and sugar palm. These fibers depicted improved chemical and economical behaviors when compared with steel and glass fibers [6]. Sivaraja and Kandasamy [2009] reported coconut fibers as reinforcement in a concrete beam along with rice husk and sugarcane waste fibers. The results of evaluation under monotonic and conventional loading of beam concrete showed a higher resistance to cracking [7]. Kriker *et al*. [2005] utilized all types of date palm waste (leaf fibers,baste stem fibers, wood trunk fibers, and surface fibers) to produce a new system, with an improved flexural strength and toughness properties, whereas compressive strength decreased with increasing the length and the fiber contents[8]. Low cost vegetable fibers were reported by Binci *et al*. [2005]as a structural material to show the increment in the compressive strength and earthquake resistance due to improved interface layers[9]. In another study by Blacklidge *et al.* [2011], sunflower husk was used to improve aging conditions of concrete composite systems for structural applications[10]. In the recent past, Sisman and Gezer [2013] reported the application of sunflower seed husks as an environmentally friendly filler for the production of low density and boosting concrete structures, which showed resistance to cracking in severe conditions [11]. Mohammed *et al*. [2009] used steel slag in the improvement of chemical and mechanical properties of concrete composite structures [12].

The present study's aim is to develop and fabricate a high efficient and recycled concrete composite system with a comparatively greater resistance and aging behaviors in severe weathering conditions. In addition, different mixing ratios and particle sizes were studied to optimize the final chemical and physical behavior of the system.

3. Experimental work

1. 3. Materials

Husk date: These types of wastes are commercially available from food industry wastes of date palm industry, collected and separated from other wastes of date seeds. This material was collected, cleaned and dried, followed by grinding in order to obtain a final suitable size in the range of 150-250 µm. These sizes were achieved using the shaker machine with different sieves.

Date seeds: These types of wastes which are commercially available from date palm industrywere collected and separated from the other wastes of husk date. This material was collected, cleaned, dried, and grinded in order to obtain a final suitable size in a range of 150-250 µm.

Cement*:* Commercial grade Portland cement was employed. Figure-1 depicts all the raw and waste materials used in the study.

H_2SO_4 (concentrated)*:* A lab grade of concentrated acidic solution of 99.9% purity was used, which was supplied by BTU (British Thermal Unit) Co.

NaOH*:* 99.9% pure sodium hydroxide flakes were used, which were supplied by BTU Company, Inc.

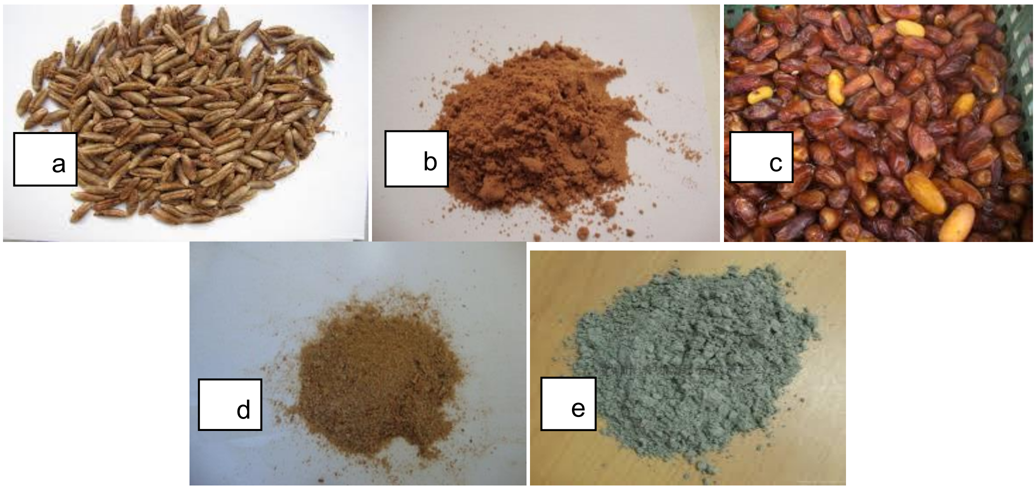

Figure 1-Solid waste materials applied, a: date seeds, b: powder of date seeds, c: date palm husk, d: powder of husk date, e: base Portland cement.

3.2. Methods

Preparation of the waste natural materials

Waste material of date (husk date and date seeds) was collected from date palm industries, washed thoroughly with tap water to remove sand and other contaminants, and dried for 48 hrs. The dried waste was grinded and sieved to fine particles by using cutter and grinder to attain a micro size ranging from 150 to 250 µm and achieve a good compatibility between wastes and the base cement.

Preparation of the new concrete blends

Various concrete blends were prepared by mixing a fixed amount of base Portland cement (3g) with different mixing ratios of husk date and date seeds (50/50, 30/70, and 70/30). Suitable amount of tap water was poured to facilitate best possible mixing. The blend mixture was then dispensed into molds to prepare the final samples. The prepared molds were left to dry for 24hrs in open air followed by treatment with 120º C for 1hr.

3.3. Methodology

Different physical and chemical properties (erosion rate, thickness, and pH) were employed, where creeping and shrinkage were measured by evaporation of hydrated groups that cause excessive deflection. Equation 1 below was used for the purposes of this test.Behaviors of the prepared blends were studied before and after bio-fillers application. In addition, scanning electron microscope (SEM, S50 type, FEI Company) was employed to study the surface structure of the composite concrete blends.

Hydrated group (%) = (weight before creeping – weight after creeping)/ weight before creeping x 100--- (1)

4. Results and discussion:

4.1. Effects of particle size of the bio-fillers on the erosion resistance of the new concrete composite blends under different exposure mediums (moisture, H_2SO_4, NaOH).

Figures-(2 and 3) demonstrate the effects of two particle sizes (150 and 250 µm) with time (day) on the erosion resistance (g) behavior of both the advanced and the base concrete blends. A great improvement in resistance behavior (up to 35%) was observed for the blend sample No 3, reinforced with 50/50 filler ratio under medium moisture environments of tap water with different salt concentrations under 50 ºC for 24 hrs, in comparison with samples 1 & 2. The sample with a size of 250 showed a superior behavior over that of 150due to its compatibility and the fewer pores among particles that may cause segregation and failure [8].

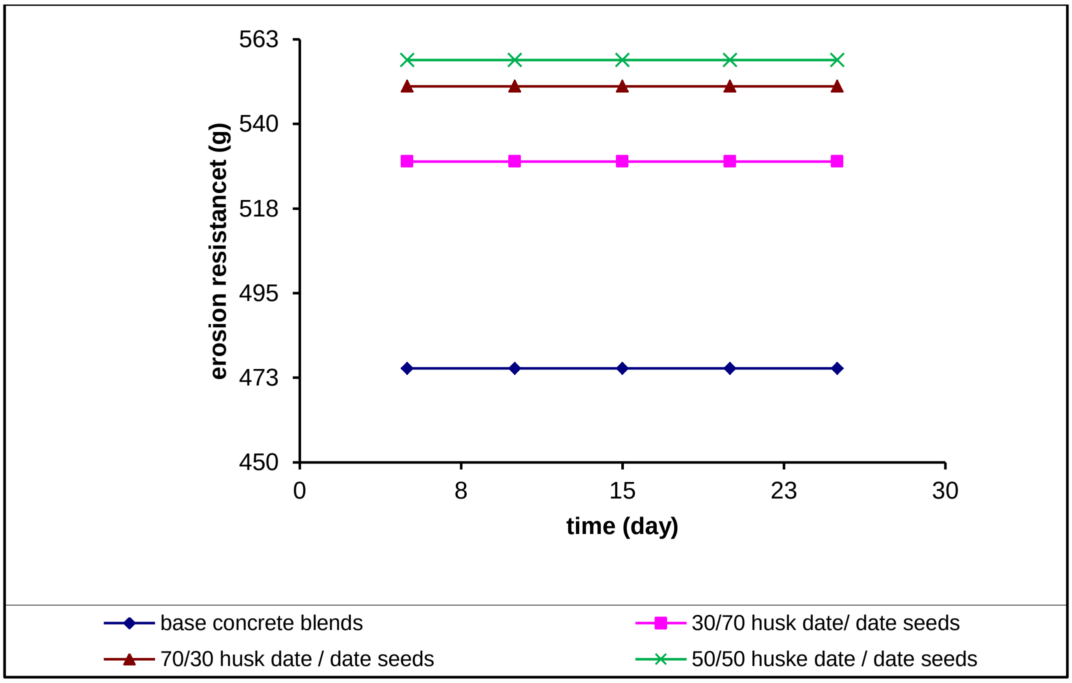

Figure 2-Erosion weight change for the 150 µm particle size under 50°C and moisture medium for base and improved blends.

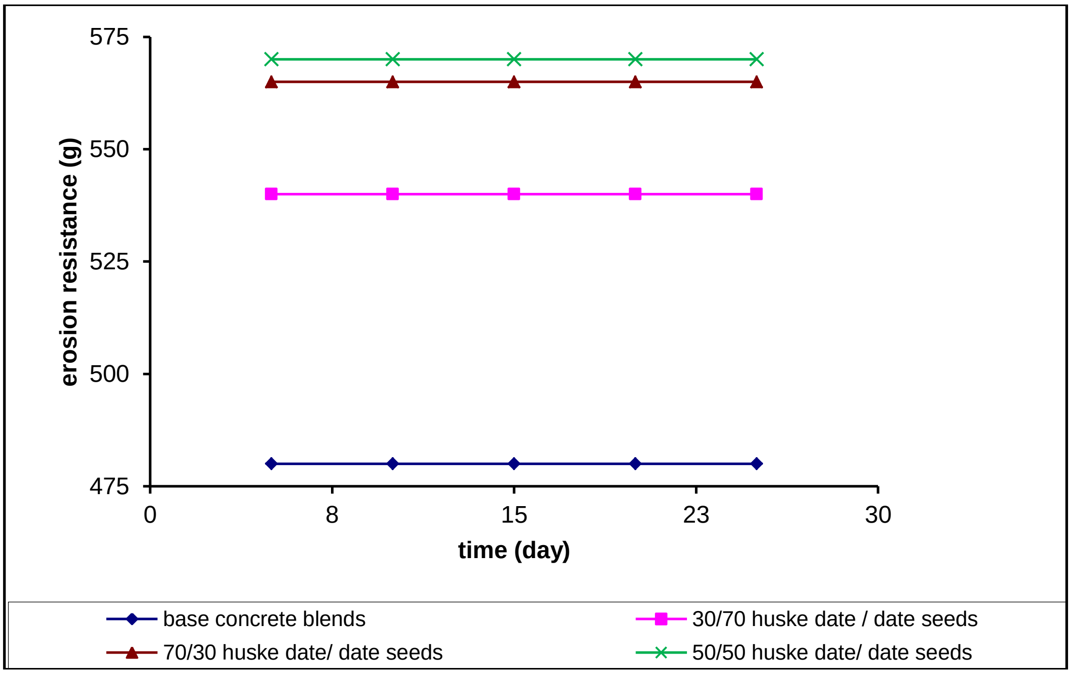

Figure 3 Erosion weight change for the 250 µm particle size under 50 °C and moisture medium for base and improved blends.

Figures-(4 and 5) show a comparative erosion resistance behavior for concrete blends with two particle sizes (150, 250) µm under acidic medium of 10% H_2SO_4. The erosion resistance values were observed to be reduced for up to 45% for the particle size of 250 µm in comparison to that of 150 µm. A comparative study was conducted on three samples with different mixing ratios of 30/70, 70/30, 50/50. The low resistance may be due to less space between particles that caused segregation and failure [8].

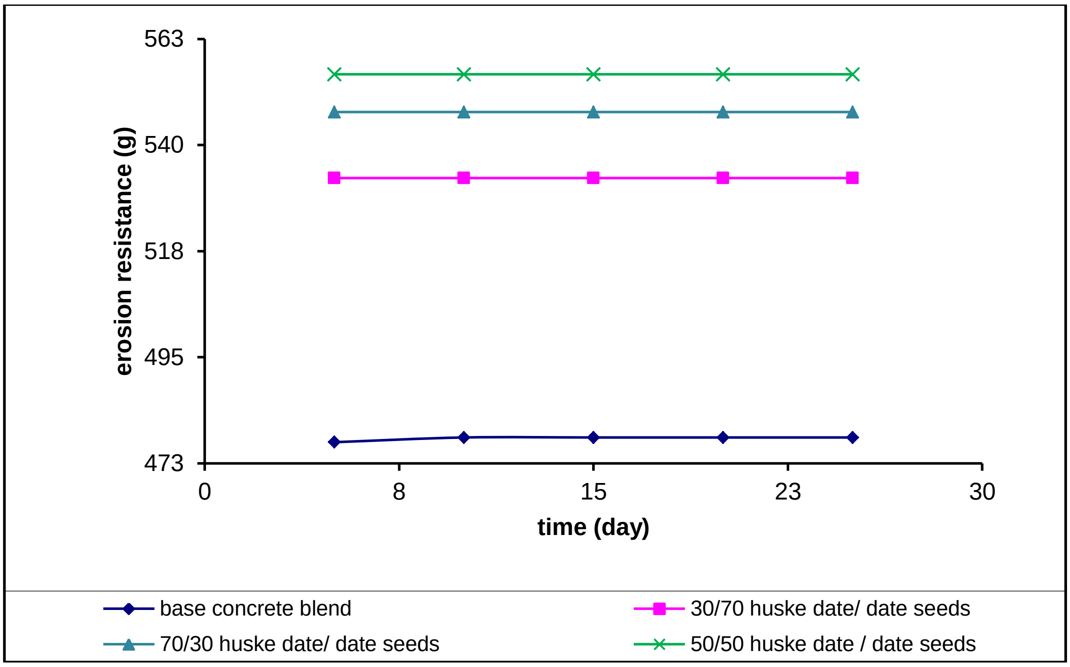

Figure 4-Erosion weight change for the 150 µm particle size under 50 ºC in 10% H_2SO_4 acidic medium.

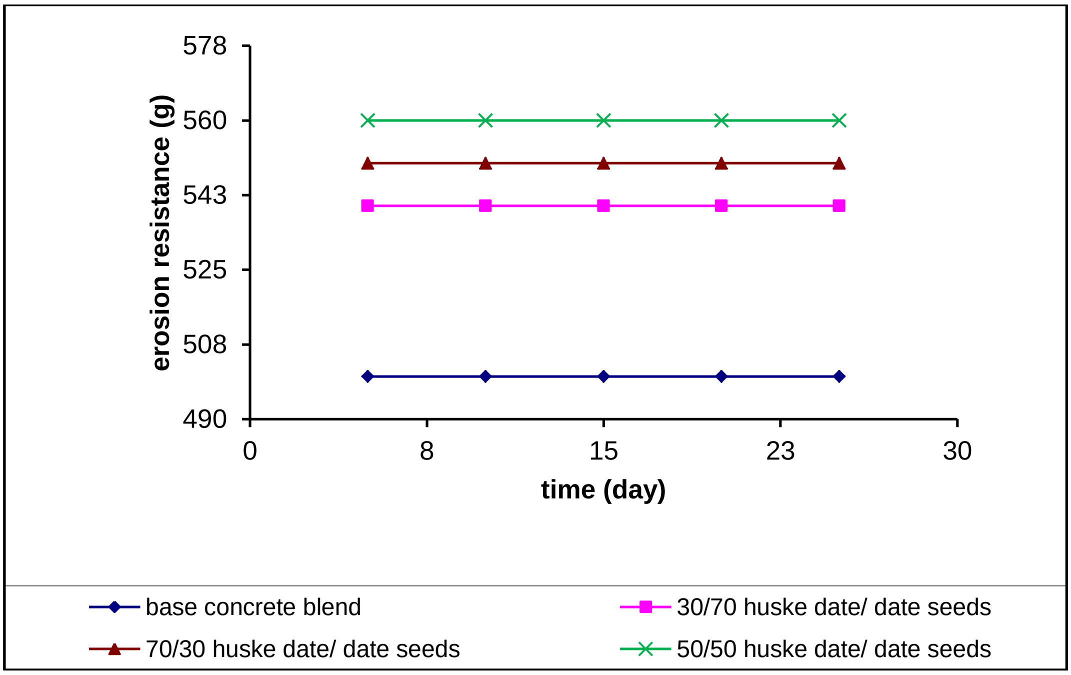

Figure 5-Erosion weight change for the 250 µm particle size under 50 ºC in 10% H_2SO_4 acidic medium.

A decrease in the erosion resistance (approx. 25%) was observed for samples with a particle size of 250 µm for both types of date waste soaked in an alkaline solution of 10% NaOH, in comparison with those of particle sizes of 150 µm. The clearer improvement was demonstrated by the optimum reinforced concrete blends No. 3, which is largely due to its compatibility and less spaces between particles, causing segregation and failure, as shown in Figure-6 and 7.

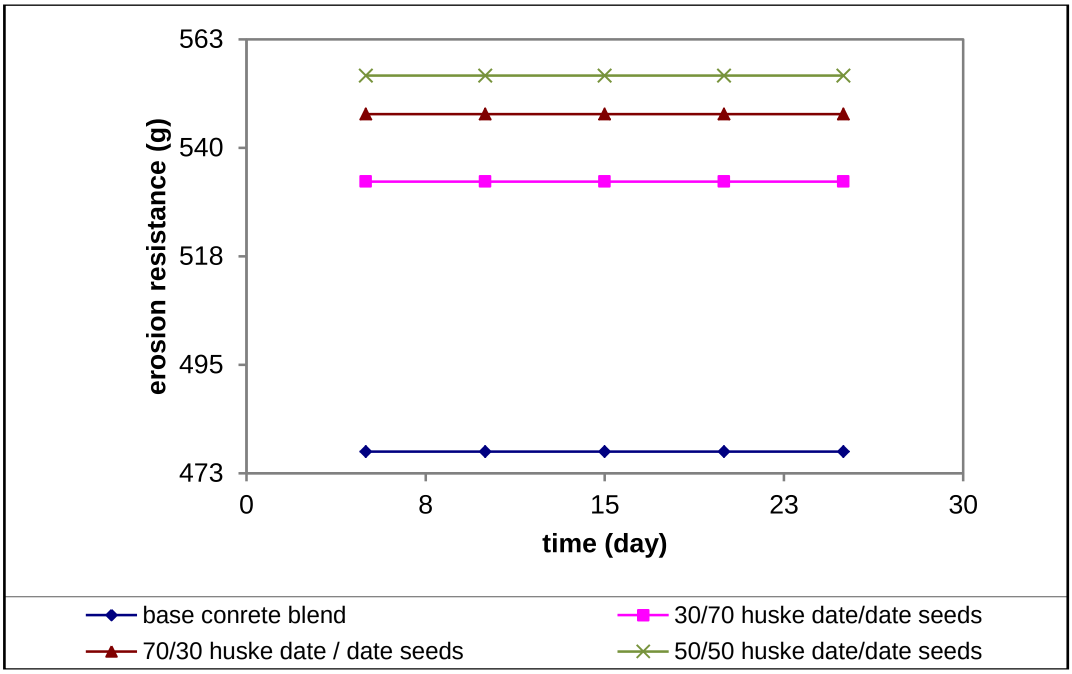

Figure 6-Erosion weight change for the 150 µm particle size under 50 ºC in 10% NaOH alkali medium.

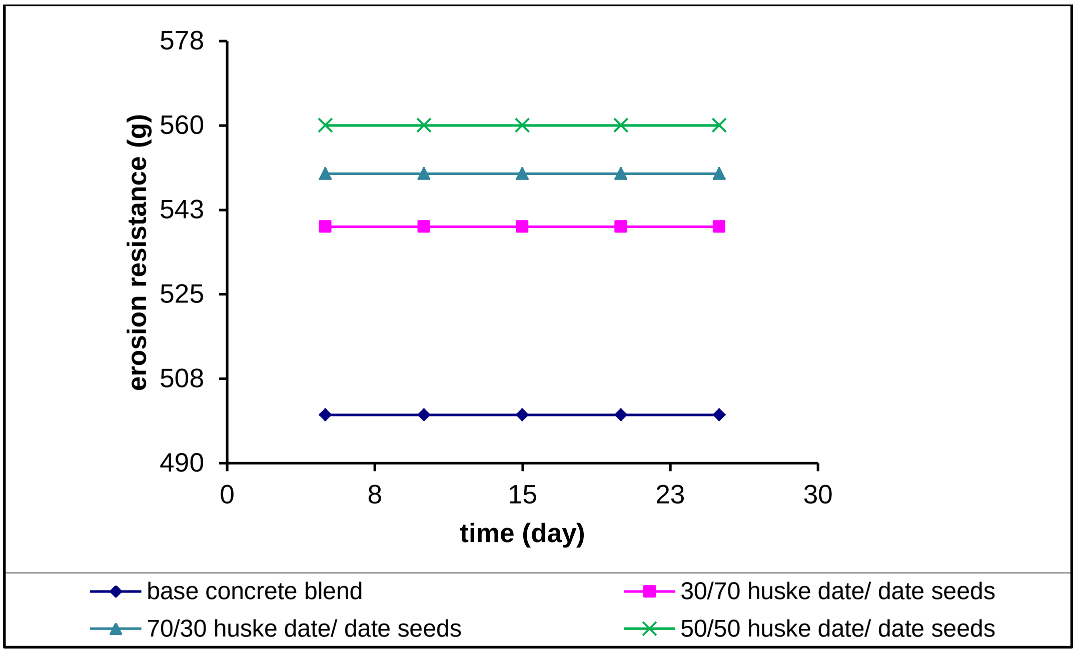

Figure 7-Erosion weight change for the 250 µm particle size under 50 ºC in 10% NaOH alkali medium.

4.2. Effects of particle size of the applied natural solid wastes on creeping thickness of the new concrete blends under different exposure mediums (10% H_2SO_4 and 10% NaOH).

Figure-8 shows the effects of the acidic solution of 10% H_2SO_4 on creeping thickness of the new concrete blends of 150 µm particle size, for both types of solids wastes (husk date and date seeds). The optimum sample No. 3 of the ratio 50/50 showed a less change in the creeping thickness for date seeds, which may be due to its compatibility and less spaces between the particles, causing segregation and failure.

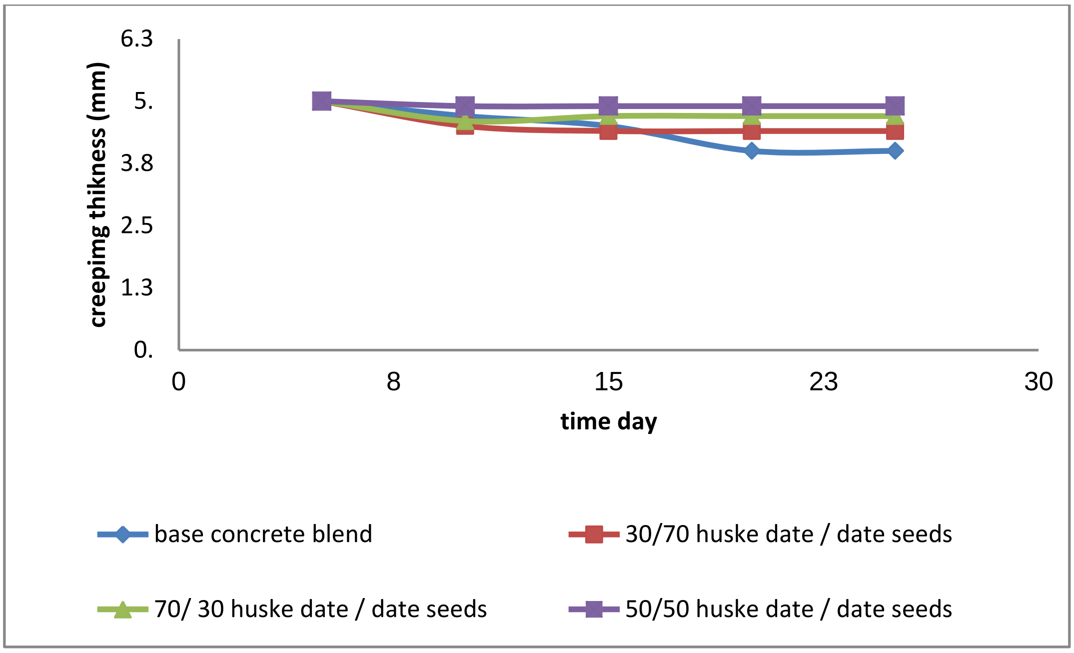

Figure 8-Effects of the acidic solution of 10% H_2SO_4 on the creeping thickness of the new concrete blends with150 particle size from both solids (husk date, date seeds).

Higher stability was observed in the creeping thickness of the improved blends reinforced by date palm waste of lower particle size (250 µm) size, because of higher compatibility and less spaces between the particles that causes segregation and failure, as depicted in Figure-9.

Similar results were observed when using alkaline soaked medium (10% NaOH), which can be attributed to the same reasons mentioned above, as shown in Figures-(10 and 11), respectively.

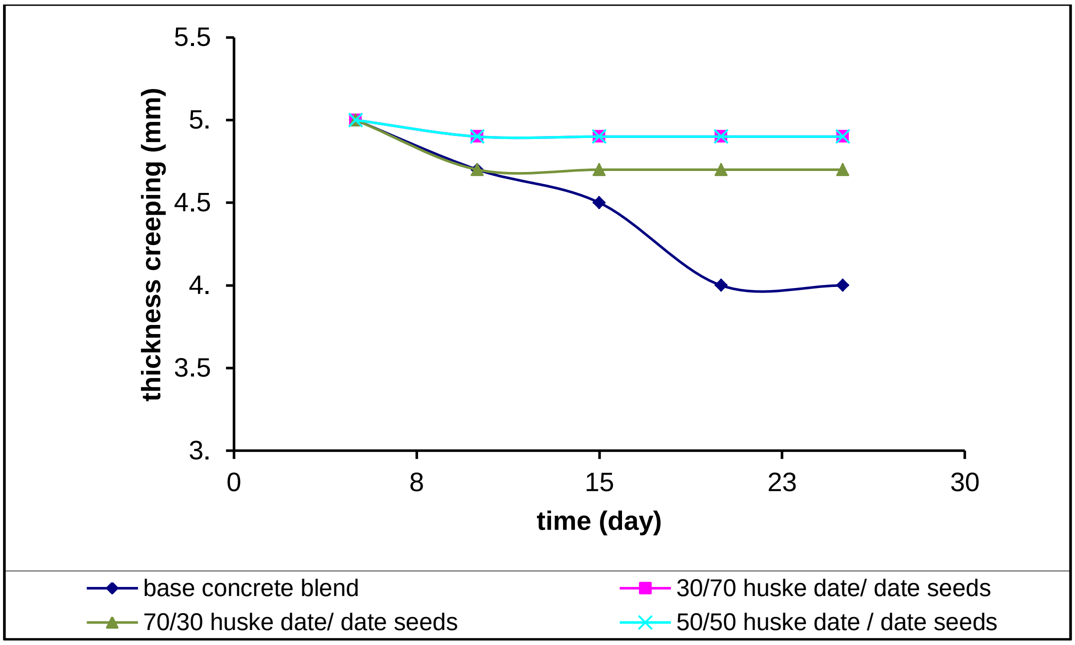

Figure 9-Effectsof the acidic solution of 10% H_2SO_4 on creeping thickness of the new concrete blends with 250 particle size from both solids (husk date and date seeds)

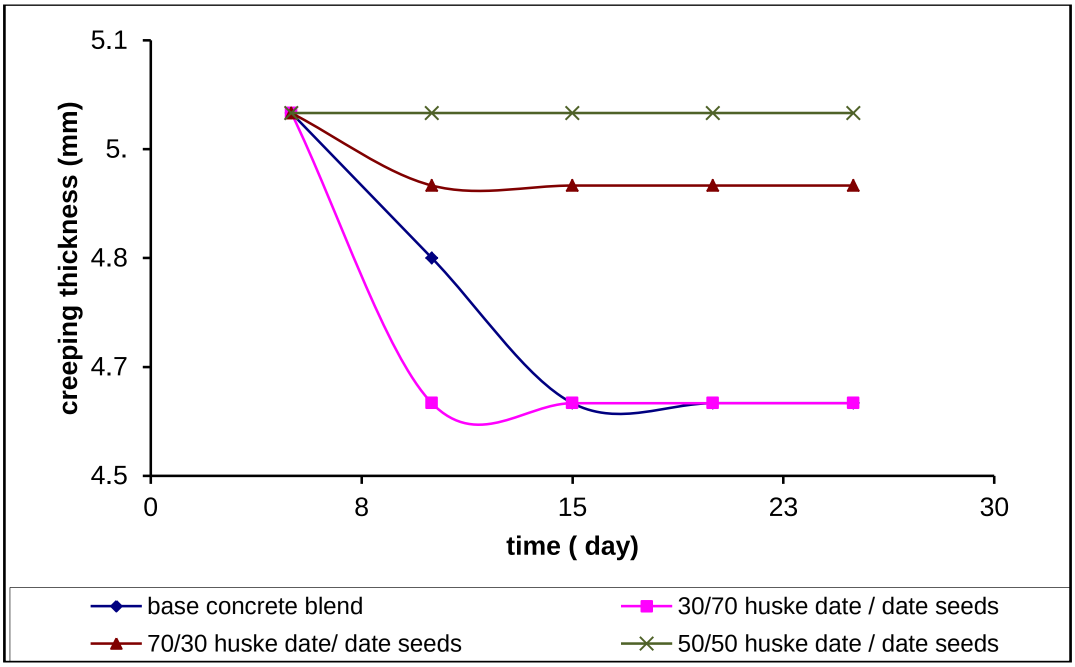

Figure 10 Effects of the alkali solution of 10% NaOH on creeping thickness of the new concrete blends of150 particle size from both solids (husk date and date seeds).

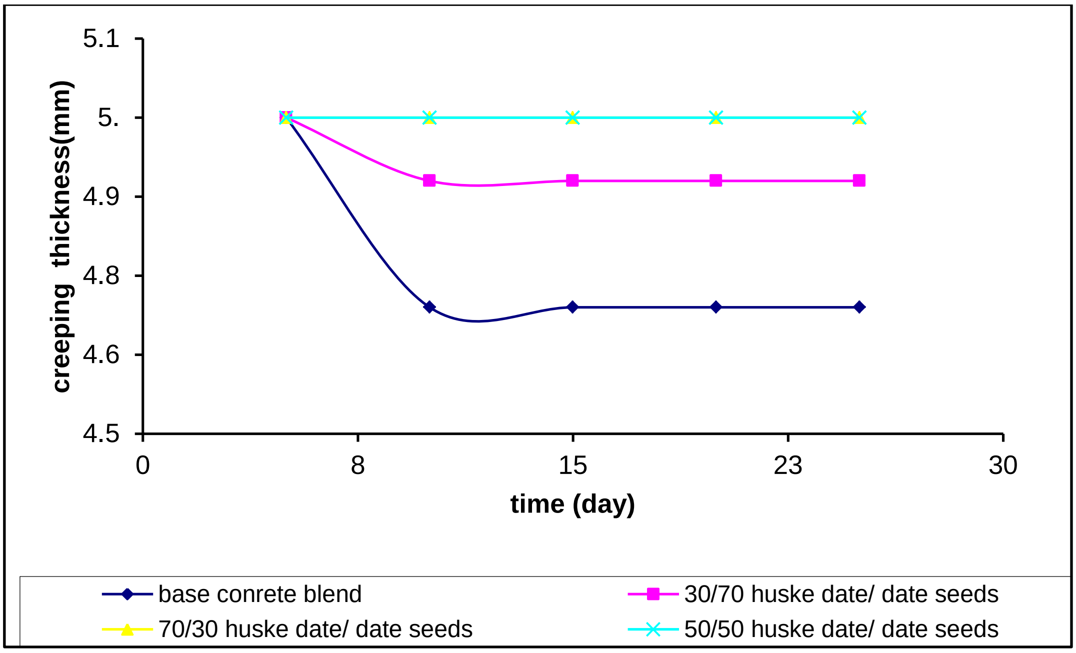

Figure 11-Effects of the alkali solution of 10% NaOH on creeping thickness of the new concrete blends with250 particle size from both solids (husk date and date seeds).

4.3. Effects of particle size on pH of the new concrete blends under different exposure mediums (10% H_2SO_4 and10% NaOH) at an optimum particle size of 250 µm.

Unstable acidity function (pH) appeared for base concrete blends rather than samples prepared under acidic medium, with a preference given to the optimum sample No 3, where good compatibility and less spaces between particles causes segregation and failure, as depicted in Figures-12 and 13. The figures present the effects of the solid wastes on the final acidity function of the base as well as the improved concrete blends. A higher stability was observed for the optimal sample No 3, containing equal amounts of both types of solid wastes, based on their resistance to losses of hydrated groups and chemical stability [5].

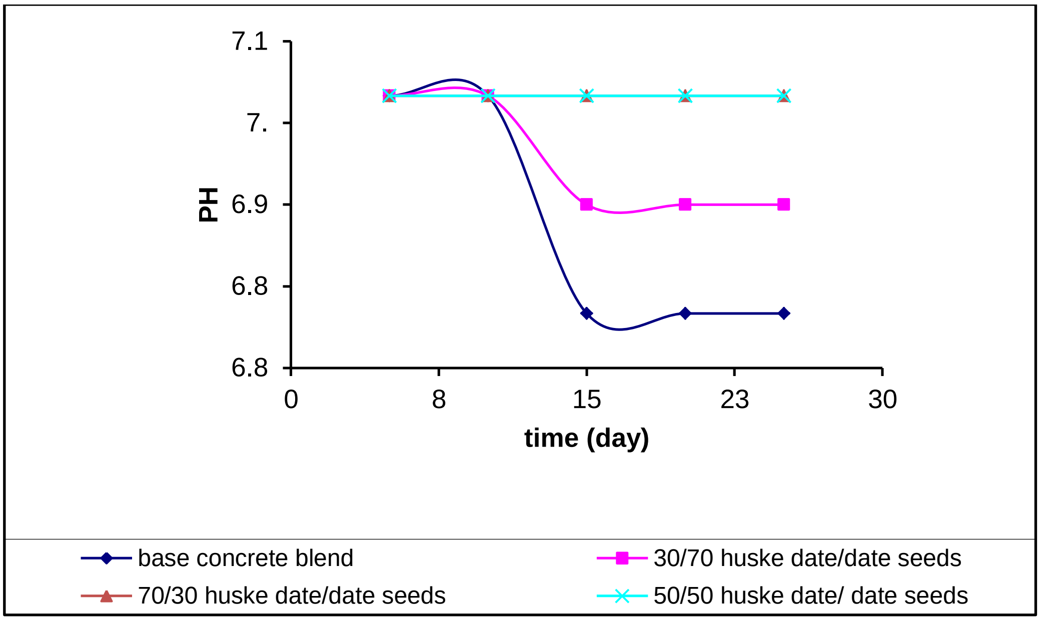

Figure 12-Effects of the acidic solution of 10% H_2SO_4 on pH of the new concrete blends of 250 particle size from both solids (husk date and date seeds).

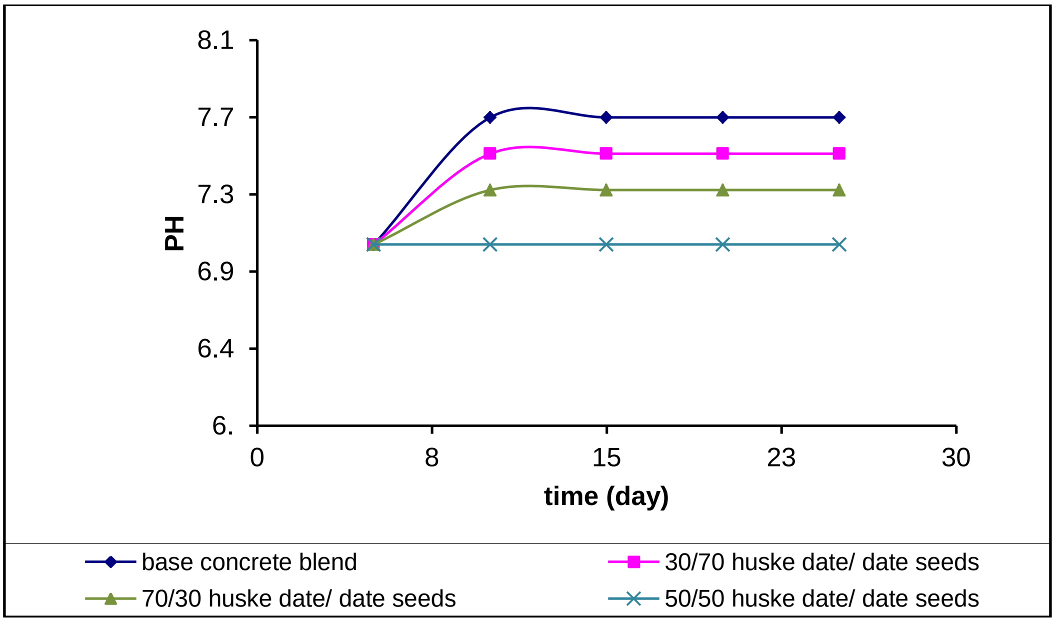

Figure 13-Effects of the alkali solution of 10% NaOH on pH of the new concrete blends of 250 particle size from both solids (husk date and date seeds).

4.4. SEM analysis for the structures of optimum and base sample blends

An SEM study was performed on the optimal and improved concrete sample No 3 and the base concrete sample (Figure-14a and Figure-14b). The SEM images of sample No. 3, reinforced with 50/50 ratio of both palm wastes, showed less pores and higher compatibility than those of the base sample without biological fillers. Higher compatibility with less intercellular spaces can be seen in the image of sample No3 (optimum particle size of 250 µm and ratio).

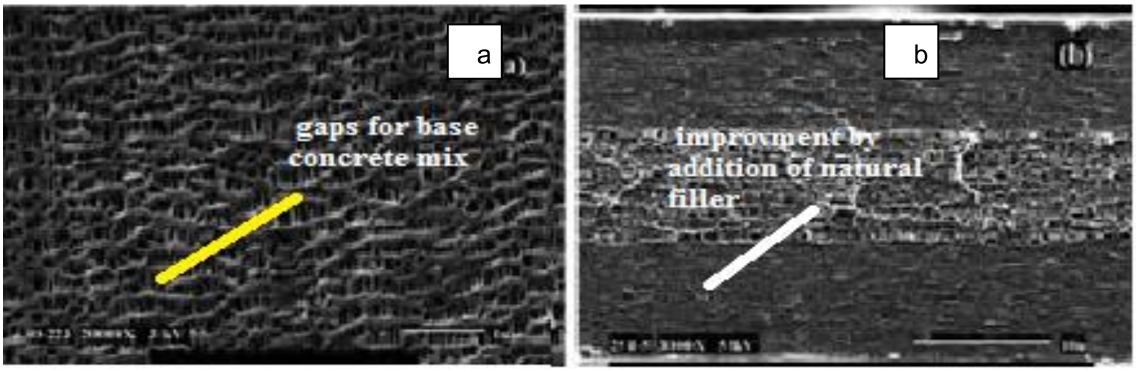

Figure 14-SEM structures of the optimum improvement sample no. 3compared with the base sample. (a) Base concrete blend, (b) optimum sample 3 reinforced by 50/50 of husk date/ date seeds.

5. Conclusions

1. The optimum sample with excellent chemical and physical properties was shown to be sample No. 3, which has an equal ratio of both types of natural wastes (husk date and date seeds). It also produced less erosion resistance and a creeping thickness and was less affected by pH medium.
2. The optimum and less particle size sample (< 250 µm) confer higher reaction compatibility and less spaces between particles that improved all physical and chemical properties, as depicted by SEM images.
3. Good resistance to erosion and creeping thickness appeared at an optimum condition of 250 µm particle size over the base material.

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