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PROPERTIES OF CEMENT MORTAR CONTAINING HOMRA AND MODIFIED WITH NANO-SILICA

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ملخص البحث

التطور فى صناعة الخرسانة و مواد البناء فى الوقت الحالى اصبح من الضروريات المهم لمواكبة العصر و التطورات السريع فى جميع المجالات و من اهم التطورات الحديث الان هى استخدام تقنية النانو و لذلك فقد قمنا فى هذا البحث بأستخدام تقنية النانو الممثله فى مادة النانو سيلكا . و ايضا استخدام مخلفات مواد البناء و منها مخلفات الطوب الاحمر(الحمرة) . و لا ن المونه الاسمنتيه هى امتداد للخرسانه فقد تم استخدام المونه الاسمنته و استبدال جزئى للاسمنت بالحمرة و النانو سيلكا و دراسة مدا تأثير هذه الاضافات على الخواص الفيزوميكانيكه للمونه الاسمنتيه.

ABSTRACT

An An ordinary concrete is a mixture of cement, sand, gravels and water. Some admixtures and additives are also added to achieve some new properties. In this paper, the properties of cement mortar containing Homra and modified with Nano-silica (NS) will be studied. Ground clay bricks(GCB) or Homra is a solid waste industrial material. It is mainly consists of aluminosilicates, silica quartz, anhydrite, and hematite. which acts as a good pozzolanic material. Recently nanotechnology (NT) has attracted a considerable scientific interest, due to the particles potential uses in Nano scale, which can change the concrete world. Nano-materials (NMs) improve the concrete characteristics. Nano-particles (NPs) gave unique chemical and physico-mechanical properties different from the conventional materials properties. There is a great interest in replacing NPs in concrete structure to modify the physico-mechanical properties and chemical of concrete.

key words (Cement Mortar, Homra, Nano-Silica**)**

1. INTRODUCTION

Li, H. et al [1] reported that, NT has attracted much scientific interest due to the potentially new performance of the particles I nanometer (10^{-9}scale). The Nano scale particles can result in modified properties from normal grain-size materials of the same chemical composition.

Jian Yang et al [2] reported that, the differing properties of GCB from recycled concrete aggregate (RCA) will affect the mix design as well as the resulting new concrete physico-mechanical properties when the inclusion level exceeds a certain limit. Separating GCB from RCA presents a practice operational difficulty in and also has big cost implications. Therefore, it is important to study the effect of GCB with various containment levels on the fresh and hardened concrete properties. They investigated the physico-mechanical properties of recycled concrete with high containment levels of GCB and RCA and to explore the potential or the limitation of this type of mixed recycled aggregate(RA) in primary concrete structures.

T. Vieira et al [3] presented an experimental study using aggregates produced from crushed clay ceramic bricks and sanitary ware aggregate. Production of different mixes of concrete where the fine aggregate was replaced (20, 50 and 100%) by each of these materials. tests of chloride ion penetration, water absorption by immersion and capillary action, shrinkage and carbonation were carried out. Notwithstanding the water requirement increasing due to the formation of agglomerated particles and the large absorption capacity of ceramic brick aggregate with sanitary ware aggregate, this paper shows that a good use of these materials may allow the production of convenient structural concrete, in mixes with sanitary ware aggregate using super plasticizers is a very effective method in preventing the clusters formation, even providing a better performance than the control concrete.

The Fuji Chimera Research Institute [4] tended to practical utilizations of SiO2 in Nano scale. Be that as it may, up to now, look into performed throughout the years has been to a great extent went for accomplishing high mechanical execution with concrete substitution materials in small scale estimate.

Sadrmomtazi A. [5] examined the impact of Nano-SiO2 on the strength of concrete. Nano-SiO2 could fundamentally build the compressive strength of concretes containing vast fly fiery debris volume at early age, by filling the pores between expansive fly ash and cement particles. Nano-SiO2 diminishes the setting time of mortar when contrasted and silica fume (small scale silica) and decrease draining water and isolation by the change of the cohesiveness.

2 Materials

2.1 Cement

The cement used in this study is the ASTM type (I) Ordinary Portland cement (OPC) (El Momtaz) produced by Lavarg Company. Some tests are conducted on a sample of cement to ensure quality testing specific weight, fineness, soundness of cement, initial and final setting time .The physical properties of the cement sample as a result of these tests are given in Table (1).

Table (1): Physical properties of cement

No.	Property	Result
1	Specific gravity	3.17
2	Fineness	2000 cm^2/g
3	Initial setting time	85 minutes
4	Final setting time	180 minutes
5	Compressive strength	Kg/cm^2
a)	3 days	205
b)	7 days	300
c)	28 days	435
6	Soundness	1mm

Fig. (1): Standard sand packages

Fig. (2): Specific weight test

2. 2 Fine aggregates

Standard sand is used as fine aggregate. CEN Standard sand (ISO standard sand) is a natural sand, which is siliceous particularly its finest fractions fig. (1). It is clean; the particles are for the most part isometric and adjusted fit as a fiddle. It is dried, screened and arranged in a present day workshop which offers each assurance as far as quality and consistency Its sieve analysis is given in table (2).The result of sieve analysis is in accordance with the British standard (B.S882:1992). Figs. (2) show the tests which are conducted on fine aggregates to get its physical properties and results are given in Table (3).

Table (2): Sieve analysis of standard sand

Sieve size	4.75	2.8	1.4	0.71	0.355	0.18
Residual %	0	0	19.3	52.5	74.1	90.1
Passing %	100	100	80.7	47.5	25.9	9.9

Table (3): Physical properties of standard sand

No	Property	Result
1	Specific gravity	2.65
2	Bulk density	1650kg/m^3
3	Grading	Percent
4	Percent of Clay and other Fine Materials	0%

2. 3 Ground clay bricks (Homra):

A recycled aggregate was prepared from Ground clay bricks, which were gathered from a development site. The quality of the waste blocks was measured by the National Standard of Fired Common Brick GB5101-2003, and the quality was resolved to be MU10 (the compressive quality surpassed 10 MPa). The Ground clay bricks were squashed before utilize. The fundamental execution of the reused total was assessed, and the review, density and pulverize file were resolved. The physical properties of reused aggregates produced using Ground clay bricks are given in Table (4). Fig.(4) outlines the reused aggregates planning process, which incorporates crushing, evaluating and sieving. The standard blunder figured from the test information was under 1. As indicated by GB/T 14685-2001, the national standard on the utilization of rock and squashed stone for structures, and in view of evaluating, the pounded reused aggregates gathered from the annihilation plant were fit the bill for use in concrete.

Table (4):Physical properties of (GCB)

Content	Quantity
Apparent density (kg/m3)	1650
Bulk density (Kg/m3)	830
Grading (mm)	5.20
Elongated particle content (%)	9
Saturated surface dry absorption (%)	16.58
Moisture content (%)	0.6
Crush index (%)	29.5

(a) **(b)** **(c)** **(d)**

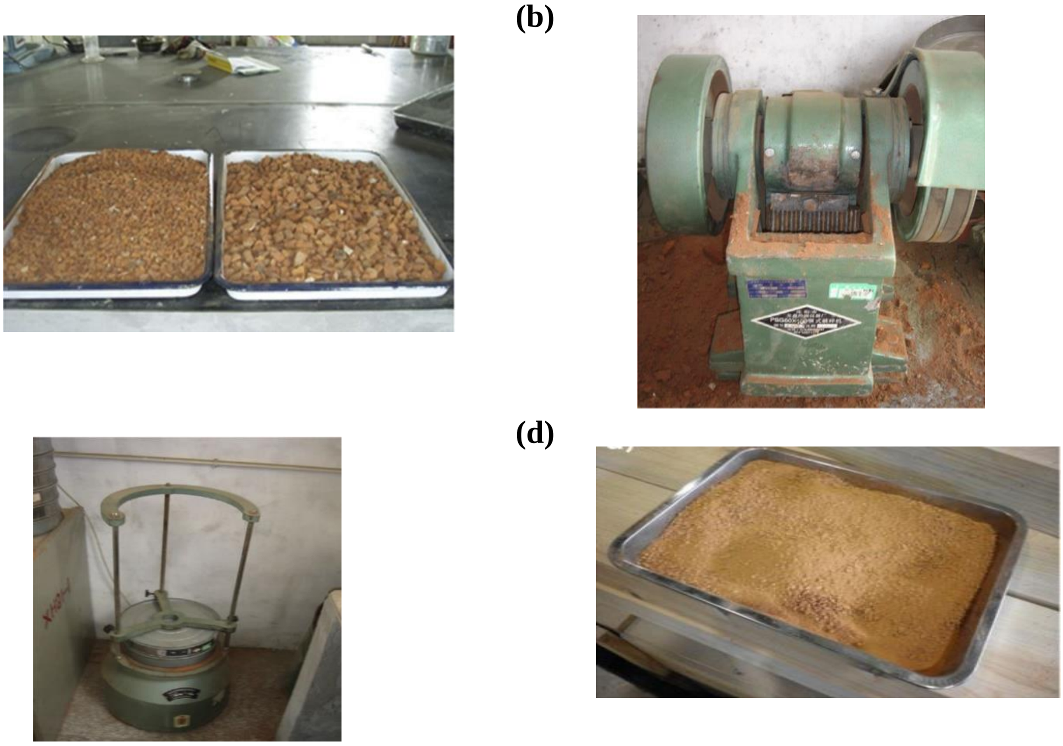

Fig. (4): Preparation process of GCB from clay bricks: (a) coarse clay bricks (b) Crushing, (c) sieving and, (d) fine clay bricks.

2. 4 Nano-silica:

Nano-silica is utilized as a part of the present trial study. Nano particles are utilized either to supplant a portion of cement or as admixtures in concrete. Nano-particles have been found to go about as cores for the concrete stage advancing cement hydration. Nano-silica has a noteworthy part and the progressions recorded in changed blends with Nano-silica are because of the synthetic response amongst SiO_2 and $Ca(OH)_2$ which is discharged amid cement hydration and furthermore because of physical adjustments, for example, the pressing variable change. The considerable reactivity of Nano-particles is credited to their high virtue and particular territory in connection to their volume. Properties of Nano-silica provided by manufacturer is given in Table (5).

Table (5): Properties of Nano-silica

No	Property	Result
1	Particle size	14nm
2	Specific surface area	$200m^2/g$

2. 5 water:

The water is used as mixing water for cement-mortar samples and it is used in curing other samples. The chemical analysis of The water is given in table (6).

Table (6): The chemical analysis

Content	Quantity
Density (gm/cm3)	1.025
Soluble salts (gm/l)	35.438
Ions	171
Carbonates (gm/l)	0.030
Bicarbonate (gm/l)	0.305
Sulfate (gm/l)	9.712
Chlorides (gm/l)	12.985
Calcium (gm/l)	0.500
Magnesium (gm/l)	1.325
Sodium (gm/l)	10.109
Others	0.472

3 MIXING RATIOS AND EXPERIMENTAL TECHNIQUE:

3.1 Mix proportions for mortar:

The water– cementations ratio (w/c) is 0.5; four contents of Homra with the percentage of 10%, 20%, 30% and 40% are constant at weight of cement. Taking the best ratio of Homra with three contents of Nano-silica particles with the percentage of 2%, 4% and 6% are constant at weight of cement. The compressive strengths and flexure of the modified cement mortars are also evaluated at the w/c ratio of 0.5 to compare with mortars without Homra or Nano-silica. The mix composition of the investigated mixes is given in Table (7).

Table (7): Mix composition of the investigated mixes

Mix No	O.P.C	H	N
OPC	100	0	0
H_{10}	90	10	0
H_{20}	80	20	0
H_{30}	70	30	0
H_{40}	60	40	0
$H_{20}N_2$	78	20	2
$H_{20}N_4$	76	20	4
H20N6	72	20	6

O.P.C: ordinary portland cement
H: Ground clay bricks (Homra)
N.s: Nano-silica

3.2 Experimental Techniques

3.2.1 Preparation of cement mortars

The mortars are prepared by mixing 1 part of cement and 3 parts of standard sand (by weight) with water content sufficient to obtain a flow of 110±5 with 25 drops of flowing. The fresh mortars are molded into and 40x40x160mm prisms for compression and flexural tests as shown in Fig. (4). The specimens are cured under water until the time of testing for 3,7and 28days .

Fig. (4): Prisms mortar

3.2.2 Compressive and flexural strength tests

The strength properties (compressive and flexural) of hardened mortars are measured for compressive according to ASTM (Designation:C-150,2007) **[7]**, a set of three prisms of the same composition and age is tested on a compressive strength machine, with maximum capacity of 2000KN force Figs. (5).

A total of twenty four mortars mixtures are prepared. The first three are the control (OPC) and the average is calculated. The second twelve mortars contain Homra as cement replacement material in percentages of 10%, 20%, 30% and 40%. The remaining nine mortars contain the best ratio of Homra (20%) and Nano-silica as cement replacement material in percentages of 2%, 4% and 6%.

(5-a)

(5-b)

 

(5-c) **(5-d)**

Fig. (5): prisms during test

4 RESULTS AND DISCUSSION

4 Mechanical properties of cement mortar (compressive and flexural strength)

4.1 Compressive strength:

4.1.1 Cement mortars modified with Homra:

Tables (8) shows the compressive strength results of the investigated cement mortars modified with Homra, which hydrated in water at different curing ages (3,7 and 28 days). From this table, it is observed that, the percentages of Homra affect the compressive strength values of cement mortars. The effect of hydration age on the compressive strength value of the control specimen and blended mortars are graphically depicted in Fig. (6).

The results show that, the blended cement mortars containing 10 and 20 % Homra have higher relative compressive strength values than the control mortar (OPC) at all curing ages. But cement mortars containing 30 and 40 % Homra have lower relative compressive strength properties values than the control mortar (OPC). So, the percentage 20 % of Homra is the best dosage of Homra to obtain high compressive strength.

Table (8): Compressive strength (Kg/cm2) of OPC and cement mortars modified with Homra at (3, 7, and 28 day).

Mixture no.	3 days	7 days	28 days
OPC	259	329	361
H_{10}	269	339	373
H_{20}	275	350	387
H_{30}	230	300	325
H_{40}	205	250	271

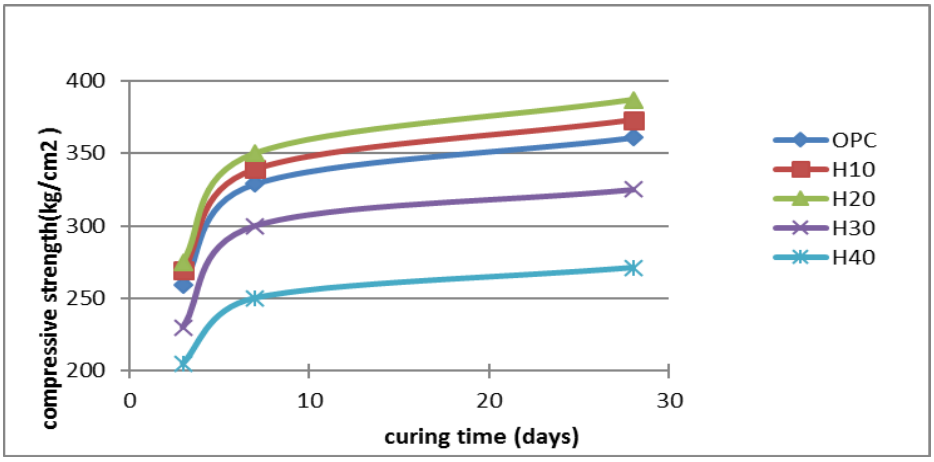

Fig. (6): Compressive strength of cement mortars containing different Homra percentages as function of curing time (3,7and 28days).

4.1.2 Cement mortars modified with Homra and Nano-silica:

Tables (9) shows the compressive strength results of the modified cement mortars with 20 % Homra and different percentages of NS, which hydrated in water at different curing ages (3,7 and 28 days). From this table, it is observed that, NS % affects the compressive strength of cement mortars. The effect of hydration time on the compressive strength of the control specimen and blended cement mortars are graphically represented in Fig. (7). It is clear that, the compressive strength increases with NS up to 4 % replacement (H20NS4), and then it slightly increases, although 6 % replacement (H20NS6) is still higher than those of the control cement mortar (OPC) and cement modified mortar with the best ratio of Homra (H20).

This might be because of the way that, the amount of NS in the blend is higher than the sum required to consolidate with the freed lime amid the procedure of hydration, prompting to abundance silica filtering out and bringing about a lack in strength as it replaces part of the cementitious material, however does not add to its strength[6-7].

As it can be seen from Figs. (8-10), the results of compressive strength for different cement specimens at 3, 7 and 28 days respectively, show that, replacing a specific amount of cement with NS at constant Homra content (20 %) would increase the compressive strength of cement mortar.

Table (9): Compressive strength (Kg/cm2) of OPC and cement mortars modified with Homra and Nano-silica at (3, 7, and 28 day).

Mixture no.	3 days	7 days	28 days
OPC	259	329	361
H_{20}	275	350	387
$H_{20}N_2$	290	366	391
$H_{20}N_4$	300	379	413
$H_{20}N_6$	304	388	419

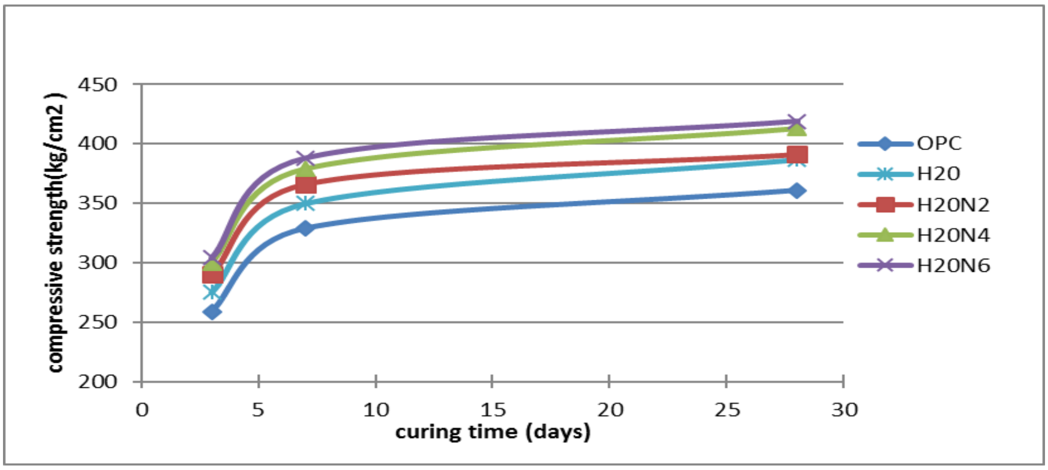

Fig. (7): Compressive strength of cement mortars containing 20% Homra and different Nano-silica percentages as function of curing time (3,7and 28days).

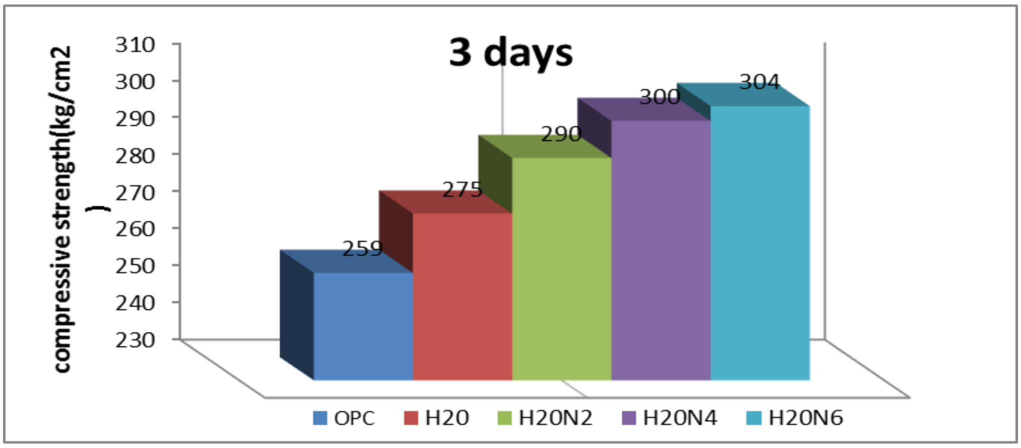

Fig. (8): Compressive strength of OPC and cement mortars containing 20% Homra and different Nano-silica percentages at (3 days)

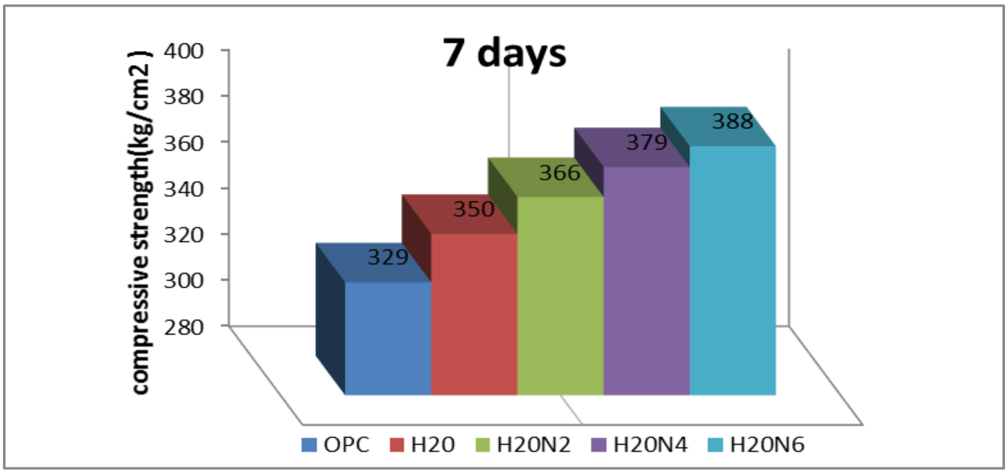

Fig. (9): Compressive strength of OPC and cement mortars containing 20% Homra and different Nano-silica percentages at (7 days)

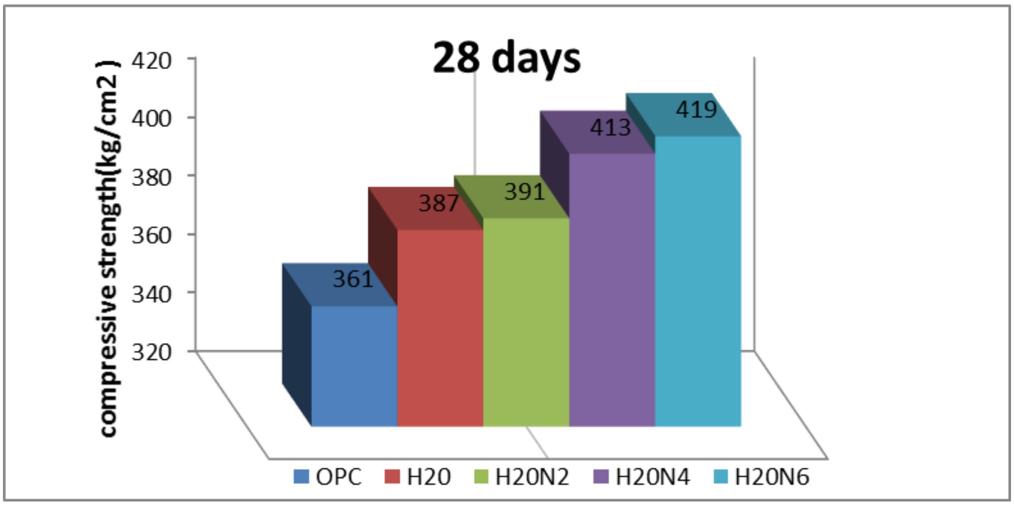

Fig. (10): Compressive strength of OPC and cement mortars containing 20% Homra and different Nano-silica percentages at (28 days)

4.2 Flexural strength:

4.2.1 Cement mortars modified with Homra:

Tables (10) shows the flexural strength results of the investigated cement mortars modified with Homra, and hydrated at different curing ages (3,7 and 28 days). From this table, it is obvious that, the percentages of Homra affect the flexural strength value of cement mortars. The effect of hydration time on the flexural strength values of the control specimen and blended cement mortars are graphically depicted in Fig. (11). The results show that, the blended cement mortars containing 10 and 20 % Homra have higher relative flexural strength values than the control mortar (OPC) at all curing ages. But cement mortars containing 30 and 40 % Homra have lower relative flexural strength obvious than the control (OPC). So, 20 % Homra is the best percentage of Homra to attain high flexural strength..

Table (10): Flexural strength (Kg/cm2) of OPC and cement mortars modified with Homra at (3, 7, and 28 day).

Mixture no.	3 days	7 days	28 days
OPC	18.4	43.4	64.8
H_{10}	21.2	49.4	70.8
H_{20}	23.1	54.2	72.0
H_{30}	20.1	45.1	63.4
H_{40}	11.4	33.4	44.8

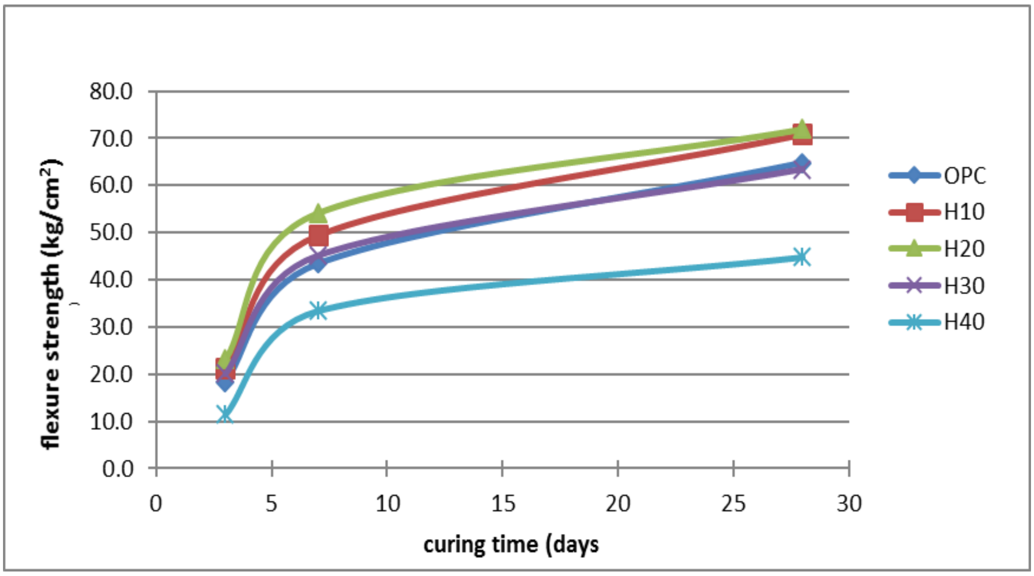

Fig. (11): Flexural strength of cement mortars containing different Homra percentages as function of curing time (3,7and 28days).

4.2.2 Cement mortars modified with Homra and Nano-silica:

Tables (11 shows the flexural strength results of the investigated cement mortars modified with 20 % Homra and different NS percentages, which hydrated in water at different curing times (3,7 and 28 days). From this table, it can be seen that, NS percentages affect the flexural strength value of the investigated cement mortars. The effect of curing time on the flexural strength of the control specimen and blended mortars are graphically shown in Fig. (16). It is seen that, the flexural strength increases with NS % up to 4 % (H20NS4), and then it slightly increases, although 6 % replacement (H20N6) is still higher than those of the control (OPC) and cement mortar containing 20 % Homra (H20).

As it can be seen in Figs. (13-15), the results of flexural strength at 3, 7 and 28 days respectively, show that, replacing a specific amount of cement with NS at constant Homra (20 %) would increase the flexural strength of cement mortar.

Table (11): Flexural strength (Kg/cm2) of OPC and cement mortars modified with Homra and Nano-silica at (3, 7, and 28 day).

Mixture no.	3 days	7 days	28 days
OPC	18.4	43.4	64.8
H_{20}	21.2	49.4	70.8
$H_{20}N_2$	23.1	54.2	72.0
$H_{20}N_4$	20.1	45.1	63.4
$H_{20}N_6$	11.4	33.4	44.8

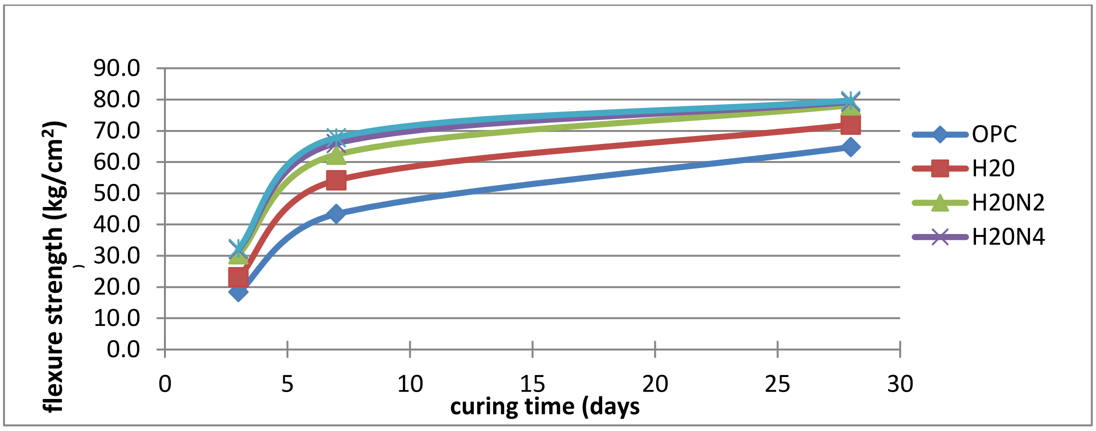

Fig. (12): Flexural strength of cement mortars containing 20% Homra and different Nano-silica percentages as function of curing time (3,7and 28days).

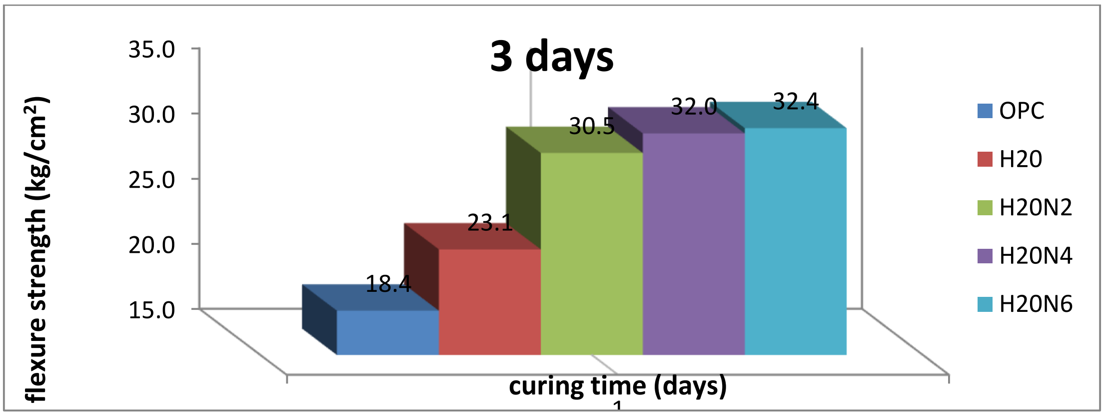

Fig. (13): Flexural strength of OPC and cement mortars containing 20% Homra and different Nano-silica percentages at (3 days)

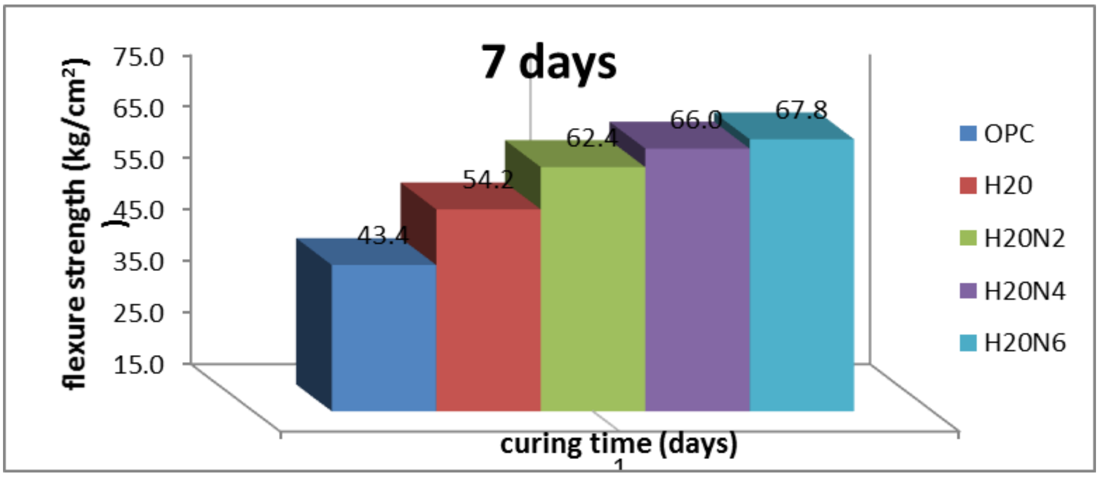

Fig. (14): Flexural strength of OPC and cement mortars containing 20% Homra and different Nano-silica percentages at (7 days)

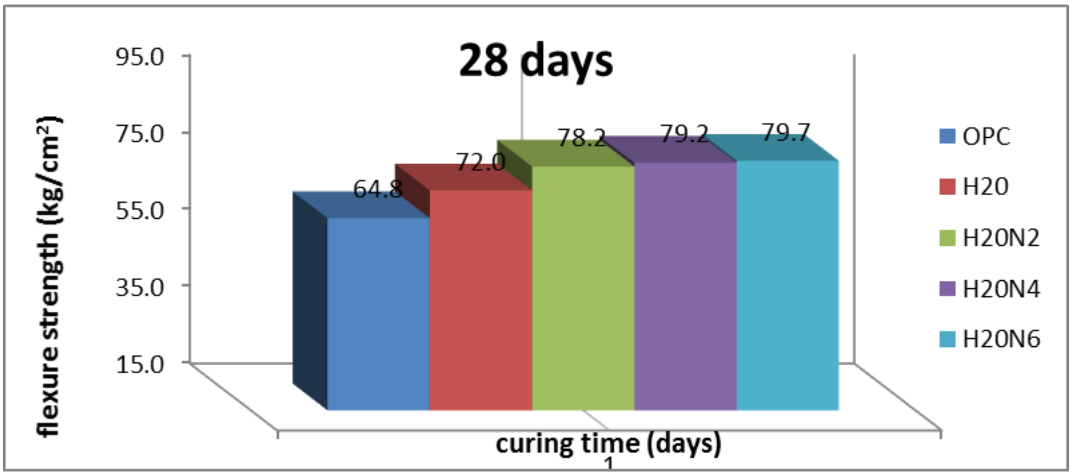

Fig. (15): Flexural strength of OPC and cement mortars containing 20% Homra and different Nano-silica percentages at (28 days)

5 SUMMARY AND CONCLUSION

A One of the most the methods to reduce the cement content in concrete mixes is the use of Homra and NS to prepare low cost blended cements. The need to develop concrete with Homra and NS is urgent for environmental reasons. Some additives are used to improve the workability, mechanical properties and durability.

In the present work, different cement mortars containing were prepared with different percentages (10, 20, 30, and 40 %). Another modified cement mortars Homra with 20 % Homra and different NS percentages (2, 4, and 6 %).

The all investigated mortars were hydrated at different curing times (3, 7 and 28 days). The mechanical properties were studied by measuring compressive and flexural strengths.

Conclusions

Mixing of Homra and NS within cement matrix is the key to develop composites having good engineering properties. It is evident from the study that, there exists an optimum concentration of Homra and NS and mix proportion to produce strong composite with desirable mechanical properties.

There is an increase in the amount of the calcium silicate hydrate (C-S-H) crystal in the concrete containing NS compared with that of the normal concrete but the amount of the Ca $(OH)_2$ crystals existing in the normal concrete, is more than that of the concrete containing the NS. Therefore, C-S-H is the most important factor due to possessing strong inter-layer forces which affect cement paste properties determination and shows more compression strength in comparison with that of the calcium hydroxide crystals, which forms 25%-30% of the hydrated cement paste. The calcium hydroxide is washed out over the time and is derived out of the concrete in sediment form and results in more voids in the hardened concrete. On the other hand, the C-S-H particles sizes are in nanometer and since NPs are in seed form, adding Nano-particles to the concrete would fulfill the voids of the material and then accumulate the whole mixture[8-10].

In the first case, it can be seen that, the compressive and flexural strengths of mixes containing 20 % Homra at the 3, 7 and 28 days were higher than that, of plain cement mortar (at zero Homra) with the same W/C ratio. But, the specimens with Homra, more than 20 % have lower relative compressive and flexural strength values than the control (OPC only). So, 20 % Homra is the best replacement level to obtain cement mortar with high compressive and flexural strengths.

In the second case, the mechanical properties of the mortars containing 20 % Homra and different NS percentage (2, 4, and 6 %) at 3, 7 and 28 days were higher than that, of OPC and cement mortar with (zero, % of NS) with the same W/C ratio. Also, the results indicated that, the increase of NS, % leads to increase the compressive and flexural strengths of cement mortar.

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