DOI: http://dx.doi.org/10.30684/etj.36.3A.8

Investigation the Effect of Nano–Particles and Recycling Mortar Additives on Physical and Mechanical Properties of Concrete

Alaa A. Abdul-Hameed
Materials Eng. Dept.
University of Technology,
Baghdad, Iraq.
adr.alaa@yahoo.com

Farhad M. Othman
Materials Eng. Dept.
University of Technology,
Baghdad, Iraq.
fmok4@yahoo.com

Raeid K. Mohammed
Materials Eng. Dept.
University of Mustansiriyah,
Baghdad, Iraq
Read1980_en@yahoo.com

Received on: 07/12/2016
Accepted on: 20/07/2017

Abstract- *In this paper a lower ratio of nano powder were used from (Al_2O_3 and ZrO_2) (0.5, 1.5and 2. 5 wt %) from cement weight, the average particle size of nano-powder were (20nm). These powders were used in fabrication of Concrete with recycle fine aggregate was replaced Natural fine aggregate(sand) in order to be used in construction application and studies the effect on the concrete. Investigation were done on the concrete including dry density, water absorption%, porosity%, compression strength, and wear rate. The results shows that The nano-Al_2O_3, nano-ZrO_2, and recycle aggregate were adding causes difference effect in the physical and mechanical properties of concrete. Compared with control concrete specimens (Co) results for same curing time, the density, and compression strength of concrete were decreased with addition recycle fine aggregate(RFA), while wear rate, water absorption, and porosity % were increased, the lower values of density, compression strength were decreased by (2.3%, 10.8%), respectively, while the higher values wear rat for 7 and 28 day curing time, water absorption and porosity % were increased by (19.8%, 21.4%, 8.8%, and 5.6%), respectively were obtained with addition (50%)RFA. While, the addition nano-Al_2O_3 and ZrO_2 with RFA were increasing the density, and compression strength, but decreasing wear rate, water absorption, and porosity %, the higher values of compression strength was increased by (9.8%), while the lower values water absorption and porosity % were decreased by (24.1%, and 16.6%), respectively were obtained with addition (1.5%) of nano-Al_2O_3 and 50% RFA. But the higher values of density was increased by (9.8%) and lower values of wear rate for 7 and 28 day curing time were decreased by (71.1%, and 66.9%), respectively was obtained with addition (1.5%) of nano-ZrO_2 and 50% RFA.*

Keywords- *Nano-Al_2O_3, Concrete, Compression strength, Recycled fine aggregate, Nano-ZrO_2r, wear rate.*

How to cite this article: A.A. Abdul-Hameed, F.M. Othman and R.K. Mohammed, "Investigation the Effect of Nano–Particles And Recycling Mortar Additives on Physical and Mechanical Properties of Concrete," *Engineering and Technology Journal*, Vol. 36, Part A, No. 3, pp. 295-303, 2018.

1. Introduction

The nano particles have unique properties and gained more attentions in all the fields and in civil engineering field [1]. Concrete is the most widely used material in the built environment. Cement acts as the main binding phase in concrete. The expansion of the construction industry it is necessary to develop low cost and more efficient types of concrete while maintaining sustainability [2]. Demand for concrete for construction is on the increase, and at the same time, there is a shortage of natural aggregates in many urban areas leads to a search for aggregates from new sources [3]. One of these sources was recycling of Construction and demolition (C&D) debris is the waste material that results from the construction, renovation, or demolition of any structure.

Many researchers have studied the subject where: In 2002, Chen et al. [4] The quantity of recycled fine aggregate in the mortar is more effective than the water/cement ratio in governing the percentage reduction in strength for recycled mortar (mortar used recycle aggregate of group A higher compression strength than the mortar used recycle aggregate of group A at same water/cement ratio). Lima et al. [5] was tested the effect of addition 50% of recycled aggregate to mortar with differed in cement/sand ratio (A (1:4), B (1:8) and w/c Ratio (A (0.7), B (1.44)). the porosity and absorption increase significantly, compared to the mortar without recycle aggregate; the compressive strength was decrease about 8% for the mortar mixture (A). While, mortar mixture (B) a gain in compressive strength. Recycled aggregate increase drying shrinkage independent of the mortar matrix, which is linked with greater porosity and absorption of recycled aggregate. Yadhu et al. [6] was used the crushed C&D wastes as a replacement for conventional sand as fine aggregate. Test results indicate that the concrete made using crushed C&D wastes gives almost as much as strength as normal concrete about (30.66N/mm^2) for 28 days. Nazari et al. [7] was studied the effect of replacement of cement with four altered contents of(0.5%, 0.1%, 1.5% and 2.0%) nano- alumina (Al_2O_3) by weight on the compressive strength and workability properties of concrete. Higher compressive strength of nano concrete compare to that of the concrete without nano-Al_2O_3. It is found that up to 2.0% of nano-Al_2O_3 particles was maximum limit could be advantageously replacement of cement. While, the optimal level of nano-Al_2O_3 could be replaced of cement was 1.0%. workability of fresh concrete was decreased with addition nano-Al_2O_3. In, 2012, Nazari et al. [8]was developed two models depended on artificial neural networks and genetic programming for determined split tensile strength and water absorption percentage of concretes containing nano-ZrO_2 at different mediums and ages of curing. Nano-ZrO_2 showed its influence on split tensile strength and percentage water absorption up to 1.0 wt% in water concrete, up to 2.0 wt% in limewater concrete and finally up to 4.0 wt% in self compact concrete (SCC). Naddafi, [9] has been studied the influence of replaced cement of concrete with four different values of 0.5,1.0,1.5 and 2.0% nano-Al_2O_3 (NA) particles by weight on mechanical properties. 2.0% of nano-Al_2O_3 was maximum level could use to improved concrete tensile strength. However, 1.0% of Cement replacement could use to obtain the concrete ultimate tensile strength. Concrete flexural strength was increased with increase nano-Al_2O_3. The addition of NS reduced the volume of permeable voids in recycled aggregate concretes at both 7 and 28 d, with significant reduction at 7 d. When compared to the control concrete, no reduction in volume of permeable voids is noticed in either of the recycled aggregate concretes due to the addition of NS [10].

The aim of research was Studying the effect of mixing nano materials and recycle fine aggregate (RFA) to the concrete mixture on their properties. A comparison between concrete physical and mechanical properties with and without additions and find the best results

2. Experimental Part

I. Materials used

Concrete samples were prepared in this research composited from ordinary Portland cement (OPC, Iraqi Cement Factory (Tassloja), fine aggregate (sand, recycle) and coarse aggregate (gravel), all the concrete samples had a water-to-cementations materials ratio (w/c) of$\approx$ 0.45 and a mixture cement fine aggregate: coarse aggregate materials ratio of 1:2:4.

The sand(natural fine aggregate) grading is observed according to the requirement of the Iraqi Specification No.45/1984, the natural sand particle size analysis were made by sieving device in powder metallurgy laboratory/materials department, the partical size analysis for natural and recycle fine aggregate shown in Figure 1.

The gravel had size from 19mm to 4.75mm and irregular shape were used. The nano ceramic oxide (γ-Al_2O_3, & ZrO_2) average grian size (20nm) was used purchased from (HWNANO brand, Hongwu international Group Ltd) and (Nanoshel. company, USA), the nano-materials specifications according to the company's manufacturing certification shown as in Table 1.

II. Concrete Samples Prepared Method

The mortar waste was recycled for used as fine aggregate to replacement the part of natural sand. Three different percentages of (10, 25, and 50%) per weight of natural sand in concrete mixture.

(0.5, 1.5, and 2.5)% of nano (Al_2O_3 and ZrO_2) were additives to concrete samples, ultrasonic generator device, type (KQ 3200E) was used for mixing nano materials. Ultra-sonication of nano materials with water for 15 min was probably a better means for proper dispersion of nano materials than mechanical mixing method. The sonication was conducted in Department of Materials Engineering/ University of Technology, Iraq.Cement concrete are mixed at an ambient temperature of about 30℃. To prepare cement concrete, the solid materials were dry mixed first, then the nano-water solution additive to dry concrete composition and mixed for about two minite. Before placing the paste, the inside mold was oiled in order to cast the sample out easily. The mold was placed on a soft board in order to make the base of specimen free of defects. The two types molds was used 10*10*10cm cube metal mold and 2*2*2cm cube plastic mold. The molded specimens were covered with plastic foil for the first 24 hr to prevent moisture loss. After removing from mold, the specimens were cured in tap water at temperature of about 28–30 ℃ until the time of testing.

Table 1: Nano oxide powder specifications

Nano powder	Model no.	Purity%	Particle size nm	SSA m^2/g	Color	Crystal form
Al_2O_3	N612	99	20-30	135.1	White	Cubic
ZrO_2	NS6130-03-369	99	20	15-40	White	Monoclinic

III. Tests and Inspections

A. Physical Testing Method

1. Dry Density

The dry density can be concluded by using the procedure specified in accordance to ASTM C642-1997[11]. The specimen was dried in oven at (100-110 °C) for 24 hours then weighed. After that, the specimen was immersed in water for 24 hours, and then the submerged weight of the specimen was obtained. This test was conducted at ages of 28 day. The dry density can be calculated from the equation [11]:

$$Dry\ density = W1/((W1 - W2) * \rho w \quad (1)$$

Were: W1: dry weight of sample (g), W2: submerge weight of the sample (g),
ρ_w: the density of water is equivalent to 1 (g/cm^3).

2. Water absorption

The specimen was used to calculate the total absorption for the reference and (coated or mixed) modified mortar (with nanoparticles). This test was carried out in agreement to ASTM C642-1997 [11].
In the test procedure, the specimens were taken and dried in oven with temperature of (100-110 °C) for 24 hours, and then the specimen was taken out and weighed. After that, the specimen was fully immersed in water for 24 hours, then removed, surface dried with a cloth and finally weighed again. This test was conducted at ages of 28 day; the percentage of total absorption can be calculated from the following equation [11]:

$$Water\ absorption\ (\%) = \frac{W2 - W1}{W1} * 100 \quad (2)$$

The average weight of dry sample (g).
W2: the average weight of wet sample (g).

3. Porosity

This test is performed in accordance to ASTM C642-1997[11].The porosity test was conducted at ages of 28 day. The test procedure was similar to that of total absorption test, with exception that the third weight of specimen was computed by using a sensitive balance. The third weight represented the submerge weight of the specimen. Porosity can be calculated by using the following equation [11]:

$$Porosity\ (\%) = \left(\frac{W2 - W1}{(W2 - W3)}\right) * 100 \quad (3)$$

Where: W1: the average dry weight of sample (g).W2: the average wet weight of sample (g), W3: the average submerges weight of sample (g).

B. Mechanical Testing Method

1. Compression test

Compressive strength of concrete 10cm edge cubes was determined in accordance to the BS EN 12390-3: 2009 [12] after (7 and 28) curing day. Tests were carried out on specimens and average compressive strength values were measured.

2. Wear Test

This test was conducted by the wear test machine (pin-on-disc). It consists of rotating disc made of tool steel had hardness (25) HRC was done. The tests were carried out by four parameters (load, time, sliding speed, and sliding distance):
A-Applied load was 5N.
B-Applied time was2min.
c- Constant sliding speed was 950 rpm.
d- Constant sliding distance was 6 cm.
The load is applied (5)N on the sample perpendicularly for (2)min and then calculating the adhesive wear rate according to the following relationship [13]:

$$W.R = \Delta W/S.D \quad (4)$$

Where:
W.R: weight sliding wear rate (g/min), ΔW: Weight difference before and after the test. S.D: Sliding distance (2πNt).

VI. Result and Discussion

The densities of prepared concrete specimens with RFA and Nano-oxide (NA and NZ) comparison with control specimen (Co) are shown in Figure 1. The replacement of NFA by RFA in concrete mixture lead to decreasing the density of concrete prepared comparison with (Co), the density of concrete with (10%, 25% and 50%) RFA were (2.368, 2.345 and 2.322)g/cm^3, respectively. While, control concrete specimen density was 2.378 g/cm^3, that may be due to the low specific weight of RFA lead to increasing volume of concrete mixture and decreasing recycle concrete density as shown, or may be the density decrease because had higher pore (void) amount in concrete matrix than that in (Co). These results are in agreement with the results obtained by Zhao et al. [14]

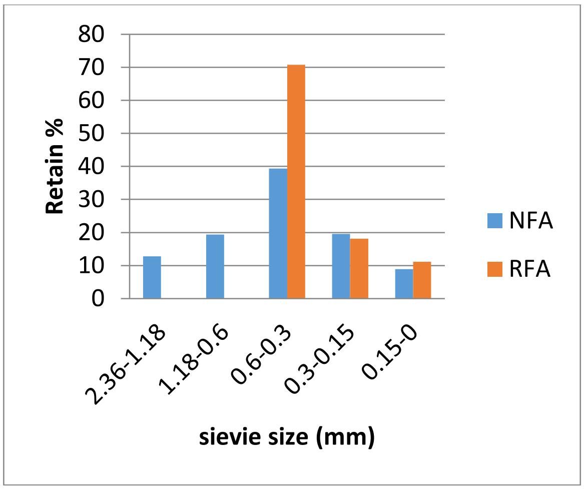
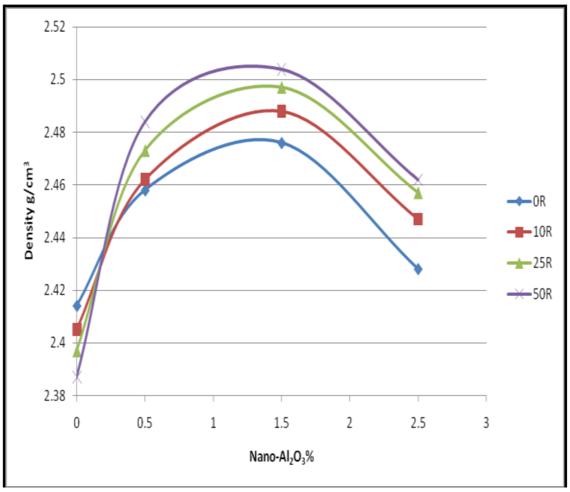


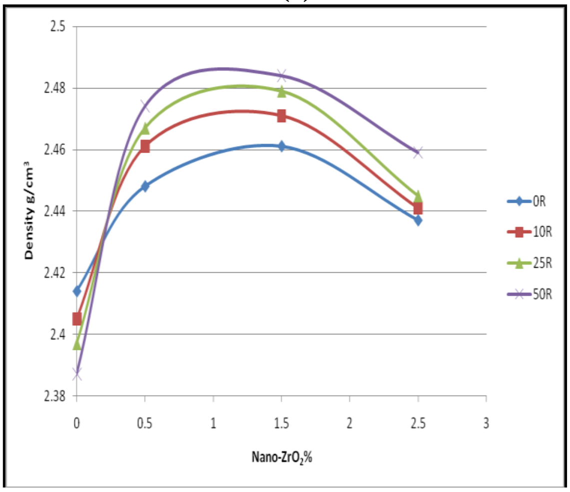
Figure 1: particle size analysis by sieving for natural and recycle fine aggregate.

The addition (0.5%,1.5% and 2.5%) by weight of nano-oxide (NA and NZ) in concrete composition to replaced cement causes to increasing the density of concrete prepared specimens, the density increase with increasing (NA and NZ) up to 1.5% and then decrease in additive more nano-oxide as explained with addition 2.5% of(NA and NZ), but, the density still higher than (Co)density. that may be due to the rapid expenditure of $Ca(OH)_2$ and creation C-S-H gel at final stage , formed during the hydration of concrete mortar, especially at the early stage that can be related to high reactivity of (NA and NZ), and It is also thought that additions of (NA and NZ) to the blended concrete can help in declining its pore size and recover the particle packing density of the blended concrete, leading to a compact volume of larger pores in the concrete and may be reduce the internal friction between aggregate particles.. The results are in conformity with the results obtained by Nazari et al. [7]

The concrete density were increased due to combinations effects of nano-oxide (NA and NZ) and RFA, the density of concrete increased with increase the of RFA % at same nano-oxide %. That may be because nano-oxide had high specific surface area and high activity would improve the hydration reaction of concrete mixture by increase amount of C-S-H gel and reduce the plated of $Ca(OH)_2$ phase that increase the packing density concrete matrix ,the nano-oxide fill the pores in concrete that reduce the porosity and increasing the density, in other word, (NA and NZ) act as filler material to fill the void in RFA ,improve the interface zone with aggregate and making concrete denser. It is a common observation that materials having high strengths are also associated with higher densities. These results are in conformity with the results obtained by Hussain et al. [15]. Figure 2 shown the effect of different additive on concrete density.



(a)

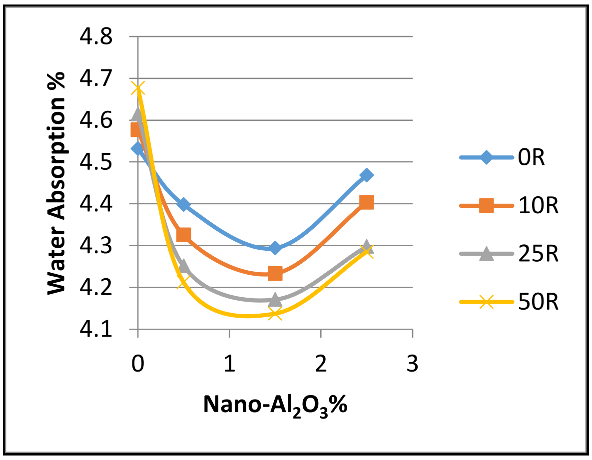


(b)

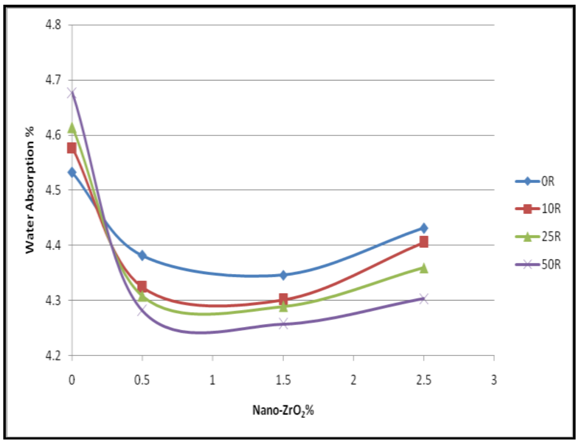
Figure 2: Density of prepared concrete samples with different (a) nano-Al_2O_3 oxide, (b) nano-ZrO_2 oxide and recycle% at 28days.

Water Absorption: Figure 3 shown that effect for addition materials. The water absorption is criteria of the pore volume or porosity of concrete after hardening, which is occupied by the water.

The additions (NA and NZ) to the concrete blended was reduced the water absorption compared with (Co) water absorption, where, the addition (0.5%,1.5%,and 2.5%)NA was reduced water absorption to(4.288, 4.122, and 4.298), respectively, while, addition (0.5%,1.5%, and 2.5%)NZ was reduced water absorption to (4.681, 4.403, and 4.417),respectively, compared with (4.833) for (Co) specimen, that may be result of more C-S-H gel formation and reduce the pore size in addition(NA and NZ) up to 1.5%,while, the increased content of nano-oxide weakens the improvement of the pore structure of the concrete may be due to space boundaries associated with the decrease of the distance between nano-oxide existing in higher addition and the ratio of crystals to C–S–H gel is reduced lead to the water absorption increase. The results are in conformity with the results obtained by Nazari et al. [8]. While, the increase percentage of NFA was replaced by RFA lead to increasing the water absorption, the increase in water absorption in samples with a relatively high content of RFA is also associated with the decreased ratio of the ordinary Portland cement, which reduces the hydration products in specimens.



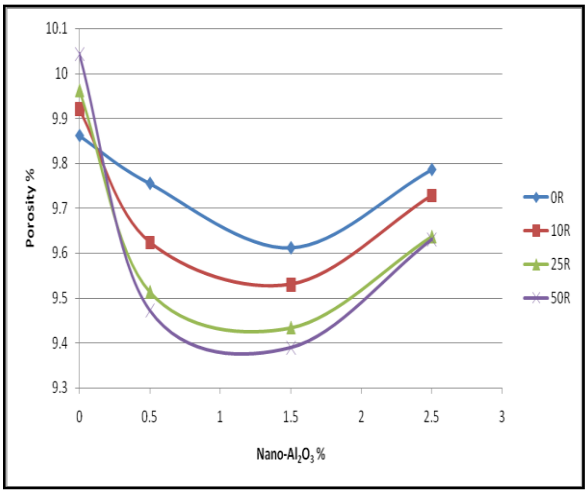
(a)



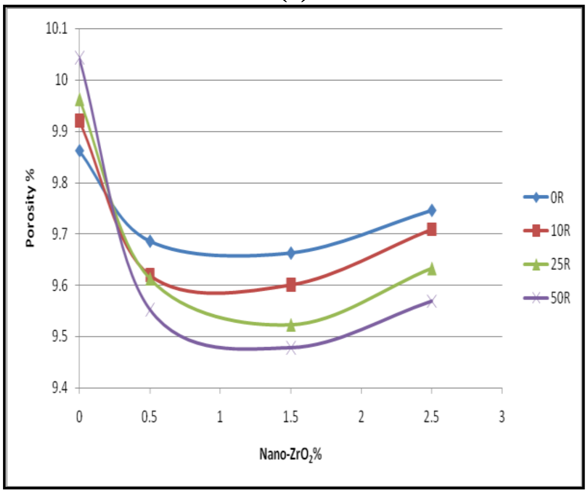
(b)

Figure 3: Water absorption percentage of prepared concrete samples with different (a) nano-Al_2O_3 oxide, (b) nano-ZrO_2 oxide and recycle % at 28 days

The water absorption of concrete specimens was reduce when both (NA and NZ) and RFA addition increasing, the water absorption was decrease with increase the nano-oxide up to 1.5% with increase RFA % then increase with addition more nano-oxide at different percentage of RFA. That may be the high density of concrete specimens with both nano and recycle and due to the effect of nano-oxide size and micro size of recycle aggregate makes the pore structure of cement mortar more homogeneous by decreasing the number of large pores and less voids ratio in the transition zone between cement paste and aggregate, without the nano materials, the CH crystals grow large and tend to be strongly oriented parallel to the aggregate particle surface. CH does not contribute appreciably to the strength of cement mortar. When the crystals are large and strongly oriented parallel to the aggregate surface, they are easily cleaved. A weak transition zone results from the combination of high void content and large, strongly oriented CH crystal these results are in agreement with the results obtained by Hosseini et al. [16]. The comparison of porosity for all concrete specimen prepared was shown Figure 4. The porosity of concrete specimens was added RFA to replacement NFA in concrete blended was higher than the porosity of (Co) specimen, that may be because the concrete properties depended on the properties of materials was product from its, the nature of recycle aggregate where the recycle aggregate have low specific gravity, high water absorption and high porosity lead to increase the porosity of concrete. These results are in agreement with the results obtained by Ashiquzzaman et al. [17].The nano-oxide (NA and NZ) was reduced the porosity percentage of concrete when its added to the concrete, these reduce in porosity% in concrete may be due to the high activity of nano-oxide lead to accelerate cement hydration make the concrete more homogeneous and compact, act as a packing to enhance the density of concrete, which leads to the porosity of concrete decreased considerably and restrict the growth of $Ca(OH)_2$ crystal and formation dense C-S-H gel lead to porosity reduce, while, the increasing nano-oxide addition to concrete blended over 1.5% lead to the distance between nano-oxide decrease with increasing content of nano-particles, and $Ca(OH)_2$ crystal cannot grow up enough due to limited space and the crystal amount is decreased, which leads to the proportion of crystal to strengthening gel small and the porosity of concrete increasing, but still lower than the porosity% of (Co) specimen. These results are in conformity with the results obtained by Kaykha et al. [18]. When nano-oxide (NA and NZ) and RFA was added to the concrete mixture the porosity % reduce as shown Figure 4. Can be attributed to that to the effects of the pozzolanic reaction of nanoparticles on the porosity and micro -particles size increasing in concrete with used RFA, which result in reduction in porosity, as the inclusion of fine particles in concrete tends to improved pore structure, therefore decrease the size and number of voids in hydrated cement paste and made concrete more dense. The effect on chemical reaction involving the transformation of $Ca(OH)_2$ to (C-S-H) further reduced the thickness of the transition zone These results are in agreement with the results obtained by Raj et al. [19].



(a)



(b)

Figure 4: porosity percentage of prepared concrete samples with different (a) nano-Al_2O_3 oxide, (b) nano-ZrO_2 oxide and recycle % at 28 days.

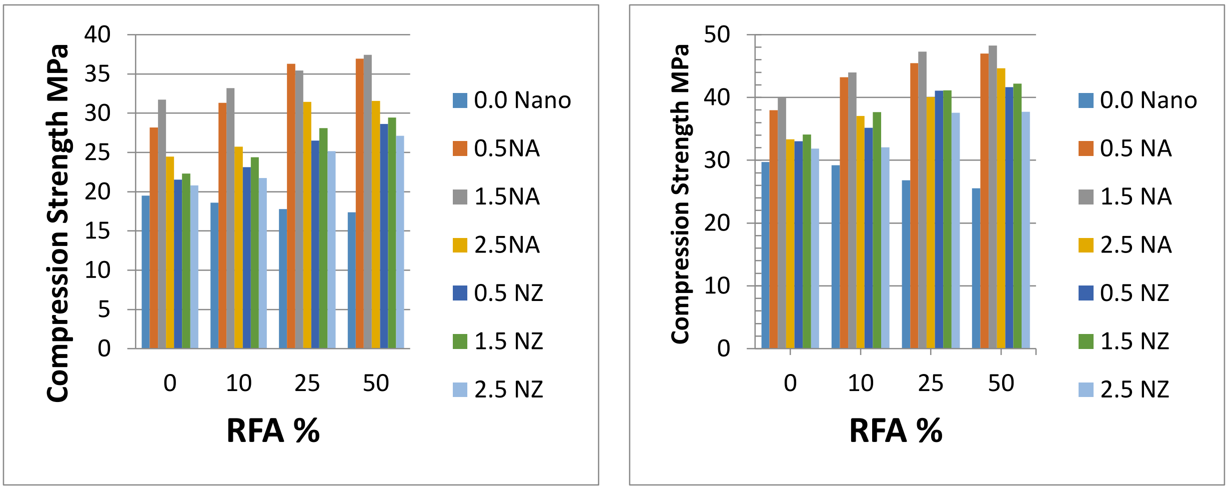
The compression strength is important test for concrete and mortar due to it exposed to compression in their serves living. The control concrete specimen (Co) (C 20/25).compression strength and the effect of replacement of NFA with RFA for different percentage (10%, 25 and 50%) on their compression strength values at 7 and 28 curing days was determined. (Co) specimen compression strength was (19.48)at 7 days and(29.74) at 28 days, These results are in agreement with the results obtained by O. U. Orie et al.[20] .It is found the recycle concrete had lower compression strength than the control concrete , the compression strength decrease with increase the RFA addition ,but at the design range (C 20/25), as shown in figure (5(a) and (b)) for 7 and 28 curing days, respectively. These lower compression strength of recycle concrete may be due to the higher porosity and water absorption comparing with the natural sand .These results are in agreement with the results obtained by Zhao et al., [14], and Ashiquzzaman et al. [17].

The compression strength values of concrete prepared specimens with addition nano materials (0.5%, 1.5% and 2.5%)of NA and NZ by weight to replace the cement in concrete mixture was found increased the compression strength of concrete compared with the(Co) specimen at 7 and 28 days, these due to the NA improved the pozzolanic action by providing more surface area and produced the more cementitious product, It results in efficient generation of C-S-H gel, rapid consuming of ($Ca(OH)_2$) which was created during hydration of Portland cement particularly at early ages related to the high reactivity of NA particles. As a result, the hydration of cement is accelerated and larger volumes of reaction products are created. Moreover, densification of the cement matrix leading to enhanced compressive strength.

The compressive strength decrease with addition more NA over (1.5%), but, still adventure addition because their compression strength higher than the compression strength of (Co) specimen. These due to NA higher than the amount required to combine with the liberated lime during the process of hydration thus leading to excess silica leaching out and causing a deficiency in strength as it replaces part of the cementitious material but does not contribute to strength. In addition, it may be due to the defects generated in dispersion of nanoparticles that causes weak zones. These results are in agreement with the results obtained by Nazari et al. [7], and Naddafi [9].The addition NZ to concrete mixture prepared was increasing the compression strength, it may be the NZ get better the particle packing density, directing to a reduced volume of bigger pores, exposed a dense formation of hydration products and a reduced contented of ($Ca(OH)_2$) crystals the concrete. It is found that the compressive strength increases with addition NZ up to (1.5%). It may be the amount of NZ and the distance between them influence the crystallization process, the crystallization will be controlled to be a suitable state through restricting the growth of $Ca(OH)_2$ crystal by nano-particles. Furthermore, the NZ located in cement paste as kernel can more support cement hydration due to their high activity.

This makes the concrete cement mortar matrix more homogeneous and dense the pore structure of concrete is improved and can restrict the growth of $Ca(OH)_2$ crystals, and the increase of crystals makes the concrete matrix further homogenous and compact. While, the compression strength decrease with addition more NZ(2.5%) these may be due to that the space between NZ reduces with increasing amount of nano-particles, and ($Ca(OH)_2$) crystal cannot grow up sufficient due to limited space and the crystal magnitude is reduced, which causes the ratio of crystal to strengthening gel small. These results are in conformity with the results obtained by Nazari et al. [8].The combination of nano-particles (NA and NZ) and micro-particles (RFA) increase the compression strength of concrete specimens prepared compared with (Co) specimen compression strength these right up to 25% of RFA then decrease with increased the RFA to 50%. This observation indicates the better action of RFA in presence of NA and NZ can be due to better filler effect and further distribution of the particles in the remaining voids leading to homogeneous concrete matrix i.e. the nano-particles play filler action to fill the void in recycle concrete, which leads to narrow and stronger ITZ of recycle concrete with nano-particles as compared to that of recycle concrete without nano particles additive and increased compressive strength. These results are in agreement with the results obtained by Hosseini et al., [16] and Patil et al. [21] .

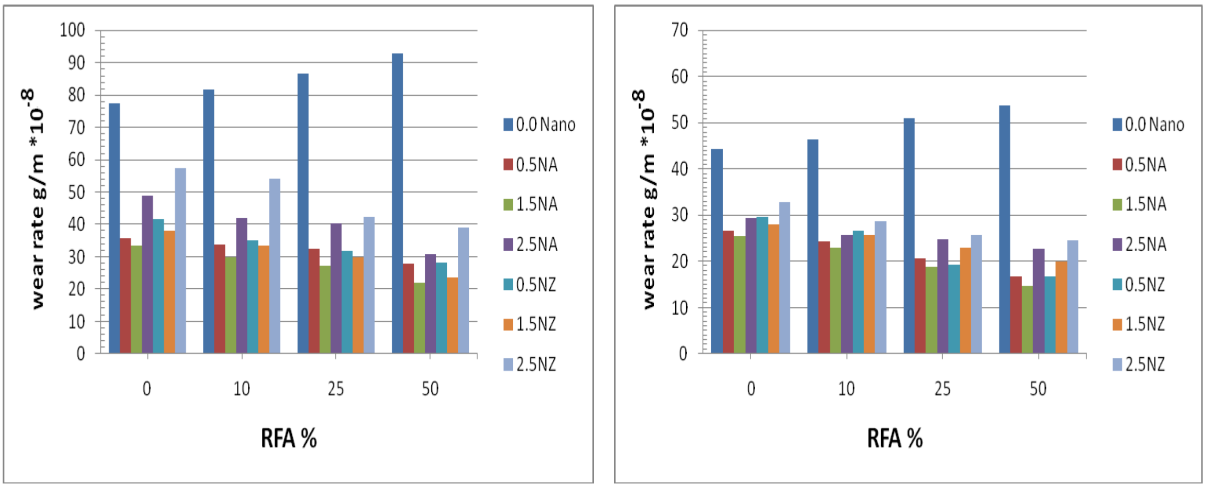
Figure (5(a))shown The comparison between the compression strength of concrete specimens at 7days, Figure(5(b)) shown The comparison between the compression strength of concrete specimens at 28days with and without addition NA and NZ ,respectively with 0%,10%, 25% and 50% RFA.



(a) (b)

Figure 5: compression strength of prepared concrete samples with different nano-Al_2O_3 oxide, nano-ZrO_2 oxide and recycle % at (a) 7 days, (b) 28 days.

The wear rate results of concrete specimens with and without nano-oxide, particles (NA and NZ) and RFA were explained in Figure (6(a)) for specimens curing for 7 days and fig. (6(b)) for specimens curing for 28 days Figs. with different percentage (0%,0.5%, 1.5% and 2.5%) of NA and NZ, respectively with different RFA (0%,10%, 25%and 50%). While, the addition of nano-particles (NA and NZ) decrease the wear rate of concrete specimens compared with control concrete specimen(Co), the addition nano-oxide more than (1.5 %) the wear rate increase but still lower than (Co) specimen wear rate. The reason behind the influence of nano materials on the accelerating the hydrated transformation of CH into the C-S-H gel which is responsible for giving the concrete blend its strength. [22]. The wear rate of results combination of nano-particles (NA and NZ) with RFA was shown these combination lower than that at (Co) specimen, the increase (NA and NZ) and (RFA) over (1.5% and 25%), respectively, the wear rate increasing, but still lower compared with (Co) specimen.



(a) (b)

Figure 6: Wear rate of prepared concrete samples with different nano-Al_2O_3 oxide, nano-ZrO_2 oxide and recycle % at (a) 7 days, (b) 28 days.

4. Conclusion

The effect of addition nano-powder (NA and NZ) and RFA to concrete mixture on concrete physical and mechanical properties can concluded by:

1. The replacement NFA by RFA was reduced the density, and compression strength of concrete with increase RFA%. While, increasing RFA% was increased water absorption%, porosity%, and wear rate.
2. The addition nano-oxide powder (NA and NZ) to concrete mixture to replaced part of cement weight was increased the density, and compression strength of concrete, and was reduced water absorption%, porosity%, and wear rate.
3. The combination of nano-oxide (NA and NZ) and micro (RFA) was lead to increase the density, and compression strength of concrete higher than used either only nano-oxide or micro(RFA) ,and reduced water absorption%, porosity%, and wear rate.
4. The addition of nano-materials and recycled fine aggregate to the concrete mixture had a considerable effect on the concrete physical properties; the higher density value was increased by 9.8% compared with Co sample with 50% RFA and 1.5% ZrO_2, while the lower density value was decreased by 2.3% at 50% RFA. The higher water absorption value was increased by 8.8% compared with Co sample with 50% RFA, while, the lower value of water absorption was decreased by 24.1% with 50% RFA and 1.5% NA. The higher porosity value was increased by 5.6% compared with Co sample with 50% RFA, while lower porosity value was decreased by 16.6% with 50% RFA and 1.5%NA.
5. The higher compression strength was increased by 9.8% compared with Co sample with 50% RFA and 1.5% NA, while the lower compression strength was decreased by 10.8% with 50% RFA.
6. the higher values wear rat for 7 and 28 day were increased by (19.8%, and 21.4%), respectively were obtained with addition (50%)RFA. lower values of wear rate for 7 and 28 day were decreased by (71.1%, and 66.9%), respectively was obtained with addition (1.5%) of nano-ZrO_2 and 50% RFA

Reference

[1] B. Bhuvaneshwari, S. Sasmal, T. Baskaran, N.R. Iyer, "Role of Nano Oxides for Improving Cementitious," Building Materials, JCES, Vol. 1, No. 2, PP. 52-58, 2012.

[2] R. Gammampila, P. Mendis, T. Ngo, L. Aye, A.S. Jayalath, R.A.M. Rupasinghe, "Application of Nanomaterials in the Sustainable Built Environment," ICSBE, Kandy, 13-14, 2010.

[3] R.S. Ravindrarajah and C. Tam, "Recycling concrete as fine aggregate in concrete," International Journal of Cement Composites and Lightweight Concrete, 1987.

[4] H. Chen, T. Yen and K. Chen, "Use of building rubbles as recycled aggregates," Elsevier Science, Cement and Concrete Research 33, 125–132, 2003.

[5] P.R.L. Lima, B. Leite, Influence of CDW Recycled Aggregate on Drying Shrinkage of Mortar, Open Journal of Civil Engineering, 2, 53-57, 2012.

[6] G. Yadhu and S.A. Devi, "An Innovative Study on Reuse of Demolished Concrete Waste," JCEE, Vol. 5, Issue 5, 1000185, 5:5, 2015.

[7] A. Nazari, S. Riahi, S. Riahi, S. F. Shamekhi, A. Khademno," Influence of Al_2O_3 nanoparticles on the compressive strength and workability of blended concrete,"Journal of American Science;6(5), 2010.

[8] A. Nazari and S. Riahi, "Computer-aided Prediction of the ZrO2 Nanoparticles Effects on Tensile Strength and Percentage of Water Absorption of Concrete Specimens," J. Mater. Sci. Technol., 28(1), 83-96, 2012.

[9] M.F. Naddafi, "A Study of The mechanical properties of cement mortar with nano-Al2O3 particles," Applied Mathematics in Engineering, Management and Technology, 2(6), 430-434, 2014.

[10] F. Shaikh, H. Odoh and A. Tahn, "Effect of nano silica on properties of concrete containing recycled coarse aggregates," Proceedings of the ICE-Construction Materials. 168 (2): pp.68-76, 2014.

[11] Standard Test Method for Density, Absorption, and Voids in Hardened Concrete, ASTM-Designation C:642, 1997.

[12] BS EN 12390-3: 2009. Testing hardened concrete. Part 3: Compressive strength of test specimens. British Standards Institute, 2009.

[13] F.M. Othman, A.A. Abdul Hameed and M.M. Salih, Characterization of Nano Powder Incorporated for Building Applications, Eng. & Tech. Journal, Vol.33, Part (B), No.6, 2015.

[14] Z. Zhao, S. Remond, D. Damidot and W. Xu, "Influence of fine recycled concrete aggregates on the properties of mortars," Elsevier, Construction and Building Materials 81, 179–186, October 2015.

[15] S.T. Hussain and G.K. Sastry, Study of Strength Properties of Concrete by Using Micro Silica and Nano Silica," IJRET, Volume: 03 Issue: 10, 2014.

[16] P. Hosseini, A. Booshehrian and A. Madari, "Developing Concrete Recycling Strategies by Utilization of Nano-SiO^2 Particles," Waste Biomass Valor, 2:347–355, 2011.

[17] M. Ashiquzzaman and S.B. Hossen, "Cementing Property Evaluation of Recycled Fine Aggregate," IRJES, 2319-1821, Vol. 2, No. 5, PP. 63-68, 2013.

[18] M.M. Kaykha, and F. Soleymani, "Assessments of the effects of ZrO2 nanopowders on porosimetry and mechanical properties of concrete," Journal of American Science; 8(1), 2012.

[19] I.R.I. Raj and B. Shanmugavalli, "A Study on the Effect of Silica Fume on the Properties of Recycled Aggregate Concrete," IJRD, Vol. 2, No. 3, 2015.

[20] O.U. Orie and P. Osamede, "Mechanical Properties of Guarea Thompsonii Sawdust Modified Concrete," JETEAS, 5(4): 285-290, 2014.

[21] K. Prerana, K. Patil and V.S. Shingade," Effect of Nano-silica on Mechanical Properties of Recycled Aggregate Concrete," IJARIIE, Vol-2 Issue-4, 2016.

[22] F.M. Othman, A.A. Abdul Hameed and S.I. Ibrahim, "Studying the Effect of Nano Additives and Coating on Some Properties of Cement Mortar Mixes," Eng. &Tech. Journal, Vol. 34, Part (A), No.3, 2016.

Author(s) biography

Alaa A. Abdel-Hamead, PhD. in Material Technology/ Powder coating, University of Technology, Baghdad, Iraq.

She is Assist. Prof. Dr. in Materials Engineering Department, University of Technology, Baghdad, Supervision of more than 10 MSc and PhD thesis, and Published more than 50 research and 2 Books.

Farhad M. Othman, PhD. in Mechanical engineering, Casting, Engineering Collage, Baghdad University, Baghdad, Iraq.
He is Assist. Prof. Dr. in Materials Engineering Department, administrator of continue education center, University of Technology, Baghdad, Iraq, and member of Iraqi engineerss union, Baghdad.

Raeid K. Mohammed, MSc. in Materials Engineering, Engineering Collage, Al-Mustansiriyah University, Baghdad, Iraq.
He is assist. lect. in Materials Engineering Department, Engineering Collage, Al-Mustansiriyah University, Baghdad, Iraq, and member of Iraqi engineerss union, Baghdad.