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EFFECT OF USING CRUSHED SAND AND CARBON FIBER WITH DIFFERENT ASPECT RATIO ON SOME PROPERTIES OF REACTIVE POWDER CEMENTITIOUS COMPOSITE

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ABSTRACT

This research studies the effect of crushed sand, aspect ratio of micro Carbon fiber (MCF) and nano-micro activated Metakaolin (NMAM) on the compressive strength, modulus of rupture, ultra sonic pulse velocity, density and electrical resistivity of reactive powder cementitious composite. The results show that the mixture which content crushed sand, 10% nano-micro activated Metakaolin and water/cementitious ratio 0.24 considerable improvements in all properties at all ages. The percentage increase were (110.6, 111.39, 31.58, 11.67, 257.47) % at 28 days respectively with respect to the mixture which content normal sand. The results also showed that the specimen that contain micro Carbon fibers getting a slight increase in modulus of rupture and go down a slight decline in electrical resistivity when increasing the aspect ratio of 4000.

Keywords: crushed sand, micro Carbon fiber, nano-micro activated Metakaolin, electrical resistivity, aspect ratio.

1. INTRODUCTION

1.1 General

There are many improvements needed in concrete, especially for uses in renewal and expansion of the world's infrastructure, e.g. increased durability, decreased brittleness, increased tensile strength, and routine use of large volumes of nontraditional materials like fly ash. Nano modification can probably help solve many of these problems. However, concrete has been slow to catch on the revolution in the nanotechnology that is ongoing in many materials. *Garboczi* (2010).

Balapgol et al (2002) studied the results of an experimental study on strength and durability of concrete with crushed basalt stone fine aggregates as a substitute to diminishing natural sand. The test results indicate that the performance of concrete with crushed basalt stone fine aggregates were excellent. The compressive strength of concrete for different grades increased from 8 % to 26 %, the flexural strength was increased from 1 % to 5 % and coefficient of permeability was decreased significantly. The test results indicated that strength and durability of concrete would be better with crushed sand replacing natural sand.

Ahmad and *Mahmood* (2008) presented comparative study based upon experimental work on two important properties of concrete i.e. workability and strength of concrete by using locally available material with crushed sand as fine aggregates a substitute to diminishing natural sand. The tests results indicate that the performance of concrete with crushed sand as fine aggregates was better than natural sand. The compressive strength of concrete for different mix ratios increased from 7% to 33% where as workability was decreased 11% to 67% with crushed sand as compared to natural sand.

An experimental investigation was carried out by *Hameed et al. (*2009) to study the effect of fiber aspect ratio on the flexural properties of metallic fiber reinforced concrete (MFRC). High performance metallic fibers of different aspect ratios were used. The dosage of fibers was kept 20 kg/m^3,(0.25% by volume fraction) for all the fibered concrete mixtures. Three point bending tests were performed on both control (without fibers) and fibered notched prismatic concrete specimens of cross section 100 x 100mm and clear span of 450mm. The results showed that the flexural properties of concrete matrix is significantly improved by the addition of high performance metallic fibers. Moreover, it was found that the level of improvement in flexural properties of MFRC varies with the aspect ratio of fibers. Out of the two different aspect ratios of metallic fibers used in this study, the fibers with larger aspect ratio showed better efficiency in improving the flexural response of MFRC.

Morsy et al. (2010) studied the physico-mechanical behavior of nanomaterials and ordinary Portland cement (OPC) was also studied. 6%nano Metakaolin (NMK) by weight of cement and the Carbon nanotube (CNTs) was added by ratios of (0.005, 0.02, 0.05 and 0.1) % by weight of cement. The blended cement: sand ratio used was 1:2. The blended cement mortar was prepared using water/binder ratio of 0.5 by weight of cement. The fresh mortar pastes were first cured at 100% relative humidity for 24 h and then cured in water for 28 days. The results showed that the replacement of OPC by 6 wt. % NMK increases the compressive strength of blended mortar by 18% as compared to control mixture and the combination of 6 wt. % NMK and 0.02 wt. % CNTs increased the compressive strength by 29% more than control.

An experimental work was carried out by *Mahdi (2011)* on some physical and mechanical properties of fiber reinforced composite reactive powder concrete. The materials used were micro high reactivity Metakaolin (MHRM) particle size ≥ 0.91 and ≤1.271 µm, water/ cementitious ratio 0.17and dosage of superplasticizer (Sika®Viscocrete® Hi-Tech 36) equal to 6 % by weight of cement. Three types of sand with particle size ranging between 150 to 600 µm: Normal sand (Al-Akhydir), glass

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sand and slag sand were used. Results showed that the highest compressive strength obtaind when using the normal sand. The results also showed that the RPC containing 10%MHRM reinforced with micro Carbon fibers reveal higher compressive strength, flexural strength and splitting tensile strength where the percentage of increase reaches, at the age of 28 days, to (80.79, 157.72 and 219.02)% respectively as compared with reference mixture.

1.3 Objectives

The Primary objectives of this research are:

- To research for materials that improve the properties of reactive powder cementitious composite using nano-micro activated Metakaolin.
- To increase the interconnection between the components of concrete that lead to increase the compressive strength which used crushed sand.
- To evaluate the effect of length of micro Carbon fiber on the mechanical properties of reactive powder cementitious composite

2. MATERIALS

2.1 Cement

Ordinary Portland cement is manufactured by a company known as united cement under the commercial name (Tasloga-Bazyan cement) type I was used throughout this research. Its chemical and physical properties of cement used throughout this research are shown in Tables 1and 2 respectively. Test results indicated that the adopted cement was conformed to the *Iraqi specification* No.5/1984.

2.2 Sand

Two types of fine aggregates were used in this research with size less than 550 and greater than 150 microns. The first typeAl-Ekhaider natural sand was taken from the quarries of the Karbala city and the second type of sand was crushed, broken down in the laboratory of construction materials.

2.3 Nano-micro activated Metakaolin

Nano-micro activated Metakaolin (NMAM) was obtained from the burning of Kaolin at temperature of 700ºC for a period of one hour and thenquenching in water immediately after canceling from the oven and leaving it for 48 hours and then drying it in an oven drying at a temperature of 100±5. The chemical composition of the NMAMis shown in Table-3. Particle size NMAM ≥ 250 nano and ≤1.759 micro used in this work conforms to the chemical and physical requirements of *ASTM*C618 (2006) Class N pozzolan. Tables 4 and 5 show the chemical and physical requirements, respectively.

2.4 Mixing water

In this research was used drinking water in all mixtures.

2.5 High range water reducing admixture

The superplasticizer used was a Modified carboxylic acids based polymer manufactured and supplied by **SIKA**® under the commercial name Sika® ViscoCrete®-1.

2.6 Carbon fibers

The micro Carbon fibers used in this research was brought from Alibaba Company. It has small diameter 0.001mm and a length of (2, 4, 6 and 8) mm.

2.7 Concrete mix design

This research included the design of eight mixtures in the reactive powder cementitious composite reinforced or unreinforced with micro Carbon fiber 2% by weight of cement with different aspect ratio as follows:
1. Used normal sand with Portland cement at a ratio of 1:1 and water / cement ratio 0.46 (Reference) (RPCC-NS)
2. Used crushed sand with Portland cement at a ratio of 1:1 and water / cement ratio 0.46 (RPCC-CS)
3. Crushed sand was used with Portland cement at a ratio of 1:1 with the addition 5% of Sika ViscoCrete-1 by weight of cement and water / cement ratio 0.22 (RPCC-CS-SP).
4. Used crushed sand with Portland cement at a ratio of 1:1 with the addition of 5% of Sika ViscoCrete-1 by weight of cement and water / cement ratio 0.24, nano-micro activated Metakaolin10% by weight of cement. (RPCC-CS-SP-NMAM).

The other mixtures were the same as mixture 4 except using of micro Carbon fiber with length (2, 4, 6 or 8) mm.

2.8 Casting and curing of test specimens

When finishing the casting process, the specimens were directly covered with plastic cover for 24 hours to prevent water evaporation fromthem,The specimens were demoulded after 1 day and left in moisten tank until the time of test.

3. RESULTS AND DISCUSSION

A parametric study was carried out to investigate the effect of crushed sand, 10 % nano-micro activated Metakaolin, HRWRA (SV-1), and 2% of micro Carbon fibers by weight of cement with different aspect ratio on properties of reactive powder cementitious composite.

3.1 Compressive strength

The compressive strength is the main important property of the hardened concrete from which most of the properties can be evaluated to determine validity as construction. Where the compressive strength depends mainly on the percentage of water/ cement ratio, age and mixing ratios in the case of reactive powder cementitious composite (RPCC), the amount and type of mineral and chemical additives play significant impact on the compressive strength.

Figures 1, 2 and Table-6 show the compressive strength of different types of reactive powder cementitious composite that containt normal sand, crushed sand, Sika

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ViscoCrete-1, nano-micro activated Metakaolin and micro Carbon fibers of different aspect ratios and ages of 3, 7, 14 and 28 days.

The results showed that the compressive strength of specimen that used crushed sand was higher than the specimen that used normal sand (reference mixture). The percentage increase at age 28 days was 25.96%.This is due to the strength of interconnections between the cement paste and crushed sand, as a result of surface roughness.

The specimen that use the crushed sand and Sika ViscoCrete-1 (superplasticizer) revealeda significant increase in compressive strength as compared to the reference mixture and the percentage increase was 98.9% at age 28 days. This behavior is due to minimizing the water/ cement ratio as the low percentage of water increases the compressive strength.

The specimen that used crushed sand, Sika ViscoCrete-1 and nano-micro activated Metakaolin revealed a considerable increase in compressive strength as compared to the reference mixture. The percentage increase was 110.6%at age 28 days. The increase in the compressive strength is due to the presence of nano-micro activated Metakaolin. It leads to increas the react with $Ca(OH)_2$which results from hydration of cement and thus made up the largest amount of (C-S-H) which is a stable cement compound.$Ca(OH)_2$ is the compound of leaf crystals in large aggregates surrounding the particles (interface) and the link is weak aggregates, leading tothe possibility of failure in the region of intra-aggregate and cement paste because of the vulnerability of the region consequently, this interaction leads to increase density of the region which results are compatible with results found by Bentur (2002)

In addition, the use of micro Carbon fibers 2% by weight of cement with different lengths (2, 4, 6 and 8) mm [with different aspect ratio (2000, 4000, 6000 and 8000)] is to study its impact on the compressive strength. The results showed that the length ofthe fiberhas no significant effect on compressive strength, especially when the length offibe r(4, 6 and 8) mm, whereas the compressive strength values were relatively close as shown in Table-1 and Figure-2. The impact offiberon the compressive strength was clear where the percentage increase for mixture that reinforced with fiber 8 mm length was 129.25% at age28 days with respect to reference mixture

3.2 Ultrasonic pulse velocity

This is unlike the traditional tests are prepared a according to standard conditions may not represent the reality of the situation in the workplace in addition to low cost as well as the possibility of execution tests of the specimen in successive periods.

From Figures 3, 4 and Table7 the ultrasonic pulse velocity can be seen for all specimens containing normal sand, crushed sand, Sika ViscoCrete-1, nano-micro activated Metakaolin and micro Carbon fibers with different lengths at ages 3, 7, 14 and 28 days.

The results showed that the ultrasonic pulse velocity of the specimen which used crushed sand was higher than the specimen that used normal sand (reference mixture) at all ages and the percentage increase was 8.03% at age 28 days. The specimen that used crushed sand and Sika ViscoCrete-1 revealed an increase in the ultrasonic pulse velocity whereas the percentage increase was 28.25% at age28 days as compared to the reference mixture.

The specimen that used crushed sand, Sika ViscoCrete-1and nano- micro activatedMetakaolin revealed a considerable increase in the ultrasonic pulse velocity as compared to the reference mixture where the percentage increase was 31.58%at age 28 days.

In addition, the use of micro Carbon fibers 2% by weight of cement with different lengths (2, 4, 6 and 8) mm was to study its effect on ultrasonic pulse velocity, the results showed that there was too slight increase when increasing the length of 4 mm which means that there is no effect when increasing length more than 4 mm. This behavior may be due to the small size of concrete components which was less than 550 microns, the length of fiber 4mm which was almost more than six times the diameter of the largest particle sand.

3.3 Modulus of rupture

In this research studies the effect of using of crushed sand as compared with normal sand and the addition of Sika ViscoCrete-1, nano-micro activated Metakaolin and micro Carbon fibers with different lengths on the modulus of rupture of reactive powder cementitious composite at 3, 7, 14 and 28 days as shown in Figures 5, 6 and Table-8.

The results revealed a clear increase in the modulus of rupture when using crushed sand as compared with the mixture that used normal sand at all ages. The percentage increase was 44.3% at age 28 days.

The specimens that used crushed sand, Sika ViscoCrete-1 showed a significant increase in the modulus of rupture as compared to reference mixture. The percentage increase was 78.48%.

The specimens that use crushed sand, Sika ViscoCrete-1and nano-micro activated Metakaolin revealed a considerable increase in the modulus of rupture as compared to the reference mixture where the percentage increase was 111.39 %at age 28 days. The reason for the increase is attributable to high fineness of the nano-micro activated Metakaolin in addition to efficiency Bozzolana which has a role in the increase at different ages. The process of burning the Kaolin leads to the conversing of a larger amount of crystalline silica to amorphous silica which has ability to interact with a larger amount of Ca $(OH)_2$ to form more stable compounds.

In addition to that, micro Carbon fibers were used with ratio 2% by the weight of cement with different lengths (2, 4, 6 and 8) mm to study the length effect of micro Carbon fibers on modulus of rupture. The specimen containing 2mm micro Carbon fibers revealed significant increase in the value of modulus of rupture. The percentage increase was 193.67 % at age 28 days whereas the value of modulus of rupture was higher when used with lengths (4, 6 and 8) mm but the effect of length was little after 4mm. This behaviour may be due to fineness of

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the ingredients of mixture whereas the maximum size was less than 550micron.

3.4 Density

The density of important properties of reactive powder cementitious composite has relation with mechanical properties as compressive strength, electrical resistivity, and ultrasonic pulse velocity. There are several factors which control in determining the density of reactive powder cementitious composite reinforced with micro Carbon fibers such as type of sand, superplasticizer, nano-micro activated Metakaolin and micro Carbon fibers. The result showed that the density of all mixtures increases with age and showed that the use of crushed sand result in higher density than those mixtures that use of normal sand and specially mixture that containing nano-microactivated Metakaolin as shown in Figure-7 and Table-9.

In addition, it is clear from Figure-7 and Table-9 that when using micro Carbon fiber 2% by the weight of cement with different lengths (2, 4, 6 and 8) mm, there is no significant decrease in density, the ratio used few that led to a slight increase in density and may also be the reason distribution of random systematic and compacting well.

3.5 Electrical resistivity

Figures 8, 9 and Table-10 show the electrical resistivity of all specimens containing normal sand, crushed sand, Sika ViscoCrete-1, nano - micro activated Metakaolin and micro Carbon fibers with different lengths and at the ages 3, 7, 14, 28days.

The results showed a clear increase in electrical resistivity when using crushed sand as compared with the mixture that used normal sand at all ages and the percentage increase was 13.95 % at age 28 days, whereas the specimen that used crushed sand and Sika ViscoCrete-1 showed a significant increase in electrical resistivity compared to the reference and the percentage increase (160.59%) at age 28 days. The specimen that used the crushed sand, Sika ViscoCrete-1 and nano- micro activated Metakaolin showed an extraordinary increase in electrical resistivity as compared to the reference mixture and the percentage increase was (257.47%) at age 28 days. 2% micro Carbon fibers by weight of cement with different lengths (2, 4, 6 and 8) mm were used to study its effect on the electrical resistivity. The specimen that contains micro Carbon fibers revealed a significant decrease in electrical resistivity, whereas the percentage decline of the mixtures containing crushed sand, Sika ViscoCrete-1 and 8mm micro Carbon fibers was 45.7% as compared with the same mixture, but without containing Carbon fiber at age 28 days as shown in Figure-9.

4. CONCLUSIONS

According to the results obtained from the experimental work of this investigation, the following conclusions can be deduced:

- The compressive strength, ultrasonic pulse velocity, density, electrical resistivity and modulus of rupture of specimen that used crushed sand were higher than the specimen that used normal sand.
- The specimen that used the crushed sand and Sika ViscoCrete-1 (superplasticizer) revealed a significant increase in compressive strength, ultrasonic pulse velocity, electrical resistivity and modulus of rupture as compared to the reference mixture and the percentages of increase were (98.9, 28.25, 160.59 and 78.48)% at age 28 days respectively.
- The specimen that used crushed sand, Sika ViscoCrete-1and nano- micro activatedMetakaolin revealed a considerable increase in compressive strength, ultrasonic pulse velocity, electrical resistivity and modulus of rupture as compared to the reference mixture and the percentages of increase were (110.6, 31.58, 257.47 and 111.39) %at age 28 days respectively.
- The specimen that contain micro Carbon fibers revealed a significant decrease in electrical resistivity, whereas the percentage decline of the mixtures containing crushed sand,Sika ViscoCrete-1 and 8mm micro Carbon fibers was 45.7% as compared with the same mixture, but without containing Carbon fiber at age 28 days.
- The specimens that used crushed sand,Sika ViscoCrete-1and nano-micro activatedMetakaolin revealed considerable increase in the modulus of rupture as compared to the reference mixture where percentage of increase was111.39 %at age 28 days.
- The value of modulus of rupture when using (4, 6 and 8) mm was higher than 2mm but the effect of length was little after 4mm

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Table-1. Chemical composition and main compounds o cement.

Oxides composition	Content %	Limits of Iraqi specification No.5/1984
CaO	60.78	---
SiO_2	20.54	---
Al_2O_3	5.88	---
Fe_2O_3	3.28	---
MgO	1.93	<5.00
SO_3	1.87	<2.80
L.O.I.	2.31	<4.00
Insoluble residue	0.15	<1.5
Lime Saturation Factor, L.S.F.	0.89	0.66-1.02
Main compounds (Bogue's equations)		
C_3S	41.737	-
C_2S	27.48	-
C_3A	10.038	-
C_4AF	9.97	-

Chemical analysis has been conducted by National Center for Geological Survey and Mining.

Table-2. Physical properties of cement.

Physical properties	Testresults	Limits of Iraqi specification No.5/1984
Specific surface area (Blaine method), m^2/kg	2341	≥230
Setting time (Vicate apparatus), Initial setting, hr:min Final setting, hr:min	 2:35 4:30	 ≥00:45 ≤10:00
Compressive strength, MPa 3 days 7 days	 20.8 25.3	 ≥15.00 ≥23.00
Soundness (Autoclave method), %	0.03	≤0.8

Table-3. Chemical analysis of nano-micro activated Metakaolin.

Oxide composition	Oxide content %
SiO_2	48.98
Al_2O_3	36.34
Fe_2O_3	1.72
Na_2O	1.1
K_2O	0.50
MgO	0.77
CaO	1.9
L.O. I.	4.67

*Chemical analysis has been conducted by National Center for Geological Survey and Mining.

Table-4. Chemical requirements of pozzolan ASTM C618 (2006).

Oxide composition	Pozzolan class N	NMAM
SiO_2+AlO_3+Fe_2O_3, min.%	70	89.14
SO_3, max. %	4	2.95
Loss on ignition max. %	10	4.67

Table-5. Physical requirements of pozzolan ASTM C618 (2006).

Physical properties	Pozzolan class N	NMAM
Strength activity index with Portland cement at 28 days ,min. % of control	75	201.13
Flow, max. %	115	110
Specific gravity	-	2.6 1

Table-6. Compressive strength for various types of mixtures.

Mixture	Compressive strength MPa			
	Age (days)			
	3	7	14	28
RPCC-NS	24.8	39.4	48.6	54.7
RPCC-CS	33.5	52.4	62.7	68.9
RPCC-CS-SP	61.7	94.3	103.5	108.8
RPCC-CS-SP-NMAM	66.1	99.7	108.6	115.2
RPCC-CS-SP-NMAM-2mm	68.7	103.3	112.8	118.7
RPCC-CS-SP-NMAM-4mm	71.4	104.1	117.3	122.6
RPCC-CS-SP-NMAM-6mm	73.8	107.9	118.2	123.5
RPCC-CS-SP-NMAM-8mm	74.2	106.6	118.6	124.1

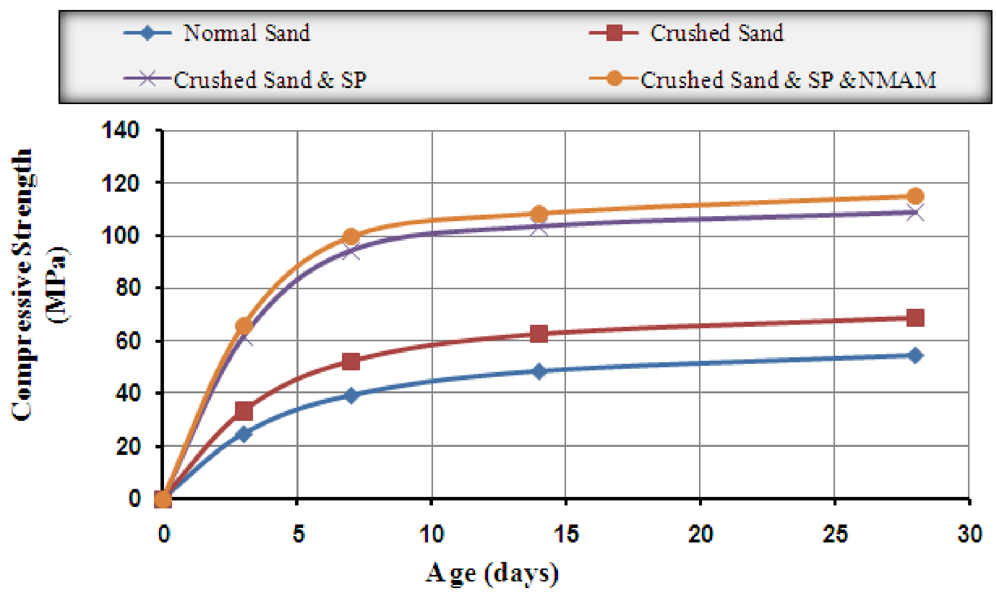

Figure-1. Effect of normal sand, crushed sand, ViscoCrete-1and nano-micro activated Metakaolinon the Compressive strength with age.

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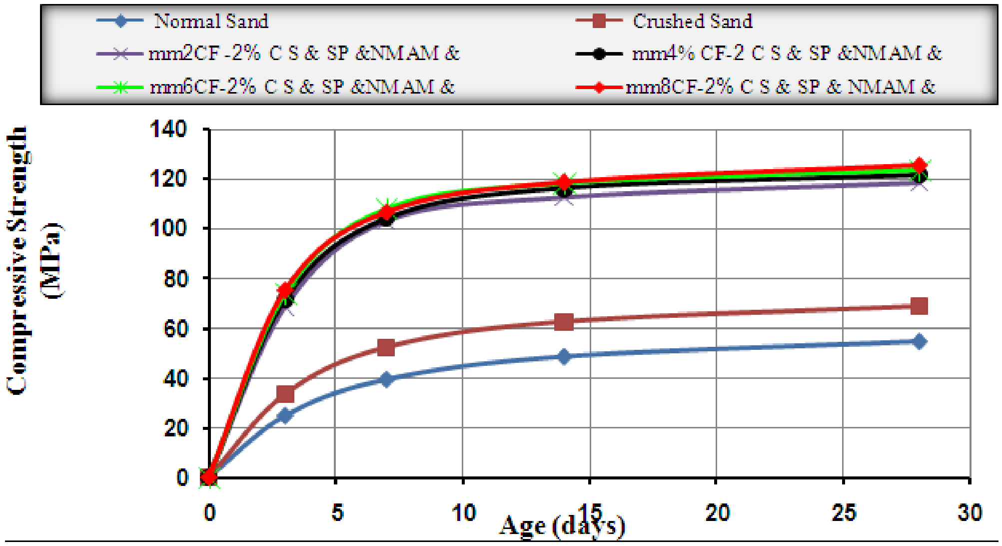

Figure-2. Effect of length of micro Carbon fibers (2, 4, 6 and 8) mm in mixture that content crushed sand, ViscoCrete-1 and nano-micro activated Metakaolinon the compressive strength with age.

Table-7. Ultrasonic pulse velocity (km/sec) for various types of mixtures.

Mixture	**Ultrasonic Pulse Velocity** (km/sec)			
	Age (days)			
	3	**7**	**14**	**28**
RPCC-NS	2.56	3.47	3.59	3.61
RPCC-CS	2.75	3.67	3.86	3.9
RPCC-CS-SP	3.07	4.25	4.59	4.63
RPCC-CS-SP-NMAM	3.23	4.43	4.72	4.75
RPCC-CS-SP-NMAM-2mm	3.28	4.49	4.74	4.76
RPCC-CS-SP-NMAM-4mm	3.34	4.57	4.75	4.86
RPCC-CS-SP-NMAM-6mm	3.35	4.58	4.78	4.87
RPCC-CS-SP-NMAM-8mm	3.35	4.59	4.84	4.89

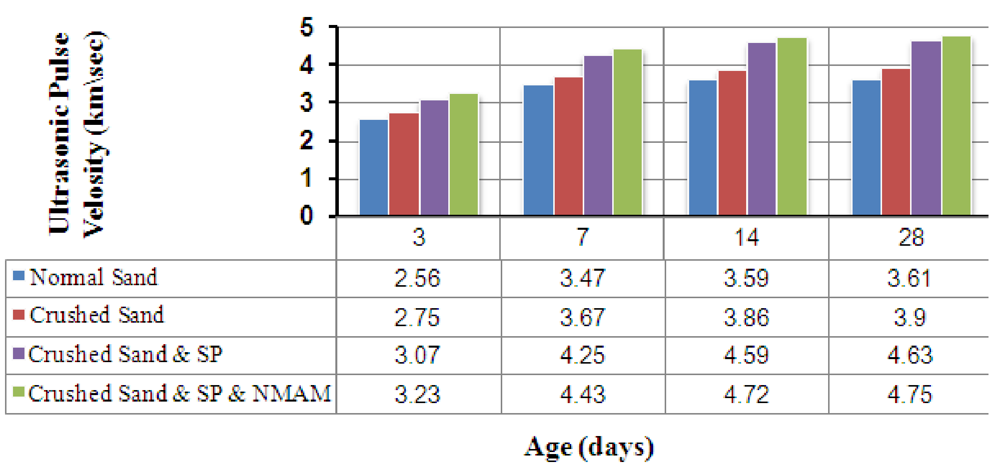

Figure-3. Effect of normal sand, crushed sand, ViscoCrete-1and nano-micro activated Metakaolinon the Ultrasonic pulse velocity with age.

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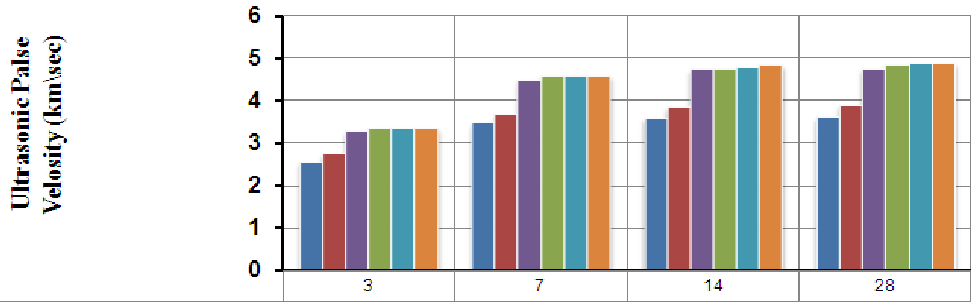

	3	7	14	28
Normal Sand	2.56	3.47	3.59	3.61
Crushed Sand	2.75	3.67	3.86	3.9
CS & SP& NMAM & 2% CF-2mm	3.28	4.49	4.74	4.76
CS & SP & NMAM & 2 % CF-4mm	3.34	4.57	4.75	4.86
CS & SP & NMAM & 2% CF-6mm	3.35	4.58	4.78	4.87
CS & SP & NMAM & 2% CF-8mm	3.35	4.59	4.84	4.89

Figure-4. Effect of length of micro Carbon fibers (2, 4, 6 and 8) mm in mixture that content crushed sand,ViscoCrete-1and nano-micro activated Metakaolinon the Ultrasonic pulse velocity with age.

Table-8. Modulus of rupture for various types of mixtures.

Mixtures	**Modulus of rupture** (MPa)			
	Age (days)			
	3	**7**	**14**	**28**
RPCC-NS	2.7	5.1	6.7	7.9
RPCC-CS	5.2	8.7	10.5	11.7
RPCC-CS-SP	6.6	10.7	12.7	14.1
RPCC-CS-SP-NMAM	8.4	13.2	15.1	16.7
RPCC-CS-SP-NMAM-2mm	11.9	18.7	21.8	23.2
RPCC-CS-SP-NMAM-4mm	14.8	23.2	25.7	27.6
RPCC-CS-SP-NMAM-6mm	15.2	23.7	26.3	27.9
RPCC-CS-SP-NMAM-8mm	15.4	23.8	26.9	28.3

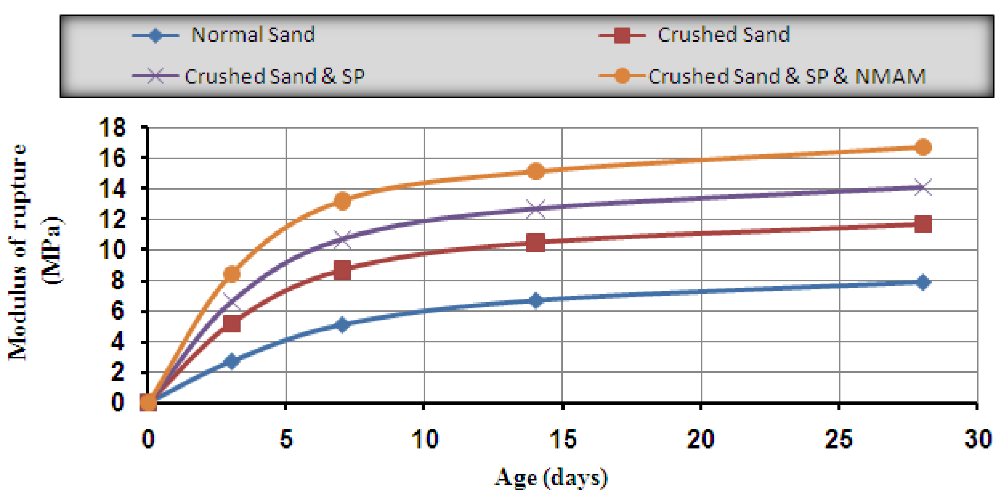

Figure-5. Effect of normal sand, crushed sand, ViscoCrete-1and nano-micro activated Metakaolinon the modulus of rupture with age.

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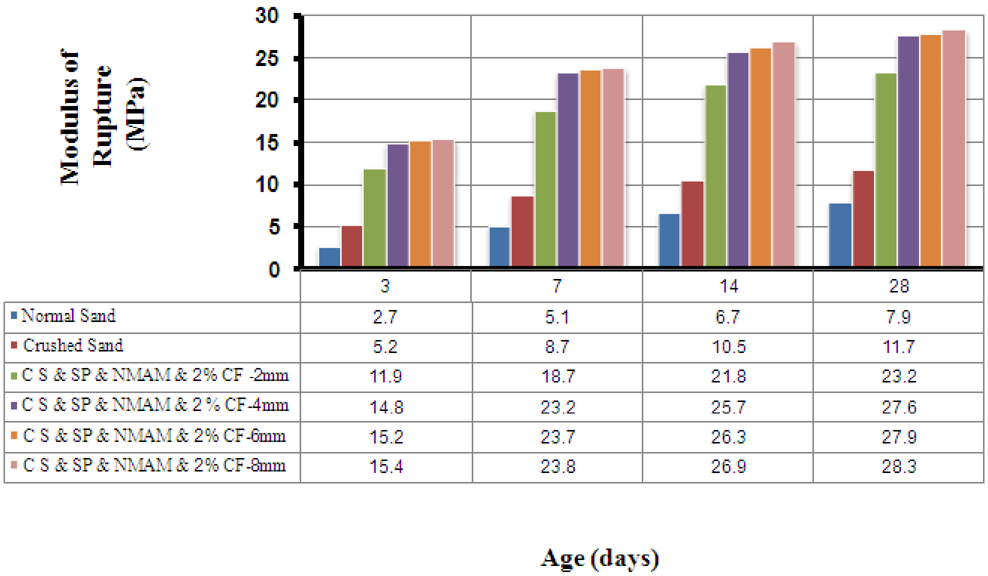

Figure-6. Effect of length of micro Carbon fibers (2, 4, 6 and 8) mm in mixture that content crushed sand, ViscoCrete-1and nano-micro activated Metakaolinon the modulus of rupture with age.

Table-9. Density for various types of mixtures.

Mixtures	**Density kg/m^3**
	28 days
RPCC-NS	2145.2
RPCC-CS	2215.4
RPCC-CS-SP	2335.3
RPCC-CS-SP-NMAM	2395.6
RPCC-CS-SP-NMAM-2mm	2394.7
RPCC-CS-SP-NMAM-4mm	2394.82
RPCC-CS-SP-NMAM-6mm	2394.93
RPCC-CS-SP-NMAM-8mm	2394.98

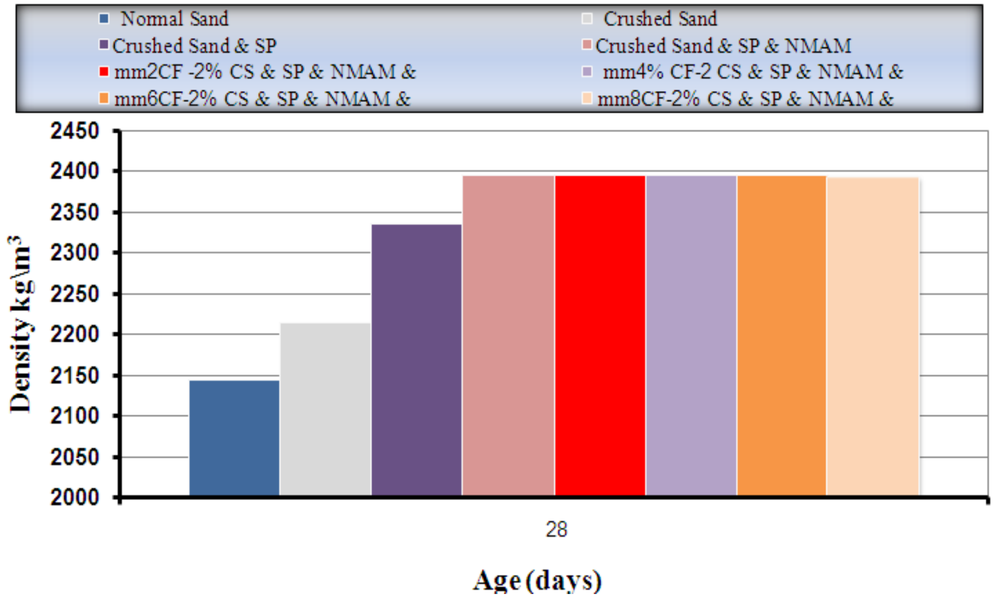

Figure-7. Effect of normal sand, crushed sand, ViscoCrete-1, nano-micro activated Metakaolinandlength of micro Carbon fibers (2, 4, 6 and 8) mm on the Density at 28 days.

Table-10. Electrical resistivity (kΩ.cm) for various types of mixtures.

Mixtures	**Electrical resistivity** (kΩ.cm)			
	Age (days)			
	3	7	14	28
RPCC-NS	33	51.6	57.2	60.9
RPCC-CS	38.9	58.1	65.3	69.4
RPCC-CS-SP	92.7	139.2	152.3	158.7
RPCC-CS-SP-NMAM	132.6	192.4	213.3	217.7
RPCC-CS-SP-NMAM-2mm	61.9	93.5	102.1	108.4
RPCC-CS-SP-NMAM-4mm	59.8	87.3	97.1	103.9
RPCC-CS-SP-NMAM-6mm	57.7	82.9	92.4	99.3
RPCC-CS-SP-NMAM-8mm	47.9	78.5	87.7	95.8

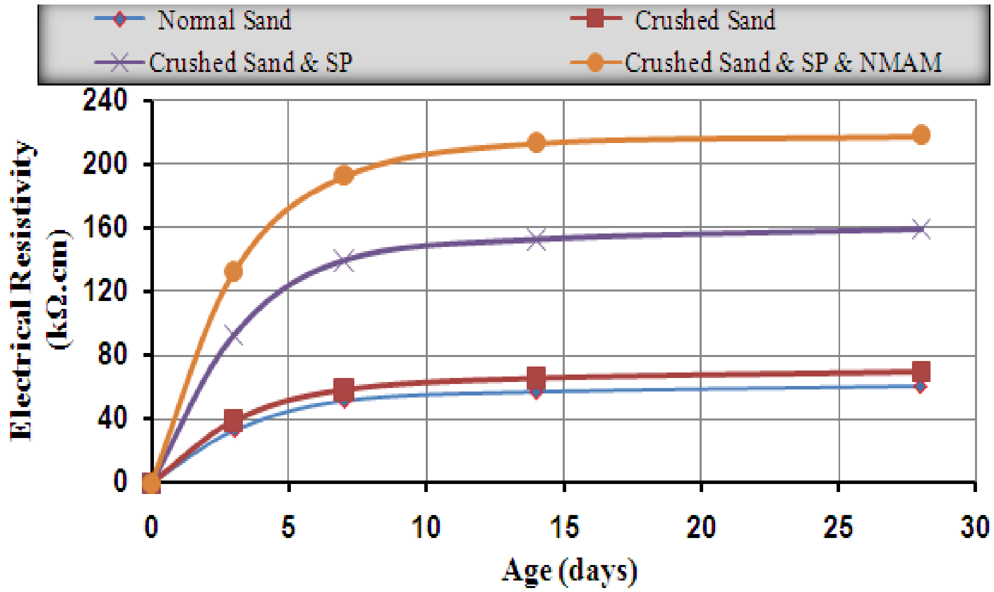

Figure-8. Effect of normal sand, crushed sand, ViscoCrete-1and nano-micro activated Metakaolinon the electrical resistivity with age.

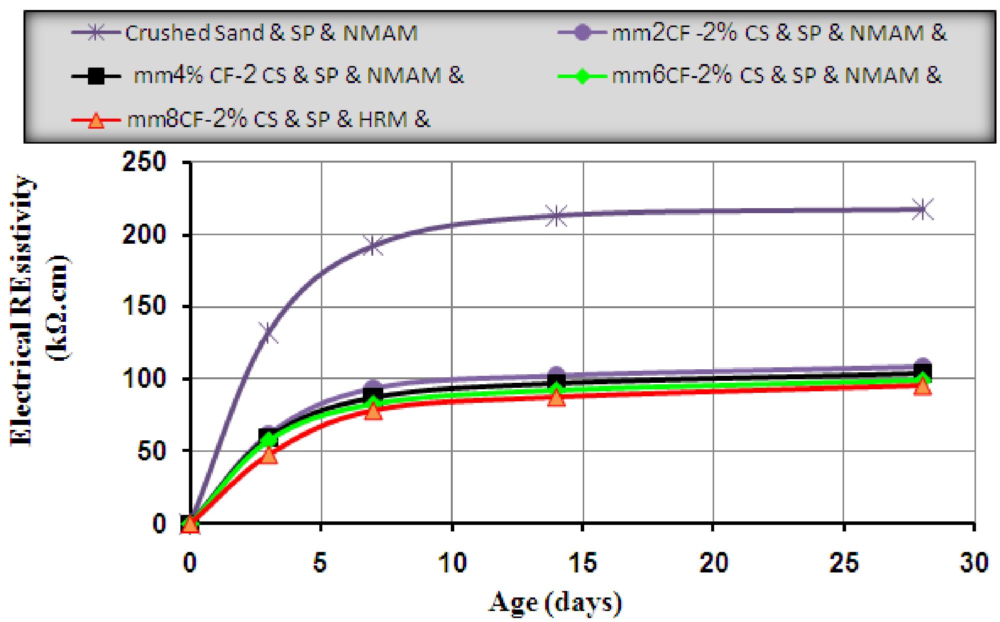

Figure-9. Effect of length of micro Carbon fibers (2, 4, 6 and 8) mm in mixture that content crushed sand, ViscoCrete-1and nano-micro activated Metakaolinon the electrical resistivity with age.

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