Australian Journal of Basic and Applied Sciences, 5(10): 560-563, 2011
ISSN 1991-8178

# Comparison of Mechanical of the Concrete Samples Containing Micro-Silica and Nano-Silica

[1]Mahdi koohdaragh, [2]Hamed Hajkhan Mohamadi

[1]Faculty of Engineering, Ajabshir Branch, Islamic Azad University, Ajabshir, Iran.
[2]Faculty of Engineering, Ajabshir Branch, Islamic Azad University, Ajabshir, Iran.

**Abstract:** In recent years, identification of concrete micro-structures like structures related to cement paste and specially hydratation have been of significance in order to investigate technology utilizations of nano-particles in concrete industry. This technology is used in artificial pozolan production e.g. nano-silica. In this lab study, some mechanical and strength features of concretes containing nano-silica and micro-silica are considered through some experiments of compressive strength, tensional strength, influence and absorption of water. The research resulted in compressive and tensional strength increase via adding nano-silica.

**Key words:** Nano-silica, Micro-silica, Influence and Strength.

## INTRODUCTION

Although concrete is the most utilized structural material, some problems like extreme use of cement, low strength in contrast to invasive ions and the necessity of mineral or chemical material adding should be considered and solved.

Cement is one of main components in concrete and its main product of hydratation i.e. C-S-H is of nano-structure. The strength and mechanical qualities of potent concrete is mainly depended on structure improvement, paste transport and aggregate through adding various compositions. Silica is one of the most important components in concrete micro-structure quality improvement. Therefore, wide researches are performed over pozolan adding on concretes along recent years. Micro-silica pozolan adding has the best performance on concretes. The treat of this material is in the form of spherical grains of 0.01 micrometer because of containing plethora amorphous silica (90%). Making use of this new pozolan material has been common since 80s A.D. in concrete. Furthermore micro-silica, nano-silica is another new pozolan material which contains high percentage of silica. This new pozolan exists commercially and in the emulation form in water. It is expected it had better performance than micro-silica because of having high degree of amorphous silica (more than 99%) and small size of particles (1- 50 nano-meter). Nano-silica has the least particle measures and the most percentage of amorphous silica in contrary to other pozolan therefore, its reactivity should be higher than other pozolan. According to its extreme reactivity, the amount of its utilization is much less than other ones. In general, materials in nano measures have totally different, irregular and uncontrolled treatments. As the size of particles shrinks, their qualities will be changed too. 2 features distinguish nano materials from other groups: the increase of material surface and quantum affections. These can lead to changes or special qualities in nano material such as: affecting reactions, mechanical strength and particular electric characteristics.

According to the effects of utilizing nano-silica in concrete like improvement of micro-structure, decrease of influence and porosities and also increase of compressive strength, it can be concluded that utilization of nano-silica in concrete will decrease cl ions influence in it. This is approved by the researches of Collepardi *et al.,* (Colleparidi, 2007). Qing *et al.,* researched the affect of nano-silica on hard cement paste in comparison to micro-silica and considered their reactions in cement paste. They showed that the reactivity of nano-silica particles is higher than silica soot (Qing, 2007). Li showed that in concretes containing nano-silica the strength is higher than normal concretes or usual ones (Li. 2004). The characteristics of cement mortar containing nano-silica were tasted and considered in a research done in South Korea (Jo, li, 2007,2004 ). The results from this lab study shows that compressive strength of mortars containing nano-silica are higher than mortars containing micro-silica in the age of 7 and 28 days. Therefore, it can be approved that the nano particles are more effective than micro-silica. On the bases of other study in China done on the effects of nano particles on the flexible and compressive strength of cement mortar, adding nano-silica to cement mortar improved compressive and flexible strength in contrast to usual mortar. In experiments carried out by Ji, samples of concrete containing pure micro-silica and micro-silica with nano-silica were constructed and their influence in the presence of water was measured. Experiments results showed significance enhancement in strength of concrete containing nano-silica against water influence (Ji, Hui, Hanehara, Ke, Gengying. 2005, 2004, 2001, 2005 and 2004). The aim of this study is to consider the affect of adding nano-silica to the composition of traditional concrete and its comparison

**Corresponding Author:** Mehdi Koohdaragh, Daculty of Engineering Ajabshir Branch, Islamic Azad University, Ajbshir, Iran.
E-mail: mehdi_k550@yahoo.com

to micro-silica. This study emphasizes the concrete mechanical parameters and influence. So, experiments as compressive strength, tensional strength, water absorption and influence were used in lab study program.

***Experiment Program and Sample Structure:***

***Consumed Materials:***

Colloidal amorphous nano-silica with emulation of 50% in the trade name of Cembinder 50 (Lima Nano Pars Co) is introduced in this research. Above mentioned nano-silica contained more than 99% amorphous silica. Tiny grained were of twice-rinsed natural kind and coarse-grained of broken 2.25. The utilized cement was Portland 425-1 and 3rd generation ultra-lubricants was Glenium 110P. This material is dark, clear color and it weights 1.1g.cm3 in 20°. This ultra-lubricant is of neutral and has no characteristic except lubricating. The consumed water is drinking water of Ajabshir city (of Southern Azerbayjan). Table 1 shows mentioned characteristics.

**Table 1:** Characteristic of materials.

| Materials | Sand 6-19 mm Sand (fine) 0-6 mm |
|---|---|
| Cement | Portland 425-1 (Sufian Cement Factory) |
| Ultra-lubricants | Glenium 110P |
| Water | Ajabshir Drinking Water |
| Nano-silica | Colloidal Amorphous (Cembinder 50) |

***Concrete Mixtures Plan:***

In this study, 7 concrete mix plans in lab program of 180 days with replacement of 4.5% and 7.5% and slump of 7-10 cm are considered. Also Brazilian compressive strength testing is used for identifying concrete compressive strength in the standard of ASTMC 496 on cylinder testate with diameter of 150mm and height of 300mm.

**Table 2:** Concrete mix design for specimens.

| Plan Name | Cement(Kg) | Water(Kg) | Micro-silica(Kg) | Nano-silica(Kg) | سنگدانه |
|---|---|---|---|---|---|
| Testate | 400 | 180 | 0 | 0 | 1750 |
| N- 4.5 | 382 | 180 | 0 | 18 | 1750 |
| N- 7.5 | 370 | 180 | 0 | 30 | 1750 |
| M- 4.5 | 382 | 180 | 18 | 0 | 1750 |
| M- 7.5 | 370 | 180 | 30 | 0 | 1750 |
| MN- 2- 5.5 | 370 | 180 | 8 | 22 | 1750 |
| MN- 5.5- 2 | 370 | 180 | 12 | 8 | 1750 |

***Concrete Samples Structure, Preparation and Storage:***

In order to construct the mixtures, at first the consumed materials are weighted exactly. Then, sand, fine sand and weighted neutral filler are poured into an electric lift in mixer and finally, weighted water is added to the extent that the particles reach SSD (Saturated with Surface Dryness) position and the composition is mixed for 30 seconds. After preparation of micro-silica or nano-silica, cement is added and while being mixed, remained amount of water except a very small amount is added and the composition is mixed for 2 minutes. At last, the water which contains ultra-lubricates is added and for another 2 seconds mixing process continues. It should be considered that in constructing mixture containing micro-silica or nano-silica, at first these materials and demanded amount of water are mixed in a small mixer with special blades of mixing liquids. In concrete samples these materials with a scarce amount of lubricants will be turn into grout and is added to mixture before adding cement. Right after finishing mixture, the slump experiments are performed on composition. Then, the samples are casted and densified on a shaker table. The samples will remain in casts for 24 hours and during this time their surface will be dampened. After opening casts, the samples are placed in lime in processing condition. The moderate environmental temperature of lab is 19- 23 centigrade degrees.

***Representing Experiment Results:***

***Compressive and Tensional Strength Experiment:***

Cubic samples of 10 cm with breaking 3 samples from each plan for 7 plans of compressive strength experiment mixture in the age of 3, 7, 28, 90 and 180 days were performed. Their results are shown in Table.3. It can be seen that adding nano-silica or micro-silica into concrete in all the ages will cause compressive strength of concrete samples. As comparing the strength of nano-silica and micro-silica, the priority of nano-silica in compressive and tensional strength are inferred specially in primary ages. But, the difference between nano-silica and micro-silica decreases as time passing and reaching 28 days-old. The optimized effect related to the presence of nano and micro-silica on strength increase is shown in Table.3. (Figure 1)

**Table 3:** Compressive strength in different age of concrete.

| | Testate | N- 4.5 | N- 7.5 | M- 4.5 | M-7.5 | MN-2- 5.5 | MN-5.5-2 |
|---|---|---|---|---|---|---|---|
| 3 days | 25.5 | 35.8 | 49.0 | 56 | 57.5 | 61.2 | 57.9 |
| 7 days | 26.3 | 45.3 | 56.1 | 60.3 | 61 | 70.3 | 68.3 |
| 28 days | 34.9 | 47.6 | 60.0 | 63.2 | 63.9 | 79.6 | 69.8 |
| 90 days | 29.6 | 41.2 | 52.9 | 85.5 | 59.7 | 90.6 | 79.4 |
| 180 days | 30.5 | 39.8 | 59.5 | 75.3 | 61.9 | 84 | 81 |

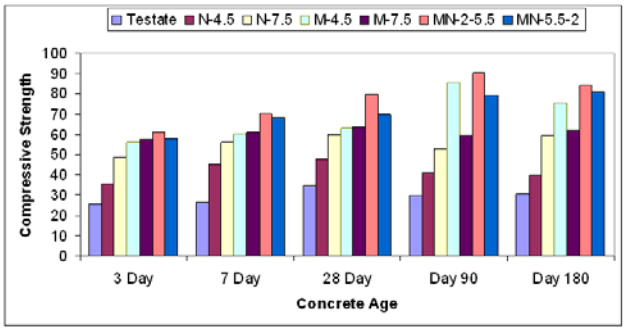


**Fig. 1:** Compressive strength in different age of concrete.

Brazilian compressive strength testing is used for identifying concrete compressive strength in the standard of ASTMC 496 on cylinder testate with diameter of 150mm and height of 300mm. The results are represented in graph 2 in the form of increase change of compressive strength percentage related to neon-silica toward testate sample.

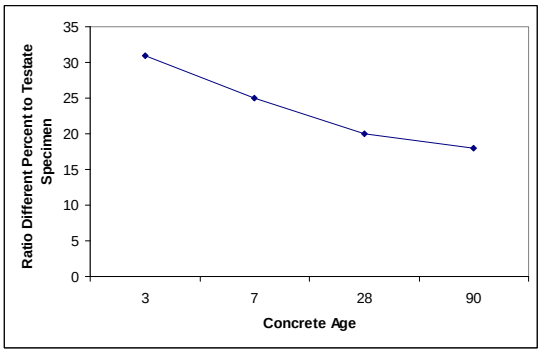


Fig. 2: Ratio different percent to testate specimen in first mix design.

***Water Influence Experiment:***

This experiment is carried out on all of the plans on the bases of BSEN-12390-8:2000 standards at the age of 28 days and on 3 samples of each plan. Figure 3 shows the results of this experiment. The results show the priority of nano-silica over micro-silica from water influence points at the age of 28 days. This priority can be attributed to quick pozolan reactions and filler effect of nano particles in omitting influence porosities of water toward micro-silica particles.

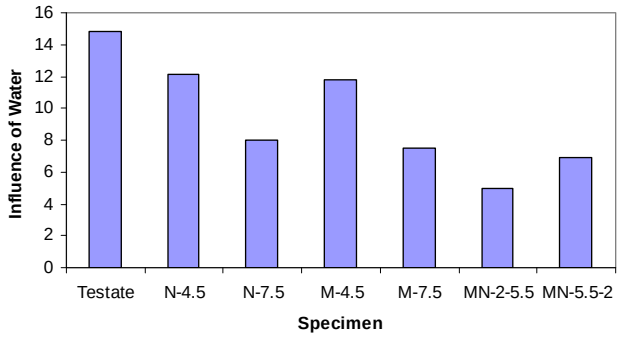


**Fig. 3:** Influence of water in specimens.

***Analyses and Interpretation of Results:***

As the size of particles reach to nano measures like nano-silica, the surface of particles and the number of atoms increases. The presence of atom in surface with this measures leads to free and unsaturated links which is unstable. On the other hand, as the size of particles decrease the atom inequality degrees increase the chemical reaction. Therefore, nano-silica has high level of energy and atoms activity will react with outside atoms and as a result pozolan actions of nano-silica will be much more than micro-silica. This seems reasonable according to the surface of nano-silica which is more than silica soot. The use of nano-silica in concrete leads to micro-structure improvement. Nano-silica can react quickly with crystal calcium-hydroxide and produce C-S-H.

In that case, the measure and amount of calcium-hydroxide crystals decrease and instead the C-S-H jelly can fill the porosities of cement paste. Also, nano-silica particles can fill the porosities of jelly structure and cause dense matrix.

The priority of nano-silica in compressive strength is inferred in primary ages. But, this decrease as time passing and its high activity is 7- 28 days-old. Similar results are reported by Jo *et al.,* They showed that adding 3-12% nano-silica will lead to 3-4 times mortar strength.

***Conclusions:***

On the bases of performed experiments and special samples of nano-silica and silica soot in this lab project, it can be concluded that:

a) It can be seen that adding nano-silica or micro-silica into concrete in all the ages will cause compressive strength of concrete samples. As comparing the strength of nano-silica and micro-silica, the priority of nano-silica is inferred.
b) The velocity of nano-silica containing samples in primary ages is much more than silica samples containing soot. As time passes, this velocity increases in the samples containing micro-silica specially in the samples of 7.5% micro-silica at the age of 7-28 days and the difference between compressive strength of nano-silica and silica soot becomes scarce with equal replacing percentage as reaching 28 days.
c) The results of water influence show significant effect of nano-silica over water influence decrease in concrete toward testate at the age of 28 days. At last, it can be said that nano-silica has tangible priority over micro-silica in water influence decrease at that age.

## REFERENCES

Colleparidi, M., J. Ogoumah Olagot, R. Troli, F. Simonelli and S. Collepardi, 2007. (Combination of Silica Fume, Fly Ash and Amorphous Nano-Silica in Superplasticized High-Performance Concretes), Enco, Engineering Concrete, Ponzano Veneto, Italy.

Gengying Li. 2004. (Properties of high volume fly ash concrete incorporating nano-SiO2 Cement and Concrete Research), 34: 1043-1049.

Hanehara, S., M. Ichikawa, 2001. (Nanotechnology of cement and concrete). Journal of the Taiheiyo Cement Corporation, 141: 47-58.

Hui Li, Hui-gang Xiao, Jie Yuan, Ou Jinping. 2004. (Microstructurer of cement mortar with nanoparticles). Composites: Part B., 35: 185-189.

Ji, T., 2005. (Preliminary study on the water permeability and microstructure of concrete incorporating nano-SiO2). Cement and Concrete Research, 35: 1943-1947.

Jo, B.W., C.H. Kim, G.H. Tea, J.B. Park, 2007. (Characteristics of cement mortar with nano-SiO2 particles), Construction and Building Materials, 21: 1351-1355.

Ke. Y.C., P. Stroeve, 2005. (Polymer-Layered Silicate and Silica Nano composites). Amsterdam: Elsevier B.V., 52-55, 330-341.

Li, G., 2004. (Properties of high-volume fly ash concrete incorporating nano-SiO2), Cement and Concrete Research, 34: 1043-1049.

Li, H., H.G. Xiao, J. Yuan, J.P. Ou, 2004. (Microstructure of cement mortar with nano-particles), Composites: Part B., 35: 185-189.

Qing, Y., Z. Zenan, K. Deyu, K. Rongshen, 2007. (Influence of nano-SiO2 addition on properties of hardened cement paste as compared with silica fume), Construction and Building Materials, 21: 539-545.