Journal of Engineering and Computer Sciences, Qassim University
Vol. 13, No. 1, pp. 15-30 (Jan. 2020 /Jumada Al-Awwal 1441H)

Effect of Silica Fume on Cement Mortar Cubes with Partial Replacement of Sand by Natural Pozzolan

Hany A. Dahish[1,3], Saud Almutairi[1], Ahmed F. Elragi[2,3], Sherif M. Elkholy[2]
[1] Civil Engineering Department, College of Engineering, Qassim University, Unaizah 51452, Saudi Arabia
[2] Civil Engineering Department, College of Engineering, Qassim University, Buraydah 51452, Saudi Arabia
[3] Civil Engineering Department, Faculty of Engineering, Fayoum University, Fayoum, Egypt
E-mail: ha.dahish@qu.edu.sa, had00@fayoum.edu.eg

(Received 23/12/2019, accepted for publication 03/03/2020)

Abstract. This paper presents an experimental investigation of the effect of silica fume (SF) in addition to the possibility of using local natural pozzolan (LNP) as fine aggregate replacement in cement mortars on the mechanical properties of cement mortars. The availability of local natural pozzolan in volcanic areas in Al-Madinah Al-Munawarah, KSA stimulated studying the possibility of utilizing LNP as a partial substitution for sand to reduce the density of the concrete and to improve the properties of eco-friendly concrete. The experimental work was carried out on seventy-five cement mortar cubes of 50 mm, nine cubes as control specimens, twelve cubes were made by replacing sand by volume with local natural pozzolan at replacement levels of 10, 20, 30 and 40% without addition of SF, fifteen cubes were made by replacing sand by volume with LNP at replacement levels of 10, 20, 30 and 40% and by replacing 5% of cement with silica fume, fifteen cubes were made by replacing sand by volume with LNP at levels of replacement of 10, 20, 30 and 40% and by replacing 10% of cement with silica fume. Twenty-four cubes were made without sand replacement and with cement replacement by weight with SF at replacement levels of 10, 20, 30 and 40%. The specimens were tested after 7, 14 and 28 days. The addition of SF showed a marked influence on the properties of the produced cement mortar cubes.

Keywords: Silica fume, cement mortars, sand replacement, local natural pozzolan, mechanical properties

1. Introduction

The available local natural pozzolan in Al-Madinah Al-Munawarah, KSA may be used in the manufacturing of blended cement [1]. The partial replacement of cement with natural pozzolan (NP) has been investigated by many researchers [2 to 7]. The effect of partial substitution for sand in concrete with different materials such as plastic waste, waste foundry, granite quarry, spent garnets, copper slag… etc. on its properties had been investigated by many researchers.

Thorneycroft *et al.* [8] replaced 10% of sand with plastic waste to save about 820 million tons per year of natural sand. The partial substitution of fine aggregate in concrete with plastic waste improved energy absorption for concrete under impact loading [9]. The partial substitution of sand in concrete with waste foundry sand reduced the consistency and compressive strength of it [10]. The partial replacement of fine aggregate in mortar with spent garnets in addition to fly ash up to 25% did not affect the strength while the replacement level of 40% gave thermal stability for the concrete [11 and 12].

The replacement of sand in mortars with granite quarry up to 60% increased its strength [13]. The 15% sand replacement and 5% cement replacement in concrete with limestone fines increased its strength [14]. Karatas *et al.* [15] replaced the sand in mortars with raw vermiculite. The strength of cement mortars decreased under the effect of high temperatures. The partial replacement levels up to 50% of fine aggregate in concrete with copper slag were recommended for the production of eco-friendly concrete [16]. In this research, the possibility of partial substitution for sand by volume with local natural pozzolan and partial substitution for cement by weight with silica fume in cement mortars to improve its mechanical properties was studied.

2. Materials

The used materials are as follows.

2.1 Natural Sand (NS) and Local Natural Pozzolan (LNP)

The properties of natural sand and LNP are shown in Table (1).

Table (1): Natural sand and LNP properties

	NS	LNP	
Bulk density	1670	1100	kg/m^3

Specific gravity	2.60	2.51	
Moisture content	0.10	1.33	%
Absorption	0.21	5.23	%

The Particle distributions for the used natural sand and LNP are shown in Figure (1). The chemical composition of LNP is shown in Table (2).

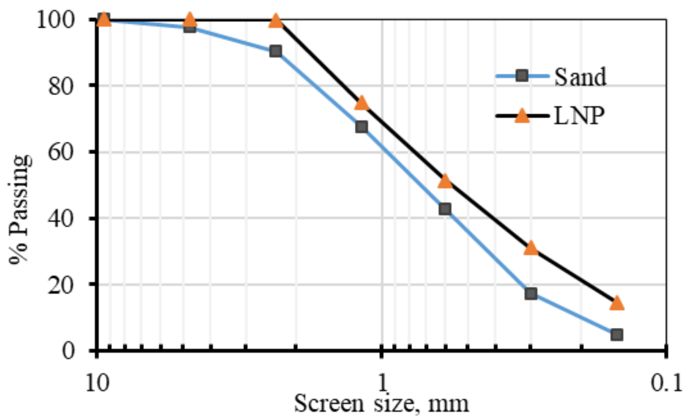

Fig. (1). Particle distributions for natural sand and LNP

Table (2): Chemical compositions of (LNP)

Oxides	**SiO_2**	**Al_2O_3**	**Fe_2O_3**	**CaO**	**MgO**	**SO_3**	**K_2O**	**Na_2O**	**Loss on ignition**
Weight, %	41.12	15.44	17.35	11.21	4.47	0.18	1.05	0.25	2.2

2.2 Ordinary Portland Cement (Opc)

Table (3) shows the chemical properties of the used OPC.

Table (3): Chemical properties of cement

Oxides	**SiO_2**	**Al_2O_3**	**Fe_2O_3**	**Ca O**	**Mg O**	**SO_3**	**LOI (%)**	**Fineness (cm^2/g)**
Cement	19.97	5.85	3.43	64.13	0.6	2.8	1.6	3148

2.2 Silica Fume

Table (4) shows the chemical properties of the used silica fume.

Table (4): Chemical properties of silica fume

Oxides	**SiO_2**	**Al_2O_3**	**Fe_2O_3**	**Ca O**	**Mg O**	**SO_3**	**Fineness (cm^2/g)**
Silica Fume	92	1.0	1.0	0.3	0.6	0.3	150000-200000

3. Experimental Program

The experimental work was conducted to study the effect of silica fume in addition to partial replacement of sand in mortars with LNP at replacement levels of (10%, 20%, 30% and 40%) on the mechanical properties of cement mortars. Seventy-five cement mortar cubes of 50x50x50 mm were tested. The specimens were divided into 5 groups. The first three groups for the case of sand replacement with LNP at various levels of replacement were divided according to the percentages of cement substitution by weight with SF, the first group without cement replacement, the second group with 5% cement substitution by weight with SF and the third group with 10% cement replacement by weight with SF. The other two groups for the case of cement substitution by weight with SF at replacement levels of (10%, 20%, 30% and 40%) were divided according to the curing period.

The specimens were prepared according to ASTM C 109. The specimens were covered for 24 hours with polyethylene sheets after casting. The specimens were demolded after 24 hours and immersed in water storage tanks at a temperature of 22 ± 2 °C. The first three groups were tested after 28 days and the other groups were tested after 7 and 14 days.

3.1 Test Procedures

The ratio of water/cementitious materials was 0.49 for all specimens. Table (5) shows the quantities of used materials. The electrically driven mechanical mixer was used for mixing process. For the first three groups, the levels of replacement of sand by volume with local natural pozzolan were (10%, 20%, 30% and 40%) and the levels of replacement of cement by weight with SF were (0%, 5% and 10%). For the other groups, the levels of replacement of cement by weight with SF were (0%, 10%, 20%, 30% and 10%).

Table (5): Quantities of used materials

Group	Specimen	Sand replacement with LNP %	Natural Sand (gm)	Natural Pozzolan (gm)	Silica Fume, (gm)	Cement (gm)	Tested after, (days)
1	0SF00	0%	1356	0.0	--	490	28
	0SF10	10%	1220	90	--	490	28
	0SF20	20%	1084	180	--	490	28
	0SF30	30%	949	270	--	490	28
	0SF40	40%	814	360	--	490	28
2	5SF00	0%	1356	0	24.5	465.5	28
	5SF10	10%	1220	90	24.5	465.5	28

	5SF20	20%	1084	180	24.5	465.5	28
	5SF30	30%	949	270	24.5	465.5	28
	5SF40	40%	814	360	24.5	465.5	28
3	10SF00	0%	1356	0	49.0	441	28
	10SF10	10%	1220	90	49.0	441	28
	10SF20	20%	1084	180	49.0	441	28
	10SF30	30%	949	270	49.0	441	28
	10SF40	40%	814	360	49.0	441	28
4	0SF7D	0%	1356	0	--	490	7
	10SF7D	0%	1356	0	49	441	7
	20SF7D	0%	1356	0	98	392	7
	30SF7D	0%	1356	0	147	373	7
	40SF7D	0%	1356	0	196	294	7
5	0SF14D	0%	1356	0	--	490	14
	10SF14D	0%	1356	0	49	441	14
	20SF14D	0%	1356	0	98	392	14
	30SF14D	0%	1356	0	147	343	14
	40SF14D	0%	1356	0	196	294	14

4. Methods

4.1 Compressive Strength

Compressive strengths were measured on 50 mm mortar cubes. The compressive strengths were measured after 7, 14 and 28 days. The average values of each three specimens tested under compression were reported.

4.2 Ultrasonic Pulse Velocity (Upv).

The pulse speed of the ultrasonic device gives an indicator to how dense is the hardened concrete. The value of pulse velocity increases as the concrete density increase. The ultrasonic pulse tests were done for the hardened cement mortars after 28 days.

5. Results and Discussion

5.1 Compressive Strength

Figure (2) shows the cement mortar cubes after compression testing for the levels of replacement of cement with silica fume at levels 0%, 5% and 10% and replacement of sand with LNP at various levels.

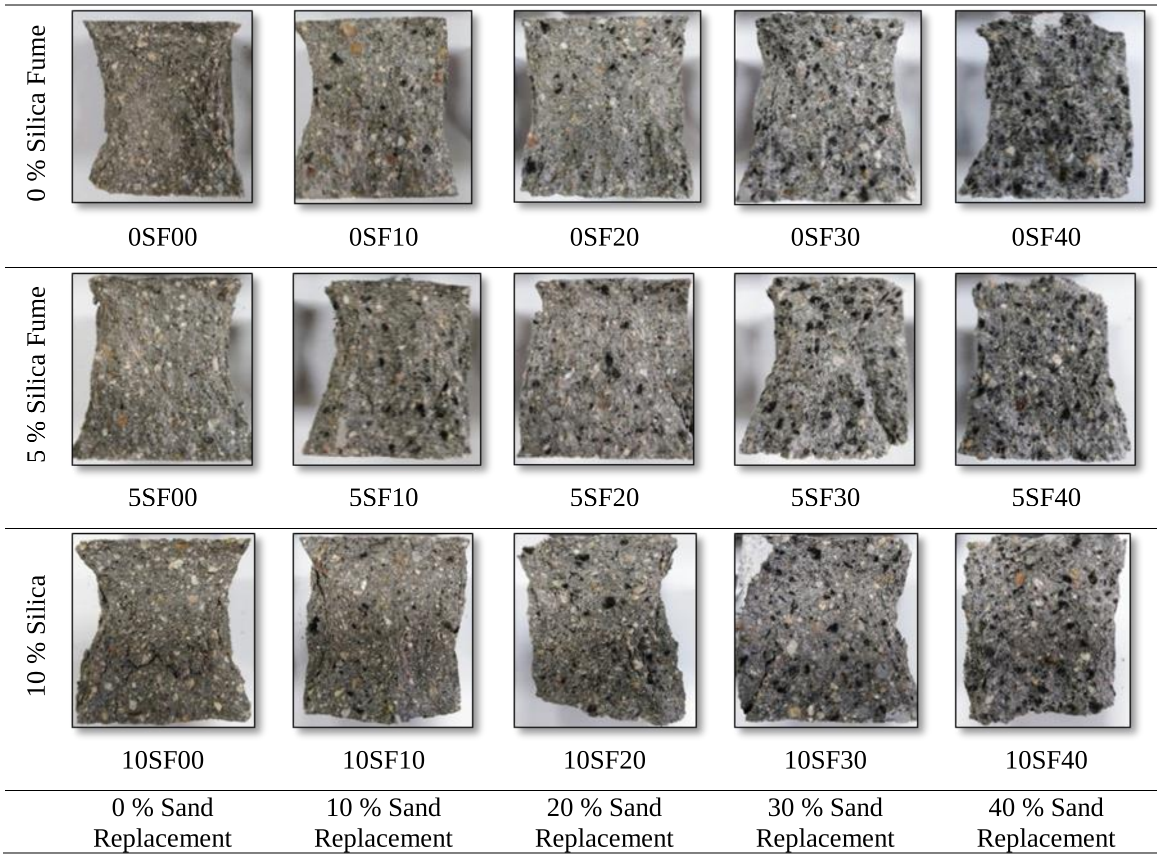

Fig. (2). Cement mortar cubes after compression testing

5.1.1 Effect of silica fume without sand replacement

The effect of using silica fume as partial substitution for cement in mortar cubes on the compressive strength of mortars cubes after 7, 14 and 28 days is shown in Table (6).

The compressive strengths of specimens 0SF7D, 0SF14D and 0SF00 without addition of silica fume that tested after 7, 14 and 28 days were 30.0, 35.4 and 45.9 MPa, respectively. The compressive strengths of specimens 10SF7D, 10SF14D and 10SF00 with 10% cement replacement with silica fume that tested after 7, 14 and 28 days were 38.9, 48.1 and 62.6 MPa, respectively.

Table (6): Compressive strengths of mortars (without LNP)

Specimen	Percentage of SF, %	Duration, day	Average stress, MPa
0SF7D	0	7	30.0
0SF14D	0	14	35.4
0SF00	0	28	45.9
10SF7D	10	7	38.9
10SF14D	10	14	48.1
10SF00	10	28	62.6

20SF7D	20	7	31.0
30SF7D	30	7	29.5
40SF7D	40	7	25.3
20SF14D	20	14	45.2
30SF14D	30	14	40.0
40SF14D	40	14	36.0

Figure (3) shows the relationship between compressive strength and curing durations in cases of 0 and 10% cement replacement by weight with silica fume. It can be seen that the compressive strengths after 7 and 14 days reached 65% and 77% of the compressive strength after 28 days in case of specimens without silica fume, and reached 62% and 77% of the compressive strength after 28 days in case of specimens with 10% cement replacement with silica fume. The 10% replacement of cement with silica fume increased the compressive strength of specimens at different durations when compared with specimens without silica fume.

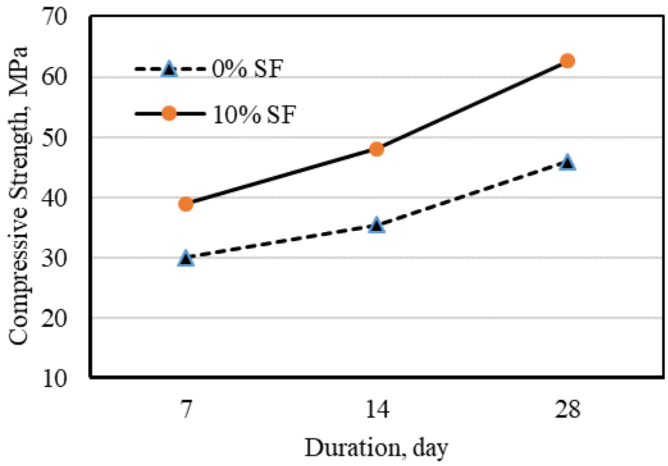

Fig. (3). Compressive strengths of mortar cubes at different durations (0 and 10% SF)

Figure (4) shows the relationship between compressive strength and levels of cement replacement with silica fume after 7 and 14 days. It can be seen that the 10% cement replacement by weight with silica fume increased the compressive strength at different durations when compared with specimens without silica fume or specimens with more than 10% cement replacement with silica fume.

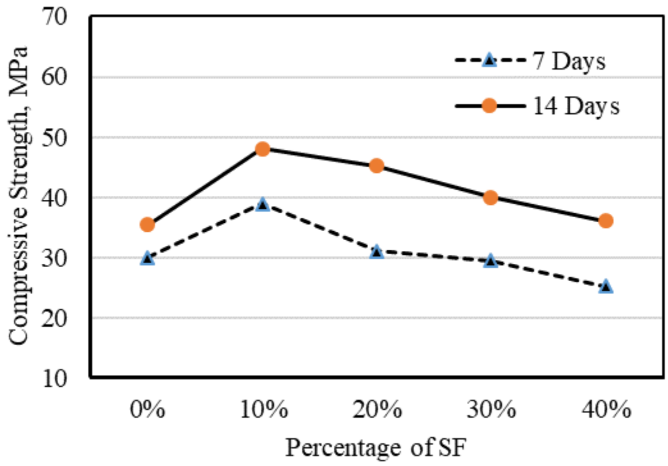

Fig. (4). Compressive strengths of mortar cubes after 7 and 14 days (SF, 0 to 40%)

5.1.2 Effect of sand replacement with LNP (No silica)

The effect of using LNP as partial substitution for sand in mortar cubes on the strength of mortars cubes after 28 days is shown in Table (7) and Figure (5). The strength of specimens 0SF00, 0SF10, 0SF20, 0SF30 and 0SF40 at sand replacement levels of 0, 10, 20, 30 and 40% were 45.9, 48.7, 47.3, 44.6 and 38.3 MPa, respectively. The sand replacement with LNP at levels of 10% and 20% increased the compressive strengths by 6% and 3.1%, respectively and the replacement levels of sand of 30% and 40% decreased the compressive strengths by 3% and 16.7%, respectively when compared with control specimen. It was found that the replacement of sand in cement mortars by volume with local natural pozzolan by more than 20% showed low compressive strength when compared to those with less than 20% replacement level after 28 days.

Table (7): Compressive strengths of mortars after 28 days (no silica)

Specimen	Average load, kN	Average stress, MPa
0SF00	114.8	45.9
0SF10	122.3	48.7
0SF20	119.1	47.3
0SF30	111.7	44.6
0SF40	95.6	38.3

Journal of Engineering and Computer Sciences, Qassim University
Vol. 13, No. 1, pp. 15-30 (Jan. 2020 /Jumada Al-Awwal 1441H)

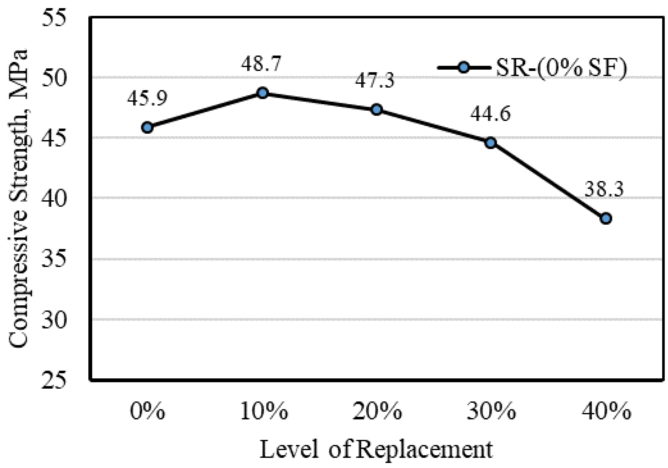

Fig. (5). Compressive strengths of mortar cubes (no silica)

5.1.3 Effect of sand replacement with LNP (5% silica fume)

The effect of sand replacement with LNP in addition to 5% cement replacement by weight with SF on the strengths of cement mortars after 28 days is shown in Table (8) and Figure (6). The compressive strengths of specimens 5SF00, 5SF10, 5SF20, 5SF30 and 5SF40 at levels of replacement of sand with local natural pozzolan of 0, 10, 20, 30 and 40% were 60.5, 56.1, 54.8, 46.4 and 42.8 MPa, respectively. The sand replacement with LNP at levels of 0, 10, 20 and 30% increased the compressive strengths by 31.80%, 22.10%, 19.40% and 1.10%, respectively when compared with control specimen without SF. The replacement levels of sand in cement mortars with LNP less than 30% increased the compressive strength while the replacement levels of sand in cement mortars with LNP by more than 30% resulted in reduction of the compressive strength in the presence of 5% SF as cement partial substitution by weight after 28 days.

Table (8): Compressive strengths of mortars after 28 days (5% silica fume)

Specimen	Average load, kN	Average stress, MPa
5SF00	151.3	60.5
5SF10	140.2	56.1
5SF20	137.1	54.8
5SF30	116.1	46.4
5SF40	107.0	42.8

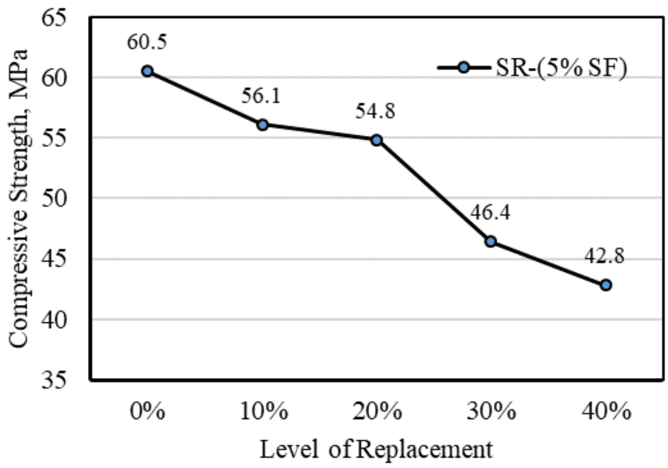

Fig. (6). Compressive strength of mortar cubes (5% silica fume)

5.1.4 Effect of sand replacement with LNP (10% silica fume)

The effect of substitutions of sand with LNP and 10% cement replacement with silica fume in cement mortars on the strengths of it after 28 days is shown in Table (9) and Figure (7). The compressive strengths of specimens were 62.6, 58.8, 54.7, 52.0 and 47.6 MPa for sand replacement with local natural pozzolan at replacement levels of 0, 10, 20, 30 and 40%, respectively.

The replacement of sand with LNP at levels of 0, 10, 20, 30 and 40% increased the compressive strengths by 36.4%, 28.1%, 19.1%, 13.2% and 3.6%, respectively when compared with control specimen without SF. It was found that the replacement of sand with LNP in addition to 10% cement replacement with silica fume increased the compressive strengths of cement mortars when compared with control specimen without SF.

Table (9): Compressive strength of mortars after 28 days (10% silica fume)

Specimen	Average load, kN	Average stress, MPa
10SF00	156.5	62.6
10SF10	147.0	58.8
10SF20	136.7	54.7
10SF30	130.0	52.0
10SF40	118.9	47.6

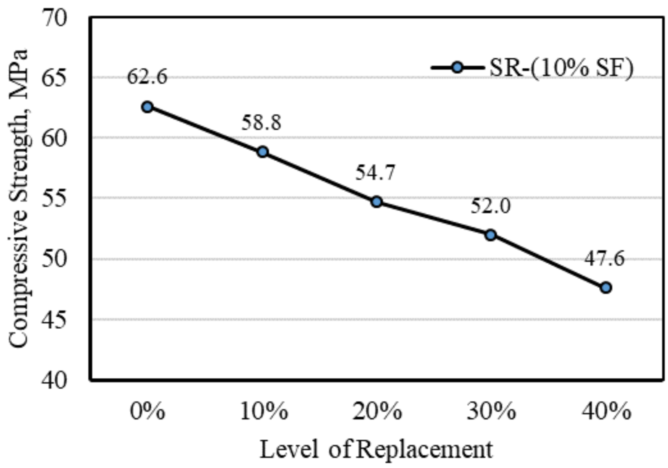

Fig. (7). Compressive strength of mortar cubes (10% silica fume)

5.1.5 Effect of silica fume and sand replacement with LNP

The compressive strengths of cement mortars at various levels of replacement of sand by volume with LNP and levels of cement replacement by weight with SF of 0%, 5% and 10% are shown in Figure (8). It was found that the replacement of sand by volume with LNP up to 20% improved the compressive strength of cement mortars without SF. It was found that the replacement of cement by weight with silica fume at level of 5% in addition to replacement of sand by volume with LNP at levels up to 30% improved the compressive strength of cement mortars. It was also found that the replacement of cement by weight with silica fume at level of 10% in addition to replacement of sand by volume with LNP at levels up to 40% improved the compressive strength of cement mortars.

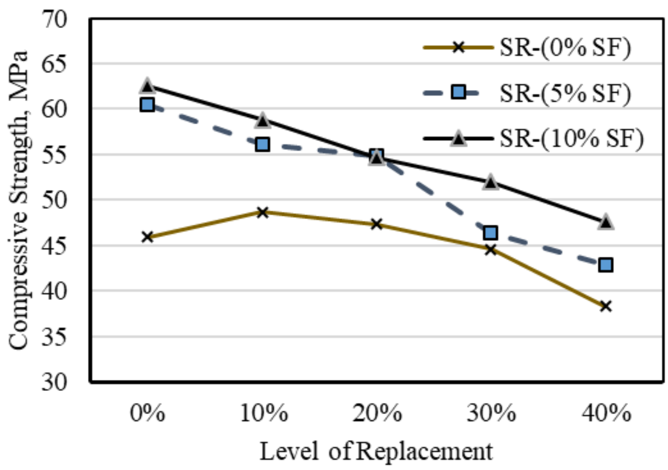

Fig. (8). Compressive Strength of Mortar Cubes after 28 days (0%, 5% and 10% SF)

5.2 Ultrasonic Pulse Velocity

Table (10) and Figure (9) show the pulse velocities of specimens after 28 days. The ultrasonic pulse velocity was 3498 m/s for control specimen. The pulse velocities were 3320, 3450, 3440 and 3400 m/s for specimens without SF and with sand replacement with LNP at levels of 10, 20, 30 and 40%, respectively. The pulse velocities were 3828, 3613, 3515, 3425 and 3372 m/s for specimens with 5% cement replacement with SF and with sand replacement with LNP at levels of 0, 10, 20, 30 and 40%, respectively. The pulse velocities were 4012, 3885, 3801, 3709 and 3522 m/s for specimens with 10% cement replacement with SF and with sand replacement with LNP at levels of 0, 10, 20, 30 and 40%, respectively. The increase in the replacement level of sand in cement mortar cubes with LNP decreased the pulse velocities.

Table (10): Ultrasonic pulse velocities after 28 days

Sand Repl. Levels with LNP	0%	10%	20%	30%	40%
0% Silica Fume	3498	3320	3450	3440	3400
5% Silica Fume	3828	3613	3515	3425	3372
10% Silica Fume	4012	3885	3801	3709	3522

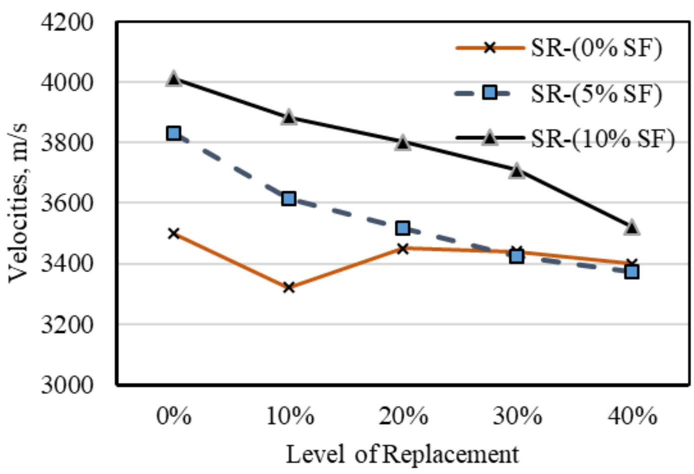

Fig. (9). Ultrasonic pulse velocities

5. Conclusions

The main objective of this study is the investigation of the effect of utilization of LNP as a partial substitution for sand in addition to partial replacement of cement with silica fume in cement mortar cubes on its properties. The compressive strengths were measured after 7, 14 and 28 days, and the ultrasonic pulse velocities were measured after 28 days.

The following conclusions have been reached:

1. The 10% cement replacement with silica fume increased the compressive strength of cement mortars at different durations.
2. The utilization of LNP as a partial substitution for sand increased the compressive strength of specimens for levels of replacement up to 20%.
3. The replacement of sand by volume in cement mortars with LNP at replacement levels up to 30% in addition to 5% cement replacement with silica fume increased the compressive strengths of mortar cubes.
4. The replacement of sand by volume in cement mortars with LNP at replacement levels up to 40% in addition to 10% cement replacement with silica fume increased the compressive strengths of mortar cubes.
5. The utilization of LNP as partial replacement for sand decreased the pulse velocities, so that it may be used as isolations.

6. Acknowledgment

The authors appreciate the support received from Deanship for Scientific Research at Qassim University (QU), Saudi Arabia, for supporting this project under the Standard Research Grants funding - Research Centre for Applied Sciences (Project no. 5154-enuc-2018-1-14-S).

7. References

[1] M. Kemal Ardoga, Sinan T. Erdogan and Mustafa Tokyay, “Effect of particle size on early heat evolution of interground natural pozzolan blended cements”, Construction and Building Materials 206 (2019) 210–218.

[2] K. Ezziane, A. Bougara, A. Kadri, H. Khelafi, E. Kadri, “Compressive strength of mortar containing natural pozzolan under various curing temperature”, Cement & Concrete Composites 29 (2007) 587–593.

[3] S. Ahmad, K. Own Mohaisen, S. Kolawole Adekunle, S. U. Al-Dulaijan, Mohammed Maslehuddin, “Influence of admixing natural pozzolan as partial replacement of cement and microsilica in UHPC mixtures”, Construction and Building Materials 198 (2019) 437–444.

[4] S. Ahmad, I. Hakeem, and M. Maslehuddin, “Development of UHPC Mixtures Utilizing Natural and Industrial Waste Materials as Partial Replacements of Silica Fume and Sand”, Scientific World Journal, Volume (2014), Article ID 713531.

[5] K. Yang, Y. Jung, M. Cho, S. Tae, “Effect of supplementary cementitious materials on reduction of CO2 emissions from concrete”, J. Clean. Prod. 103 (15) (2015) 774–783.

[6] G.K. Al-Chaar, M. Al-Kadi, P.G. Asteris, “Natural pozzolan as a partial substitute for cement in concrete”, Open Constr. Technol. J. 7 (2013) 33–42.

[7] G.K. Al-Chaar, M. Alkadi and P.G. Asteris, “Natural pozzolan as a partial substitute for cement in concrete”, Open Construction and Building Technology Journal, 7 (2013) 33–42.

[8] J. Thorneycroft, J. Orr, P. Savoikar, R.J. Ball, “Performance of structural concrete with recycled plastic waste as a partial replacement for sand”, Construction and Building Materials Journal, 161 (2018) 63–69.

[9] Maher Al-Tayeb Mustafa, Ismail Hanafi, Rade Mahmoud, B.A. Tayeh, “Effect of partial replacement of sand by plastic waste on impact resistance of concrete: experiment and simulation”, Structures Journal, 20 (2019) 519–526.

[10] Paulo Ricardo de Matos, Matheus Felipe Marcon, Rudiele Aparecida Schankoski, Luiz Roberto Prudêncio Jr, “Novel applications of waste foundry sand in conventional and dry-mix concretes”, Journal of Environmental Management 244 (2019) 294–303.

[11] Ghasan Fahim Huseien, Abdul Rahman Mohd Sam, Kwok Wei Shah, A.M.A. Budiea, and Jahangir Mirza, “Utilizing spend garnets as sand replacement in alkali-activated mortars containing fly ash and GBFS”, Construction and Building Materials Journal 225 (2019) 132–145.

[12] Mariyana Aida Ab Kadir, Mohammad Iqbal Khiyon, Abdul Rahman Mohd. Sam, Ahmad Beng Hong Kueh, Nor Hasanah Abdul Shukor Lim, Muhammad Najmi Mohamad Ali Mastor, Nurizaty Zuhan, Roslli Noor Mohamed, “Performance of spent garnet as a sand replacement in high-strength concrete exposed to high temperature “, Journal of Structural Fire Engineering, (2019), Vol. 10, Issue 4, pp. 468-481.

[13] Cheah Chee Ban, Lim Jay Sern, Mahyuddin B. Ramli, “The mechanical strength and durability properties of ternary blended cementitious composites

containing granite quarry dust (GQD) as natural sand replacement", Construction and Building Materials Journal, 197 (2019) 291–306.

[14] Zakaria Skender, Abderrahim Bali & Ratiba Kettab, "Self-compacting concrete (SCC) behaviour incorporating limestone fines as cement and sand replacement", European Journal of Environmental and Civil Engineering; APR 25 (2019).

[15] Mehmet Karatas, Ahmet Benli, Hasan Anil Toprak, "Effect of incorporation of raw vermiculite as partial sand replacement on the properties of self-compacting mortars at elevated temperature", Construction and Building Materials Journal, 221 (2019) 163–176.

[16] Aysegul Petek Gursel and Claudia Ostertag, "Life-Cycle Assessment of High-Strength Concrete Mixtures with Copper Slag as Sand Replacement", Advances in Civil Engineering, Volume (2019), Article ID 6815348.

Journal of Engineering and Computer Sciences, Qassim University
Vol. 13, No. 1, pp. 15-30 (Jan. 2020 /Jumada Al-Awwal 1441H)

تأثير غبار السيليكا على مكعبات المونة الأسمنتية مع الإستبدال الجزئي للرمل بالبوزولان الطبيعي

هاني أحمد داهش[1, 3], سعود المطيري[1], أحمد فؤاد الراجي[2, 3], شريف محمد الخولي[2]
[1]قسم الهندسة المدنية - كلية الهندسة - جامعة القصيم – عنيزة – 51452 – المملكة العربية السعودية
[2]قسم الهندسة المدنية - كلية الهندسة - جامعة القصيم – بريدة – 51452 – المملكة العربية السعودية
[3]قسم الهندسة المدنية - كلية الهندسة - جامعة الفيوم – الفيوم – جمهورية مصر العربية
E-mail: ha.dahish@qu.edu.sa, had00@fayoum.edu.eg

(قدم للنشر في 2019/12/23 وقبل للنشر في 2020/03/03)

ملخص البحث. يعرض هذا البحث دراسة تأثير استخدام غبار السيليكا بالإضافة إلى دراسة إمكانية استخدام البوزولان الطبيعي المحلي كبديل جزئي للرمل في مكعبات المونة الأسمنتية وتأثيره على الخواص الميكانيكية للمونة الأسمنتية. إن توفر البوزولان الطبيعي في المناطق البركانية بالمدينة المنورة كان السبب الرئيسي لدراسة إمكانية استخدامه كبديل جزئي للرمل لتقليل كثافة الخرسانة بالإضافة إلى تحسين خواص الخرسانة صديقة البيئة. تم اجراء الاختبارات المعملية على عدد خمسة وسبعون مكعباً من المونة الأسمنتية بأبعاد 50 مم تم تقسيمها كالتالي : (تسع مكعبات كعينات مرجعية ، اثنى عشر مكعب يتم فيهم الاستبدال الجزئي للرمل بالبوزولان الطبيعي بالحجم بنسب تتراوح من 10% إلى 40% بدون إضافة غبار السيليكا، خمسة عشر مكعب يتم فيهم الاستبدال الجزئي للرمل بالبوزولان الطبيعي بالحجم بنسب تتراوح من 10% إلى 40% بالإضافة إلى استبدال 5% من وزن الأسمنت بغبار السيليكا، خمسة عشر مكعب يتم فيهم الاستبدال الجزئي للرمل بالبوزولان الطبيعي بالحجم بنسب تتراوح من 10% إلى 40% بالإضافة إلى استبدال 10% من وزن الأسمنت بغبار السيليكا، أربعة وعشرون مكعباً يتم فيهم استبدال الأسمنت بغبار السيليكا بالوزن بنسب تتراوح من 10% إلى 40% بدون استبدال الرمل بالبوزولان الطبيعي). تم اجراء اختبار الضغط للمكعبات بعد الفترات سبعة أيام ، وأربعة عشر يوماً و ثمانية وعشرون يوماً من المعالجة. أظهرت النتائج تأثيراً ملحوظاً لغبار السيليكا على خواص مكعبات المونة الأسمنتية والتي تم فيها الاستبدال الجزئي للرمل بالبوزولان الطبيعي المحلي.