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The Feasibility of Basalt Rock Powder and Superfine Sand as Partial Replacement Materials for Portland Cement and Artificial Sand in Cement Mortar

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Abstract:
The research gap on the feasibility of basalt rock powder (BRP) and superfine sand (SS) in preparation of cement mortar is significant. This study examines probable changes occurred in the modified cement mortar due to incorporation of certain quantity of basalt rock powder and superfine sand in mixture proportion. The cement mortar included Portland cement, artificial sand and water as principal mixture constituents. Then, basalt rock powder and superfine sand were added as partial replacement materials for Portland cement and artificial sand respectively. Therefore, replacement percentages were 10%, 15%, 20%, 25% and 30% when the basalt rock powder replaced Portland cement and in case the artificial sand was replaced by superfine sand, 10%, 20%, 30%, 40% and 50%. Then, the strength indexes such as flexural strength, compressive strength, ultrasonic pulse velocity and dynamic elastic modulus were investigated. The results show that the presence of basalt rock powder in mixture proportion increased the flexural and compressive strengths of cement mortar however the cement mortar that contained superfine sand illustrated inadequate mechanical performance as flexural and compressive strengths decreased remarkably. Moreover, when basalt rock powder and superfine sand were included together in mixture proportion, the cement mortar's mechanical performance declined compared to that of the reference cement mortar. Despite the fact that basalt rock powder and superfine sand weakened the cement mortar's mechanical properties, it was found that they can be added into the cement mortar as partial replacement of Portland cement and artificial sand in the following ratios: from 10% to 25% when basalt rock powder replaces Portland cement and from 10% to 20% when artificial sand is replaced by superfine sand.

Keywords: *basalt rock powder, superfine sand, artificial sand, cement mortar, mechanical properties*

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1. Introduction

The application of basalt rock powder (BRP) and superfine sand (SS) in preparation of cement mortar remains a recent innovation in construction materials production industry. It is well known that the production of cement mortar requires enormous amount of cement and medium sand. However, essential mineral admixture resources for concrete and cement mortar production have been reported insufficient as construction demand has promptly increased in recent years. In addition, the rise of cement production and consumption in diverse construction projects has been blamed to be among anticipating causes to the environmental pollution and global drastic climate change. Hence, this study emphasizes on modifying the cement mortar mixture proportion by adding basalt rock powder as Portland cement partial replacement and superfine sand as artificial sand partial replacement.

Even though basalt rock powder and superfine sand appeal to offer a limited range of applications in construction, they can anticipate in promotion cementitious composites sustainability development. Countless studies have discussed the significance of basalt rock powder, superfine sand and other recently discovered mineral admixtures on the development and improvement of physical, chemical and mechanical properties of cement mortar and concrete. Yet, the shortage in findings related to the implementation of basalt rock powder and superfine sand in civil engineering materials production remains significant. The inclusion of basalt rock powder and superfine sand in cement mortar preparation as partial replacements of Portland cement and fine aggregate respectively, is considered to be an effective approach to diminish environmental concerns that initiated by their abundant unexploited disposals in the environment. Moreover, this strategy would as well reduce the magnitude of carbon dioxide emissions in the atmosphere generated by the cement manufacturing industry.

According to (Dobiszewska and Beycioğlu, 2017; Singh et al., 2017) primary motives for the increasing consumption of Portland cement include industrial revolution, recent technology development, rapid population growth and increase of living standards. The technological process of clinkerization which is common in modern cement production is responsible for a great consumption of energy and the emission of carbon dioxide to the environment. It has been reported that around 0.7-1 tonne of CO_2 is released for every tonne of cement production (Carvalho et al., 2018). Moreover, the production of a tonne of cement requires 60-130 kg of fuel oil or its equivalent and about 105 kWh of electricity depending on the cement type and production process (Tchamdjou et al., 2017).

The topic related to sustainability and durability of cementitious structures has attracted the scientific community. Many researchers and academicians have turned their efforts towards encouraging usage of construction wastes and industrial by-products as additives or substitute for cement and fine aggregate in concrete mixtures (Liu et al., 2013; Mehdipour and Kamal, 2018; Khandaker, 2003; Kannan et al., 2017). In fact, several discovered alternative mineral admixtures have a great importance in improvement of the mechanical behavior of cementitious composites and reduction of environmental pollution. In addition, the mortars made by including alternative mineral admixtures illustrate benefits such as low cost, diminution of permeability, improvement of strength or other properties of cement mortar and concrete. (Naceri and Makhloufi, 2009; Uysal and Yilmaz, 2011; Liu et al., 2013; Topcu et al., 2009; Shyam et al., 2017). Eventually, (Hafsa and Mishra, 2016) considered basalt rock powder as a relevant partial replacement of Portland cement thanks to exceptional structural properties that basalt rock presents.

According to (Pu et al., 1999) in southwest China precisely Chongqing the exploitation of superfine sand started as early as in the 1950's. (Lian and Chen, 1996; Wu and Lian, 1999) stated that the scarcity in raw materials resulted from decades of excessive excavation for the search for resources of coarse aggregates and medial sand. Therefore, (Zhao, 2013) reported that China is amongst countries that have been greatly affected by shortage in natural fine aggregate supply. For instance, in areas like Chongqing, Henan, Sichuan, Shandong and other places coarse and medium aggregates resources are rarely found but SS supply is available in abundance. SS unlike BRP has been used for construction purposes for many years. Traditionally, SS is used as plastering mortar component and it is also involved in brick and block works. The shortage in fine sand supply suitable for cement mortar and concrete production has pushed researchers to establish innovative solutions. (He et al., 2012) attempted to use SS in the mixture proportion as medium sand replacement and the findings illustrated that the modified cement mortar exhibited inferior mechanical performance. According to (Tu et al., 2012) in superfine sand concrete the increase of sand ratio implicates decrease of slumps and strength. Hence, SS has great effect on the concrete workability, especially on the concrete fluidity. Moreover, SS concrete illustrates a good frost resistance and impermeability.

When basalt rock powder is added into cement mortar to replace a portion of Portland cement, such addition illustrated a significant influence on the cement mortar's mechanical properties as it improves the flexural and compressive strengths of the produced cement mortar. Previous research works with regard to implementation of BRP in cement mortar or concrete preparation insisted that it improves rheological properties and workability of the cement mortar. It also accelerates the development of early age strength of mortars and the presence of BRP into cement paste decreases the yield stress and viscosity (Kmecová et al. 2014; Schankoski et al., 2017). Moreover, basalt waste added into the cement mortar mixture proportion enhances the resulted mortar's compressive strength. And also when basalt waste is used as a replacement of clinker in production of cement, it was reported that it reduces the CO_2 emission. In addition, hydration products observed on surface of BRP particles show the nucleation effect of mineral mixtures (Mendes et al., 2016). The superfine sand due to its small fineness modulus, large surface area and porosity, it increases cement, water, moisture and slurry content of concrete.

This study opts to investigate modifications occurred in mechanical performance of the cement mortar due to incorporation of basalt rock powder and superfine sand into the mixture proportions. The reference cement mortar consisted of Portland cement, water and artificial sand. However, the evaluated cement mortar included Portland cement, artificial sand, basalt rock powder, superfine sand and water. The basalt rock powder has been added in proportion of 10%, 15%, 20%, 25% and 30% by Portland cement weight and superfine sand 10%, 20%, 30%, 40% and 50% of artificial sand weight. To evaluate the effect of BRP and SS on the mechanical performance of the cement mortar, several mixture proportions were designed and assessed through experimental procedure. Then, based on the strength indexes such as flexural strength, compressive strength, ultrasonic pulse velocity and dynamic elastic modulus, the replacement ratios of BRP and SS that exhibited nearly similar results as those of the reference cement mortar were selected.

2. Experimental study

2.1 Raw materials

Cement: Qilian Mountains brand Portland cement with strength grade 42.5 was supplied by Gansu Cement Factory Ltd. Accord-ing to the cement manufacturer, it had a Blaine fineness of 348 m^2/kg.

Table 2.1 Portland cement performance index

Stability	Specific surface area m^2/kg	Condensation time (min)		Flexural strength (MPa)		Comprehensive strength (MPa)	
		Initial setting	Final setting	3d	28d	3d	28d
Qualified	348	145	220	5.5	7.6	21.6	48.7

Table 2.2 Chemical composition of Portland cement

Portland cement components	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	SO_3	Loss on ignition
Specification value %	-	-	-	-	≤ 5.0	≤ 3.5	≤ 3.0
Measured value %	30.54	3.78	4.16	54.25	1.43	2.83	1.67

Superfine sand: The superfine sand used in the experiment, was collected from yellow river beds in Lanzhou. We purchased the superfine sand from a local sand supplier company. The fineness modulus ranges from 0.6 to 1.18.

Table 2.3 Sieve analysis of superfine sand

Sieve size (mm)	Mass percentage of retained (%)	Cumulative mass percentage of retained (%)
4.75	-	-
2.36	-	-
1.18	0.37	0.37
0.6	15.04	15.41
0.3	28.9	44.31
0.15	37.6	81.91
< 0.15	18.05	99.96

Basalt rock powder was produced from local natural basalt rocks in accordance to the Chinese National Standards. It was also like superfine sand purchased from a local sand supplier company. No preliminary tests were effectuated before its use.

Table 2.4 Basalt rock powder chemical components

Component	C	O	Al	Si	K	Ca	Fe
Mass ratio	29.07	42.89	4.82	10.97	0.72	4.24	3.68

Artificial sand: The artificial sand was obtained after crushing local natural rocks. The synthetic sand used in cement mortar mixture had 2.36 mm maximum aggregate size, was produced in Lanzhou, Gansu province.

Like previously described on superfine sand, we used divers sieve sizes to determine its fineness modulus before using it in preparation of the cement mortar mixture.

Table 2.5 Sieve analysis of artificial sand

Sieve size (mm)	Mass percentage of retained (%)	Cumulative mass percentage of retained (%)
4.75	-	-
2.36	10	10
1.18	20	30
0.6	24	54
0.3	38	92
0.15	6	98

Table 2.6 Artificial sand performance index

Mud content	Apparent density	Bulk density	Void ratio	Fineness modulus
%	kg/m^3	kg/m^3	%	
3	2620	1520	42	2.8

2.2 Mixture proportions

Table 2.7 Cement mortar mixture constituents

Cement mortar blocks	Cement (kg/m^3)	Basalt rock powder(kg/m^3)	Artificial sand (kg/m^3)	Water (kg/m^3)	Substitution (%)
C0	450	0	1350	225	0
C1	405	45	1350	225	10
C2	382.5	67.5	1350	225	15
C3	360	90	1350	225	20
C4	337.5	112.5	1350	225	25
C5	315	135	1350	225	30

Table 2.8 Cement mortar mixture proportions

Cement mortar blocks	Cement (kg/m^3)	Artificial Sand (kg/m^3)	Superfine Sand (kg/m^3)	Water (kg/m^3)	Substitution (%)
H0	450	1350	0	225	0
H1	450	1215	135	225	10
H2	450	1080	270	225	20
H3	450	945	405	225	30
H4	450	810	540	225	40
H5	450	675	675	225	50

Figure 2.1. Portland cement

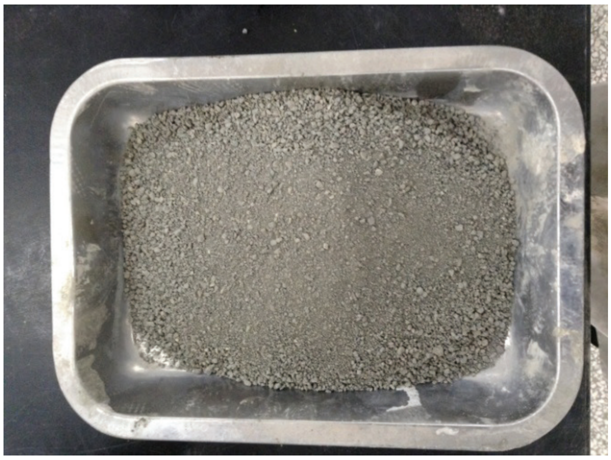

Figure 2.2. Artificial sand

Figure 2.3. Basalt rock powder

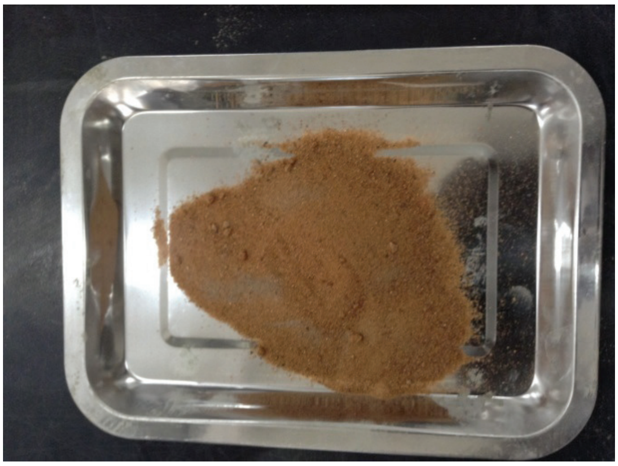

Figure 2.4. Superfine sand

2.3 Experimental program

According to "Cement mortar strength test method (ISO method)" GB/T17671-1999, 40 mm × 40 mm × 160 mm prism cement mortar test blocks were prepared. The experimental procedure proceeded with accurately weighting the amount of material required to prepare the test block according to the designed mixing ratio and then use the universal cement mixer to stir the materials used. During mixing, water was added cautiously. At first the water is put into the stirring pot, after the Portland cement was added, start stirring, then stir at low speed for 30s, and at the same time start the second 30s, and evenly the fine aggregate was added. Immediately after the mixture was obtained, it was molded on a vibrating table and the mortar was placed in two layers into the test mold during vibration molding.

The test samples were cured in moisture for 24 hours and under the specified curing conditions after demolding. After the samples reached the required testing age, tests were carried out. The evaluation involved non-destructive testing methods to measure the mass, ultrasonic pulse velocity and dynamic elastic modulus, besides the measurements were resumed after 120 days. Moreover, the flexural strength test was carried out, and after each fracture, the compressive strength test proceeded. During the entire loading process, the pressure receiving surface was the two sides of the test sample, and the area is 40 mm×40 mm. The range of 2400 N/s ± 200 N/s is evenly loaded until destruction. The ages for determining the flexural strength and compressive strength were 3, 7, 14, 21, 28, 56, 90 and 120 days, respectively.

3. Results and discussions

3.1 Partial replacement of Portland cement with basalt rock powder

3.1.1 Compressive strength

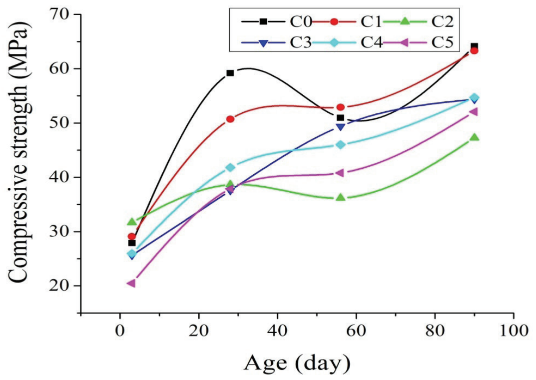

Figure 3.1 Rate curves of compressive strength of cement mortar samples at different testing ages

As shown in Figure 3.1, the effect of using BRP on physical and mechanical characteristics of cement mortar was evaluated. The graph shows that BRP decreased the compressive strength of cement mortar. In early ages, cement mortar with 30% replacement of Portland cement with basalt rock powder illustrated the lowest compressive strength. However, cement mortar containing 15% Portland cement substitution with basalt rock powder indicated the highest compressive strength. Therefore, in the period from 28d to 56d compressive strength significantly increased. The overall trend indicates that at the age of 90 days the best compressive strength results were spotted on the reference cement mortar and the mortar mixture with 10% replacement of Portland cement with basalt rock powder proceeded. Also, it is evident that the cement mortar with 15% substitution of Portland cement with basalt rock powder indicated considerably the lowest compressive strength. Briefly, incorporation of BRP into the cement mortar reduced its strength ability but it is noteworthy to report that the best results amongst modified mixtures was spotted on the cement mortar that contains 10% replacement of Portland cement with basalt rock powder. Its compressive strength diminution was estimated about 1.3% compared to that of reference mortar.

3.1.2 Flexural strength

As indicated in Figure 3.2, the flexural strength changes spotted in cement mortar were graphically presented. The overall results show that flexural strength decreased. Flexural strength tests were carried out at 3d and 28d after the cement mortar samples were prepared. In early ages, only cement mortar that contains 30% substitution of Portland cement with basalt rock powder illustrated the lowest increase rate in flexural strength compared to mortar mixtures. As the age increased, the trend as well changed. Besides, flexural strength sharply inclined for all evaluated mixtures including the reference cement mortar. The overall trend demonstrates that as the age increases, the flexural strength also increases. Moreover, the cement mortar with less amount of BRP illustrated relatively higher flexural strength than those cement mortar mixtures that have more quantity of BRP.

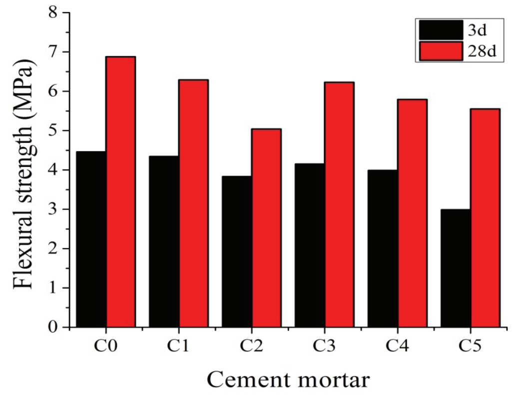

Figure 3.2 Rate curves of flexural strength of cement mortar samples at 3 and 28 days

3.1.3 Dynamic elastic modulus

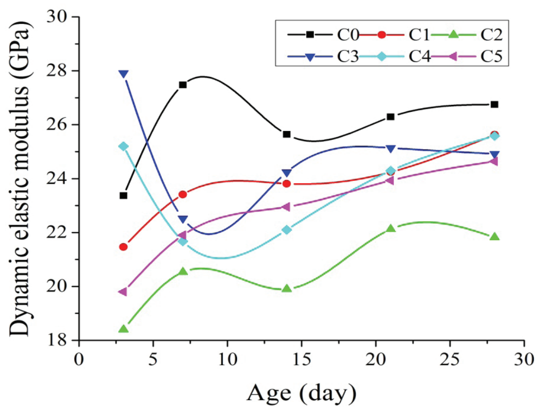

Figure 3.3 Rates curves demonstrate the variation of dynamic elastic modulus of cement mortar samples at different ages

The Figure 3.3 plots the results of the dynamic elastic modulus of cement mortar in interval between 3d and 28d. The graph shows that basalt rock powder affected the elasticity of cement mortar. For instance: at the age 3d, the cement mortar that contains 20% replacement of Portland cement with BRP showed comparably higher value than other mortar mixtures with more than 16% increase over the reference mortar. Whereas the cement mortar that contains 15% replacement Portland cement with BRP demonstrated the lowest value. Moreover, at age of 7d, dynamic elastic modulus sharp increase was spotted on the reference mortar, cement mortar containing 10%, 15% and 30% amount of BRP. Therefore, controversial results were noted on the cement mortar mixtures that contain 20% and 25% BRP. The period between 7d and 14d was marked by incline of dynamic elastic modulus except for reference cement mortar and the cement mortar with 15% BRP which was gradually declining. In the interval from 14d to 21d, the graph indicates a slight growth of dynamic elastic modulus for all mortar mixtures. Finally, at the age of 28d, reference mortar exhibited the highest dynamic elastic modulus. Therefore, mortar mixtures that contain BRP illustrated lower elasticity but it is essential to note that the cement mortar that contains 10% and 25% indicated the best results amongst the modified mixtures with decrease rate roughly 4.2% and 4.4% respectively compared to the reference cement mortar.

3.1.4 Mass

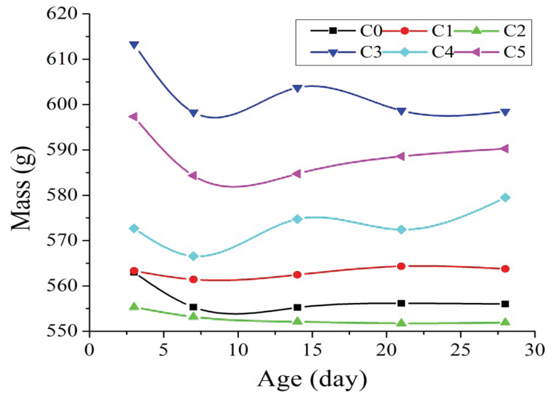

Figure 3.4 Rates curves illustrate the mass variation of cement mortars at different ages

As shown in Figure 3.4, the mass changes of cement mortar were graphically evaluated. Overall results show that addition of BRP changed the weight of cement mortar. At the age of 3d, cement mortar with 15% replacement of Portland cement with BRP weighted lower than other considered mixtures. On the contrary, the cement mortar 20% substitution of Portland cement with basalt rock powder was reported to be the heaviest amongst tested mixtures. The period between 3d and 7d was marked by a slight decline of mortar mixtures weight. Cement mortar mixtures with BRP content indicated dramatic rise of weight except for cement mortar that contains 15% BRP. Therefore, at the age of 28d, the heaviest mortar mixture was the cement mortar that contains 20% BRP with more than 7% increase rate. The lowest weight value was spotted on the cement mortar that contains 15% BRP with roughly 0.6% incline rate compared to the reference cement mortar. Briefly, the incorporation of BRP into the cement mortar sharply increases its weight.

3.1.5 Ultrasonic pulse velocity in longitudinal direction

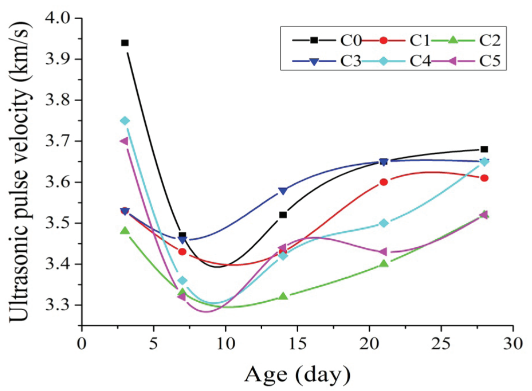

Figure 3.5 The variation of ultrasonic pulse velocity of cement mortars in longitudinal orientation at different testing ages

The Figure 3.5 indicates the evaluation of ultrasonic pulse velocity taken in longitudinal direction of the cement mortar. The incorporation of basalt rock powder into cement mortar reduced its ultrasonic pulse velocity. Overall trend shows that the reference cement mortar showed higher ultrasonic pulse velocity compared to other considered mixtures. For instance, at the age of 3d cement mortar with 15% and 25% basalt rock powder illustrated a decrease estimated about 11.6% and 4.7% respectively. Besides, at the age of 28d, the results noted that the decrease rate on those previously cited mortar mixtures became roughly 10.6% and 7.4 % respectively. Briefly, basalt rock powder decreased longitudinal ultrasonic pulse velocity.

3.1.6 Ultrasonic pulse velocity in transverse direction

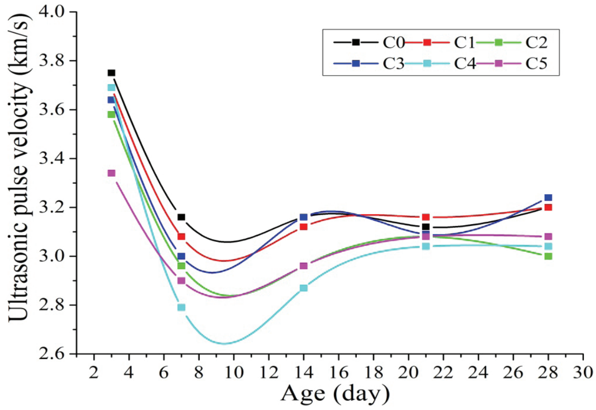

Figure 3.6 The variation of ultrasonic pulse velocity of cement mortars in transverse orientation at different testing ages

The Figure 3.6 illustrates results of ultrasonic pulse velocity taken in transverse direction of the cement mortar. Like it was noted when ultrasonic pulse velocity was taken in longitudinal direction, the graph shows that basalt rock powder decreases ultrasonic pulse velocity of the cement mortar. The best results of ultrasonic pulse velocity were spotted at the age of 3d. Therefore, the reference mortar presented higher ultrasonic pulse velocity compared to modified mixtures. For instance: at the age of 3d, the cement mortar with 25% and 30% indicated a decrease rate of estimated about 6.3% and 15.2% also, the results taken the age of 28d on previously tested mortar mixtures illustrated that diminution of ultrasonic pulse velocity was approximately 22.8% and 21.8%.

3.2 Partial replacement of artificial sand with superfine sand

3.2.1 Flexural strength

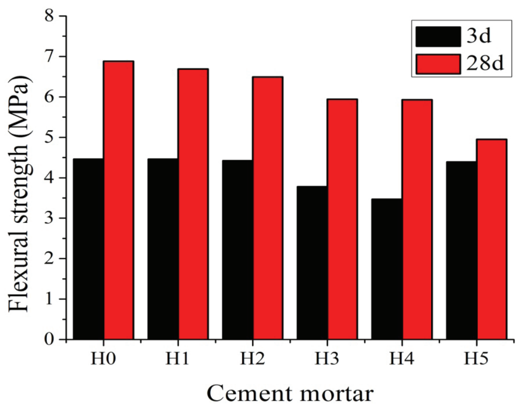

Figure 3.7 The variation of flexural strength of cement mortar at varying age

As demonstrated in the Figure 3.7, the flexural strength of cement mortar increases with increase of curing time. From the graph, it is evident that addition of superfine sand (SS) into artificial sand (AS) cement based mortar decrease the flexural strength of cement mortar. At the age of 3d, the reference cement mortar indicated the highest flexural strength in comparison to the modified cement mortar mixtures. At the same time, the lowest flexural strength was spotted on cement mortar that contains 40% replacement of AS with SS. Moreover, the flexural strength trend kept gradually increasing and at 28d the noted results showed a sharp increase of flexural strength amongst tested mixtures. The highest flexural strength was spotted on the reference mortar. However, amongst modified mixtures, the remarkable flexural strength was noted on cement mortar than contained lower amount of SS 10% replacement of AS with a drop of nearly 3% compared to reference mortar.

3.2.2 Compressive strength

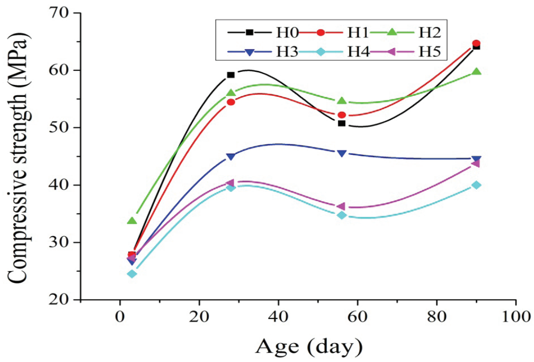

Figure 3.8 The variation of compressive strength of cement mortar at varying age

As shown on Figure 3.8, the compressive strength values of cement mortar were analyzed. The overall results indicated a sharp increase in the period of initial 28d, however between the interval of 28d to 56d the compressive strength dropped generally in tested mixtures, then the trend changed to increasing rate until 90d. At the age of 28d, cement mortar mixtures achieved more than 50% of strength that they exhibited at the age of 90d. For instance: the growth rate of reference cement mortar compressive strength in the period between 28d and 90d was roughly 8%. Moreover, amongst modified mixtures, the cement mortar containing 10% AS replacement with SS exhibited an increase rate in terms of flexural strength estimated nearly 16%. The cement mortar that contained 40% artificial sand substitution with SS indicated the lowest comparable compressive strength decrease of approximately 40% in comparison with reference cement mortar. Broadly, the incorporation of a high quantity of SS as partial replacement of AS significantly decreases compressive strength of cement mortar. But, as the graph indicates, high compressive strength of cement mortar could be achieved if less than 10% AS is replaced with SS.

3.2.3 Mass

As illustrated in Figure 3.9, the mass of the cement mortar was evaluated at different ages. The analysis of the results shows from the age of 3d to 7d the mass of all weighed samples considerably decreased. Eventually, the cement mortar mixtures containing SS exhibited higher mass compared to the reference cement mortar. In addition, the graph shows that the mass of cement mortar decreases with increase of curing time. For instance, the decrease rate of mass of the mixture in the period between 3d and 28d was roughly: 1.1% for the reference mortar and 0.4% for the cement mortar that contains 10% artificial sand replacement with superfine sand. Briefly, the presence of superfine sand as partial replacement of artificial sand notably increased the mass of the cement mortar. Thus, any amount of superfine sand incorporated into the mixture proportion as partial replacement of artificial sand can change its mass. Therefore, the smallest increase amongst modified mixtures was spotted on the cement mortar that contains 50% replacement of artificial sand with superfine sand.

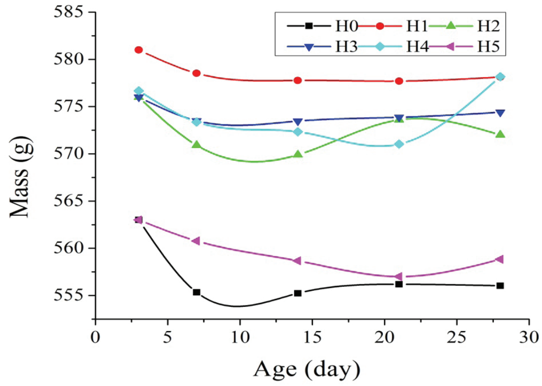

Figure 3.9 The variation of cement mortar mass at varying age

3.2.4 Ultrasonic pulse velocity in longitudinal direction

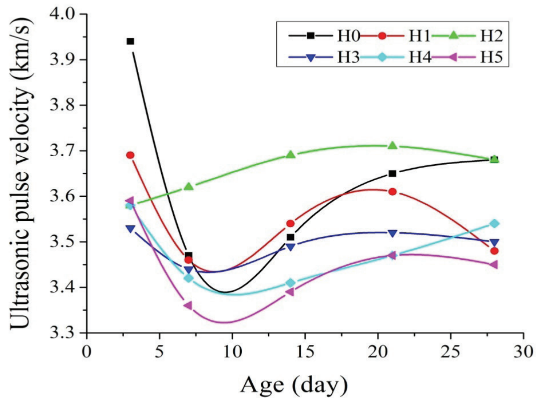

Figure 3.10 The alteration of ultrasonic pulse velocity in longitudinal orientation at varying age

The Figure 3.10 illustrates the evaluation of ultrasonic pulse velocity taken in longitudinal direction. The results show a reduction of velocity as the age increases. At the age of 3d, reference mortar showed the best velocity on the contrary, the cement mortar that contains 30% substitution of AS with SS demonstrated the lowest velocity. Moreover, the measurements taken at the age of 28d indicated that ultrasonic pulse velocity dropped compared to the results obtained on 3d. The highest ultrasonic pulse velocity was noted on the reference mortar and cement mortar that contains 20% replacement of AS with SS. However, the lowest ultrasonic pulse velocity was spotted on cement mortar with 50% replacement of AS with SS. Eventually, based on given results it is evident that SS considerably could reduce ultrasonic pulse velocity in the cement mortar mixture.

3.2.5 Ultrasonic pulse velocity in transverse direction

The Figure 3.11 shows analysis of ultrasonic pulse velocity in transverse direction. It gives a detailed description of ultrasonic pulse velocity changes occurred in the cement mortar over a period of 28d. As it was spotted in the assessment of ultrasonic pulse velocity in longitudinal direction, the highest velocity was reported at the age of 3d. Also, in interval between 3d and 7d velocity decreased. Then, it slightly increased. At the age of 3d, the reference cement mortar indicated the highest ultrasonic pulse velocity but amongst modified mixtures, the cement mortar that contains 10% replacement of AS with SS showed the best results. Therefore, the lowest velocity value was noted on cement mortar that contains 30% AS replacement with SS. Besides, at the age of 28d, the reference cement mortar and cement mortar that contains 20% AS replacement with SS indicated the best results. Meanwhile, the lowest results were measured on the cement mortar with 30% replacement of AS with SS. Broadly, at 28d, 20% replacement of AS with SS indicated the same result as that of reference cement mortar but other tested mixtures illustrated comparably lower values. Thus, the incorporation of SS into the cement mortar could reduce its ultrasonic pulse velocity.

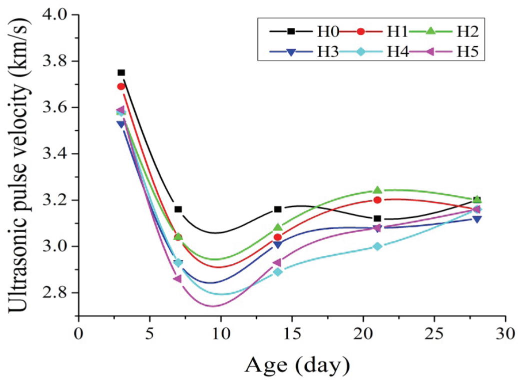

Figure 3.11 The alteration of ultrasonic pulse velocity in transverse orientation at varying age

3.2.6 Dynamic elastic modulus

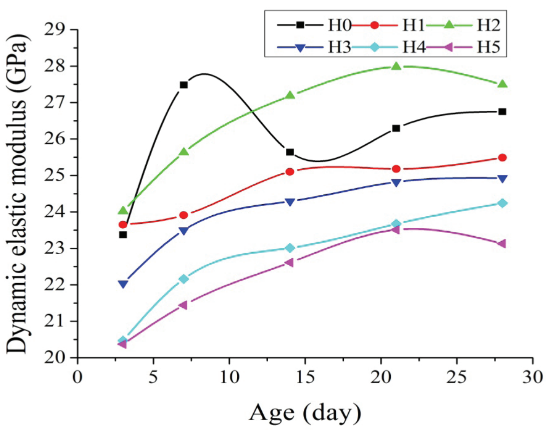

Figure 3.12 The variation of dynamic elastic modulus of cement mortar

As shown in Figure 3.12, the dynamic elastic modulus of the cement mortar was evaluated in the period between 3d and 28d. The reference cement mortar was compared with modified mixtures. The obtained results showed that dynamic elastic modulus of cement mortar increased. At the age of 3d, the cement mortar containing 20% replacement of AS with SS showed the highest dynamic elastic modulus with approximately 3% increase over the reference cement mortar. Besides, at the age of 28d, the cement mortar with 20% replacement of AS with SS remained the highest on account of dynamic elastic modulus value. Then, the reference cement mortar proceeded. To sum up, the superfine sand addition into cement mortar mixture could diminish its dynamic elastic modulus however, 20% replacement of artificial sand with superfine sand increases dynamic elastic modulus of cement mortar.

4. Conclusions

After testing formulated cement mortar samples, the following conclusions can be drawn:

1) Basalt rock powder significantly decreased the flexural strength and dynamic elastic modulus; therefore, the compressive strength and ultrasonic pulse velocity remained comparable. Besides, the weight remarkably increased. Thus, the basalt rock powder quantity ranging between 10 to 25% is considered as the appropriate partial replacement of Portland cement in cement mortar.

2) Superfine sand improved the dynamic elastic modulus and compressive strength of the cement mortar. Simultaneously, the cement mortar exhibited controversial results as the spotted values of ultrasonic pulse velocity and flexural strength at 3d were comparatively lower than those obtained from the reference mortar. But, as the age increased, at 28d SS cement mortar attained almost the same values as those of the reference mortar. Also, the weight significantly increased. The amount of superfine sand ranging from 10% to 20% opted to be the suitable partial replacement of artificial sand in preparation of cement mortar.

To sum up, in order to approve the impact of adding into the cement mortar basalt rock powder as partial replacement of Portland cement and superfine sand as partial substitution of artificial sand, the mechanical performance of formulated cement mortar was investigated through a range of strength assessment experiments. Hence, the suitable replacement of Portland cement with basalt rock powder was from 10% to 25% while on contrary the appropriate replacement for artificial sand with superfine sand ranged from 10% to 20%. Moreover, the findings confirmed that under appropriate circumstances basalt rock powder and superfine sand can be used in cement mortar preparation as partial replacements for Portland cement and artificial sand respectively to achieve profitable use of basalt rock powder and superfine sand deposit in the environment and to promote protection and conservation of natural resources.

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