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Durability of mortar containing basalt and hashma wastes dust from stones industry

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Abstract: The durability of the hardened OPC mortar made with hashma powder and basalt is examined in this study. Different proportions of hashma powder and basalt powder were added to partially replace the fine aggregate and cement, respectively. Strength and durability tests on samples of varying ages were used to assess the impact of hashma and basalt replacement on the behavior of hardened mortar. The experimental work was carried out to assess the impact of variation of basalt and hashma by replacement on different ages of mortar samples; compressive strength, sorptivity, strength as well as sulfate and acid resistance were investigated. The study found that replacing varying percentages of basalt and hashma with cement and sand resulted in a significant improvement in the mortar aspects mentioned above. The compressive strengths of samples containing (5% and_10%) basalt powder as cement samples were found higher than the control mix B0(without waste powders), while the samples containing hashma as sand achieved a higher level than mixes containing basalt as cement. In addition, the best mix among all groups mixture containing 5%BS and 30% HM (mix B5H30) improved compressive strength reached 47% higher than the control mix (without waste powders).And the loss relative residual compressive strength percentage after immersion in magnesium sulfate and nitric acids solution (180 days) was found to be 30.8% and 46.8% lower than the control mix (without waste powders) by incorporating 5%BS as cement with 30% HM as sand (mix B5H30) respectively.

Keywords: Sorptivity, waste basalt, waste hashma, dust stones, mortar.

1. Introduction

Concrete, as the most widely used construction material, is essential in the building process,(1).The excessive use of cement contributes significantly to a lot of carbon emissions on environmental (2). On the other hand, Thousands of tons of waste from the processing, grinding and polishing (basalt, hashma, granite and marble) industries are being released in Egypt. Shaqa Althueban in east Cairo is the site of a large concentration of basalt, hashma, granite and marble process companies, which are accountable for the annual disposal of hundreds of tons of waste into the environment. This kind of fine material storage presents significant environmental challenges. This fine material can be emitted into the surrounding atmosphere. The handling and disposal of dust is a severe environmental problem since it is detrimental to environment: it contributes to a great extent to the accumulation and harmful dispersion in air, water and soil of fine solid particles [3]. Many researchers have studied the applicability of waste mineral powder in mortar and concrete production. The addition of marble dust [4, 5], basalt powder [6-11], limestone powder [10-13] or granite powder [13, 14] or positively affects the strength of cement mortar and concrete as well as durability of concrete.

Rock dusts, often referred to as stone powders, are used in concrete and cement mortar primarily as inert additives i.e. fillers. Their positive effect on some properties of cement mortar and concrete is mainly related to the filler effect. The influence of stone dust on mechanical parameters of cement composites depends mainly on the stone dust replacement and the specific surface area of the additive. A partial replacement of cement for stone dust generally results in deterioration of mortar and concrete strength parameters, which are obviously related to lower, cement content [15]. However, some authors have observed that a slight dust share in cement mass, i.e. up to about 5–10%, causes the increase of material strength, when comparing it with the strength without dust additives. Lawrence et al. [16] have noted that the strength of cement mortar increases when the specific surface area of stone dust increases, Knop et al. [17].

The addition of basalt powder to a cement paste does not affect a water demand to obtain a normal consistency. Both, basalt and cement particles have similar finesses so replacement of cement by basalt powder does not make a significant impact on specific surface area of the grains. It is a main reason that normal consistency has not changed with the increase of the basalt powder content. Replacement of cement by basalt powder positively affects the mechanical properties of cement mortars i.e., flexural and compressive strength. The addition up to 8% of basalt powder leads to increase of both, flexural and compressive strength. Incorporation of waste basalt powder into cement mortar as a partial substitution of cement is environmentally friendly and economically feasible. It enables for the effective management of industrial waste and improves some properties of cementitious mortar [18].

Tennich, Kallel and Ben Ouezdou [19] were successful in replacing the sand with crushed rock dust and incorporation of marble waste helped in reducing pores. Hence, such concrete mixes had better compressive and split tensile strengths. And compared the mechanical properties concrete were made with marble waste as filler with those mixes were made without fillers, The authors pointed out mixes made with marble waste had comparable fluidic and hardened properties to that of control mixes. However, sulphate resistance of mixes with marble waste was significantly better than those mixes without any filler.

This investigation's primary goal is to evaluate the performance of mortar that has basalt dust powder partially substituted by cement and a partial substitute of hashma as sand and investigate the variation in harding properties before and after the aggressive attack (acid and sulfate attack).

2. Materials Used

2.1 Portland Cement (OPC) and Silica Fume (SF)

Standard Portland cement, CEM I-52.5N, which complies with EN 197/1, and silica fume which fulfills ASTM C1240-03a and IS:15388-2003 criteria with spherical particle sizes ranging from 0.1 µm to 1 µm and a specific surface area of 17,500 cm2/g can be used. The physical and chemical and properties of cement and silica fume are given in Table 1.

Table1. The physical and chemical characteristics of the fine materials used

Compound (%)	Cement	Silica fume	Basalt	Hashma
SiO_2	21.20	96.0	34.68	9.22
AL_2O_3	5.50	0.10	8.84	0
Fe_2O_3	3.20	1.0	30.07	8.13
CaO	63.4	0.20	12.58	75.22
MgO	0.70	0.15	5.82	3.20
SO_3	2.40	0.10	0.07	0.03
Na_2O	0.10	0.10	1.76	0.9
K_2O	0.50	0.20	1.19	0.13
CL^-	---	----	2.01	1.55
P_2O_5	---	---	0.60	0.23
loss on ignition	3.00	2.15	1.25	1.75
Color Powder	Gray	Light Gray	Dark gray	Gold yellow
Grain Size	90 µm	1 µm	43 µm	33 µm
Specific Gravity	3.15	2.17	2.5	2.08
Bulk Density (t/m3)	1.51	0.355	1.7	1.85

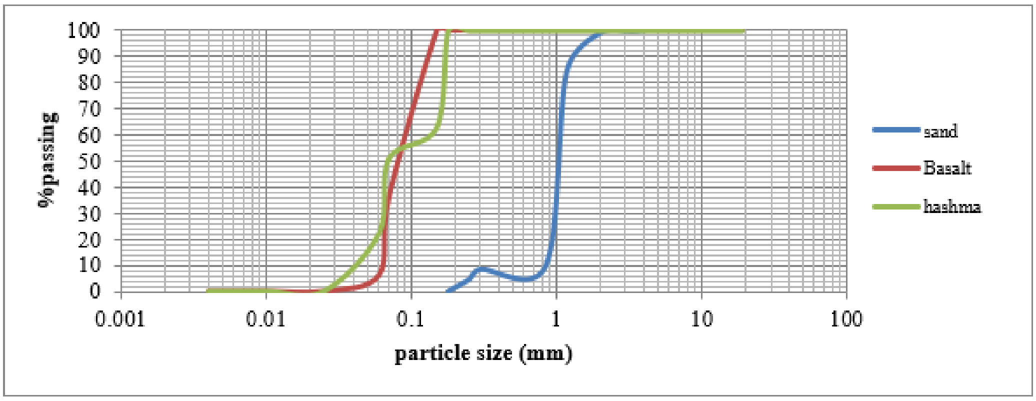


Figure 1: Sieve analysis of Sand and powders (Basalt and Hashma).

2.2 Aggregates

Natural sand that complies with ASTM C33 and ASTM C778-80 with a specific density of 2.60 and a fineness modulus of 2.75 Figure1 shows the sieve analysis sand and fine powders (basalt and hashma).

2.3 Recycled basalt and Hashma Dust Powders.

Basalt powder was used with BET 12,850 cm2/gm as a cement substitute. The used basalt powder has a specific gravity of 2.5. The XRD for the used basalt is shown in Figure 2. Which hashma powder and basalt powder pass through sieves No. 80–180 and No. 100–150, respectively.

2.4 Chemical Admixture

Self-compacted concrete (commercial name Sika Viscocrete 3425) was produced with the proper consistency by using a polycarboxylates superplasticizer with a density of 1080 kg/m3. Sulfate ions were obtained from magnesium sulfate ($MgSO_4$). 99.9% of the magnesium sulfate was pure. The 90% concentration of nitrate acid (HNO_3) solution was utilized as the source of attack acid. Every chemical was imported from El-Gomhoria Company located in Cairo. Chemically neutral water (PH=7) was used to mix and cure the mortar and hardened cement paste specimens.

3. Experimental Study

3.1 Mixture Proportion

Total mixes were divided into six groups (20 mixes) used to investigate by using waste material industrial basalt (BS) and hashma (HM) in mortar mix. The twenty mortar mixes were constantly used with 15 % silica fume (SF) as partial cement replacement and water binder 0.39 .Group 0 (G0) was a control mix without basalt and hashma powders. Four mixes were using varying amounts of basalt as partial cement substitute (5,10,15 and 20%) in group 1(G1).Group 2(G2) incorporated varying amounts of hashma as a partial sand substitute (10,20 and 30%).

In group 3 (G3) 5% basalt powder as a partial cement replacement with varying amounts of hashma as partial sand substitute (10,20 and 30%) was used. In group 4 (G4) we used10% basalt powder as a partial cement replacement with varying amounts of hashma as partial sand substitute (10,20 and 30%),In group 5(G5) we used15% basalt powder as partial cement replacement with varying amounts of hashma as partial sand substitute (10,20 and 30%).In Group 6(G60) we used20% basalt powder as a partial cement replacement with varying amounts of hashma as partial sand substitute (10,20 and 30%) all mixes as shown in table 2.

3.2 Method of specimen preparation &Testing

Mixing procedures of all cement paste mixes were carried out manually. The cement was mixed with the various cement replacement materials. Mixing was based on weighting and mixing bowling for about 5 min until complete homogeneity was achieved. The mixing procedure of mortar mix used throughout this investigation was implemented by ASTM C305-82. For the mortar specimens, 50x50x50 mm cubes were prepared according to the method described in ASTM C109-99. Curing of mortar was carried out according to BS 1881: part 111: 1983. The specimens were covered with plastic sheets for a full day after casting in order to prepare them for de-molding. At normal curing temperature, all specimens were contained in water for 28 and 90 days, respectively. Mixtures were kept in sulfate and acidic media for 90 days and in for 180 days. Lastly, measurements were obtained of the fresh, hardened, and durable properties of the mixes, as seen in Figure 3(a,b).

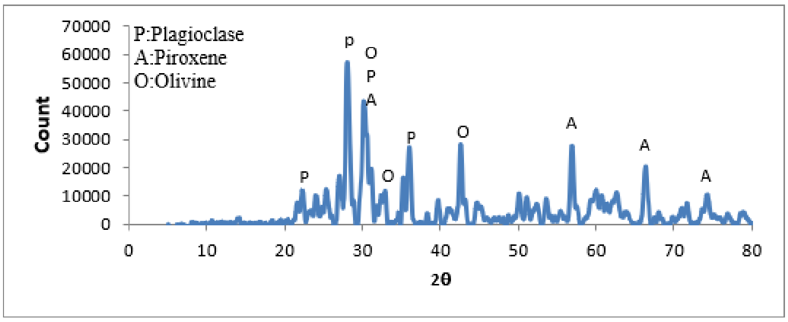


Figure 2: Basalt powder XRD diffraction patterns.

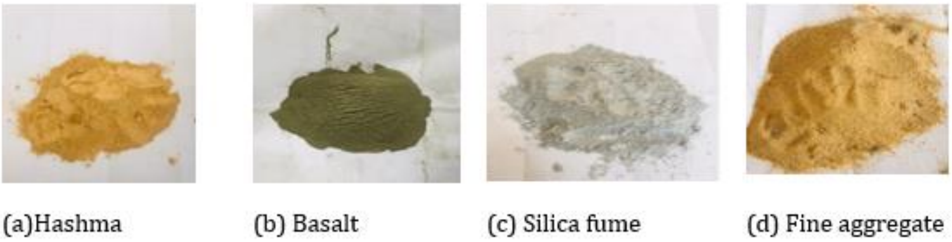


Figure3: Images of materials used in an experimental program

Table 2. Concrete mixture properties (in kg/m3).

	Mix	Cement	Basalt	Silica fume	Hashma	Sand	Water	superplastizier
G0	B0	467.5	0	82.5	0	1237.5	302.5	12.65
G1	B5	440	27.5	82.5	0	1237.5	302.5	12.65
	B10	412.5	55	82.5	0	1237.5	302.5	12.65
	B15	385	82.5	82.5	0	1237.5	302.5	12.65
	B20	357.5	110	82.5	0	1237.5	302.5	12.65
G2	B0H10	467.5	0	82.5	123.75	1113.75	302.5	12.65
	B0H20	467.5	0	82.5	247.5	990	302.5	12.65
	B0H30	467.5	0	82.5	371.25	866.25	302.5	12.65
G3	B5H10	440	27.5	82.5	123.75	1113.75	302.5	12.65
	B5H20	440	27.5	82.5	247.5	990	302.5	12.65
	B5H30	440	27.5	82.5	371.25	866.25	302.5	12.65
G4	B10H10	412.5	55	82.5	123.75	1113.75	302.5	12.65
	B10H20	412.5	55	82.5	247.5	990	302.5	12.65
	B10H30	412.5	55	82.5	371.25	866.25	302.5	12.65
G5	B15H10	385	82.5	82.5	123.75	1113.75	302.5	12.65
	B15H20	385	82.5	82.5	247.5	990	302.5	12.65
	B15H30	385	82.5	82.5	371.25	866.25	302.5	12.65
G6	B20H10	357.5	110	82.5	123.75	1113.75	302.5	12.65
	B20H20	357.5	110	82.5	247.5	990	302.5	12.65
	B20H30	357.5	110	82.5	371.25	866.25	302.5	12.65

Figure 3-a: specimen preparation &Testing

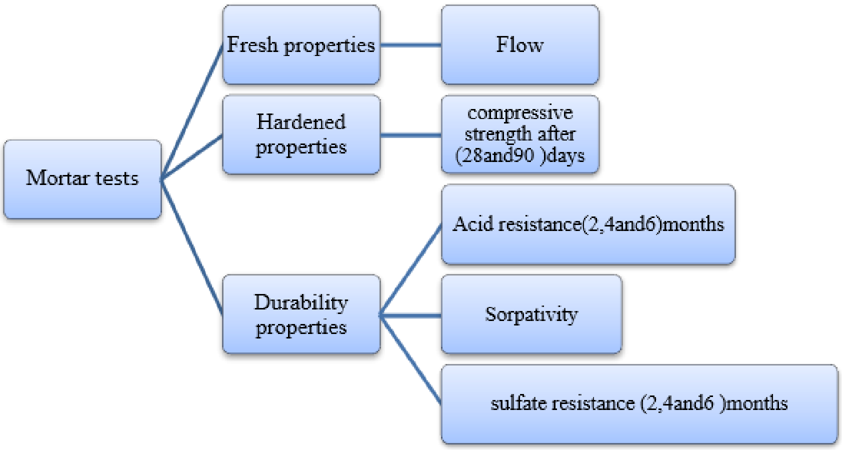


Figure 3-b: Show Fresh, hardened and durability properties.

3.2.1 Methods of ExperimentalTests

3.2.1.1 Flow Table Test

Concrete's workability was assessed using the flow table test. In this test, the fluidity or flowing characteristic of the concrete is used to determine how workable it is. A straightforward laboratory test is the flow test. Mortar flow table apparatus (MFTA) was proposed according ASTM C230-80.

3.2.1.2 Compressive strength

A compressive testing apparatus with a 2000 kN capacity was used to perform the compressive strength test. 50*50*50 mm test specimens were used to measure compressive strength. The test was run using standard curing conditions at 20°C in order to determine the compressive strength of mortar at two different ages: 28 and 90 days.

3.2.1.3 Durability Testing.

3.2.1.3.1 Water–Sorptivity Test

The purpose of this test was to measure the rate at which sorptivity permeates the concrete's surface. The samples were dried at 100°C in an oven until their weight remained constant. Weight pick-up tests using ASTM C1585-11 were used to measure the water take-up after they were placed on a support device at the bottom of the pan with a water level of 2 mm just above the top of the support device.

3.2.1.3.2 Sulfate & Acid Resistance

The water utilized for mortar needs to be transparent and free of impurities such as silt, clay, organic material, acid, chloride, sulfate, grease, industrial waste, and chemicals that could affect the durability of concrete [20, 21]. Both natural and waste watered materials contain sulfates. The density of water in lakes and brooks is typically less than 100 milligrams per liter. However, in underground water, sulfates can potentially reach a few grams per liter as a result of dissolving rocks. Whereas sulfates in high salinity waters revolve around magnesium, sodium, and potassium salts, they also evolve as gypsum in low salinity waters [21]. In order to determine the sulfate resistance of each group of samples, the compressive strength of the mortar was measured at three different ages—56, 120, and 180 days—after the samples had been preserved in a 10% $MgSO_4$ solution for 180 days.

Mineral acids that are extremely corrosive include nitric acid, or HNO_3. It's also known as spirit of niter or aqua fortis. Nitric acid is colorless when pure, but as it breaks down into nitrogen oxides and water over time, it can take on a yellow color. The concentration of the most widely available nitric acid in commercial marketing is 68% in water. Fumigating nitric acid is the term used when the concentration of HNO_3 is higher than 86%. Fumigating nitric acid can be further classified as white fuming nitric acid (above 86% & below 95% concentration) or red fuming nitric acid (above 86% concentration) based on the amount of nitrogen dioxide present. In the presence of water, nitric acid also generated as nitrate radicals.

$$\mathbf{3NO_2 + H_2O \Longrightarrow 2HNO_3 + NO} \qquad \mathbf{(22)}$$

Following a 90-day curing period, the specimens were removed out of the water and grouped into categories. The first group of specimens was retained in a 5% nitric acid solution, while the second group was in a 10% magnesium sulfate solution for two, four, and six months. After being submerged in the aggressive media, the specimens were removed and cleaned with distilled water to assess the hardened mixes' resistance to acid and sulfate. Three cubes were subjected to compressive strength testing, and the mean value was observed. Using the following relationship, the relative residual compressive strength (%) caused by acid and sulfate attack was assessed:

$$\text{Relative residual compressive strength (\%)} = \frac{(CS)AT}{(CS)A0}\times 100$$

Where:

$(C.S)_{A0}$: the compressive strength value measured (after 90 curing days in water) before immersion in the solutions (magnesium sulfate or nitric acid).

$(C.S)_{At}$: the compressive strength value determined after 56, 120, and 180 days of immersion in acid or sulfate. (23)

4. Findings and Discussion

4.1 Fresh Properties

The initial consistency of fresh mortar observed showed that the replacement of cement by BS in the cement has not improved consistency (flow diameter): whereas values of B5, B10, B15 and B20 (G1) decreased flow values 2, 3,5,6% respectively compared control mix, those results agreement Lawrence et al. [16].

Partial replacement of sand by hashma (B0H10, B0H20 and_B0H30) (G2) has led to decreasing in flow 8,10 and 12% respectively compared to reference mix(G0). Additionally; incorporation of 5% BS powder with varying hashma by substituted (10, 20 and 30%)_(G3) decreased followability by 9%,10%and12% for mix B5H10 ,B5H20, B5H30 respectively compared to control mix(G0). Also, In group four (G4) was observed reduction in flow was observed reaching reach 10%,11% and13% for mixes B10H10, B10H20, B10H30 respectively compared to control mix(G0), Group five (G5) and six (G6) also showed decreased in flow reaching 14%,16%,18%,16%,18% and 24%, B15H10, B15H20, B15H30, B20H10, B20H20 and B20H30 respectively compared to control mix (G0) as shown fig 4.

According to Li et al. [24], a lower fineness modulus, a poorer particle size gradation, and a higher specific surface area of fine powder all led to a decrease in mortar flowability. The above results showed that basalt powder which was finer than hashma powder, has led to an increase in the flow of mixes containing basalt powder compared to mixes containing hashma powder . Also poor particles size gradations in powders were affected by decreased flowability in all groups.

4.2 Hardened Properties

4.2.1 Compressive Strength

The compressive strength after 28 and 90 days, for the mortar mixture with basalt powder replacement by (5 and

10)% of cement recorded an improvement by 9 and 2%, the replacement cement by basalt of (15 and 20) % lead to decreasing compressive strength by 17 and 25 % compared to control mix(G0) respectively. Loss in strength was noted when basalt was more than 10% replacement, the cement paste was not enough for binding between mixes particles, see fig 5.

This might be related to the use of supplementary cementitious materials (SCM) as filler, which was thought to improve the cement paste's porosity and decrease permeability. Actually, filler materials are frequently added as strengthening and long-term property-enhancing additives. [25,26].

For mixes containing the replacement of sand by hashma (10,20and 30)% showed an increase by 11,19 and 33% respectively compared to control mix (B0).The mixture B5H30 recorded the highest strength among all mixes reaching 47% compared to control mix (B0).The possible reason for increasing strength was due to packing of hashma and basalt.

This explains an interesting phenomenon that, the filler effect of additional materials, which is especially noticeable for fine materials, increases the hydration rates of clinker and thereby provides additional surfaces for the nucleation of C-S-H, improving the mechanical properties of blended cements. (27).

That is why mortar mix B10H30 showed higher compressive strength. However, further replacement of Bs beyond 10% limit reduced the compressive because there was not enough cement paste available for binding, which decreased the strength. For mortar mixes 15 and 20 % cement replacement by basalt but, with addition of (10,20 and 30)% sand replacement by hashma , compressive strength improved. According to Im et al., these results concur.According to Im et al. (28, 29), the limestone filler increases strength in proportion to the cement amount and enables higher packing densities and mechanical performance.

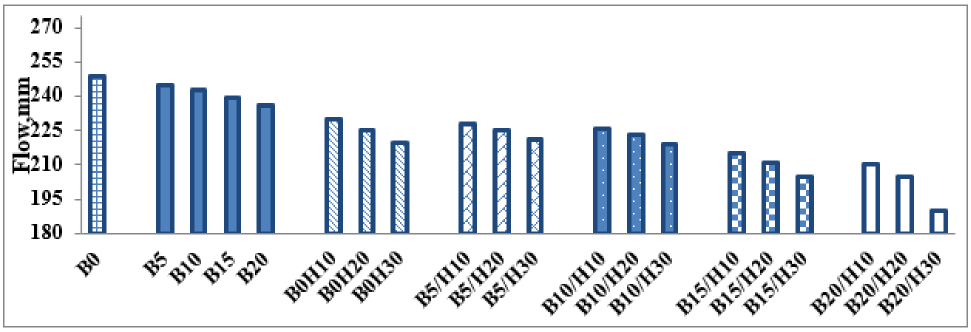


Figure 4 : show the followability of fresh mortar for all mixes.

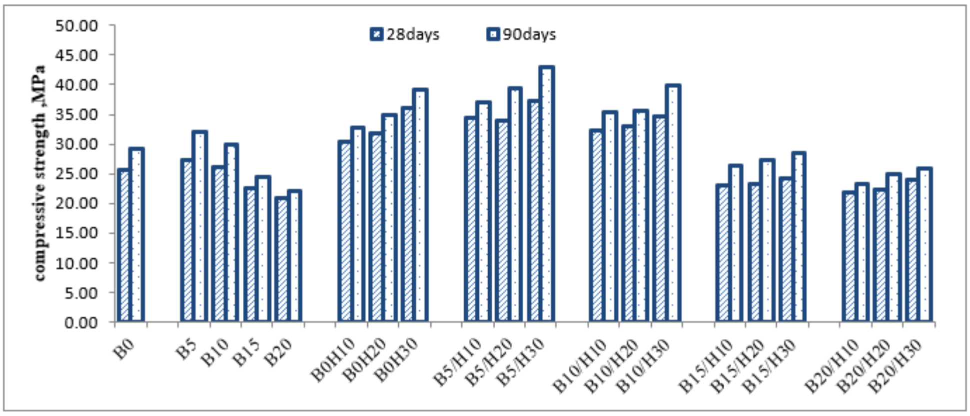


Figure 5: compressive strength for mortar after 28 and 90 days for all mixes in this study.

4.3 Durability properties

4.3.1 (Sorptivity)

Sorptivity is used to evaluate mortar cubes' long-term durability. A sample of mortar is partially immersed in distilled water in a bottle. Capillary action, which is mostly governed by the number and continuity of capillary pores, is the essential component that absorbs water inside the mortar cube samples. Because of this, the mortar cubes' mass grows and is tracked over time, making it possible to calculate the sorptivity. The sorptivity test results for each mixture are demonstrated in Figure 6 and range from 12.9 to 3.6*g*m

/cm2·sec−0.5 *10-4. In group one (G1)B5 mix had the lowest value of sorptivity which was 6.78gm /cm2·sec−0.5 *10-4 after 90 days which decreased by 27.9% compared to the control mix, Also mix B10 showed lower sorptivity than control mix which reached 22.9% after 90 days ,In contrast B15 and B20 showed higher sorptivity than control mix reaching 20.5%&47.6% after 90 days. In group2 mixes (B0H10,&B0H20,&_B0H30) recorded lower sorptivty compared to control mix reaching 14.9%,&26.54%_& 45.94% after 90 days respectively. Also, in group 3 mixes (B5H10,B5H20&B5H30)showed lower sorptivity than control mix by 41%, &41.9%,_&47.56% after 90 days respectively. In group four (G4) mixes (B10H10, B10H20, &B10H30) showed lower values of sorptivity compared to control mix which decreased by 30.3%, 33% &_38.3% after 90 days respectively. In group 5 mixes (B15H10, B15H20,_&B15H30) showed higher values of sorptivity after 90 days compared to control mix, reaching 17.8%, 16.9%,&7.1% respectively. Also, in group 6 mixes (B20H10, B20H20,)& B20H30) showed higher the values of sorptivity after 90 days compared to control mix, which increased by 39.2%, 33.9%,&30.3% respectively ,The sorptivity results were agreement with compressive strength result.

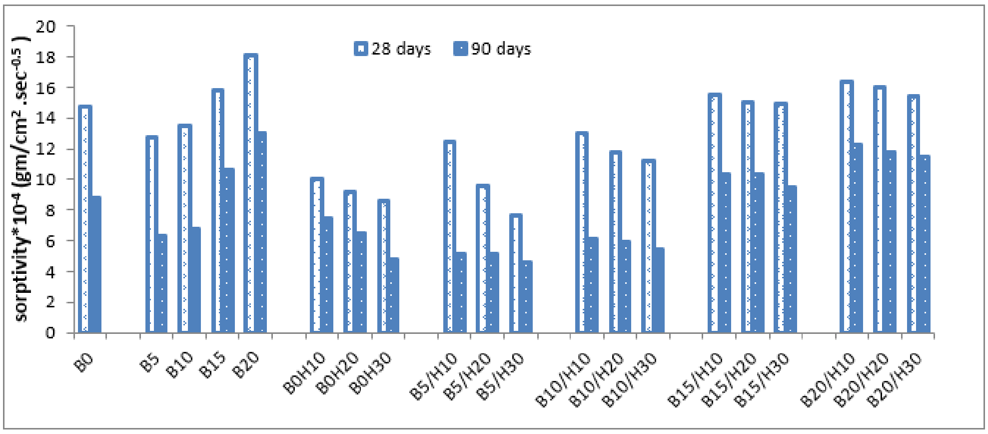


Figure 6 show sorptivity for mortar after 28 and 90 days

4.3.2 Sulfate resistance (strength loss)

Specimens of mortar cubes were submerged in 10% magnesium sulfate (MgSO4) solution for 2, 4, and 6 months following their 90-day underwater curing period (35). Fig. 7(a,b, and c) shows the relative retained compressive strength (%) results. The results presented in Figure (7-a) demonstrate that, after 2, 4, and 6 months of immersion, the specimens made of (OPC+15SF) (control mix G0) had strength percentage losses of 17.8, 29.5, and 41.3%, respectively, relative to their initial strength: the first observation for the relative residual strength for mixes containing basalt (5 %) in first group (G1) improved resistances sulfate immersion after2, 4 and 6 months by 17.2%,20.5%,33.3% compared to control specimen B0 for mixes with basalt 10% the relative residual strength decreased by 13.34%,24.9%and 35.2 respectively compared control mix B0 (OPC+15SF) . Obviously, mixes containing basalt (15% &20%) in first group (G1) showed deterioration in resistances to sulfate attack after (2,4and6 months) by 17.82%, 30.73%, 38.85% for mixes containing 15% basalt and decreased by17.93%,30.8%and 39.5 for mixes contain 20% basalt .compared control mix B0.Mixes in second group (G2) showed improvement after two, four and six months by (14.9%,27.86%,37.59% for B0H10 and by 11.11%,21.54%,33.92% for B0H20 and by 6.55%,18.39% and30.95% for B0H30) respectively compared reference mix (G0),that chemical composition of hashma dust comparable marble rock dust ,those result agreement Tennich, Kallel and Ben Ouezdou [19] .

The third and fourth groups (G3&G4) recorded improvement in sulfate attack compared to G0 after two, four and six months they showed a decreased by (16.7%,27.16%,35.57% for B5H10 and by 14.8%,24.92%,33.93% for B5H20 andby4.76%,21.85%,30.8%forB5H30& 12.5%,25.77%,35.67forB10H10andby10.85%,24.51%,35.57%forB10H20andby11.74%,23.1%,35.32%forB10H3), compared to corresponding mix before in sulfate solution as shown in fig (7-b).

The fifth and sixth groups (G5&G6) recorded deterioration in sulfate attack after two, four and six months by (22.45%,30.39%,36,73% for B15H10and by 22.04%,28.66%,36.02%B15H20andby21.35%,28.38%,35.4%forB15H30),andby(25.62%,39.98%,41.81forB20H10andby24.06%, 38.45%,40.98%for B20H20 and by23.1%,37.75%,40.98%forB20H30) as shown in fig (7-c).

The best performance among all groups with only hashma was B0H30 in second group (G2) appeared to show loss in strength less than control mix. This might be explained by the fact that mortar contains smaller hashma particles, as reduced penetration of sulfate ions results from their filling of the mortar's internal pores or fissures.

The best performance among all groups was of B5H30 .Numerous investigations were conducted in preceding years regarding, the use of mineral dust powder as a cement substitute and its effect on the durability of concrete. The porosity of cement composites is primarily determined by the physical impacts of various geological sources of rock dust, wherein the fineness of the rock dust is an important factor. The porosity of the cement matrix decreases when rock dust with a finer grain size is substituted for cement. However, the degree of this decrease also depends on the amount of rock dust that is present. [30]. Panesar and Zhang [31] observed that when limestone powder was substituted for cement below 20%, the porosity of the concrete improved. Sun and Chen reached the same conclusion [32]. Nevertheless, concrete mixes B15, B20, B15H10, B15H20, B15H30, B20H10, B20H20, and B20H30 exhibited a notable decrease in compressive strength at higher replacement levels of SCMs, which was attributed to a weaker bond [33, 34].

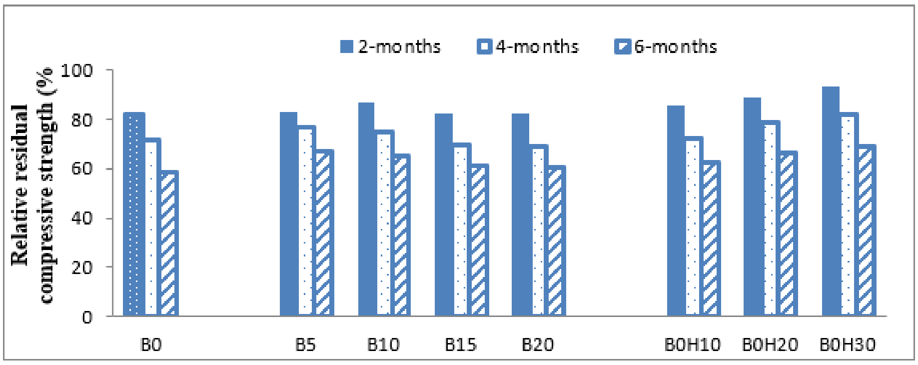


Figure 7-a:Relative residual compressive strength (%) for specimens made of mixes after immersion in 10% magnesium sulfate (MgSO4) solution for 2, 4 and 6 months for Control specimens G0 , basalt G1 and hashma G2.

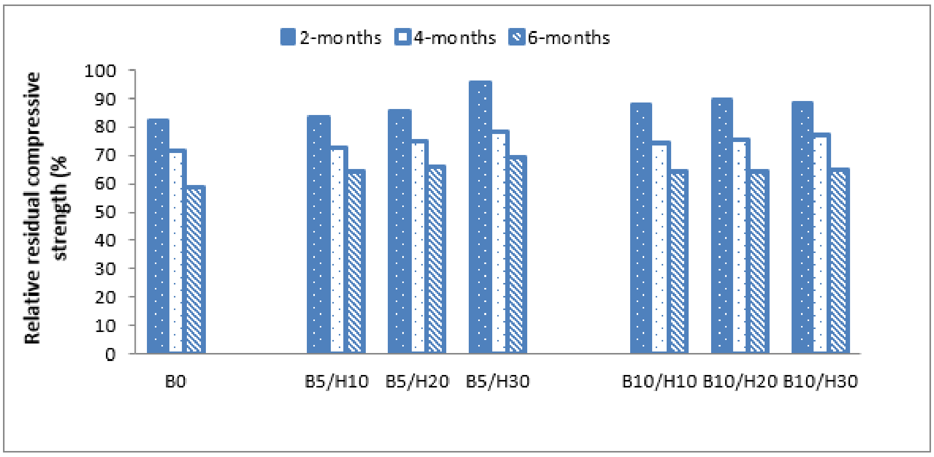
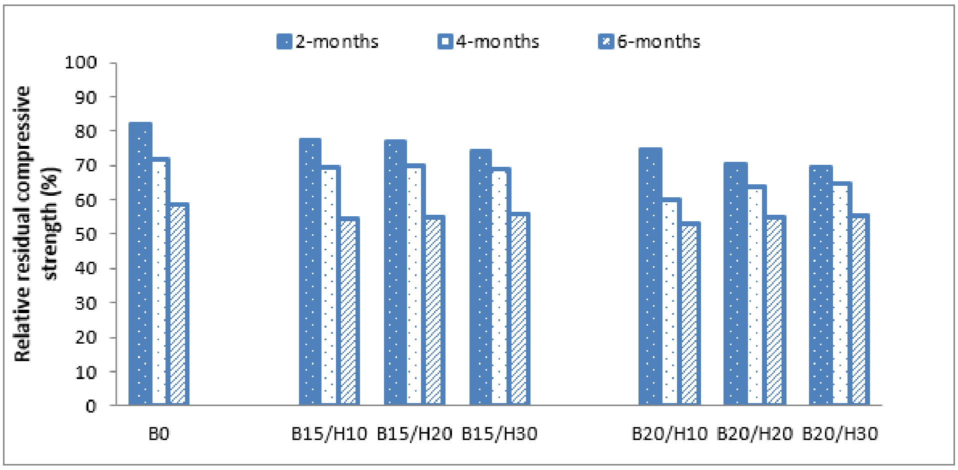


Figure (7-b): Relative residual compressive strength (%) for specimens made of mixes after immersion in 10% magnesium sulfate (MgSO4) solution for 2, 4 and 6 months for G0,G3 and G4.



Figure(7-C) : Relative residual compressive strength (%) for specimens made of mixes after immersion in 10% magnesium sulfate (MgSO4) solution for 2, 4 and 6 months for G0,G5 and G6.

4.3.3 Acid resistance (strength loss):

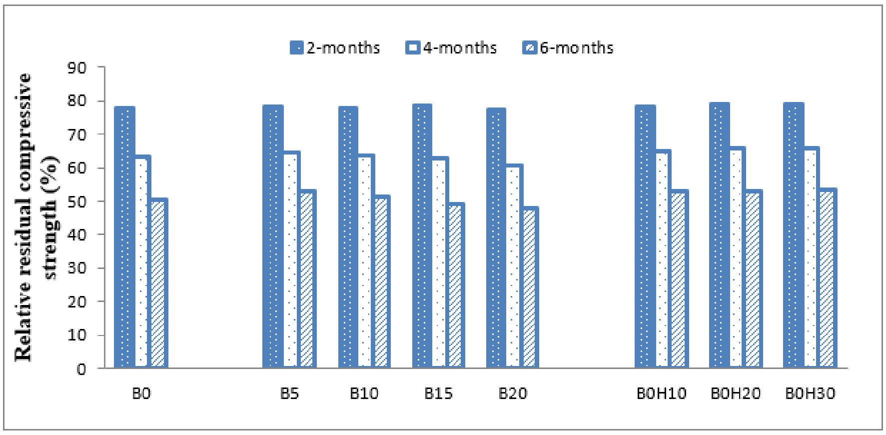
The acid attack of mixture at the end of 90 days curing and immersion in 5%HNO_3 through 6 months are show in fig 8(a,b,c) which shows the relative residual compressive strength %: it was observed in mortar based on hashma replacement as fine aggregate significantly improved the resistance to acids compared with control mix. . According to Koenig et al. [48], the resistance against acid attack increased as the CaO content increased.

The loss in compressive strength after six months reached 49.8% for control mix (G0). The mortar mixes G1 containing (5%&10%) basalt powder (B5&B10) showed loss in the relative residual compressive strength % by46.8%&48.9% respectively these results were less than reference mix (B0) ,which indicated a slightly enhancement to acid attack : in contrast mixes containing (15%&20%) basalt powder(B15&B20) showed higher levels of deterioration reaching 50.22%&52.15 compared to control mix(B0) ;Also for G2(B0H10,B0H20 andB0 H30) the relative residual compressive strength after six months reached 47.17%,46.58%&46.49% respectively that, results were achieved improvement compare to reference mix(B0) as shown in figure 8-a.

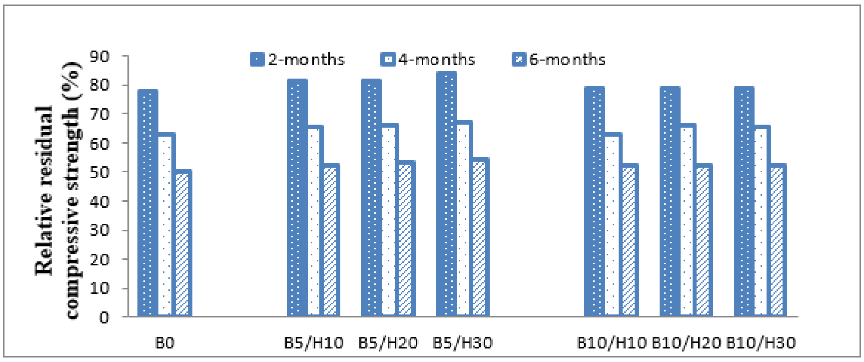
The third and fourth groups (G3&G4) recorded improvement in acid attack after six.months.by.(47.91%,46.58%,45.44%forB5H10,B5H20&B5H30),and(47.68%,47.6%,47.56%. forB10H10,B10H20&B10H30.), respectively compared reference mix (G0) as shown in fig (8-b).

Figure 8-c: The drops in the relative loss compressive strength percentage after 6 months recorded for the specimens in fifth group (B15H10, B15H20&B15H30) by52.04%,51.82%,51.49% ;and in sixth group(B20H10, B20H20 and B20H30) were loss 52.29%,52.031 % 50.7% after 6 months . These results indicate that mix B20H10 performed badly against nitric acid attack, as seen by the largest drop in the relative residual compressive strength percentage when compared to control samples.

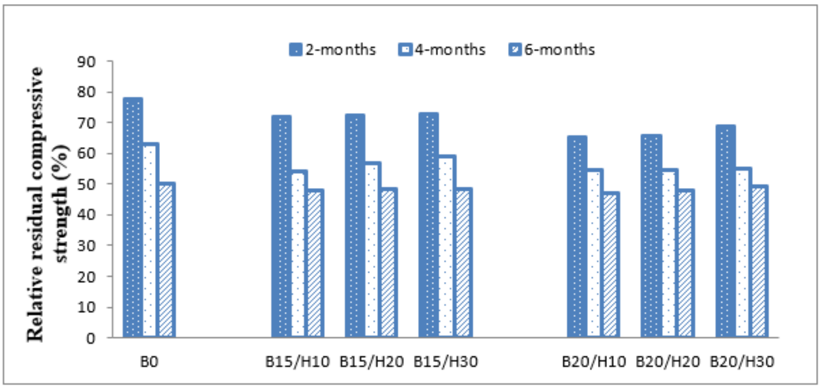
The degree of deterioration in the cement matrix of the specimens attacked by nitric acid is actually determined by a number of factors, including the developed pore structure and the solubility of the formed salts. The enhanced resistances of mixture B5H30 may be associated to best packing and fines powder made of a homogenous matrix and a reduce pore which prevent entering to attack cement paste. These findings concur with the previous studies that revealed improve packing improve durability (35) which was an agreement with compressive strength and sorptivity results.



Figure(8-a): Relative residual compressive strength (%) for specimens made of mixes after immersion in 10% nitrate acid (HNO3) solution for 2, 4 and 6 months for G0,G1 and G2.



Figure(8-b): Relative residual compressive strength (%) for specimens made of mixes after immersion in 10% nitrate acid (HNO3) solution for 2, 4 and 6 months for G0,G3 and G4.



Figure(8-c): Relative residual compressive strength (%) for specimens made of mixes after immersion in 10% nitrate acid (HNO3) solution for 2, 4 and 6 months for G0,G5 and G6.

The behavior of blended concrete mixes in acid and sulfate attack was found to be superior to that of control concrete. This was determined by computing the compressive strength loss of both blended mixes and control concrete in solutions containing acid and sodium sulfate. This was caused by the concrete being packed more effectively by finer basalt and hashma particles than by cement and natural sand. An additional factor was the addition of mineral admixtures or additives to the concrete, which enhanced the blended concrete's resistance to chemicals.(36)

5. Conclusions

The significance of this study reflects the fact that cement is replaced by basalt powder and sand by hashma powder. The experimental investigation presented in this paper allows for the illustration of the following conclusions:

1. The flowability for mixes samples containing (5%, 10%, 15and_20%) basalt powder as cement samples were found were higher than mixes containing (10%,20and_30%) hashma powder as sand , whereas values of B5, B10, B15 and B20 (G1) decreased flow values by 2, 3,5,6% respectively Partial replacement of sand by hashma (B0H10, B0H20 and B0H30) (G2) has led to decrease in flow 8,10 and 12% respectively.
2. At 90 days, compressive strength improved by 9% by incorporating 5% basalt powder as an optimum cement replacement ratio compared to control mix (without waste powders).
3. Inclusion of Hashma powder as a sand replacement significantly improves compressive strength with increasing replacement ratio up to 30% compared to control mix (without waste powders).
4. Maximum improved compressive strength after 90 days reached 47% higher than the control mix (without waste powders) by incorporating 5%BS as cement replacement with 30% HM as sand replacement (mix B5H30).
5. Sorptivity decreased by 27.9, 45.94 and 47.56% for mix containing 5%BS, 30%HM and (5%BS+30%HM) respectively. This is explained the reduction in porosity that those result were an agreement with compressive strength.
6. At six months in sulfate solution, the relative residual compressive strength percentages were enhanced sulfate resistance 33.3, 30.95 and 30.8% for mix containing 5%BS, 30%HM and (5%BS+30%HM) respectively compared to the control mix (without waste powders).The enhanced resistances of mixtures may be associated to best packing and fines powder made of a homogenous matrix and a reduce pore which prevent entering to attack mortar.
7. At six months in acid solution, the relative residual compressive strength percentages were enhanced acid attack 46.8, 46.49 and 45.44% for mix containing 5%BS, 30%HM and (5%BS+30%HM) respectively compared to control mix (without waste powders) .The general trend in all groups indicates that resistance of basalt powder and hashma powder to nitric acid was not significant enhancement after immersion in nitric acid solution for six months compared to control mix

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