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Investigation some properties of recycled lightweight concrete blocks as a fine aggregate in mortar under elevated temperature

S. Z. Abeer[1], Zaid Ali Hasan[2], Shereen Qasim Abdulridha[2]
[1] Roads and Transport Department, College of Engineering, University of Al-Qadisiyah
[2] Babylon Technical Institute, Al-Furat Al-Awsat Technical University

ABSTRACT

The main objective of this study is to assess the effect of utilizing waste material (lightweight concrete blocks) as partial replacing of fine aggregate. To do so, seven mix designs were utilized to prepare 168 mortar specimens (84 cubes and 84 prism) with the replacement ratios of 10% and 20% waste material fine aggregate instead of traditional sand at different temperatures of 24 °C, 200 °C, 400 °C, and 600 °C. The combination of two type waste material together in one mixture (waste lightweight concrete blocks with waste clay bricks or waste lightweight concrete blocks with waste glass) was tested with and without fiber (1% polypropylene fiber by volume). The physico-mechanical properties of mortar specimens involving flow rate, fresh density, weight loss, compressive strength, flexural strength and water absorption were determined. The hardened tests were implemented at age of 28 days. The results demonstrated fresh density experienced a decrease when utilizing recycled materials especially waste lightweight concrete block at 20%. Compressive strength showed improving with replacing normal sand by waste materials and that enhancing was clear at high temperatures. The specimens that utilized waste lightweight concrete block with waste glass aggregate illustrated clearly reduction in water absorption comparing with control mix at different temperatures.

Keywords: Waste materials, Recycle aggregate, Elevated temperatures, Mechanical properties

Corresponding Author:

Shereen Qasim Abdulridha,
Babylon Technical Institute,
Al-Furat Al-Awsat Technical University,
Address.
E-mail: inb.sh.qasim@atu.edu.iq

1. Introduction

Pollution crisis is one of the most important risk that facing the world generally and the Middle East especially due to a massive amount of waste materials resulting of construction or demolition buildings. Different characteristics desired in the structural member and on the other hand the accumulation of recyclable materials, researchers have been motivated to investigate the possibility of reusing these materials and defining the limitations, advantages, and disadvantages of its using again. The reuse waste materials in construction is considered eco-friendly and feasible to mitigate the problems that are emerging today such as nonbiodegradability and the high cost of re-industrialization in addition saving the natural resources from consuming for sustain the sustainability [1–4]. Large amounts of the extracted materials consumed by construction sector, according to statistics the materials used directly or indirectly in construction are 55 billion tons in 2002 (42% of the total extracted materials) [5]. Where the use of recyclable wastes can be considered as a sustainable solution to control material resources and prevent or reduce its depletion and must not squander the alternative materials (known as waste) in landfills, especially with this dramatic increase in the extraction of virgin materials all around the world.

The experiments have been investigated the ability to replace the natural fine aggregate in mortars and concrete [1,6–8]. Autoclaved aerated concrete was one of the waste materials that adapted for recycled to use in concrete. Topcu I B and Sarıdemir M (2007) [9] used autoclaved aerated concrete (AAC) as recycled aggregate to produce concrete and determined experimentally different properties such as unit weight and compressive strength. The study refers to decreasing the unit weight of concrete when using AAC waste as coarse aggregate more than when using it as fine aggregate. Also, the compressive strength extremely decreased as a result of increasing the replaced amount of AAC waste utilized. Zaetang Y (2013) [10] used autoclaved aerated concrete (RA) and two other types of natural aggregate as coarse aggregate to produce lightweight pervious concrete (LWPC). The density of LWPC reduced about (3-4) times compared to concrete with natural aggregate, it was about 558-775 kg/m^3.

T. M. Borhan [11] (2015) replaced partially fine and coarse aggregate by lightweight concrete (autoclaved aerated concrete). The samples were tested at ambient temperature (saturated surface dry) and at 55 ^{o}c. It was observed that the compressive strength, splitting tensile and density decreased as the ratio of replacing increased, it also decreased when increasing the temperature to 55^{o}c. Fenyvesi O and Jankus B (2015) [12] tried to develop new concrete from autoclaved aerated concrete waste. The excessive absorption property of the samples led to consider it is ideal to maintain appropriate indoor air condition. On the other hand, it is suitable for preparing covering panels according to the tensile strength test. Chindaprasirt P et al (2015) [13] investigated the effects of using AAC waste to produce lightweight pervious concrete. Different tests were performed such as density, splitting and flexural tensile strength, compressive strength and etc. It was found that the LWPC produced has low density of 775-900 kg/m^3 with enhanced compressive strength (1.9-4.1 MPa) and also flexural and splitting strength.

Suwan T and Wattanachai P (2017) [14] utilized replacing AAC waste as aggregate to produce lightweight concrete, and also specified optimum mix proportion. The study observed that existence of AAC inside the specimens provides water to continue curing, which led to developing compressive strength.

To proceed forward with recycling materials related to concrete mortars, a need arises to do more studies, especially when it is subjected to high temperatures, where limited studies are available in this field.

2. Materials and methods

The materials used to produce mortar mixtures in this work were cement, natural sand, superplasticizer, waste materials (lightweight concrete block, clay bricks, and glass) as a partial replacing of fine aggregate, and polypropylene fibers. Ordinary Portland cement (Type CEM II/A-L 42.5R) used in this study and conformed to the Iraqi Specification No. 5 [15] as shown in Table 1. Natural sand with grading range of 1.18 to 0.15 mm was utilized as a fine aggregate. Glenium 54 superplasticizer for improving the workability of fresh mortar (from BASF Company) has been used and complied to ASTM C494 Type F [16].

The lightweight concrete block used as a waste materials (broken parts) brought from (Assad Babel factory) with compressive strength 4 MPa and 550 kg/m^3 density. Clay bricks waste (parts) from (ASO brick factory) was utilized. The clay bricks conformed to the Iraqi Specification No. 25 [17]. Waste glass has been obtained from broken bottles after washing, cleaning, and drying. All waste materials have been crushed and grinded range of 1.18 to 0.15 mm sieve for partial replacing of natural sand, in addition the waste materials socked in water for 12 hour then dried to reach saturated surface dry (SSD) condition. Polypropylene fibers used to reinforce the cement mortar from Sika Company, and their properties are shown in Table 2.

The binder/sand ratio was (1:2.75), and water/binder (0.35) while, the superplasticizer dosage (2.5% by cement weight) have been fixed for all mixtures. First mixture (control mix (R1) without any replacement of fine aggregate (R1)) has been cast. Two mixtures with 10% and 20% replacing normal sand y waste lightweight concrete block aggregate (R2 and R3) separately and respectively. Mixes (R4 and R5) have 20% replacing sand by combination waste materials included 10% waste lightweight concrete block aggregate with 10% waste clay brick and 10% waste lightweight concrete block aggregate with 10% waste glass respectively.

While the mixes (R6 and R7) have same replacing of the pervious mixes (R4 and R5) but with adding fixed ratio 1% Polypropylene fibers (by volume). The mixes details are shown in Table 3.

The fresh mortar mixed by using planetary mixer according to the following procedure: two minute for dry mixing (all materials) with low speed 140 rpm. Then, the water and the superplasticizer (which have been mixed previously together) added and all the ingredients were mixed at the low-speed rate for one minute. Afterwards, the mixer stopped for one minute (rest time). Thereafter, all materials mixed for four minute at high speed (285 rpm). For mixtures that containing Polypropylene fibers, adopting the same procedure used previously but, the mixing continuous for a half minute for adding all amount of the fibers gradually then, all materials with fibers mixed at high speed for another four minutes.

The fresh mortar after mixing has been used for testing the flow for mortar mixtures then cast in standard molds (cubes and prisms) and vibrated. After 24 hours, the specimens lifted and stored in water tanks at room temperature for 28 days. When the age of the samples reach to 28 days the specimens lifted from the water tank and dried by towel then putted in the oven for one hour at different temperatures (200, 400, and 600) ^oC, the specimens left for cooling to the room temperature then used for testing (weight loss, compressive strength, flexural strength, and water absorption) and comparing the results with other specimens test under normal conditions (24 ^oC).

Table 1. Chemical composition of lime cement

The chemical composition of Portland cement	
Oxides	Content, %
CaO	63.2
SiO_2	22.3
Al_2O_3	4.4
Fe_2O_3	3.8
MgO	3.1
SO_3	1.8
Free lime	0.8
Loss on Ignition	3.0
Lime Saturation Factor	0.85
Insoluble residue	1.1

Table 2. Properties of polypropylene fiber

Properties of polypropylene fibers	
Length (mm)	12
Demeter (mm)	0.032
Density (kg/m^3)	910
shape	Straight
Tensile properties (MPa)	6600-7000
Melting point (ºC)	160

Table3. Mix proportions details for mortar (g)

Mix designation	Cement	Sand				Water/ Binder	SP	Polypropylene fibers
		Natural	WLC	WB	WG			
R1	500	1375	0	0	0	175	12.5	0
R2	500	1237.5	137.5	0	0	175	12.5	0
R3	500	1100	275	0	0	175	12.5	0
R4	500	1100	137.5	137.5	0	175	12.5	0
R5	500	1100	137.5	0	137.5	175	12.5	0
R6	500	1100	137.5	137.5	0	175	12.5	7.69
R7	500	1100	137.5	0	137.5	175	12.5	7.69

WLC: waste lightweight concrete blocks, WB: waste clay bricks, WG: waste glass, SP: Superplasticizer.

* This table calculated for three prisms of mortar with dimensions 40×40×160 mm.

3. Results and discussions

3.1. Flow test

The slump values of fresh mortar were performed by the slump flow test according to ASTM C1437 [18]. The results presented in Table 4 and Figure 1, refer to the maximum flow for the control mix (R1) while, by replacing sand with the waste of lightweight concrete blocks the flow reduced by 8% and 10% for 10% and 20% replacing respectively. It is apparent that the flow of fresh mortar when utilized waste of lightweight concrete blocks tended to decrease with increase the percent of replacing. That result of the flow depending on the raw material and manufacturing process in addition to the irregular shape of waste aggregate which are often angular shape and high water absorption even if pre-soaking or adding extra water [19].

The flow rate of the combination mixes (R4 and R5) demonstrated degradation by 19% and 13% respectively. Generally, adding Polypropylene fiber to mixes have negatively effects on the flow property. The flow rate lowered by 23% and 22% for (R6, and R7) comparing with same mixes without Polypropylene fiber (R4 and R5) that could be attributed to the plasticity of fresh mortar restriction caused by Polypropylene fibers that increasing with the volume increase of fibers led to reduction flow rate [20].

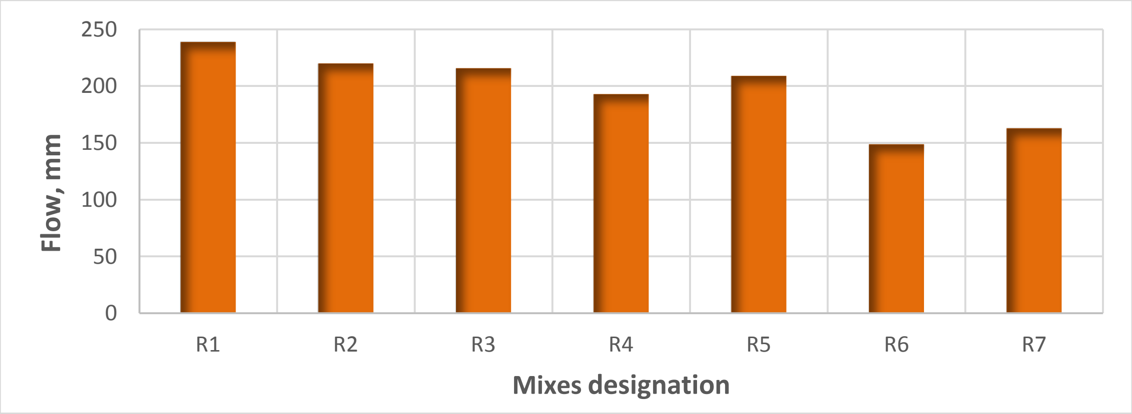

Figure. 1. Flow rate for fresh mortar mixtures

3.2. Density

The fresh density of mortar mixtures illustrated in Table 4 and Figure 2, for control mix the density was 2293 kg/m^3. The density of mortar decreased with a higher content of lightweight concrete blocks aggregate without segregation or bleeding was observed during mixing and casting. The decline in density was 6.3% and 12.3% for 10% and 20% replacing respectively and that can be result of very low density of lightweight concrete blocks which approximately between 400-800 kg/m^3 [21]. The utilizing of combination different waste materials as partial replacing of fine aggregate depending on its densities. The mixes R4 and R5 have been lower density as regarding to control mix (R1) by 6.8% and 7.8% respectively therefore the mix of waste lightweight concrete block with waste glass have the lowest value. Whereas, adding Polypropylene fiber led to very slightly increased in bulk density of mortar comparing with same mixes but without fibers. Polypropylene fibers have ability for reducing micro voids and lowering the size and orientation of calcium hydrated by restricting the growth of CH crystalline, where the interfacial transition zone (ITZ) was denser as comparing with mixes without fibers [22].

Table 4. Results of mortar mixtures test

Mix designation	R1	R2	R3	R5	R5	R6	R7
Flow (mm)	239	220	216	193	209	149	163
Density Kg/m3	2293	2148	2011	2137	2113	2133	2176

Mix designation		R1	R2	R3	R5	R5	R6	R7
Weighting loss %	200 °C	5.9	8.5	11	9.1	6.4	8.2	5.3
	400 °C	7.9	10.7	13.3	9.7	10	11.3	8.9
	600 °C	9	11.8	14.2	11.7	11.4	12.2	12.1
Compressive strength MPa	24 °C	50	47.3	43.3	47.5	38.3	49.3	53.1
	200 °C	43.7	42.6	36.7	35.3	38.3	34.7	36.4
	400 °C	34.3	33.4	22.06	32.8	30.3	33.1	41.8
	600 °C	23.1	18.2	15.5	26.4	31.2	33.0	23.2
Flexural strength MPa	24 °C	5.00	4.45	3.26	4.16	4.43	3.69	4.73
	200 °C	4.50	4.33	3.29	3.24	3.54	3.71	4.14
	400 °C	1.66	2.36	0.97	3.07	2.76	1.75	3.43
	600 °C	0.39	0.36	0.19	1.48	1.53	0.87	0.57
Water absorption %	24 °C	9.09	12.51	7.96	9.84	7.79	9.92	8.71
	200 °C	9.11	13.13	7.64	10.14	7.66	9.99	7.95
	400 °C	11.81	14.95	8.65	10.59	8.61	11.52	9.47
	600 °C	13.57	16.34	10.95	12.37	11.09	13.59	11.62

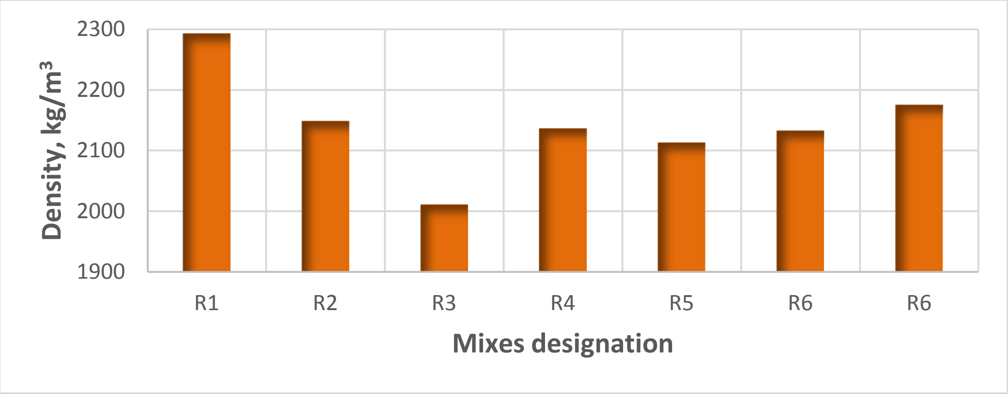

Figure. 2. Density results for fresh mortar mixtures

3.3. Weight loss

The weight loss were measured by calculated the ratio of original weight for each sample (before exposure to heating) to the weight after getting exposed to the elevated temperature (residual weight). Generally the weight loss increased with increasing the temperature, and that can be attribute to the change of mechanical properties of mortar, where the cement losses the ability of binding property by evaporated internal water in calcium silicate hydrated [22]. Figure 3, showing the highest reduction in weight at 600 °C for all mixes comparing with 400 °C and 200 °C. Mix R3 (20% replacing lightweight concrete block) showed highest weight losing as comparing with other mixes for different temperatures (200, 400, and 600) °C and that related to the homogeneity of waste lightweight aggregate that adversely affected by high temperature (thermal stresses) caused an increasing in weight loss rate especially above 400 °C [23].

The combination waste materials replacing natural sand fluctuated depending materials that used in mixture. Generally, the mixture that contained from 10% waste lightweight concrete block with 10% waste clay bricks showed the highest percent of weight loss (9.1%, 9.7%, and 11.7%) at 200 °C, 400 °C, and 600 °C respectively. No clearly significant effect of embedded Polypropylene fibers in mortar on weight loss, the fibers have no influence on hydroxides CH or water evaporation in matrix [24, 25].

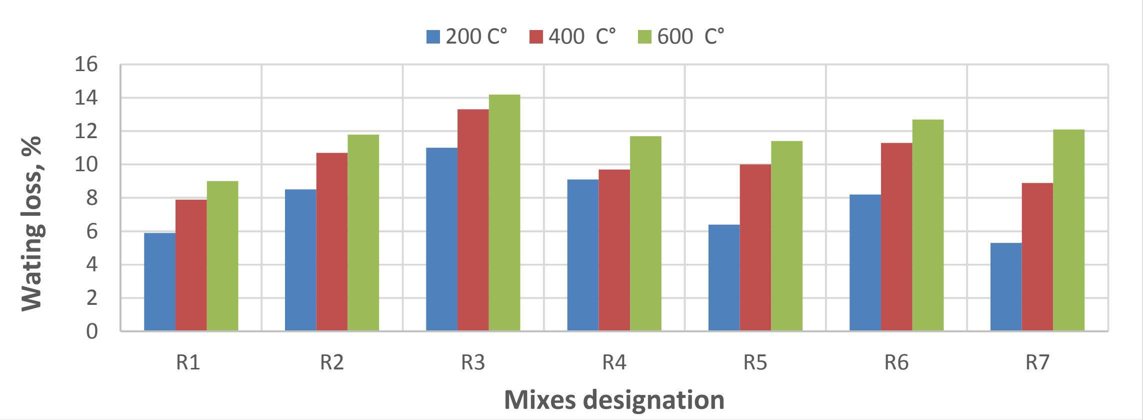

Figure 3. Weight loss results for mortar mixtures

3.4. Compressive strength

The results of compressive strength are shown in Table 4, and Figures 4-7. At ambient temperature (24 °C) comparing with control mix the compressive strength enhanced by 6% for replacing natural sand by 10% waste lightweight concrete blocks with 10% waste glass with fiber (R7). While, utilizing lightweight concrete block has negative effect on compressive strength at 10% and 20%. The reduction in compressive strength was 5.4% and 13.4% for R2 and R3 respectively. The slightly decreasing in compressive strength for utilizing lightweight concrete block aggregate can be due to its ability to absorb water during preparation and that can provide a good source for continuous cement curing (internal) and improving compressive strength [26].

The combination mixture consist of waste lightweight concrete block with waste clay bricks and mixture that have waste lightweight concrete block with waste glass observed reduction in compressive strength by 5% and 23.4% respectively. In general adding fibers have no clearly significant effect in compressive strength for the combinations. The results of compressive strength was comparable to the value of control mix (R1).

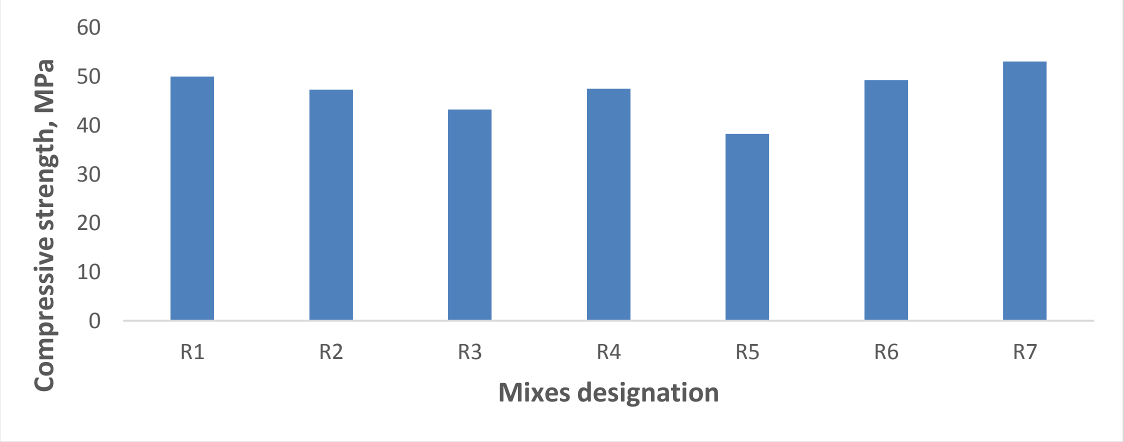

Figure 4. Compressive strength at 24 °C

Whereas at 200 °C the control mix exhibit degradation in compressive strength by 13% and that may be attributed to the dehydration of mortar by driving out the free water and that leads to loss of physically bound water significantly affects on the mechanical properties [27]. For replacing natural aggregate with waste lightweight concrete block the compressive strength lowered by 2.5% for 10% and 16% for 20% replacing that could be due to occurring capillary micro cracks resulting the volumetric thermal expansion of waste materials under high temperatures (200 °C- 400 °C) [28]. The compressive strength of utilizing more than one type of waste materials as replacing 20% of normal fine aggregate depends on materials that used in mixture. Using waste lightweight concrete block with waste clay brick or waste lightweight concrete block with waste glass (R4 and R5) led to reduce compressive strength by 19.2% , 12.3% comparing to the control mix at 200 °C respectively as shown in Figure 5. Utilizing fiber have negative effects on compressive strength comparing with same mixture without polypropylene fiber. At 200 °C the temperature inside the specemen less than the temperature outside therefore the fiber not reach to melting point (160 °C). For that the lowering in compressive strength could be attributed to the voids resulting from polypropylene fiber addition and existence weak bonding between fiber and cement paste [29].

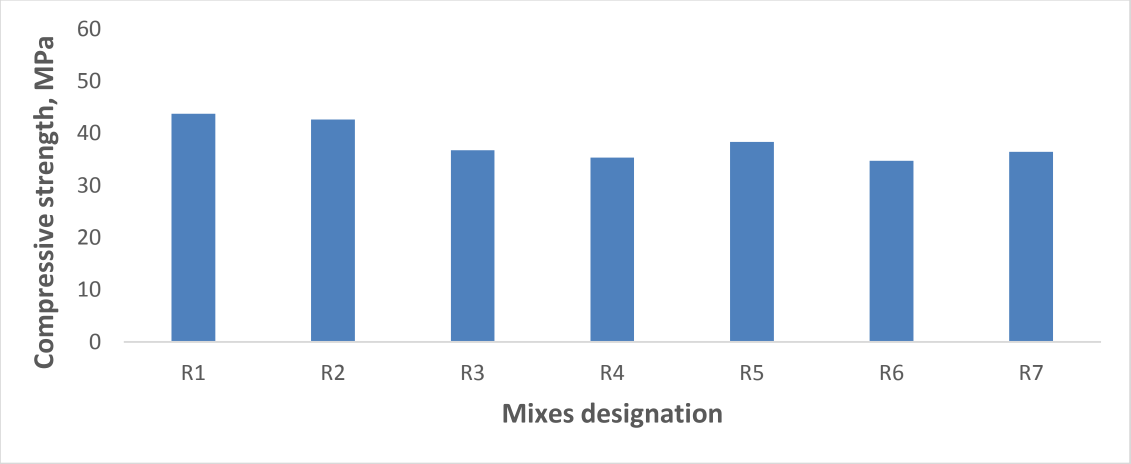

Figure 5. Compressive strength at 200 °C

With increasing temperature of oven to 400 °C the reduction in compressive strength rate for control mix reached to 31% as compared with corresponding result at 24 °C and that back to the dehydration of ettringite and calcium silicate hydrate (C-S-H) which is leading to the reduction in compressive strength especially when the temperature reached to 300 °C[30]. When replacing sand with waste lightweight concrete block the compressive strength showed slightly reduction by 2.6% for 10% but the clearly reduction was 35.6% at 20% replacing and this reduction results volumetric thermal expansion as presented in Figure 6. [28]. However, the compressive strength values have been more than the control specimens by 30% and 21% for 10% waste glass in addition to 10% waste lightweight concrete blocks, 10% waste glass in addition to 10% waste lightweight concrete blocks with 1% Polypropylene fibers respectively. The mixture that having waste lightweight concrete block with waste clay bricks or waste lightweight concrete block with waste glass (R4, R5) presented reduction in compressive strength by 4.3% and 11.6% respectively as regarding to reference mixture (R1). Definitely at 400 °C the polypropylene fiber totally melted leaving continuous voids that affected negatively on compressive strength values.

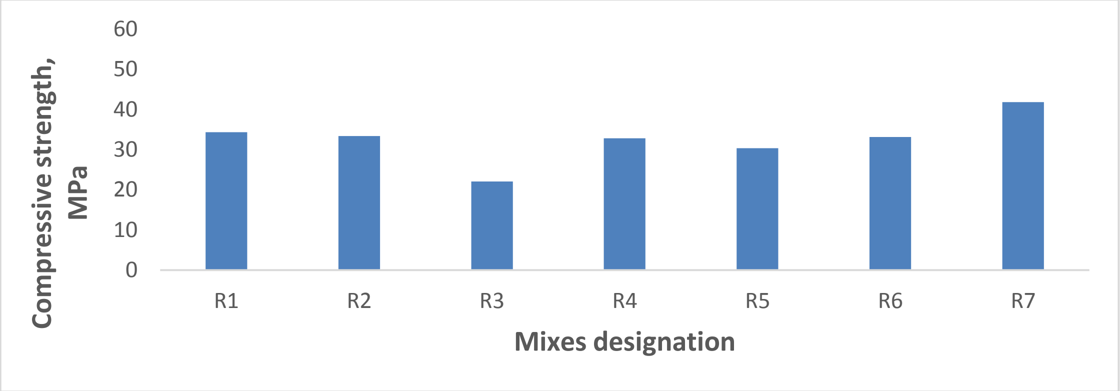

Figure 6. Compressive strength at 400 °C

At high temperature 600 °C the compressive strength observed massive deterioration more than 53% for control mix comparing with same mixture at ambient temperature. It was reported that when the temperature increased from 400 °C to 600 °C, dehydroxylation of calcium hydroxide occurs, combined with the formation of microcracks in the mortar. The compressive strength reduced because of that bonding between the hydration products and fine aggregates was badly weakened [31]. The compressive strength was showed reduction at 10% and 20% by 21.2% and 32.9% respectively for replacing waste lightweight concrete blocks aggregate. That can be attribute to develop cracks with increasing temperature where the materials become weaker as comparing with control mix at 600 °C [32]. All combination mixture observed higher compressive strength by 14.2% and 35% for (R4 and R5) as comparing with control mixture (R1) at 600 °C. The voids produced results melting polypropylene fiber led to reduce the compressive strength of mixtures comparing with same mixes without fibers.

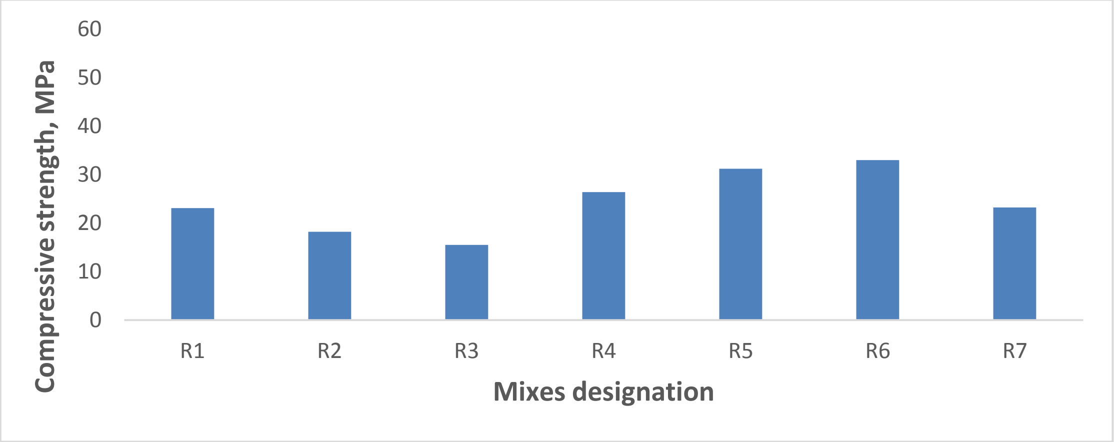

Figure 7. Compressive strength at 600 °C

3.5. Flexural strength

In the present research and from results illustrated in Table 4 and Figures 8-11, it can be noticed that the flexural strength values for all mixtures have been lower than the control mixture at room temperature. In all levels of used waste lightweight concrete block, the flexural strength showed reduction by 11% for 10% and 34.8% for 20% as compared with normal mix. That can attribute to the fact that the waste aggregate have voids in its structure and these voids produced by the reaction by caladium hydroxide from cement hydrated or lime with aluminum powder [11]. The results of flexural strength combinations for different waste aggregates were fluctuated depending on the waste aggregate used. The values of flexural strength lowered by 16.8% and 11.4% for R4 and R5 comparing with control mix (R1) as showing in Figure 8. Incorporated 1% Polypropylene fibers to improve flexural strength by 6.7% for mix R7 as considered to R5. Polypropylene fibers have ability to improve flexural strength by restricted propagate initial cracks in the cement matrix due to high strength bonding with the cement paste [33].

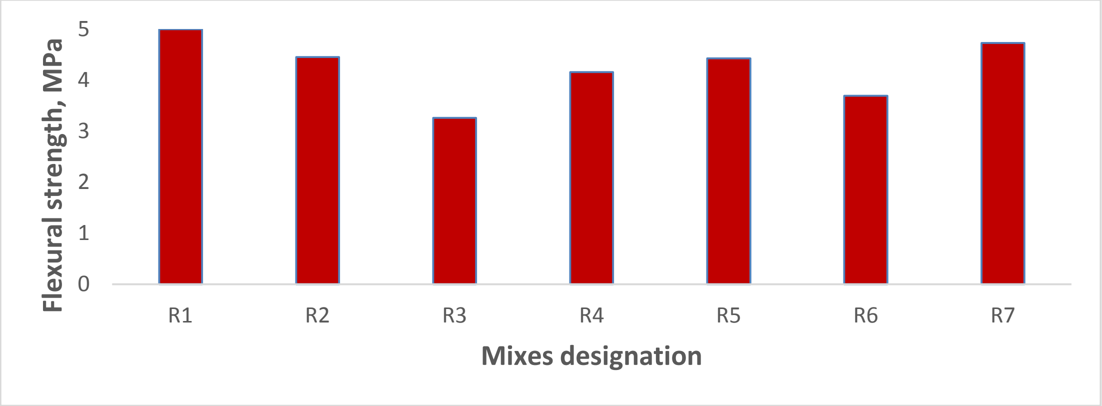

Figure 8. Flexural strength at 24 °C

Flexural strength for control mix was demonstrated the maximum value at 200 °C, while the reduction in flexural strength was 10% comparing with same mix at ambient temperature. The flexural strength was more sensitive to the temperatures than compressive strength due to microcracks in the specimens comparing with same one under room temperature [34]. The mixture having waste of lightweight concrete block aggregate presented slightly reduction by 3.7% for 10% and 4.6% for 20% replacing in flexural strength at 200C, that remain almost for evaporated free water and capillary cracks occurring [28]. The utilizing more than one type of waste materials for replacing fine aggregate in one mixture led to reduce the flexural strength by 28% and 21.3% for R4 and R5 respectively comparing with control mix at 200 °C as presented in Figure 9 . Utilizing Polypropylene fibers led to enhance the flexural strength at 200 °C comparing with same mixtures without fiber. Generally from 160 °C, polypropylene fibres start to melt and create a connected porosity where the vital role of this porosity to lowering cracks by evacuating vapor over pressures [35, 36].

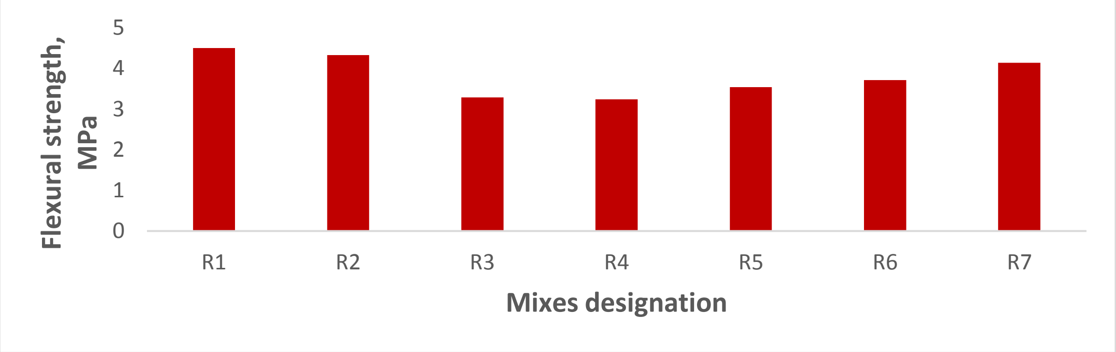

Figure 9. Flexural strength at 200 °C

At 400 °C the flexural strength presented clearly reduction by 66.8% as regarding to same mix at normal temperature. It was obvious dehydroxylation of calcium hydroxide happened when the trmperature more than 300 °C. The microcracking were occurred at that temperature and affected on flexural strength by weakening the bond between the aggregate and cement paste [37, 38]. The degradation in control mixture more than mixture with waste lightweight concrete block aggregate at 400 °C and that return to calcium carbonate ($CaCO_3$) exists in waste aggregate which make it more resistant to elevated temperatures than calcium hydroxide $Ca(OH)_2$ in normal mortar [39]. While, at high percent of replacing waste lightweight concrete block aggregate observed clearly lowering in flexural strength after 400C due to remove water crystallization and decompose free $Ca(OH)_2$ where shrinkage occurs in this stage [40]. All combinations mixtures with more than one type of waste aggregate replacing showed clearly improving by (85% and 66.2% for R4 and R5) in flexural strength comparing with control mix at 400 °C and that due to the effect of replacing materials that appeared more resistant to the high temperatures. Polypropylene fibers at 400 °C had certainly melted, calcined, and create porosity where the crack propagation cannot stop therefore, flexural strength shows reduction [24, 41].

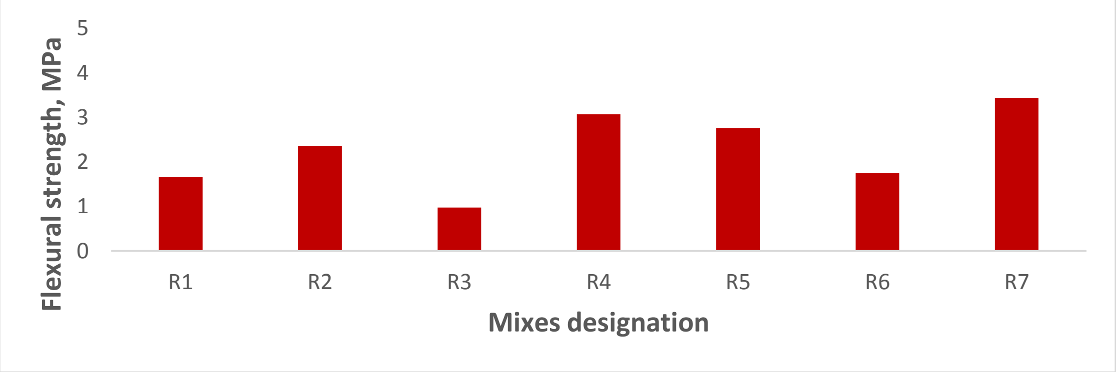

Figure 10. Flexural strength at 400 °C

At 600 °C very small part of the flexural strength was left, a continuous drop strength reach to 92.2% comparing with ambient temperature for control mix. The flexural strength decreasing at this stage caused by dehydration of calcium silicate hydrated (CSH) gel in addition to the transformation of silica sand (quartz) [42]. The flexural strength for mixture contained waste lightweight concrete blocks aggregate showed high reduction especially at 600 °C according to speed up cracks formation in the internal structure of the body where the flexural strength too sensitive to these cracks [32]. Generally, the mixture with combination waste aggregate observed more correspond to high temperature, the flexural strength was (1.48 and 1.53) MPa for (R4 and R5) compared to 0.39 MPa for control mixture at 600 °C as illustrated in Figure 11. The mixes with Polypropylene fibers at 600 °C observed reduction in flexural strength propriety by 41.2% and 62.7% for R6 and R7 comparing with R4 and R5 respectively, which may be attribute to spalling phenomenon that had better manifestation in mixes without Polypropylene fibers [43]. The Evaporation of Polypropylene fibers at high temperature and left voids created high number of cracks effect negatively on flexural strength [44].

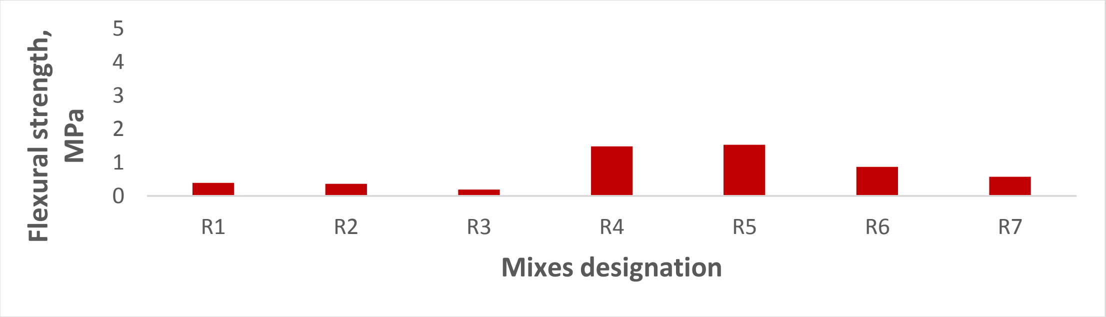

Figure 11. Flexural strength at 600 °C

3.6. Water absorption

The water absorption increased with increasing temperature, for reference mix the rate of absorption increased clearly beyond 200 °C by 30% and 49.2% for 400 °C and 600 °C respectively due to decomposition of hydration products which is leaving high ratio of porosity [45]. Significantly utilizing waste lightweight concrete block observed high percent of water absorption comparing with control mix that may be the high percent of pores and capillary suction. The water absorption increase with increasing temperatures especially after 400 °C because of surface cracks resulting thermal stress [46]. The combination mixtures that including more than one type of waste aggregate fluctuated in water absorption prosperity depending on the materials used. The mixture having waste lightweight concrete block with waste glass had the lowest water absorption comparing with same group, where the water absorption for R5 reduced by 14.3%, 15.9%, 27.1%, and 18.2% for 24 °C, 200 °C, 400 °C, and 600 °C respectively comparing with control mix as shown in Table 4 and Figure 12. Adding polypropylene fibers change the properties of water absorption. In general the water absorption increased when the fibers percent increased, that may be because of the poor dispersion of polypropylene fibers that leading to increase the volume of pore in the matrix [47]. The water absorption increasing with increased temperature due to melt polypropylene fibers in addition to cracks propagation at high temperature [24].

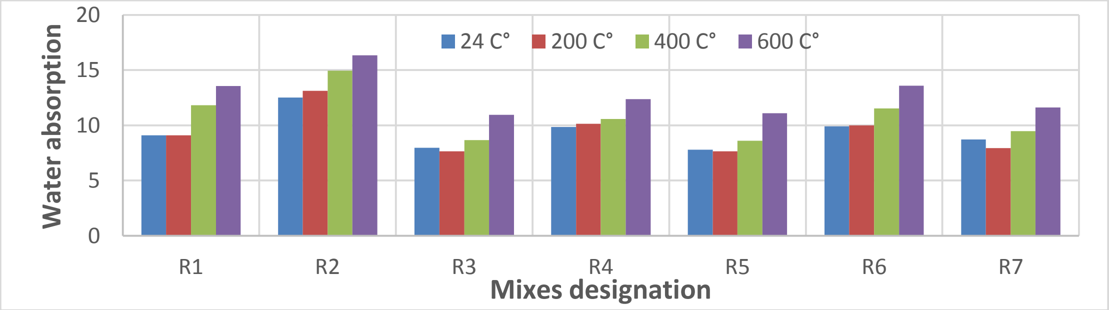

Figure 12. Water absorption for mortar mixture at different temperatures

4. Conclusions

The current study involved investigation the effect of utilizing lightweight concrete block with different type of waste materials as partial replacing of fine aggregate in mortar at high temperature. Depending on the experimental findings, we can conclude that:

- The flow of fresh mortar decreased with increasing percent of replacing natural sand with any type of recycling materials, whereas adding Polypropylene fiber have negative impact on flow. The fresh density also experienced a decrease when utilizing recycled materials especially waste lightweight concrete block at 20% of replacing.
- Weight loss increased with increasing the temperature, Mix R3 (20% replacing lightweight concrete block) showed highest weight losing as comparing with other mixes for different temperatures (200 °C, 400 °C, and 600 °C).
- The compressive strength improved with replacing normal sand by waste materials and that enhancing was clear at high temperatures. At 24 °C compressive strength was increased by 6% for the combination of waste lightweight concrete block with waste glass. While at 400 °C, the compressive strength of mixture with waste lightweight concrete block and waste glass was improved by 30%.
- Flexural strength for control mix was higher than other mixes having waste materials at 24 °C. All combination mixes illustrated higher strength than the control especially at 400 °C and 600 °C. The fiber addition led to improving flexural strength and that enhancing was clear at 200 °C.
- The water absorption increased with increasing temperature, significantly utilizing waste lightweight concrete block observed high percent of water absorption comparing with control mix at different temperatures. The specimens that utilized waste lightweight concrete block with waste glass aggregate illustrated clearly reduction in water absorption comparing with control mix at different temperatures. Fiber addition led to increase in water absorption for different temperatures.

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