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Production of Load Bearing Concrete Masonry Units (blocks) From Green Concrete Containing Plastic Waste and Nano Silica Sand Powder

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ABSTRACT

Industrial development has recently increased, including that of plastic industries. Since plastic has a very long analytical life, it will cause environmental pollution, so studies have resorted to reusing recycled waste plastic (sustainable plastic) to produce environmentally friendly concrete (green concrete). In this research, producing environmentally friendly load-bearing concrete masonry units (blocks) was considered where five concrete mixtures were compressed at the blocks producing machine. The cement content reduced from 400 kg/m^3 (B-400) to 300 kg/m^3 (B-300) then to 200 kg/m^3 (B-200). While (B-380) was produced using 380 kg/m^3 cement and 20 kg/m^3 nano-silica sand powder, and 10% plastic waste instead of coarse aggregate. Finally (B-285) included 285 kg/m^3 cement and 15 kg/m^3 nano silica sand powder and 10% plastic waste replacement for coarse aggregate. All production of concrete masonry unit types. According to IQS 1077 /1987, except (B-200) and (B-285) type B. When increasing the curing age from 14 to 28 days, blocks (B-285and B-380) change from type B to A. The compressive strength of the types (B-400, B-300, B-200, B-380, and B-285) was (9.65, 7.11, 5.35, 6.57, and 5.86) MPa, respectively, at 14 days and (11.98, 9.33, 6.84, 8.62 and 7.64) MPa respectively at 28 days.

Keywords: plastic waste, green concrete and concrete masonry units.

إنتاج وحدات البناء الخرسانية الحاملة (كتل) من الخرسانة الخضراء المحتوية على نفايات بلاستيكية ومسحوق رمل السيليكا

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الخلاصة

في الآونة الأخيرة ، ازداد التطور الصناعي ، بما في ذلك الصناعات البلاستيكية ، وبما أن البلاستيك له عمر تحليلي طويل جدًا ، فسوف يتسبب في تلوث بيئي ، ولذلك لجأت الدراسات إلى إعادة استخدام النفايات البلاستيكية المعاد تدويرها (البلاستيك المستدام) في إنتاج خرسانة صديقة للبيئة (الخرسانة الخضراء). في هذا البحث تم انتاج وحدات بناء خرسانية حاملة صديقة للبيئة (كتل) حيث يتم كبس خمسة خلطات خرسانية في الماكنة المستخدمة لإنتاج الكتل. تم خفض محتوى الأسمنت من 400 كغم / م ^{3} (B–400) إلى 300 كغم / م ^{3} (B–300) ثم إلى 200 كغم / م ^{3} (B–200) بينما (B–380) تم استخدام 380 كغم / م ^{3} أسمنت و 20 كغم / م ^{3} مسحوق رمل السيليكا النانوي و 10٪ نفايات بلاستيكية بدلاً من الركام الخشن أخيرًا (B–285) تم استخدام 285 كغم / م ^{3} من الأسمنت و 15 كغم / م ^{3} من مسحوق رمل السيليكا النانوي و 10٪ نفايات بلاستيكية كبديل للركام الخشن جميع وحدات البناء الخرساني من النوع A وفقًا للمواصفة العراقية رقم 1077 لسنة 1987باستثناء (B–200) و (B–285) فقد كانتا من النوع B. عند زيادة عمر المعالجة من 14 إلى 28 يومًا تغير البلوك (B–285 و B–380) من النوع B إلى A. كانت مقاومة الانضغاط للأنواع (B–400 و B–300 و B–200 و B–380 و B–285) هي (9.65 و 7.11 و 5.35 و 6.57 و 5.86) ميجا باسكال على التوالي في 14 يومًا ، و (11.98 ، 9.33 و 6.84 و 8.62 و 7.64) ميجا باسكال على التوالي في 28 يومًا.

الكلمات الرئيسية: النفايات البلاستيكية , الخرسانة الخضراء ,وحدات البناء الخرسانية

1. INTRODUCTION

Concrete masonry units are made of concrete in many shapes (like rectangular) shapes with or without a hollow core. It is produced automatically in molds. Concrete masonry units are used in residential buildings, schools, hospitals, industrial buildings, etc. Concrete masonry units have the advantage that they can use them to construct load-bearing and non-load-bearing walls. It can be produced sustainably using recyclable materials such as fly ash, waste glass, tires, and plastics **(Isler, 2012)**. Green concrete was produced for the first time in Denmark in 1998, so the label green concrete does not mean the color but rather an environmental concept for concrete in which waste is used in its production. Green concrete production is usually low because waste is used as a partial substitute for cement or aggregates, reducing energy consumption and less harm to the environment **(Neeraj and Nikhil, 2018)**. The low recycling rate of plastic waste contributes significantly to environmental pollution, so it is important to use plastic waste in various applications, such as its use in concrete as aggregate **(Alqahtani,et al.,2017)**. Globally, the use of plastic had increased astronomically since the twenties of the last century, when plastic was developed for the first time for industrial use. Some stunning statistics showed that in 2013, produce 299 million tons of plastic were produced worldwide. Plastic waste is often buried, and this process causes potential environmental risks. Thus, some research has focused on using plastic waste in concrete for various purposes **(Babafemi, et al., 2018)**. The sustainable materials used in green concrete decrease CO_2 emissions by minimizing the amount of cement used in buildings. Cementitious materials such as fly ash, silica fume, rice husk ash, slag, and metakaolin are sustainable materials used to improve the properties of concrete **(Altwair, et al., 2020)**. Silica is a compound consisting mainly of oxygen and silicon, two widely present elements in the earth's crust. Silica sand is non-flammable and non-toxic and does not cause danger to the environment. Silica sand contains a high percentage of silica, up to 99%, and it is effective and can be used as a partial substitute for cement when its size is less than 75 microns **(Pachipala, 2017)**. Silica sand is used as a partial replacement for cement in proportions (5, 10,15, and 20) % reduces the pollution resulting from the cement manufacturing process accompanied by the emission of carbon dioxide (CO_2), thus achieving the principles of green concrete by alternative cementitious materials, where the best replacement ratio was 15 % of cement weight **(Hemanth and Manikantha, 2020).**

2. LITERATURE REVIEW

Concrete masonry unit is defined according to the Iraqi specification (IQS 1077 /1987) as a unit for building walls whose basic dimensions are not less than 300 mm in length, 200 mm in width and 100 mm in height, provided that none of them exceeds 650 mm and is used for the construction of load-bearing walls. The blocks are made of Portland cement and aggregates of normal or lightweight or both and water with or without additives **(IQS 1077 /1987)** .

A concrete masonry unit is defined according to the American Standard (ASTM C90 − 16a) as a concrete masonry unit made of hydraulic cement, aggregate, and water with or without other materials. There are three types of concrete block units of normal weight, medium weight, and lightweight. These units are suitable for both loaded and unloaded walls **(ASTM C90 − 16a)**.

Many governmental and private institutions and researchers conducted research and feasibility studies on the environment and the performance of building units containing plastic waste. The designers and engineers found that the cost of construction decreases when using plastic waste in the production of concrete building units and improves the durability of blocks by reducing thermal cracks and pollution and building environmentally friendly green buildings **(Vanitha, et al.,2015)**.

The size of the coarse aggregate used in the production of concrete blocks should be passing through a sieve of 9.5 mm and retained on a sieve of 4.75 mm, and the fineness modulus of fine aggregates should be from 2.2 to 2.8. The ratios of cement to aggregate used are 1:7, 1:9, and 1:11. These ratios are common in producing building blocks with compressive strengths ranging from 4.5 MPa to 12 MPa **(Frasson et al.,2012)**.

Through a study, it was found that plastic waste PET (polyethylene terephthalate) can be reduced by recycling and using it as fine aggregate in the unloaded concrete blocks with replacement ratios (5, 10, 15, and 20) % by weight of sand. Several factors in the design of the concrete blocks were adopted; the ratio of cement to aggregate (A/C), the ratio of water to cement (W/C), the size of plastic waste, and the percentage of replacing plastic from the weight of the fine aggregate. The results showed that the best ratio is 1:3 cement to aggregate and the ratio of replacing 20% of plastic waste from the weight of the fine aggregate with a W/C ratio of 0.5, which gave the best compressive strength of the block (14.5 MPa) **(Waroonkun et al.,2017)**.

Plastic waste from lead-acid batteries was used at (50 and 70) % of the volume of fine aggregate to produce concrete building blocks. It was found that the density decreases by (32.5 and 39.5) % for replacement percentages of (50 and 70) %, respectively, at 28 days. Compressive strength decreased by (28.1and 37.4) % for (50 and 70) % plastic waste, respectively, compared to the reference mixture at 28 days **(Aljubori, et al.,2019)**.

When using plastic waste (PET) in a block by replacement percentages are (0, 3,7,20, and 30)% from the volume of sand with a C/A ratio of 1:3 and W/C ratio of 0.45 found from the results, the compressive strength of the block decreased from 19.5 MPa for reference mix to 8 MPa for a mix containing 3 % PET and range of compressive strength between (6-8) MPa for (20 -30) % PET. The reason for this reduction in compressive strength because low compressive strength of PET and its irregular shape **(Rahman, et al.,2013)**.

Compressive strength and unit weight was tested at 30 days. It was found through the results that the unit weight decreased by (36 and 45.43)% for the percentages of plastic (25 and 50)%, respectively, and the compressive strength decreased by (27.99 and 41)% for the percentages of plastic 25% and 50%, respectively for the mixing ratio 1:1:1 **(Velazco, et al.,2021)**.

The use of fly ash as a replacement for cement concrete masonry units leads to reducing the consumption of cement and improving the properties of concrete, so carbon dioxide (CO_2) emissions are reduced. Also, reduce the number of waste plastic bottles, as the research was considered one of the green projects **(Fataniya ,et al.,2015)**.

3. MATERIALS AND EXPERIMENTAL WORK

3.1 Materials

3.1.1 Cement

Ordinary Portland cement (OPC) 42.5 R is used for all concrete mixes commercially known as (Al-mass). The physical and chemical properties are conformable with **Iraqi specification (No. 5/2019)** as presented in **Table 1** and **Table 2**, respectively.

Table 1. Physical test of cement

Physical properties	Test result	Requirements of IQS No.5/2019 for (OPC)
Fineness (Blaine method) m^2/kg	386	≥ 280
Initial setting (min)	165	≥ 45 min
Final setting (min)	260	≤ 600 min
Soundness (autoclave method) %	0.12	≤ 0.8
Comp. strength(MPa) at 2days	28	≥ 20
Comp. strength(MPa) at 28 days	46	≥ 42.5

Table 2. Chemical composition and the main compounds of cement used.

Oxide composition and chemical properties	Test results	Limits of IQS No.5 /2019 for (OPC)
Lime (CaO)	62.77	-
Silica (SiO_2)	20. 65	-
Alumina (Al_2O_3)	4.87	-
Iron oxide (Fe_2O_3)	3.43	-
Magnesia (MgO)	4.35	≤ 5%
Sulfate (SO_3)	2. 50	≤ 2.8% for C_3A > 3.5%
Loss on Ignition (L.O.I.)	1.36	≤ 4%

Insoluble residue (I.R.)	0.91	≤ 1.5%
Main Compounds (Bogue's equation)		
Tri calcium silicate (C_3S)	53.77	-
Di calcium silicate (C_2S)	18.72	-
Tri calcium aluminate (C_3A)	7.10	-
Tetra calcium aluminate - ferrite (C_4AF)	10.43	-

3.1.2 Fine aggregate

Using sand as a fine aggregate in condition saturated surface dry (SSD) and conformable to the **Iraqi specification (No.45/1984)** zone three, sieve analyses, chemical and physical requirements of natural sand are presented in **Table 3** and **Table 4,** respectively.

Table 3. Grading test of fine aggregate.

Sieve size (mm)	Passing %	Requirements of IQS No.45/1984 zone 3
10	100	100
4.75	100	90– 100
2.36	93.8	85 – 100
1.18	80.8	75 – 100
0.6	61	60 – 79
0.3	21.8	12 – 40
0.15	1.8	0 – 10

Table 4. Chemical and physical test of fine aggregate.

Property	Test result	Standard Test Method	Requirements of IQS No.45/1984 zone 3
Sulfate content as SO_3, %	0.101	Guidelines IQS. No.3/500,2018	≤ 0.5
Specific gravity	2.58	ASTM C128-07a	-
Fineness modulus, %	2.4	ASTM C125-07	-
Dry rodded density kg/m^3	1694	ASTM C29/C29M	-
Absorption, %	0.8	ASTM C128-07a	-

3.1.3 Coarse aggregate

Crushed gravel from the Al-Nibaee region was used as a coarse aggregate in a condition of saturated surface dry (SSD) of a nominal maximum size 10 mm. The gravel was conformable to the **Iraqi specification (No.45/1984)**, and chemical and physical requirements are presented in **Table 5**.

Table 5. Chemical and Physical tests of coarse aggregate.

Property	Test result	Standard test method	Requirements of IQS No.45/1984 (5-14) mm

Sulfate content as a SO_3, %	0.05	Guidelines IQS. No.3/500,2018	≤ 0.1
Specific gravity	2.62	ASTM C127-07	-
Aggregate impact value, %	14.4	BS 812 :part112:1990	≤ 45
Abrasion test (Loss Angeles), %	17.4	ASTM C131-06	≤ 35
Aggregate crushing value, %	17.77	BS 812 :part110:1990	-
Dry rodded density kg/m^3	1608	ASTM C29/C29M	-
Absorption, %	0.7	ASTM C127-07	-

3.1.4 Plastic waste aggregate

Plastic waste was considered a coarse aggregate of a nominal maximum size 10 mm. It was obtained from shampoo bottles, vegetable boxes, and detergent bottles. In the beginning, plastic waste was crushed and shredded into small particles in the bob AL sham region using a plastic scrap grinder machine and finally graded on sieves to obtain the desired size. The chemical and physical tests of waste plastic aggregate are presented in **Table 6**.

Table 6. Chemical and physical tests of waste plastic aggregate

Property	Test result	Standard test method	Requirements of IQS No.45/1984 (5-14) mm
Sulfate content as SO_3, %	Nile	Guidelines IQS. No.3/500,2018	≤ 0.1
Specific gravity	0.95	ASTM C127-07	-
Aggregate impact value, %	0.00	BS 812 :part112:1990	≤ 45
Abrasion test (Loss Angeles), %	0.00	ASTM C131-06	≤ 35
Aggregate crushing value, %	0.00	BS 812 :part110:1990	-
Dry rodded density kg/m^3	455	ASTM C29/C29M	-
Absorption, %	0.00	ASTM C127-07	-

3.1.5 Nano silica sand powder

Silica sand was used as powder and replaced by the weight of cement in different proportions. The used silica sand in this research is extracted from the Urathma region, in Anbar Governorate, and it was ground in the building research center to a micrometer and grounded to a nanometer degree in the University of Technology as shown in the particle size analysis test, **Fig.1.** Chemical and Physical tests for nano silica sand were carried out and compared with ASTM C 618 as shown in **Table 7** and **Table 8,** respectively

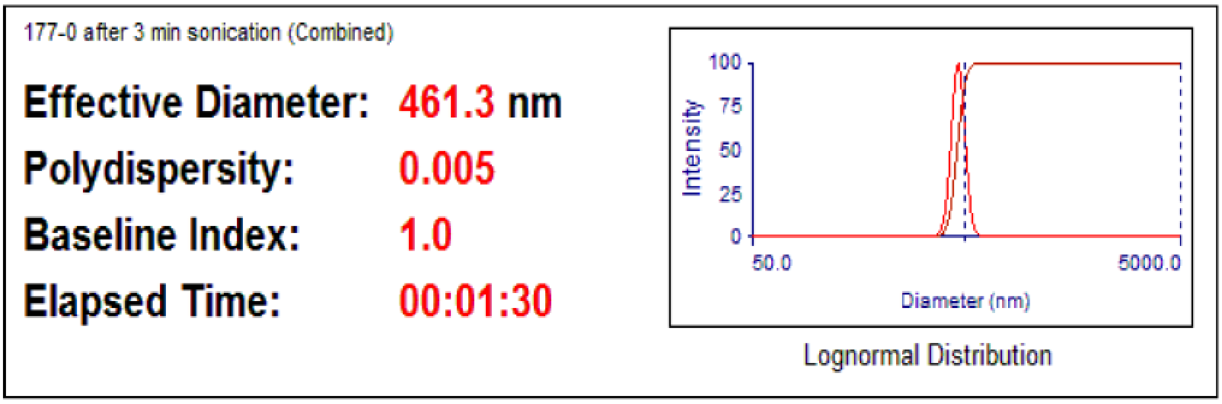


Figure 1. Practical size analyses for silica sand powder

Table 7. Chemical test of nano silica sand powder

Property	Test result	Chemical Requirements for Class N (Natural Pozzolan) ASTM C618-19
Silicon oxide SiO_2, %	80.5	-
Aluminum oxide (Al_2O_3), %	6.32	-
Ferric oxide (Fe_2O_3), %	3.22	-
SiO_2 plus Al_2O_3 plus Fe_2O_3, %	90.04	70.0 Min
SO_3 %	2.10	4.0 Max
Loss on ignition, %	1.41	10.0 Max
Moisture content, %	1.8	3.0 Max
Calcium oxide (CaO) , %	4.66	-
Magnesium oxide (MgO), %	1.23	-

Table 8. Physical requirements of nano silica sand powder

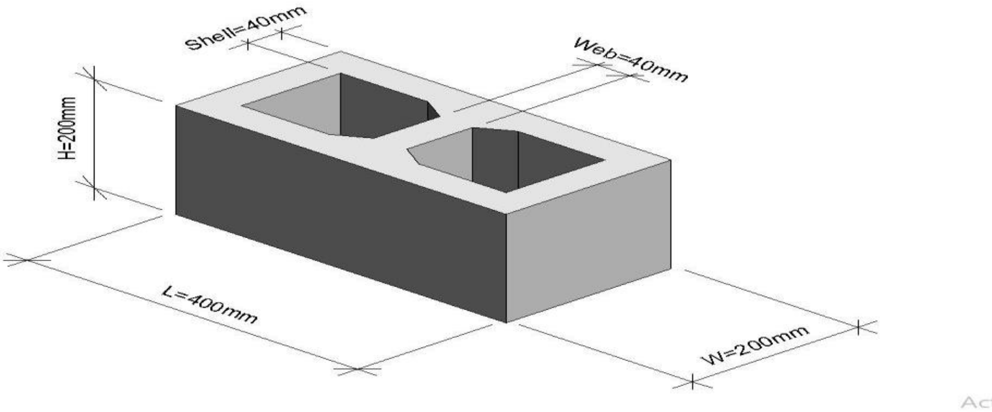
Property	Test result	Physical Requirements for Class N (Natural Pozzolan) ASTM C618-19
Amount retained when wet sieved on 45 μm, %	0	34 Max
Strength activity index with Portland cement at 7 days, percentage of control	87.46	75 Min
Strength activity index with Portland cement at 28 days, percentage of control	92.54	75 Min

3.2 Experimental work

3.2.1 Compression of concrete masonry units

The concrete block units were compressed by a mechanical compressor (owned by Al-Mutasim Company) in the building research center with dimensions (400×200×200) mm, as shown in **Fig.2** A and B.

A- Compression machine with a capacity of 12 blocks



B- Dimensions of concrete masonry unit (block)

Figure 2. Compression machine and dimensions of concrete masonry units (blocks).

3.2.2 Stages of work

Stage 1: Reducing cement content: in order to reduce cement consumption and the cost of producing block

1- After many trials in a normal concrete cube, the same mix as the reference mix (B-400) was used, with reducing the water content by 10 %, as shown in **Table 9.**

2- Reducing cement content to 300 kg/m^3 (B-300) and the reduction of water content by 16.5 %, as shown in **Table 9**

3- More reducing cement content up to 200 kg/m^3 (B-200) and the reduction of water content by 22.8 %, as shown in **Table 9**

Stage 2: Using sustainable materials: To extract the waste plastic and reduce cement content (producing sustainable block).

1- Replacing 10% of plastic waste from the volume of coarse aggregate and 5% of nano silica sand powder from the weight of cement for a mix containing 400 kg /m^3 (B-380) that needs to reduce the water content by 6.4%, as shown in **Table 9**

2- Replacing 10% of plastic waste from the volume of coarse aggregate and 5% of nano silica sand powder from the weight of cement for mix the containing 300 kg /m^3 (B-285) that's needed to reduce water content by 7.6 %, as shown in **Table 9.**

Table 9. Mix details of the concrete masonry units (blocks).

Block mix	Cement kg/m^3	Fine aggregate (Sand) kg/m^3	Coarse aggregate (gravel) kg/m^3	Plastic waste kg/m^3	Nano silica sand kg/m^3	Reduction of Water content,%	Powder: Fine: Coarse. ratio
B-400*	400	727	1020	0	0	-10	1:1.8 :2.5
B-300	300	727	1020	0	0	-16.5	1: 2.4: 3.4
B-200	200	727	1020	0	0	-22.8	1: 3.6: 5.1
B-380	380	727	918	27.5	20	-6.4	1:1.8 : 2.4
B-285	285	727	918	27.5	15	-7.6	1: 2.4 :3.2

* Reference mix that containing cement content 400 kg/m^3

Concrete building blocks are classified according to their uses according to Iraqi standard specification IQS 1077 / 1987.

Type A: For general use in external, internal, or internal walls exposed to moisture or climatic influences below or above ground level.

Type B: For use above ground level in internal or external walls that are protected from moisture or climatic influences.

3.2.3 Curing concrete masonry units (blocks).

The blocks were covered with a plastic sheet to prevent water evaporation for 24 hours and then immersed in a water curing tank at a temperature of approximately(23 ± 2 °C) according to IQS

1077 / 1987 and ASTM C192/C192M-16a. They were tested at ages (14 and 28) days, as shown in **Fig. 3.**

Figure 3. Curing methods for concrete masonry units.

3.2. 4 Testing of concrete masonry units (blocks).

The test was carried out 14 days after the completion of block production according to the Iraqi standard specification IQS 1077 /1987, and for more investigation, the units were tested at 28 days also.

3.2. 4 .1 Dimensions of concrete masonry units (blocks).

The dimensions of the samples were measured carefully. They included length, width, height, the thickness of the shell, and web at 14 days according to I.O.G.32/1989, as shown in **Fig.4.**

A- Measuring the length of the block

C- Measuring the high of the block B- Measuring the width of the block

Figure 4. Dimensions measurement of concrete masonry units (blocks).

3.2.4.2 Absorption test of concrete masonry units (blocks) at 14 days.

The samples were immersed in water for 24 hours, then wiped with a piece of wet cloth and weighed to obtain the saturated surface dry weight. Then after, the samples were dried in a ventilated oven at a temperature of (100 – 115) °C for not less than 24 hours. The weight loss should not exceed 0.2% for two consecutive readings in 2 hours. The absorption is calculated according to Eq. 1 below according to **I.O.G.32/1989**.

$$Absorption\ \% = \frac{M2-M1}{M1} \times 100 \qquad (1)$$

Where:-

M1= Dry weight (kg)

M2= Saturated surface dry weight (kg)

3.2.4.3 Compressive strength test of concrete masonry units (blocks).

The samples were placed in a compressive strength test machine between two wood boards. Any suitable load speed up to half of the expected maximum load is considered, and then applying a constant speed for the remaining period between (1-2) minutes is adopted according to **I.O.G.32/1989** as shown in Fig. 5 . To calculate the compressive strength. Eq. (2) is adopted

$$F = \frac{P}{A} \qquad \textbf{(2)}$$

Where:

F =Compressive strength at Mpa;

P = Maximum applied load at N;

A = Area of applied load (400×200) mm^2.

Figure 5. Compressive strength test for concrete masonry units (blocks).

4. RESULTS AND DISCUSSION

4.1 Dimensions of Concrete masonry units (blocks)

All dimensions of concrete masonry units, including (length, width, height, the thickness of the web, and shall) were conformed to the Iraqi standard specification. IQS 1077/ 1987 as presented in **Table10.**

Table 10. Dimensions results for concrete masonry units (blocks).

Block symbol	Dimensions (mm)					Limits of IQS 1077 / 1987. (mm)				
	L*	W**	H***	Web	Shall	L	W	H	Web	Shall
B-400	400	200	198	38	40	400±3	200± 3	200± 3	≥20	≥20
B-300	400	200	198	37	40					
B-200	399	200	199	38	40					
B-380	400	200	198	39	40					
B-285	400	200	199	40	39					

*L: length, ** W: width, *** H: height

4.2 Absorption of concrete masonry units (blocks).

The results of the absorption are plotted in **Fig. 6.** The percentage of absorption increased when the content of cement in concrete mixtures decreased, whereas the absorption increased up to (15.15 and 57.60) % when reducing cement content to 300 kg /m^3 and 200 kg /m^3 respectively for (B-300 and B-200) compared to B-400(reference). This can be interrupted by a reduction of masonry units' microstructure efficiency (increased pore) with the reduction of the cement hydration process and bonding with aggregate **(Braga, et al., 2014).** The results are still less than the limits of IQS 1077/1987 , and that is so encouraging.

The use of 10 % plastic waste from the volume of coarse aggregate and 5% of nano silica sand powder from the weight of cement in (B-380) led to a slight increase in absorption up to (3.63) % compared to the reference mix (B-400), and that is very encouraging results by using waste plastic safely.

Finally, the use of 10 % plastic waste from the volume of coarse aggregate and 5% of nano silica sand powder from the weight of cement in (B-285) led to an increase the absorption up to (10.80) % compared to the reference mix (B-300) which results (4.21) % much less than the requirement of masonry units in IQS 1077/ 1987.

The increase in absorption when using plastic aggregate as partial replacement may be attributed to plastic's shape, which leads to an increase in voids that may increase absorption **(Aljubori, et al.,2019)**.

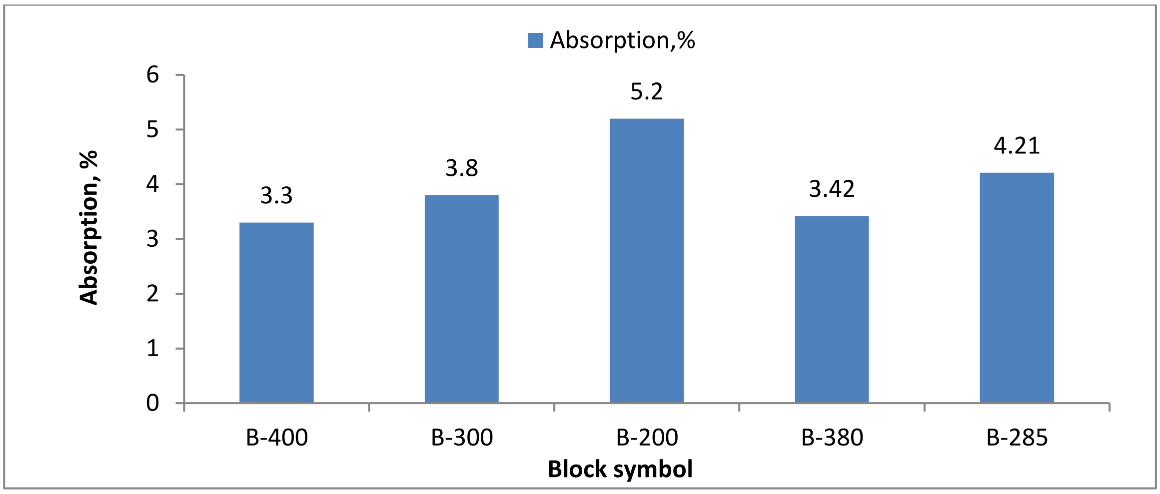


Figure 6. Absorption results for different mixes of block

4.3 Compressive of concrete masonry units (blocks).

The compressive strength results for all different block mixes are plotted in **Fig.7.**

For stage (1): when reducing cement content from 400 kg/m^3 to 300 kg/m^3 led to a reduction in compressive strength up to (26.32 and 22.12) % at (14 and 28) days, respectively, compared to B-400. That attributed to the less bonding and less C-S-H formation from the C_3S hydration led to less compressive strength **(Li, et al., 2020)**. Although the reduction is up to 26.32 %, the block is still in type A (7 MPa Min. average for three blocks and 15 % Max. absorption average for three blocks).

While when more reduction in cement content up to 200 kg/m^{3,} the block transfer to type B (5 MPa Min. average for three blocks and 20 % Max. absorption average for three blocks), the reduction up to (44.66 and 42.90) % at (14 and 28) days respectively compared to B-400.

For stage (2): when replacement of 10% of plastic waste from the volume of coarse aggregate and 5% of nano silica sand powder from the weight of cement for a mix containing 400 kg /m^3 (B-380) led to a reduction in compressive strength is up to (31.91 and 28.05) % at (14 and 28) days respectively compared to B-400. Although the reduction is up to 31.91 %, the block is still in type A (7 MPa Min. average for three blocks and 15 % Max. absorption average for three blocks). The reason for the decrease in the compressive strength may be due to the weakness of the bonding strength between the smooth surface of the plastic aggregate and the cement paste, which leads to a weakening of the transition zone and a decrease in the compressive strength of concrete, and also deformation shape of plastic aggregate under load, i.e., act as a void in the concrete mass **(Aljubori, et al.,2019)**.

When replacing 10% of plastic waste from the volume of coarse aggregate and 5% of nano silica sand powder from the weight of cement for a mix containing 300 kg /m^3 (B-285), the block transfer to type B (5 MPa Min. average for three blocks and 20 % Max. absorption average for three blocks), the reduction up to (17.58 and 18.11) % at (14 and 28) days respectively compared to B-300.

Finally, it must be known that the effect of extra age of curing till 28 days led to change the block type from B to A that is to say the better quality of block, so it is recommended to manufacture with increasing curing age till 28 days as happened in B-380 and B-285 and almost happen in B-200, that important target can manufacture take in consideration.

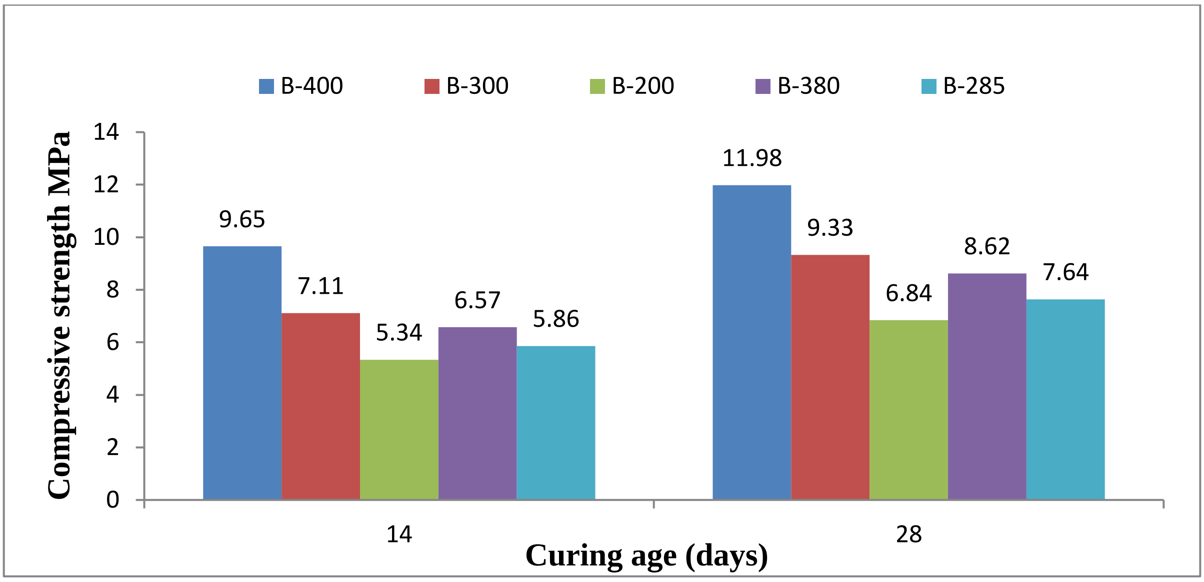


Figure 7. Compressive strength results with curing age for different block mix

5. CONCLUSIONS

1. All dimensions of the production concrete masonry units, including (length, width, height, and thickness of the web and shell) conform to the Iraqi standard specification IQS 1077/ 1987.

2. All manufactured load masonry units (blocks) with the specification limits of compressive strength and absorption in IQS 1077/ 1987.

3. All production of concrete masonry units types A according to IQS 1077 /1987 expect (B-200) and (B-285) type B. When increasing the curing age from 14 to 28 days, blocks (B-285and B-380) change from type B to A.

6. FUTURE SCOPE

1. Using other waste materials such as glass, rubber, fly ash with different percentages of weight cement replacement, etc.

2. More studies of using a high percentage of replacement of waste plastic as partial replacement of coarse aggregate, more than 20%.

3. More studies of using a high percentage of replacement of nano silica sand powder as partial replacement of cement weight more than 10%.

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