Evaluation of Using Waste of Bottles in Concrete as Sustainable Construction

Zainab Hasan Abdulabbas
Faculty of Engineering,University of Kufa.
zainab.alhasnawi@uokufa.edu.iq
Shereen Qasim Abd-Alridha
Technical Institute-Babylon/Al-Furat Al-Awsat Technical University
Shereen_Qasim@Yahoo.com

Abstract:

In the current study attention was focused on effects of using wastes of plastic and glass of juices and soft drink bottles in concrete, and the optimum percent's of the wastes were detected giving the best properties of concrete. Total number of concrete mixes was (12), which have different wastes additions details. These mixes included: three mixes have plastic fibers (1, 2, 3)% by cement weight, three mixes have glass with ratios of (10, 15, 20)% as a replacement of sand volume, three mixes have pieces of plastic bottle caps with ratios of (15, 20, 25)% as a replacement of gravel volume .The mix that has the optimum properties in these three groups, was selected to merge these types of wastes in one mix. Therefore, two additional mixes were prepared; one mix contains addition of 2% plastic fibers and 15% glass; and the other mix contains 20% plastic bottle caps and 15% glass, in addition to the reference mix without any waste additions. The achieved tests comprise; compressive strength, modulus of elasticity, flexural strength, ultrasonic pulse velocity, density, absorption and fire resistance. Tests results give good indications about using these waste in concrete; when two types of wastes are added to the mixes (plastic fiber with glass C11 or pieces of bottle caps and glass C12) the compressive strength is improved noticeably, the residual compressive strength is about (75% and 83%) with total ratio of wastes about 35% at age of 7 and 28 days, respectively, in mix C12, and (76 .7% and 70.5%) with total ratio of wastes about 17% at age of 7 and28 days, respectively, in mix C11.

Key words: waste materials, recycled plastic, recycled glass, and sustainable construction.

الخلاصة

تركَز الاهتمام في الدراسة الحالية على تأثيرات إضافة المخلفات البلاستيكية والزجاجية لعلب العصائر والمشروبات الغازية على الخرسانة ومعرفة النسب المثلى للمخلفات المضافة التي تعطي أفضل خصائص للخرسانة. العدد الكلي للخلطات الخرسانية المفحوصة كان (١٢) خلطة بمختلف النسب للمخلفات المضافة. هذه الخلطات تتضمن: ثلاث خلطات تحتوي (١، ٢، ٣)% ألياف بلاستيكية كنسبة من وزن السمنت، وثلاث خلطات تحتوي (١٠، ١٥، ٢٠)% مخلفات زجاجية كنسبة مستبدلة من حجم الرمل، وثلاث خلطات تحتوي (١٥، ٢٠، ٢٥)% قطع أغطية العلب البلاستيكية أضيفت كنسبة مستبدلة من حجم الحصى، الخلطة التي لها افضل خواص في هذه المجاميع الثلاثة، تم اختيارها لدمج هذه الانواع من المخلفات في خلطة واحدة بحيث تم تحضير خلطتين اضافيتين؛ خلطة تحتوي ٢% ألياف بلاستيكية و١٥% مخلفات زجاجية، وخلطة تحتوي ٢٠% قطع أغطية العلب البلاستيكية و١٥% زجاج، بالإضافة للخلطة المرجعية التي لا تحتوي على مخلفات. الفحوصات المنجزة شملت مقاومة الانضغاط، معامل المرونة، مقاومة الانثناء، الموجات فوق الصوتية، الكثافة، الامتصاص، ومقاومة الحريق. نتائج الفحوصات اعطت مؤشرات جيدة حول استعمال هذه المخلفات في الخرسانة ؛ فعند إضافة نوعين من المخلفات للخلطات (الياف بلاستيكية مع الزجاج C11 أو قطع أغطية العلب مع الزجاج C12) تحسنت مقاومة الانضغاط بشكل ملحوظ إذ أن مقاومة الانضغاط المتبقية بحدود (٧٥% و ٨٣%) لمجموع نسبة مخلفات بحدود٣٠% بعمر ٧و٢٨ يوم على التوالي في الخلطة C12 و (٧٦،٧% و ٧٠،٥%) لمجموع نسبة مخلفات بحدود ١٧% بعمر ٧و٢٨ يوم على التوالي في الخلطة C11.

الكلمات المفتاحية: مواد النفايات، إعادة تدوير البلاستيك، إعادة تدوير الزجاج، والبناء المستدام.

1.Introduction

from several points of view, wastes reuse is so important. It aids to protect and continue raw resources, reduces the environment pollution, and in addition to its benefits in keeping energy processes of production. Wastes and by-products materials must be counted as appreciated resources just pending suitable handling and application. Plastic wastes are familiar types of wastes. It has risky effects on the environment because of their extended biodegradation time. Hence, the usage of these items in other productions is a reasonable method for decreasing their harmful impacts, **(Ismail and AL-Hashmi 2008)**.

Recycled plastics lose its strength with frequently of recycling. Therefore, plastic wastes will terminate in landfills. In this situation as an alternative of recycling it frequently, if it is employed to be used as aggregates in concrete, it will add an advantage to the industry of construction. Plastic wastes as coarse aggregate are distinguished by lighter weight in assessment to the natural aggregates, and have high crushing resistance **(Subramani and Pugal 2015; Mathew *et. al.*, 2013)** study the plastic aggregate properties, they found that the complete replacement of natural coarse aggregate with plastic wastes coarse aggregate is not practicable. Replacement with percentage of 20% attained the higher value of compressive strength. The same results was confirmed by **(Subramani and Pugal 2015**) in their study.

On the other hand, Bulky amounts of glass wastes are arranged as solid waste. According to the estimation of United Nations, 200 million tons are the quantity of the annually disposed glass wastes. Contrasting to another waste yields, glass is eternal, and therefore harmful to the environment. With great importance is the investigation approved by **(Byars *et. al.*, 2004)** on this topic. They reported that the products involving glass aggregate were found absolutely to have the same characteristics which are identical to products without glass. In concrete, glass could cause reaction and the reactivity growths with the content of alkalis in cement and the size of particles above 1mm. Particles smaller than 1mm might lessen the impending for alkalis silica reactions. The alkalis silica actions could be effectively compact to zero by spending fly ash, GGBS or metakaolin.

Corinaldsi, *et. al.*, (2005) considered the recycle of crushed glass as sand for mortars. They stated that in case of glass waste finely crushed below 75 μm, the influence of alkalis silica reactions did not happen and the durability of mortar is assured. Moreover they reported that there is no actions that have been noticed with size of particle more than 100 μm. Accordingly, specifying the possibility of the glass waste reprocess as fine aggregate in concrete and mortars **(cited by Abbas *et. al.*, 2011)**.

2. Aim of the study

An attempt has been made, in the present study, to assess the technical feasibility of the use of recycled plastic, glass of juices, and soft drink bottles in concrete, and detect the optimum percents of the waste giving the best properties of concrete. In addition to an attempt to incorporate the exhausting of these two types in the same mix so as to give a sustainable possibility to deal with maximum amount of wastes.

3. Experimental program:

The experimental program was done at concrete laboratory of civil engineering department at university of Kufa involving the following details:

3.1.Materials:

3.1.1.Cement:

Ordinary Portland cement (O.P.C.)(Type I) was used in this work, and manufactured by The Kufa Factory of Cement and come across the Iraqi specification **(IQS No.5 :1984)**. The chemical analysis and physical properties of the cement used in the present study has been revealed in Tables (1) and (2) individually.

Table(1). Chemical analysis of the cement used at the existent work

Oxide	(%)	Limit of Iraqi specification *(IQS No.5 : 1984)*
CaO	63.64	…………
SiO_2	21.64	…………
Fe_2O_3	3.05	…………
Al_2O_3	6.10	…………
MgO	2.13	≤ 5.0
SO_3	2.21	≤ 2.8
Free lime	1.35	…………
L.O.I.	1.49	≤ 4.0
IR	0.79	≤ 1.5
Compound composition	**(%)**	**Limit of Iraqi specification *(IQS No.5 : 1984)***
C_3S	39.74	…………
C_2S	29.31	…………
C_3A	10.49	…………
C_4AF	10.10	…………
LSF	0.88	0.66-1.02

Table 2. Physical properties of cement used at the existent work

Physical properties	Test results	Limit of Iraqi specification (IQS No.5 : 1984)
Fineness (Blain method) cm2/gm	3085	≥2300
Setting time (Vicat method)		
Initial hrs:min	1:35	≥0:45
Final hrs:min	4:26	≤10:00
Compressive strength: 3 days	17.37	≥15
: 7 days	22.95	≥23

3.1.2. Fine Aggregate:

Al-Akaidur region natural sand was used. The gradation of it lies within the second zone according to The Iraqi requirement **(IQ.S 45/1984)** as shown in **Table (3)**. Which displays sieve analysis of it**.**

Table 3. Results of sieve analysis test of Fine Aggregate used.

Sieve size (mm)	%passing	IQ.S No. 45 Zone (2)
10	98.12	100
4.75	93.20	100-90
2.36	76.45	100-75
0.15	60.85	90-55
0.6	47.35	59.35
0.3	22.12	30-8
0.15	7.77	10-0

3.1.3. Coarse Aggregate:

Coarse aggregate from Badra and Jassan's quarry with maximum size 20 mm was used. The sieve analysis of test lies within the limits of Iraqi specification **(IQ.S 45/1984)** as shown in **Table (4)**.

Table 4. Results of sieve analysis test of coarse Aggregate used

Sieve size (mm)	%passing	IQ.S No. 45 Zone (2)
37.5	100	100
20	100	95-100
10	33.2	30-60
5	8	0-10

3.1.4. Waste Materials :

Waste materials are comprised glass and plastic wastes of used bottles of soft drinks and juices. They are prepared as following:

Plastic waste:

a. The body of plastic bottles was deformed to pieces with the size of 2 mm wide and 20 mm long and it is used as fibers, as shown in **Plate (1)**.

b. The plastic bottle caps was deformed to pieces with size of (10×10) mm used as coarse aggregate, as shown in **Plate (2)**.

Plate 1. Plastic fiber.

Plate 2. Plastic pieces

Glass waste: The glass bottles were crashed into small pieces which passed sieve of size 5 mm and were used as fine aggregate, as shown in **Plate (3)**.

Plate 3. Crashed glass

3.1.5. Water

Ordinary clean tap water was used in this work for mixing and curing of all specimens.

3.2. Mix design:

British mix design method **(B.S. 5328, Part 2:1991)** was used to prepare concrete mixes with target compressive strength of 30MPa at an age of 28 days. **Table (5)** shows mix proportions of the reference mix. The total number of concrete mixes that were done was (12) mix, which have the following details:

1. C1: the reference mix without any addition of waste materials.
2. C2: in which, the plastic fibers were added with 1% by weight of cement.
3. C3: in which, the plastic fibers were added with 2% by weight of cement.
4. C4: in which, the plastic fibers were added with 3% by weight of cement.
5. C5: in which, the glass was added with 10% as a replacement of sand volume.
6. C6: in which, the glass was added with 15% as a replacement of sand volume.
7. C7: in which, the glass was added with 20% as a replacement of sand volume.
8. C8: in which, pieces of plastic bottle caps were added with 15% as a replacement of gravel volume.
9. C9: in which, pieces of plastic bottle caps were added with 20% as a replacement of gravel volume.
10. C10: in which, pieces of plastic bottle caps were added with 25% as a replacement of gravel volume.
11. C11: in which, the plastic fibers with 2% by weight of cement and the glass with 15% as a replacement of sand volume were added.
12. C12: in which, pieces of plastic bottle caps with 20% as a replacement of gravel volume and the glass with 15% as a replacement of sand volume were added.

Table 5. Mix proportions

No.	w/c	Cement Kg/m^3	Fine aggregate Kg/m^3	Coarse aggregate Kg/m^3	Slump mm
C1 **Reference mix**	0.5	340	515	1385	100

3.3. Mixing, casting, and vibration:

All necessary materials for casting concrete according to detailed mix proportions were prepared, and mixed manually, and then casted in the moulds which must be previously cleaned and oiled. The specimens involve cubes, cylinders and the prisms, which are compacted by electrical vibration table.

3.4.Curing:

After a period of 24±0.5 hrs. from casting, moulds were opened and specimens were cured in a curing tank, which contained clean tap water at laboratory temperature (22±2)ºC till testing time.

3.5. Tests of hardened concrete.

3.5.1. Compressive strength test:

The test was done according to (BS.1881: Part 116:1989). Test machine used has the maximum limit (2000 KN) .The average of three cubic specimens with dimensions of 100mm for each mix was adopted at (7 days and 28 days)**.** All specimens were raised from curing tank and the outside surfaces were dried from excessive water, then specimens were tested.

3.5.2. Modulus of elasticity test:

This test was achieved according to Americans specifications **(ASTM-C469-06)**. test specimens were cylinders with dimension (height 300mm, diameter 150mm) at age (28 day) for every mix tested. The equation used for calculations was:

$$Es = [(S2 - S1) / (\varepsilon 2 - 0.000050)] \times 10^{-3} \quad \text{--------} \ (1)$$

where:

Es: Static modulus of elasticity, (GPa);

S2: Stress resulting to 40% of ultimate load, (MPa);

S1: Stress resulting to a longitudinal strain, ε 1, of 50 Millionths, (MPa);

ε 2: longitudinal strain created by stress S2.

3.5.3. Modulus of rupture test (Flexure strength test):

This test was done according to **(ASTM C 293-83)** procedure, by using concrete prisms with dimensions (100×100×400) mm. The average of two test specimens at age (28 day) for every mix were calculated.

$$Sc' = \frac{PL}{bd^2} \quad \text{--------} \ (2)$$

Where:

Sc' =Flexural strength (MPa).

P = Applied load (N).

L=Effective length (mm).

b= Prism width (mm).

d= Prism depth (mm).

3.5.4. Absorption test:

ASTM C140 was used to accomplish absorption test, the test included drying a specimen until it reached to constant weight at 105°C, it was waited and submerged in water for 48 hours, and the weight was recorded again. The growth in weight as a percent of initial weight is conveyed as a percent of absorption. The average of three test samples was considered at ages of 28 days.

3.5.5. Ultrasonic pulse velocity test:

ASTM C 597-02 was adopted to determine the pulse velocity, the specimens used were cubes of sizes (100x100x100) mm, and the direct method was implement. The results calculated by the following Equation:

$$V = L / T \quad \text{--------} \ (3)$$

Where:

V: Ultrasonic pulse velocity (Km/sec),

L: The path length (mm), and

T: The transmit time (µsec).

3.5.6. Fire resistance test (burning):

Burning resistance of 100 mm cubes at age 28 day were tested, by drying samples in electrical oven for 24 hour, then burning them with temperature (600, 800, 1000)ºC for ten minutes, and cooled gradually in air. Compressive strength of this samples was tested. This method was conducted by many researchers in literatures **(Akinwumi et.al. 2014)**.

4. Conclusions and discussions of test results:

4.1. Compressive strength test:

In construction, attainment high compressive strength is commonly favorable. This is not the unique aim, another aims must be taken into account such as exploring new construction material or new additions which are reasonable for environment. Also, saving the natural resources. From **Table 6** and **Fig.1** & **Fig2.** many observations may be detailed; in general when plastic waste was used, the compressive strength decreased noticeably, while when glass waste was used the reduction from the reference mix was enhanced at age of 28 days. When the two types merged, the compressive strength of mix C11 (contains plastic fibers with 2% and the glass with 15%) at age of 7 days increased about 48.8% if compared with mixs C3 which contains plastic fibers only with 2%, and it is about 1.11% more than mix C6 which contains glass with 15%. At age 28 day the compressive strength decreases about 14.33% compared with C3, and it is about 21.13% less than mix C6. On the other hand, the compressive strength of mix C12 (contains pieces of plastic bottle caps with 20% and glass with 15%) increased about 33.93% at age 7 days compared with C9 which contains pieces of plastic bottle caps only with 20%, and the difference between C12 and C6 which contains glass only with 15% is about 1.16%. At age 28 day the compressive strength increased about 30.77% compared with C9, and decreased about 7.32% compared with C6. From the above, it is clear that when both wastes were added the compressive strength was improved noticeably, the residual compressive strength was about (75% and 83%) with total ratio of wastes about 35% at age of 7 and 28 days, respectively, in mix C12, and (76 .7% and 70.5%) with total ratio of wastes about 17% at age of 7 and28 days, respectively, in mix C11. Moreover, the behavior of mixes strength related to wastes properties which involving low the abrasion resistance of crushed glass when compared with natural sand, the flat surface of plastic fiber caused slipping of fiber during loading, and the low hardness of plastic bottle caps compared with natural gravel.

Table 6. Compressive strength test results

No.		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
Compressive strength MPa.	7 days	25.02	11.297	12.888	9.3564	15.689	18.969	14.970	13.513	14.00	12.656	19.180	18.75
	28 days	30.82	19.005	21.753	15.952	23.460	27.554	21.87	20.170	19.53	16.166	21.730	25.538

4.2. Modulus of elasticity test results:

From observing **Table 7** and **Fig.3** modulus of elasticity decreased clearly in mixes that contain plastic fibers (i.e. C2, C3, C4), the difference in results of C2, C3 is very small, while the mix C4 with higher ratio of plastic fibers has the lowest value and it is about 18.504 GPa. less than the reference mix. In mixes involved waste materials as glass (i.e. C5, C6, C7), the values of modulus of elasticity are increased (i.e. compared with other mixes contain other types of waste materials), but they are less than the reference mix. The mix C6 has the higher value and it is about 4.636 GPa. less than the reference mix. The mix C11, in which, the plastic fibers and glass were added, modulus of elasticity is more than mixes that contain plastic fibers and less than mixes contain glass. It is about 10.179 GPa. less than reference mix. On the other hand, mixes with pieces of plastic bottle caps (i.e. C8, C9, C10), have high results

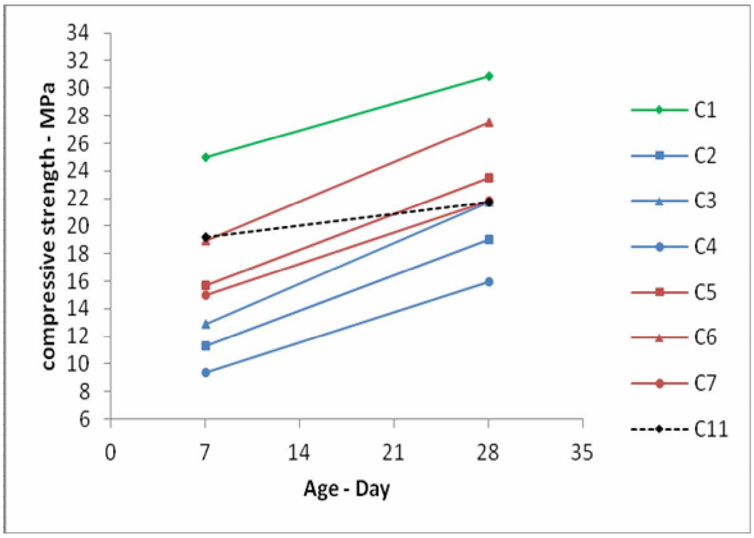

Fig 1. Compressive strength of mixes including plastic fibers and mixes including glass compared with the optimum merged mix and reference mix

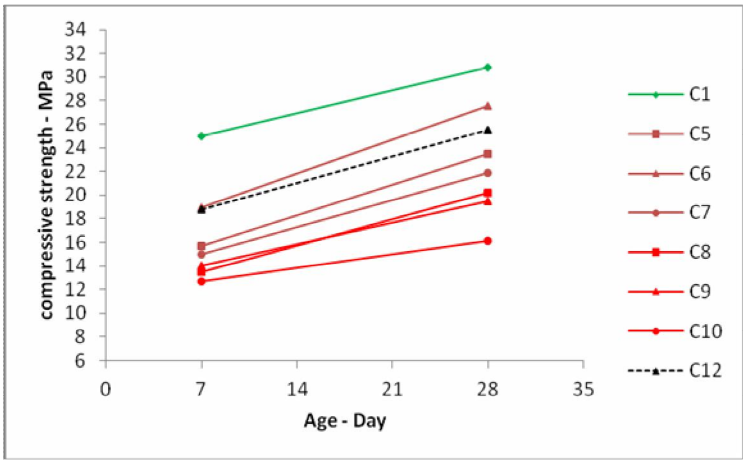

Fig 2. Compressive strength of mixes including plastic bottle caps and mixes including glass compared with the optimum merged mix and reference mix

but they also less than reference mix, and it is clear that the values of modulus of elasticity decreased with the increase of plastic bottle caps ratio. The variation between C8 and C9 is little and it is about 1.27 GPa. While C10 has the lowest value and it is about 7.068 GPa. less than reference mix. In mix C12 which, involves pieces of plastic bottle caps and the glass, the value of modulus of elasticity ranges between values of mixes comprise plastic bottle caps and that of mixes comprise glass. It is about 4.137 GPa. less than reference mix. In the light of the above discussion, flexibility of concrete mixes contains plastic fibers higher than other types. So it can be practical for highway pavement as stabilized base for flexible pavement.

Table 7. Modulus of elasticity results of all mixes

No.	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
Modulus of elasticity GPa.	28.64	16.028	16.373	10.136	21.467	24.004	19.615	27.28	26.01	21.572	18.461	24.503

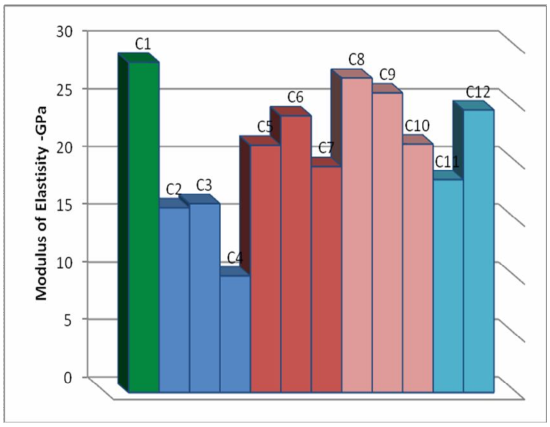

Fig.3. Modulus of elasticity of all mixes

4.3. Flexural strength test results:

Table 8 and **Fig.4** show evidently that mix C3 converges from reference mix, and has decreasing percentage of flexural strength about (12%). This decreasing percent is the lowest one among the other mixes. The mixes (C5, C6, C7) converges considerably from (C1) with decreasing percent (17.3%, 21.8%, 38.2%) respectively. Whereas mixs (C10, C9, C8) have maximum decreasing of flexural strength with percentages (78%, 71%, 69.8%) respectively. While flexural strength for mixes contained two types of wastes that includes the mix C11 is equivalence 72% from the reference mix. Also for the mix C12 is equivalence 51.7% from the reference mix.

It can be concluded that the effect of adding caps of bottles has great effect in decreasing flexural strength. This might be caused by the nature of rigidity and limited flexibility of this waste type.

Table 8. Flexural strength results

No.	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
Flexural strength MPa.	2.205	1.886	1.938	1.414	1.724	1.822	1.632	0.665	0.632	0.484	1.600	1.140

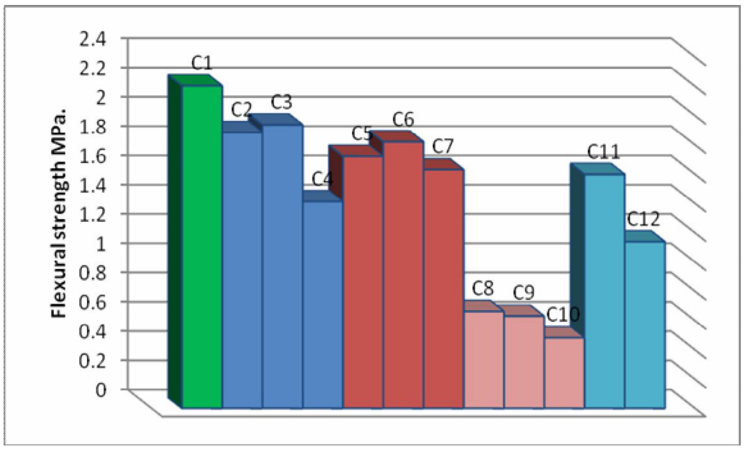

Fig.4: Flexural strength results

4.4. Absorption test results:

In **Table 9** and **Fig.5,** it can be seen that the mixes include plastic fibers and mixes include glass that has slight difference from the reference mix. While, in the mixes that contain pieces of bottle caps the absorption percent noticeably decreases, where in C8 the reducing percentage was 32.9%, that may be attributed to the reduction in the gravel content which leads to reducing absorption percent.

The mixes contains two types of wastes includes C11, C12 have absorption percentage about (93.3%-79.3%), respectively, with respect to reference mix.

Table 9. Absorption test results

No.	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
Flexural strength MPa.	7.981	8.221	7.854	8.502	8.547	7.560	7.793	5.352	5.391	5.913	7.450	6.332

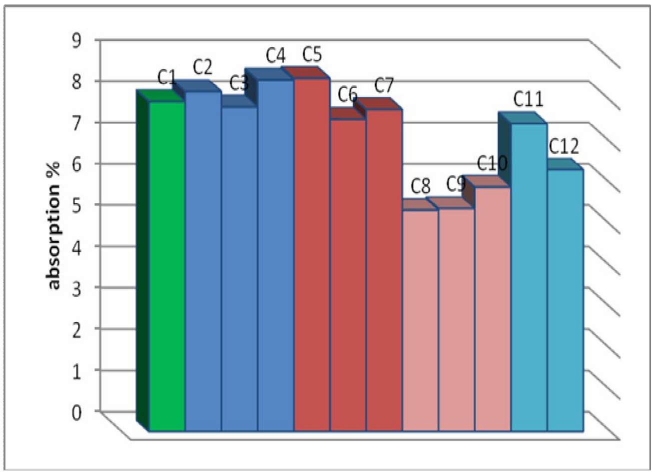

Fig.5. Absorption percentage for all mixes

4.5. Ultrasonic pulse velocity test results:

From **Table 10**, **Table 11** and **Fig.6** and **Fig.7**, It can be noticed that there is a difference between the actual compressive strength and predicted compressive strength from (UPV) test, this difference can be attributed to the effect of the addition of waste materials. It is noticeable also that the difference is large in some mixs and small in other one, this is due to the properties of every waste additions and its quantity. It can be concluded that the ultrasonic test cannot give good index about the compressive strength when plastic waste or glass waste was added to the mix due to the variance in rapidity of waves transmission through these materials. The predicted compressive strength of C6was nearest to its actual value, the variation is about 1.374 MPa.

Table 10. Ultrasonic Pulse velocity for all mixes

No.	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
UPV Km/sec.	4.39	4.24	4.305	3.75	4.17	4.368	4.368	4.138	4.306	4.458	4.208	4.337

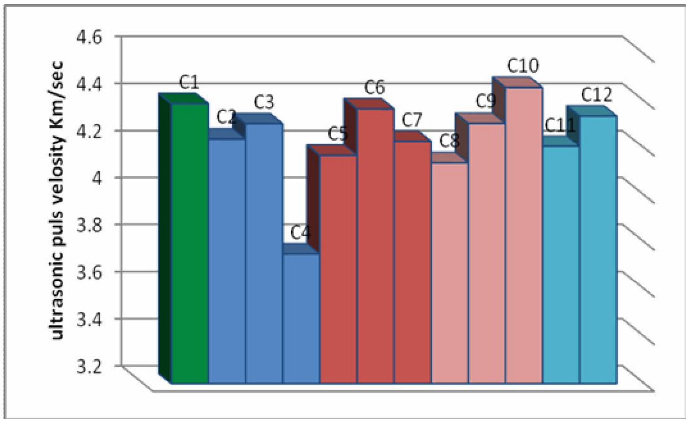

Fig. 6. Ultrasonic Pulse velocity for all mixes

4.6. Density test results:

Table 12. and **Fig. 8** show the densities of all mixes at several situations. It is clear that the behavior of all mix converged to that of reference mix when specimens were dried (i.e. the variance between dry and wet density), except the mixes contain pieces of bottle caps (C8, C9,C10) due to the low density of bottle caps compared with that of gravel. They have low variations, and about 5.35%, 5.39%, and 1.74% for C8, C9,and C10, respectively. This behavior has the same trend of absorption test. As it is known that the concrete has good resistance for high temperatures**,** but when wastes of plastic or glass are added to the concrete properties certainly will be changed. The density will be affected by increasing temperatures. Concrete densities had been slightly affected with increasing burning temperatures. The maximum reducing percentage of density is about 12.36% in C11, while the lowest one is about 2.36% in C10 at 600°C. At 800 ºC, the maximum reducing percentage is about 12.03% in C4, while the lowest one is about 5.24% for C10. While at 1000ºC, the maximum value is about 19.35% in C11, and the lower value is about 5.67% in C10. however others failed in oven.

Table 11. Actual and predicted compressive strength by ultrasonic test

Predicted Compressive Strength from (UPV) Test MPa.	Actual Compressive Strength MPa.	No.
29.268	30.8200	C1
26.727	19.0052	C2
27.854	21.75364	C3
19.882	15.95267	C4
25.673	23.46078	C5
28.929	27.55461	C6
26.673	21.8706	C7
25.158	20.1700	C8
27.876	19.5300	C9
30.584	16.16667	C10
26.269	21.73025	C11
28.408	25.53846	C12

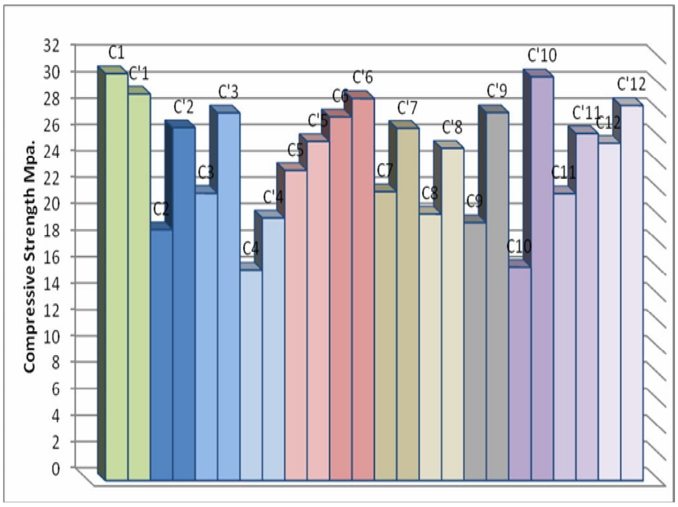

Fig. 7. Compressive strength test results of all mixes by ultrasonic test

Table 12. Density (Kg/m^3) of mixs at several situations

No.	Wet density	dry density	Burn density at 600°C	Burn density at 800°C	Burn density at 1000°C
C1	2368	2179	2124	2120.5	2102
C2	2305	2115.5	2059	2052	Failed in oven
C3	2276	2097.25	2077	2062	Failed in oven
C4	2301.333	2105.667	2030.5	2024.5	2019.5
C5	2273.833	2079.5	2074.5	2030	1971.15
C6	2376.667	2197	2138	2128	2102
C7	2284	2106	2084.5	2027.5	Failed in oven
C8	2317	2193	2169	2089	2080
C9	2291	2167.5	2140	2040	2032

C10	2117	2080	2067	2006	1997
C11	2353.333	2178	2062.5	2096.5	1898
C12	2333.833	2182.25	2139	2084	Failed in oven

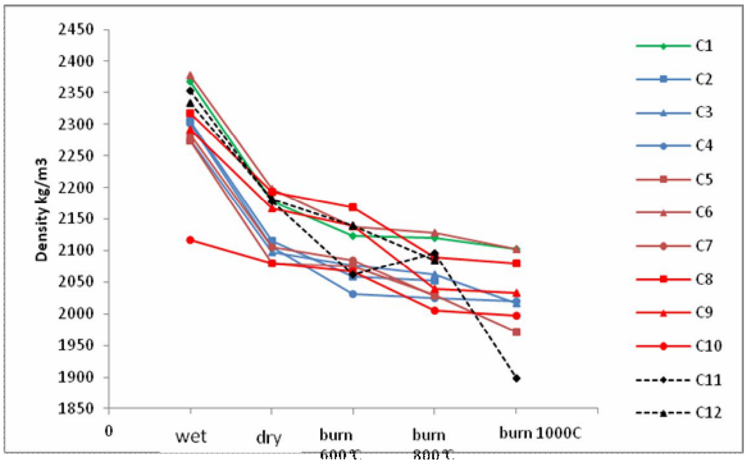

Fig.8. Density of mixes at several situations

4.7. Fire resistance:

Improvement resistance of concrete for fire is a reasonable factor, so many attempts have been done. From **Table 13** and **Fig.9**, it can be recognized that, when temperature has increased to 600°C the reduction in compressive strength in mixes C2, C3 and C4 more than reference mix C1. While, the reduction in other mixes less than C1. At 800°C, compressive strength reduction in mixes C5 and C6 has the same trend of the reference mix C1. But the reduction in others is more than that in the reference mix C1. When the temperature increases to 1000°C, the compressive strength deceases sharply and number of samples has been failed in oven. It can be concluded that the plastic fibers decrease the resistance of fire, while addition of pieces of plastic bottle caps and waste of glass in the mix individually or merged will improve fire resistance around 600°C. The compressive strength reduction is ascribed to the failure of interfacial connection because of dissenting volume variation between cement paste and aggregate (fine or/and course aggregate) through burning and the creation of rather weak hydration yields. Moreover, lack of moisture of the calcium silica hydrate causes shrinkage in cement paste **(Morley and Royels 1983)**.

Table 13. Compressive strength at various temperatures

No.	Compressive strength MPa. at temperature of:			
	22±2° C	600° C	800° C	1000° C
C1	30.82	5.21	5.36	2.3
C2	19.0052	4.82	3.3	0
C3	21.75364	3.6	2.4	1.27
C4	15.95267	2.52	1.81	1.62
C5	23.46078	9.03	5.05	2.19
C6	27.55461	12.99	5.2	0
C7	21.8706	7.26	3.11	0
C8	20.17	10.21	3.15	1.42
C9	19.53	10.64	2.63	1.02

C10	16.16667	7.79	1.5	0
C11	21.73025	8.56	2.11	0
C12	25.53846	7.32	2.25	0

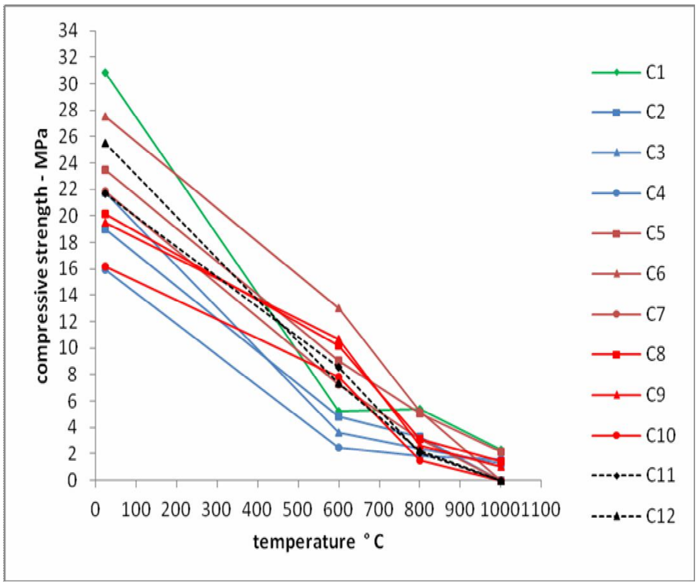

Fig.9. Compressive strength at various temperatures

5. Conclusions:

In accordance to the present study, the main conclusions can be reviewed as:

-When two types of wastes are added to the mixes (plastic fiber with glass or pieces of bottle caps and glass) the compressive strength is improved noticeably, the residual compressive strength about (75% and 83%) with total ratio of wastes about 35% at age of 7 and 28 days, respectively, in mix C12, and (76 .7% and 70.5%) with total ratio of wastes about 17% at age of 7 and28 days, respectively, in mix C11.

- In mix C12 which, involved pieces of plastic bottle caps and the glass, the value of modulus of elasticity ranges between values of mixes comprise plastic bottle caps and that of mixes comprised glass. It is about 4.137 GPa. less than reference mix. So, flexibility of concrete mixes contains plastic fibers higher than other types. So it can be practical for highway pavement as stabilized base for flexible pavement.

- The addition of plastic fibers has little effect on flexural strength while the effect of adding caps of bottles has great effect in decreasing flexural strength, while for mixes contain two types of wastes includes the mix C11 equivalence 72% from the reference mix. Also the mix C12 has equivalence 51.7% from the reference mix.

-The mixs contains two types of wastes includes C11, C12 and they have absorption percentage about (93.3%-79.3%), respectively, with respect to reference mix.

-The ultrasonic test cannot give good index about the compressive strength when plastic waste or glass waste is added to the mix. The predicted compressive strength of C6 is nearest to its actual value, the variation is about 1.374 MPa.

- The addition of plastic fibers decreases the resistance of fire, while addition of pieces of plastic bottle caps and waste of glass in the mix individually or merged will improve fire resistance around 600°C.

6. References:

Abbas, A.H., F. Al-Deen, M., and Abdulah, R.M., 2011, "Using of Glass Wastes as a Fine Aggregate in Concrete Mix" Tikrit Journal of Eng. Sciences, Vol. 18, No.3, September, pp.81-87.

Akinwumi,I. I., Olatunbosun, O. M., Olofinnade ,O. M., and Awoyera, P. O., 2014, "Structural Evaluation of Lightweight Concrete Produced Using Waste Newspaper and Office Paper", Civil and Environmental Research, Vol.6, No.7. www.iiste.org.

ASTM committee, C 78-84,1988,"Standard test method for Flexural Strength of Concrete".

ASTM C 469-02 ,2006,"Standard Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression".

ASTM committee,C 597-02, 2003, "Standard Test Method For Pulse Velocity Through Concrete".

British Standards Institution, B.S.1881,"Method for Determination of Compressive Strength of Concrete Cubes", Part 116:1983.

B.S. 5328. Part 2 ,1991,"Methods for specifying concrete mixes" British Standards Institution. 29 November.

B.S. 882-1992,"Specification for Aggregate from Natural Sources for Concrete", British Standards Institution, 8pp.

Byars, E., Zhu, H. and Morales, B. ,2004,"ConGlassCrete 1 Project. Final Report", United Kingdom, University of Sheffield, United Kingdom.

IQS, Iraqi Specification , No.5, 1984, (Specification of Portland Cement).

Ismail Z. Z. and AL-Hashmi E. A., 2008,"Use of Waste Plastic in Concrete Mix as Aggregate Replacement" Elsevier, Waste Management 28 (2008) 2041–2047 pp.2042-2046, Available online at www.sciencedirect.com.

Mathew,P., Varghese S., Paul T., and Varghese, E., 2013,"Recycled Plastics as Coarse Aggregate for Structural Concrete" International Journal of Innovative Research in Science, Engineering and Technology,Vol. 2, Issue 3, March, pp.687-690

Web Site: www.ijirset.com.

Mohammad F. Al-Deen Abbas Hadi Abbas Raed M. Abdulah,2011,"Using of Glass Wastes as a Fine Aggregate in Concrete Mix",Tikrit Journal of Eng. Sciences/Vol.18/No.3/September 2011, (81-87).

Morley,P.D.,and Royels, R.,1983,"Response of The Bond in Reinforced Concrete to High Temperature", Magazine of Concrete Research, Vol.83, No. 123, June, pp. 67-75.

Murali C.M.Vivek Vardhan, R.Prabu, Z.Mohammed Sadaquath Ali Khan, T.Aarif Mohamed and T.Suresh ,2012,"Experimental Investigation on Fibre Reinforced Concrete Using Waste Materials" International Journal of Engineering Research and Applications, Vol. 2, Issue 2, Mar-Apr, pp.278-283.

Park S.B. , lee B.C., Kim J.H.,2004,"Studies on Mechanical properties of concrete containing Waste Glass Aggregate ", Journal of cement and concrete Research , Vol 34 , 2004 , pp2181 – 2189.

Roz-Ud-Din Nassar, Parviz Soroushian,2012,"Strength and durability of recycled aggregate concrete containing milled glass as partial replacement for cement", Construction and Building Materials 29 (2012) 368–377.

Subramani , T., and Pugal, V.K., 2015,"Experimental Study on Plastic Waste as A Coarse Aggregate For Structural Concrete"International Journal of Application or Innovation in Engineering & Management (IJAIEM), Volume 4, Issue 5, May, ISSN 2319–4847, pp.144-152. Web Site: www.ijaiem.org Email: editor@ijaiem.org

TAHA, B; NOUNU, G., 2008,"Properties of concrete contains mixed colour waste recycled glass as sand and cement replacement", Construction and Building Materials; vol. 22; no. 5; 2008; pp. 713-720.

Venu Malagavelli and Neelakanteswara Rao Patura, 2011,"Strength Characteristics of Concrete Using Solid Waste an Experimental Investigation", International Journal of Earth Sciences and Engineering, Volume. 4, No. 6, ISSN 0974-5904.