Use PET Bottles Waste to Partially Substitute Sand in some Cement-based Mortar Applications

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مُسْتَخْلَص

إن كميات العوادم من زجاجات البولى إثلين ترفثلات تزداد عالمياً بانتظام. أما فى السودان فإن متوسط عوادم زجاجات البولى إثلين ترفثلات فى الاعوام 2003 - 2015 يساوى 38336 طن.

الهدف من الدراسة الحالية إعادة استخدام عوادم زجاجات البولى إثلين ترفثلات كبديل جزئى للرمل فى خلطات مونة الاسمنت فى شكل مكعبات الطوب، تغطية الجدران(البياض)، المونة و بذلك يمكن تقليل كميات النفايات وحماية البيئة من مخاطرها.

أحسن الظروف مع كمية البلاستيك 20% كانت كما يلى: كمية الماء 8%، كمية الصمغ 1%، حجم البلاستيك 4.76 مم. العينات التى تم تحضيرها لمختلف التطبيقات أعطت نتائج يمكن مقارنتها مع نتائج العينات القياسية فى إختبارات الضغط و قوة التفكك.

ABSTRACT

The amounts of PET bottles waste are steadily increasing globally. In the Sudan the PET bottles wastes average per year for the years 2003 -2015 amounts to 38336 ton.

This work aimed to reuse the PET bottles waste as a partial substitute to sand in mortar compositions in form of blocks, bricks, plaster, binding bricks mortar so as to reduce the amount of waste and save the environment from its hazards.

Best conditions for the tested variables with 20% PET amount are: 8% water amount, 1% gum amount and 4,76mm size of the PET material. The resulting products from the PET mortar compositions give comparable performance against both compressive and splitting strength.

Keywords: PET bottles, environment, sand, mortar

1. INTRODUCTION

Polyethylene terephthalate (PET) is a plastic resin and a form of polyester. PET is a polymer that is formed by polymerizing ethylene glycol and terephthalic acid [2].PET is commonly used to package soft drinks, water, juice, peanut butter, salad dressings and oil, cosmetics and household cleaners [2],[3].The PET bottle was patented in 1973 by chemist Nathaniel Wyeth [4], and since then the demand of PET for bottling keeps increasing day after day. There are Billions of bottles produced yearly, consider the following Table, as an example for these quantities [5]:

Table 1: PET Bottles Consumption in 2003(in millions)

USA	Europe	JAPAN	SUDAN
200350	111700	37500	15725

The following data shows the quantities consumed by the famous local companies for soft drink filling, provided that one ton produce 20000 bottles [6] and[7].

Table 2: Actual Local Consumption of PET Bottles in 2003

Company	PET consumed (Ton)	PET bottles (million)
Pepsi Cola 35	4200	84
Coca Cola 36	4310	86.2
Stim 37	2215	44.3
Others (estimated)	5000	100
Total	15725	314.5

The first PET bottle recycled in 1977 [4] and since then programs for PET recycling were developed and many institutions concerning PET recycling were established (e.g. PETCORE and NAPCOR). These activities were slow at the beginning because of the recycled PET low value and the large number of bottles required for making up significant quantity by weight. One ton of PET is worth approximately £120.00 (52800 SD), and it takes only 20,000 bottles to make one ton [3].Table 3 shows the amounts of RPET bottles required for producing different products [8].

Table 3: Some Uses for RPET

Bottles(567	Product
14	XL T –
14	One
63	Sweater
14	Ski
85	Fiberfill

2. MATERIALS AND METHODS

The work has been divided into:

1. Preparation of the test samples.
2. Test the prepared samples for important mechanical properties, namely compressive and splitting strength.
3. To use the sample mixtures in different mortar applications.

Samples were prepared and tested in accordance to ASTM standards [9], in the Civil Engineering laboratories at Sudan University for Science and Technology.

Samples were prepared using the following procedure:

PET plastic bottles were collected from house holds domestic and from Canteens disposables then crushed and sieved into three different sizes (9.5mm, 6.35mm, and 4.76mm). The cement mortar composition was chosen according to the standard cube used for molding (10 cm); the standard cube recipe is shown in Table 4.

Table 4: Composition of Standard Mortar Recipe

Constituent	Cement	Sand	Water
Percent	22.5	67.5	10
Weight (g)	543	1629	241

Three specimens were prepared for each experimental set. The produced cubes are released after 24 hours and cured in a water tank for 7 days at ambient temperature.

Samples that had been prepared have then been tested for the compressive and splitting strength using compression and splitting testing machines.

3. EXPERIMENTAL RESULTS

The results for the experimental samples are shown in Tables 5. to 7. the strength readings in kN for fixed area 100 cm^2.

Table 5: Effect of PET %of whole sand in compressive and splitting strength

Sample	Variable1 PET %	Average compressive strength (kN)	Average splitting strength (kN)
S1	0	185	92.33
S2	20	175	83
S3	25	168	51.66
S4	27	153	50.66
S5	30	125	41.66

Table 6: Effect of PET size in compressive and splitting strength

Sample	Variable 2 PET size in mm	Average compressive strength (kN)	Average splitting strength (kN)
S6	4.76	184.66	75
S7	6.35	172.33	55
S8	9.50	168	41

Table 7: Effect of water amount in compressive and splitting strength

Sample	Variable 3 Water %	Average compressive strength (kN)	Average splitting strength (kN)
S9	8	186	87
S10	10	173	60
S11	12	137	39

4. DISCUSSION OF THE RESULTS

Effect of PET percent in compressive and splitting strength is shown in Figure 1. As could be anticipated the effect of PET as a filler on all mortar mixtures showed lower compressive strength than the reference mixture. This is clearly because of the lack of adhesion between the soft plastic material and the mixture components.

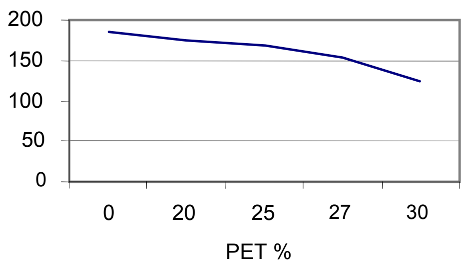

Figure 1: Effect of PET % in the cement composite compressive strength

The same effect of the PET % is applied to the splitting strength; this is shown in Figure 2.

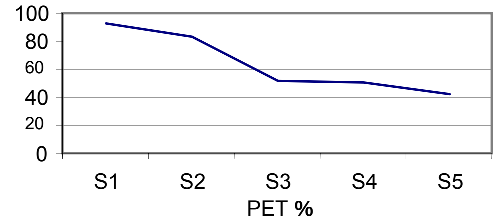

Figure 2: Effect of PET % in the cement composite splitting strength

The effect of PET % on both compressive and splitting strength is shown in Figure 3.

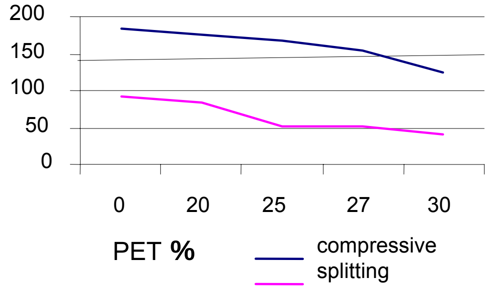

Figure 3: Effect of PET % in the cement composite strength

Effect of PET material size in compressive and splitting strength is shown in Figures 4 and 5.

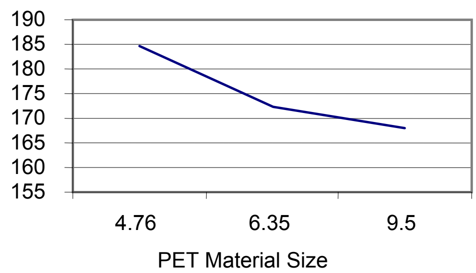

Figure 4: Effect of PET material size in the cement composite compressive strength

the lack of adhesion between the soft plastic material and the mixture components.

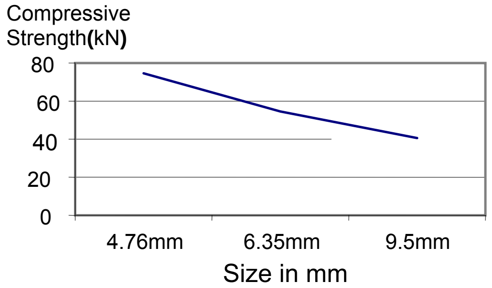

Figure 5: Effect of PET material size in the cement composite splitting strength

This result is logical because the smaller sizes are more uniform with mortar components and thus homogeneous mixtures can be made. Entrapment of the loosely placed PET is more effective in case of smaller sizes and this will enhanced the overall strength. Figure 6 shows the effect of material size on both compressive and splitting strength.

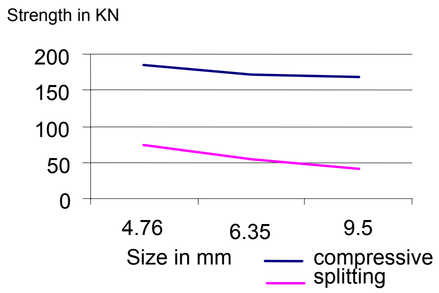

Figure 6: Effect of material size in the cement strength

Effect of Water amount in compressive and splitting strength is shown in Figures 7 and 8.

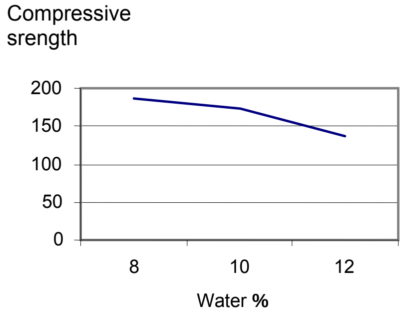

Figure 7: Effect of water amount in the cement composite compressive strength

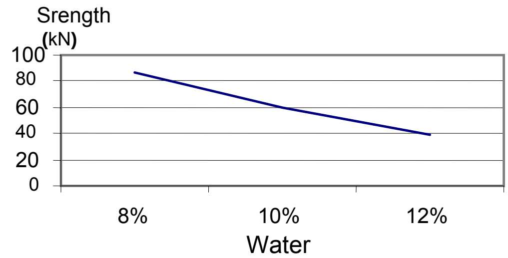

Figure 8: Effect of water amount in the cement composite splitting strength

Provided that the standard water amount is 10 % which is based on the amount of sand in the mortar mixture to make optimum mixture properties, the reverse relationship between the amount of water and the compressive strength is obvious.

The effect of water amount on compressive and splitting strength is shown in Figure 9

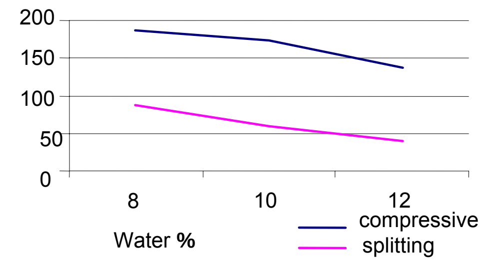

Figure 9: Effect of water amount in the cement composite strength

5. CONCLUSION

The followings are some conclusion:

1. The use of post – consumer PET bottles waste to substitute sand in mortar compositions for many applications (blocks, bricks, plaster and bricks binding mortar) is quite possible.
2. The effect of the amounts of PET in the mortar mechanical properties is very obvious with reversed relationship. The 20% PET amount gives the best mechanical

performance results compared to standard amount.

3. The effect of the material size and amount of water in both compressive and splitting strength of the mortar is noticeable, and the reversed relationship trend is also produced. However, the 4.76mm size and 8% water amount being the best conditions for these variables that give comparable mechanical performance.
4. Environmentally, PET bottles waste will cause sever problems, so using these wastes in bulky amounts will keep the environment clean. The use of PET wastes in cement based applications will give a good chance to get rid of this waste in useful way and to secure the environment from their hazards.

6. RECOMMENDATIONS

The followings are some recommendation:

1. To study other types of plastic materials for the same applications because some of them might gave better performance.
2. To design proper methods for collection in order to minimize the cost.
3. To study the thermal effects of using PET as filler in the cement based products.
4. To study the effect of Gum to facilitate the bonding between the different components so as to enhance the mechanical properties.

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