TAM METİN KİTABI



7. ULUSLARARASI
19 MAYIS YENİLİKÇİ BİLİMSEL YAKLAŞIMLAR KONGRESİ
19-20 Mayıs 2022, Samsun

EDİTÖRLER

Asst. Prof. Dr. Ali Mohammadi

Dr. Hakan GÖKGÖZ

ISBN: 978-625-8377-87-37

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IKSAD Yayınevi - 2022©

Yayın Tarihi: 10.06.2022
ISBN: 978-625-8377-87-37

KONGRE ID

KONGRE BAŞLIK

7. ULUSLARARASI 19 MAYIS YENİLİKÇİ BİLİMSEL YAKLAŞIMLAR KONGRESİ

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Mayıs 19-20, 2022/ Samsun,TURKEY

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7. ULUSLARARASI

19 MAYIS YENİLİKÇİ BİLİMSEL YAKLAŞIMLAR KONGRESİ

19-20 Mayıs 2022, Samsun

SÜRDÜRÜLEBİLİR BİR GELECEK İÇİN BETON KARIŞIMLARINDA PLASTİK ATIK MALZEMELERİN KULLANIMI

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ÖZET

Kentleşme ile birlikte her geçen gün artan nüfusun tüketim ihtiyaçlarının karşılanmasında atık malzeme kullanımı oldukça yaygın hale gelmiştir. Günümüzde endüstrileşme ve hızla gelişen teknolojiye paralel olarak, endüstri ve sanayi sektöründe hammaddelerin üretimi esnasında ve sonrasında ortaya çıkan atık malzemeler çevre kirliliği açısından büyük tehlikeler oluşturmaktadır. Doğada başıboş bir şekilde bırakılan atık malzemelerin geri dönüştürülerek çevre kirliliğinin azaltılması ile ilgili çalışmalar devam etmektedir. Atık malzemelerin geri dönüştürülmesi sonucu çevre kirliliğinin önemli oranda önlenebilmesinin yanında atık malzemelerin yeniden kullanımıyla ekonomiye kazandırılması mümkündür. Böylece atık malzemelerin kullanıldığı daha maliyeti düşük ve çevre dostu malzemeler üretebilmek mümkün olmaktadır Atık malzemelerden ekonomik fayda sağlayabilmek için farklı sektörlerde kullanılabilirliği son yıllarda üzerinde yoğun bir şekilde çalışılan önemli konulardan birisidir. Atık malzemelerin geri dönüştürülerek yeniden ekonomiye kazandırılması ile ilgili çalışılan en yaygın uygulama alanlarından biriside inşaat sektörüdür. Günümüzde atık malzemelerin beton karışımlarına eklenerek betonun dayanım ve durabilite özelliklerinin iyileştirilmesi ile ilgili çalışmalar yoğun bir şekilde devam etmektedir. Günlük hayatta üretim sonucu en yaygın olarak kullanılan atık malzemelerden birisi de plastiklerdir. Plastikler parçalanması ve doğada kaybolması en zor olan atık malzemelerdir. Bu tür atıkların depolanarak kontrol altına alınması veya yok edilerek çevreye verdikleri zararın en aza indirilmesi büyük önem taşımaktadır. Hafif yapı malzemeleri üretmek için atık plastik malzemeleri agrega olarak kullanarak geri dönüştürmek mümkündür. Ayrıca beton karışımlarına belirli çap ve uzunlukta kısa kesilmiş lifler olarak katılarak betondaki çatlakları sınırlamak için etkin bir şekilde kullanılmaktadır. Bu çalışmada atık polietilen tereftalat (PET) katkılı betonların basınç ve eğilme dayanımları incelenmiştir. Çalışma sonucunda, sade betonun basınç ve dayanım özelliklerini iyileştirmede PET atıklarının bir miktar etkili olduğu görülmüştür.

Anahtar Kelimeler: Beton, atık plastik, basınç ve eğilme dayanımı

7. ULUSLARARASI

19 MAYIS YENİLİKÇİ BİLİMSEL YAKLAŞIMLAR KONGRESİ

19-20 Mayıs 2022, Samsun

USE OF PLASTIC WASTE MATERIALS IN CONCRETE MIXES FOR A SUSTAINABLE FUTURE

ABSTRACT

With urbanization, waste materials have become quite common in meeting the consumption needs of the increasing population. Today, in parallel with industrialization and rapidly developing technology, waste materials that occur during and after the production of raw materials in the industry and industry sector pose great dangers in terms of environmental pollution. Studies on reducing environmental pollution by recycling waste materials left unattended in nature continue. As a result of the recycling of waste materials, environmental pollution can be prevented significantly, and it is possible to bring them into the economy by reusing waste materials. Thus, it is possible to produce more cost-effective and environmentally friendly materials using waste materials. The usability of waste materials in different sectors is one of the critical issues that have been intensively studied in recent years. One of the most common application areas for recycling and re-introducing waste materials to the economy is the construction sector. Today, studies on improving concrete's strength and durability by adding waste materials to concrete mixtures continue intensively. One of the most widely used waste materials resulting from production in daily life is plastics. Plastics are the most challenging waste materials to break down and disappear in nature. It is of great importance to store such wastes under control or minimize the damage they cause to the environment by destroying them. It is possible to recycle waste plastic materials by using them as aggregates to produce lightweight building materials. In addition, it is effectively used to limit cracks in concrete by adding short-cut fibers of a specific diameter and length to concrete mixes. This study investigated the compressive and flexural strengths of waste polyethylene terephthalate (PET) added concretes. As a result of the study, it was seen that PET wastes were somewhat effective in improving the compressive and strength properties of plain concrete.

Keywords: Concrete, waste plastic, compressive and flexural strength.

I. INTRODUCTION

The disposal of waste materials is one of the most critical problems of the current century. Approximately 381 million tons of plastic waste are produced annually globally, and only 10% of these wastes can be recycled [1,2]. Today, plastic materials are widely used in many fields such as packaging, automotive, electronics, and furniture. With the widespread use of plastic materials, waste has increased significantly. Plastics are artificial materials that can be easily shaped. It is possible to recycle plastic materials such as polyethylene terephthalate (PET), high-density polyethylene, low-density polyethylene, polyvinyl chloride, polypropylene and polystyrene. However, melting and reprocessing waste plastics during recycling processes is very costly. Therefore, not all of the waste plastics can be recycled. Among the plastics, PETs are frequently used in many places such as packaging, soft drink bottles, mineral water bottles,

and food packaging due to their lightness, high strength, hardness, resistance to heat, and chemical attacks [3-6]. However, the wastes generated by the excessive use of these materials in recent years have started to cause severe problems in terms of the environment. In addition to many positive features, plastic materials can remain in nature for a long time, as they are biodegradable. In recent years, alternative solutions have been sought to reduce the environmental impact of plastic waste and reduce storage costs. It is thought that the use of plastic waste in concrete will make significant contributions to reducing the use of natural resources and preventing adverse environmental effects [7-11]. When the studies conducted to investigate the impact of waste plastic materials on concrete properties are examined, it has been determined that there are conflicting results regarding the effects of plastic waste use on concrete strength properties. While some researchers stated that plastic wastes had a positive impact on the compressive, tensile, and flexural strength properties of concrete, others reported that they decreased the mechanical properties of concrete [12-16]. Therefore, within the scope of this study, the effects of waste plastic additives at different rates on the strength and workability properties of concrete were investigated. Kangavar et al., [12]; In their studies, they stated that PET wastes replaced by 10% with fine aggregate improve the strength, and if it is above this rate, it can affect the strength negatively. Hamdan [13], in his study investigating the strength properties of concrete with plastic additives, produced concretes by replacing coarse aggregates with e-plastic waste at the rate of 5%, 10%, 15%, and 20% by weight. As a result, he stated that 5% waste plastic additive increased the concrete strength by 29.86%. They reported that the use of waste plastic above this rate significantly reduces the strength. Hameed et al., 2019 [14] produced concretes by replacing plastic wastes with cement at 1, 3, 5, 7, and 10% by weight. They stated that the compressive strength of the concrete decreased as the waste plastic additive ratio increased. However, they determined that the waste plastic additive caused an increase in the flexural strength of the concrete. The highest flexural strength increase was obtained with 37.96% and 7% waste plastic waste additives. According to Batayneh et al. [15], plastic wastes were replaced by fine aggregate by 5% and 20%, and the compressive strength of concrete decreased by 23% and 72%, respectively. Vali and Asadi [16], in their study investigating the tensile strength of PET plastic bottle wastes replaced with fine aggregates in specific proportions, stated that the use of PET waste up to 10% increases the tensile strength. In comparison, the use of 15% and 20% waste causes a decrease in strength.

II MATERIAL AND METHOD

2.1.Materials

CEM I 42.5 R cement, aggregate, and waste plastic are used as binders when producing waste plastic added concrete. The coarse aggregate used is 14 mm, and the fine aggregate size is 2 mm. In addition, Polyethylene terephthalate (PET) waste collected from the municipal landfill was used in the study. PET wastes are purified from their impurities before being added to the concrete mix and then cut into 1-1.5mm thickness and 1-4mm dimensions in a particular cutting machine. The image of the waste plastics used in the study is given in Figure 1. The physical and chemical properties of the cement used in the study are shown in Table 1.



Fig.1. The appearance of waste plastics used in the study

Table I. The physical and chemical properties of cement

Chemical analyses		Physical analyses	
Composition			
Al_2O_3 (%)	5.0	Specific surface area m^2/kg	315
CaO (%)	63.6	initial setting time (min)	160
Fe_2O_3 (%)	3.7	Final setting time (min)	193
MgO (%)	2.8	Mechanical analyses	
SO_3 (%)	2.5	Compressive Strength	
Na_2O (%)	0.2	3 day (MPa)	20.0
K_2O (%)	0.5	7 day (MPa)	26.1
SiO_2 (%)	19.2	28 day (MPa)	35.3
Loss ignision	1.65		

2.2. Experimental Program

The study investigated the effects of waste plastic additives on concrete's physical and mechanical properties. For this purpose, 6 different concrete mixes were prepared, one of which is control and five of which are plastic waste additives. The materials and proportions used in the preparation of waste plastic additive concrete mixtures are given in Table II. Waste plastics were added to the concrete mixes by replacing them with fine aggregate at 5%, 10%, 15%, 20%, and 25% by weight. The amount of cement, coarse aggregate, and water were kept constant in all concrete mixtures. The concrete mixes were held in the curing pool until the test day. Properties such as unit weight, workability, the compressive, tensile, and flexural strength of the prepared concrete samples were determined.

Table II. Mix design of concrete

Mix Code	C (kg/m^3)	WPL (Kg)	W/C	Fine Agr. (kg/m^3)	Coarse Agr. (kg/m^3)
Control	380	0	200	625	1250
WPL-5	380	31	200	594	1250
WPL-10	380	62	200	563	1250
WPL-15	380	93	200	532	1250
WPL-20	380	125	200	500	1250
WPL-25	380	156	200	469	1250

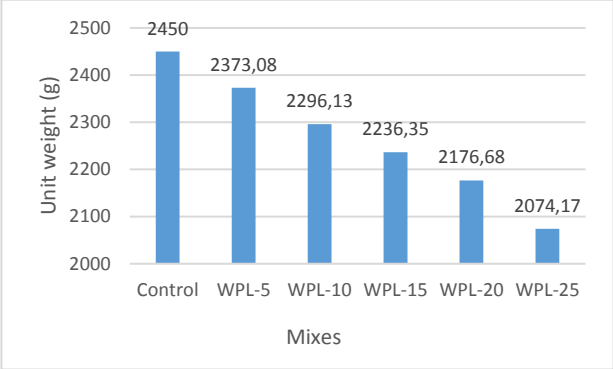
2.3. Method

Properties such as workability, unit weight, compressive strength, bending strength, and splitting tensile strength of the concrete produced by using waste plastic additive were determined. According to the TS EN 12390-2[17] standard, the slump test was carried out to assess the workability of waste plastic added to fresh concrete. [17]. The hardened concrete was investigated unit weight test following TS EN 12350-6 [18]. This study conducted the compressive strength test following TS EN 12390-3 [19] using cubic samples of 150 mm at the 7, 14, 28, and 56 days. Cubic specimens of size 150 mm were used for splitting tensile strength tests according to TS EN 12390-6 [20]. The flexural strength test by TS EN 12390-5 [21] was also conducted using prismatic specimens with 100 mmx100 mmx500 mm.

III. DISCUSSION

3.1. Unit weight

Unit volume weight values of waste plastic added to concrete are shown in Fig.2.



It was observed that the unit volume weight values of the concrete decreased with the increase in the waste plastic additive ratio. This can be explained by the fact that the density of plastic waste is lower than the density of fine aggregate.

3.2.Workability

The slump spread test results of concrete are given in Fig.2. Many factors such as the particle size and shape of the material used and the water-cement ratio used in the mixture can affect the workability of the concrete. In this study, it was observed that the workability of the concrete decreased with the increase in the waste plastic additive ratio. Similar findings have been reported in other studies. [Ochi, 2007].

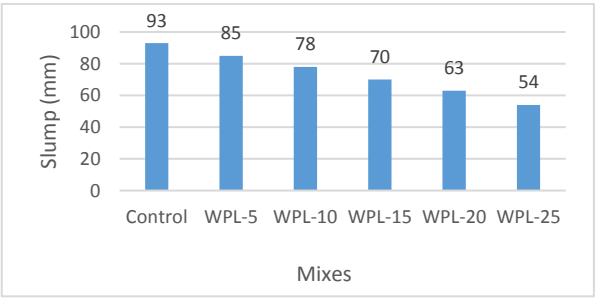


Fig. 3. The slump values of control and waste plastic added concrete

3.3. Compressive Strength

Compressive strength test results of waste plastic added to concrete are given in Table III and Figure 4.

Table III. The compressive strength results of control and waste plastic added concrete

Mix Code	Compressive Strength (MPa)			
	7 day	14 day	28 day	56 day
Control	22.4	30.9	39.2	41.7
WPL-5	21.2	28.2	38.2	40.1
WPL-10	20.2	27.6	35.1	37.2
WPL-15	19.4	26.7	33.3	35.0
WPL-20	18.9	25.8	32.0	32.9
WPL-25	17.2	23.9	28.9	30.0

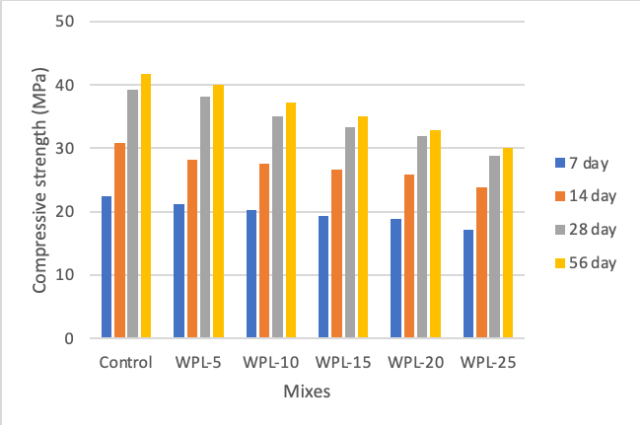


Fig.4. The compressive strength of control and waste plastic added concrete

It has been determined that the increase in the plastic additive ratio decreases the compressive strength of the concrete. When Table VII was examined, it was determined that 5%, 10%, 15%, 20%, and 25% waste plastic additives decreased the 28-day compressive strength of the concrete by 2.55%, 10.46%, 15.05%, 18.37, and 26.28%, respectively, compared to the control concrete. The waste plastic additive reduces the concrete strength because the plastic does not adhere well to the cement paste due to its hydrophobic structure. In addition, it is thought that the weak bond between the plastic added into the concrete matrix and the cement is effective in reducing the concrete strength [12-15].

3.4. Flexural Strength

Flexural strength test results of waste plastic added concrete are shown in Figure 5. It was determined that the flexural strength of the concrete decreased with the increase in the plastic additive ratio in the concrete.

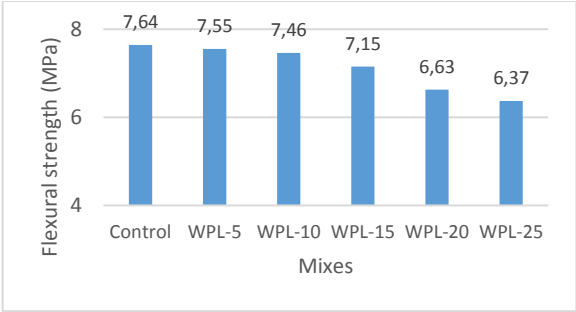


Fig. 5. The flexural strength of control and waste plastic added concrete

Fig. 5, it was determined that 5%, 10%, 15%, 20% and 25% waste plastic additives reduced the 28-day flexural strength of concrete by 1.18%, 2.36%, 6.41%, 13.22% and 16.62%, respectively, compared to the control concrete. The decrease in flexural strength with the increase in the plastic waste additive ratio in the concrete is due to the inadequacy of the plastics in limiting the cracks in the concrete matrix.

3.5. Splitting Tensile Strength

The splitting tensile strength test results of waste plastic added concrete are given in Fig. 6. It was determined that the splitting tensile strength of the concrete decreased with the increase of the plastic additive ratio in the concrete.

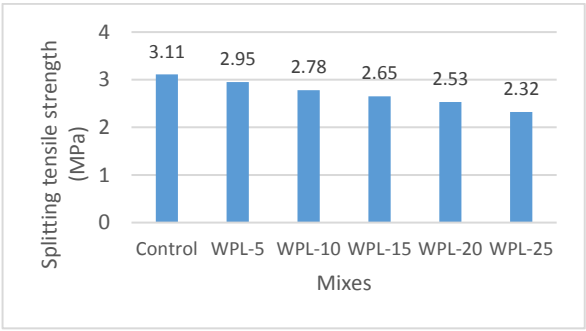


Fig. 6. The splitting tensile strength of control and waste plastic added concrete

When Figure 6 is examined, it was determined that 5%, 10%, 15%, 20%, and 25% waste plastic additives reduced the 28-day split tensile strength of concrete by 5.14%, 10.61%, 14.79%,

18.65%, and 25.40%, respectively, compared to the control concrete. The decrease in tensile strength in splitting is the weak bond between cement and plastic waste and the low strength of plastic waste. These findings are similar to those of other investigators [12-15].

IV. ConclusIon

The addition of plastic to the concrete reduced the unit weight of the concrete, and it was determined that the highest decrease was in the concrete with 25% plastic replacement. With the addition of plastic to the concrete, it has been determined that the concrete's compressive, flexural, and tensile strength properties also decrease. However, considering the benefits of using waste plastic in concrete at low volumetric ratios, such as preventing environmental pollution and obtaining lower-cost concrete, it is necessary to encourage its use.

Acknowledgment

This study was supported by the Department of Scientific Research Projects (BAP) of the University of Van Yüzüncü Yıl, Van, Turkey, with the project ID FYL-2022-10047. We thank the University of Van YYU BAP unit for supporting this study.

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