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Sustainable Enhancement of Concrete by Using Waste-Plastic Food - Packages as Economic and Environmentally Friendly Fibers, A Review.

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Abstract

Among possible solutions for a cleaner environment is reduction of using non-biodegradable materials to reduce the waste. Solid plastic waste is considered the most important kind of waste in the world, due to its non-decadence and its low organic decomposability. Therefore, it was advised to use this waste as reinforcing materials for concrete units, as it was used as a substitute for moraine in certain proportions and also as reinforcing fibers for concrete. This paper is a review of research investigations that focused on and highlighted the improvement of concrete by recycling waste-plastic food-package and using them as reinforcing fibers for concrete specimens. The impact of plastic waste fibers (PWFs) on workability, compressibility resistance, tensibility resistance, bending resistance, and elastic modulus are demonstrated. It has been noted that the fresh characteristics of concrete decline when mixing plastic fibers with concrete mixtures, while hardened characteristics could be improved by utilizing specific proportion of these fibers.

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Introduction

A daily use-up of large quantities of plastic-polymers is normally accompanied by huge quantity of waste, therefore, it must be controlled in order to avert contamination of the land and water resources. In the past, plastic-waste (PW) is either dumped in a landfill or burned [1] & [2]. Presently, this solution is unacceptable in developed states and the reason is plastics are non-decadence and combustion will lead to the release of toxic gases, which in turn pollute the air. Dependently, there is an essential requirement to recycle the waste to preserve the environment from pollution [3] & [4]. Nowadays, improving living status around the world wants to focus on environmental matters in all fields, including the building fields. The goal of the building's environmentally technical solutions is to participate in the improvement of environmental-buildings by utilizing practical with design solutions, to decrease energy utilizing-up in the industry of building materials, decrease embodied energy, and reduce cost and environmental effects. [3],[4], and [7]. Environmental goodness inside buildings is a substantial health agent and hence, it is essential to discover environmental materials for the building processes [8]. The aim of producing environmental materials is related to improving materials management, reducing waste, and gaining materials with appropriate physical and mechanical features [9] & [10]. Wastes of plastic could be utilized in many civil engineering applications like; Recycling plastic-waste and as an alternative to aggregates in specific proportions in concrete, attributed to its economic and environmental advantages [11], [12], [13], and [14]. Moreover, plastics could be utilized to enhance resistance and durability characteristics in pavement and road construction, as an insulator in constructions, as a fastener for bulk materials, and as a raw material for textile manufacturing [15], [15], [17], and [18]. Nearly three hundred twenty-two million tons of plastic products have been manufactured worldwide. In previous five years, this production has been raised to three hundred thirty-five million tons. From the aforementioned statistical data in 2016, 31.1% of the waste has been recycled, 41.6% has been utilized for capacity recovery, and 27.3% has been buried. Moreover, the production of plastic is expected to be multiple by 2035, and multiple quadruple by 2050 [16], [19], and [20]. In previous nine years, approximately two hundred and eighty million tons of PW have been generated worldwide, and this number rises every year, from this quantity, one hundred thirty million tons have been either buried or reused and the residual one hundred and fifty million tons have been considered as waste materials [21]. The large quantity of Polyethylene Terephthalate (PET) bottles leads to more waste materials, and this waste causes environmental issues. In the last years, most authors were concentrated on recycling Pw to solve the problems mentioned above [22], [23], and [24]. Plastic production was raised by 500% in the past 30 years worldwide, while plastic used-up has raised by 50% in the past decenniums. In 2050, worldwide plastic manufacturing is valued at five hundred and eighty million tons/year [25] & [26].

The main aim of this work is to prepare a review paper that can be considered as a guideline for authors whose interested in utilizing plastic waste as an environmentally friendly fiber to improve the various characteristics of concrete.

1. Types of Plastics

In general, plastics partitioned into two groups thermoplastics and thermosets. The first group is characterized by the fact that the plastics in it can be melted during exposure to temperature and hardened during cooling [20] & [27]. There are different types of plastics in this group like: Polypropylene (PP), Polystyrene (PS), Polyethylene terephthalate (PET), Polyvinyl chloride (PVC), Low-density polyethylene (LDPE), and High-Density Polyethylene (HDPE) [20], [17], and [27]. Second group is characterized by the fact that the plastics in alter chemically during exposure to temperature, thus, this kind of materials could not be reformulated or softened during when heating. this group include unsaturated polyesters, phenol, epoxy, polyurethanes, melamine, and etc. [20] & [27].

PET is considered one of the widely utilized plastics in different applications like soft drink bottles, raw materials for puff bottles, food-packaging, etc. [28].

2. Utilize of PW as a Fiber Reinforcement

Many materials like recycled PW, tire, carpet, glass, wood, and cellulose are given great toughness, electrical and thermal resistance, chemical resistance, and lightweight features pending use. Thus, these enhanced features will enable alteration and manufacturing of composite sustainable materials [47]. The target of manufacturing composite sustainable materials such as fiber reinforced concrete (FRC) fabricated from recycled materials is to enhance the tensile resistance, ductility and electro-thermal of the concrete mixtures. Four principal kinds of fibers are produced to prepare FRC such as: glass fibers (GF), steel fibers (SF), natural fibers and artificial fibers [7] & [10]. Moreover, plastic fibers are portion of artificial fibers, it could be observed in various formulations like (PP), (PS), (PET), (PVA), (PVC), (LDPE), and (HDPE), or hybrid fibers (a composite of two fibers). Plastic fibers could be manufactured naturally-fresh or recycled [29] & [31]. PET fibers could be utilized in concrete in different proportions and have a great influence on concrete characteristics as mechanical and physical characteristics. Typical appearance and size of fabricated waste plastic are demonstrated in figure 1.

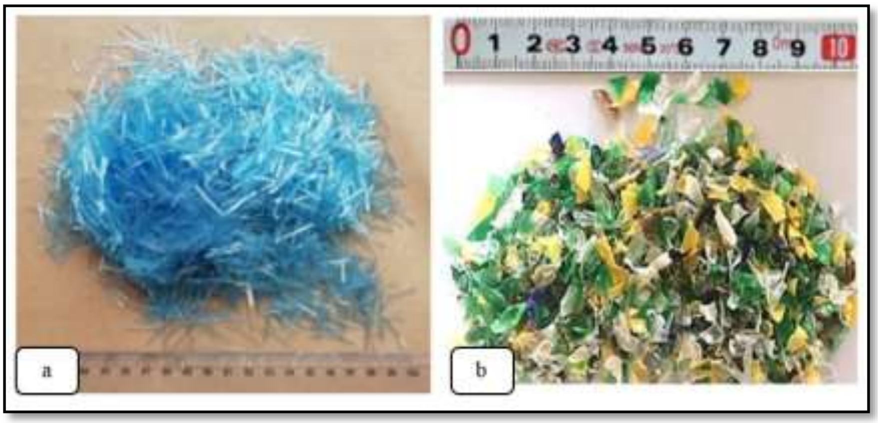

Figure 1: Typical appearance of (a) plastic waste fibers, [11] (b) plastic waste aggregates [12].

3. Fresh Characteristics

The utilization of larger fibers influences the viscosity of the concrete mixture. The fibers cut the consistency of the mixture. In addition to the traditional components of concrete, the fibers take a large ratio of the cement paste because the increment of the surface area. The presence of large fibers impedes the flow because they form a structure that clings to the coarse and fine particles of the mixture and reduce the workability of the mixture. Concrete workability is affected by two parameters the type and fraction ratio of fibers. An experimental investigation on the concrete workability for metalized plastic reinforce concrete (MPRC) was conducted by [30]. Concrete mixture containing 438kg cement, 669 kg aggregates (20 mm), 446 kg aggregates (10 mm), 638 kg sand, and 0.45 W/C ratio was investigated. The investigation shows that the addition of MPFs with volume fraction (0.5, 1, 1.5, and 2) % led to decrease the slump of concrete by (5, 8, 12, and 16) %. Many investigations of the effect of the workability of MPRC for several authors are illustrated in table 1. An investigation was conducted to study the workability of high-resistance concrete, its mixture contained polypropylene and steel fibers. the volume fraction of polypropylene fibers was (0.15, 0.3, and 0.45) % with a length of 12 mm. The study shows that values of slump reduced with increasing the ratio of the fiber [31]. The fresh properties of the concrete which reinforced with high-density polyethylene (HDPE) plastic fibers having 2 diameters and (0.4, 0.75, and 1.25) % of MPFs ratio were investigated. The study shows that the values of slump decreased significantly with increasing the fiber ratio [32].

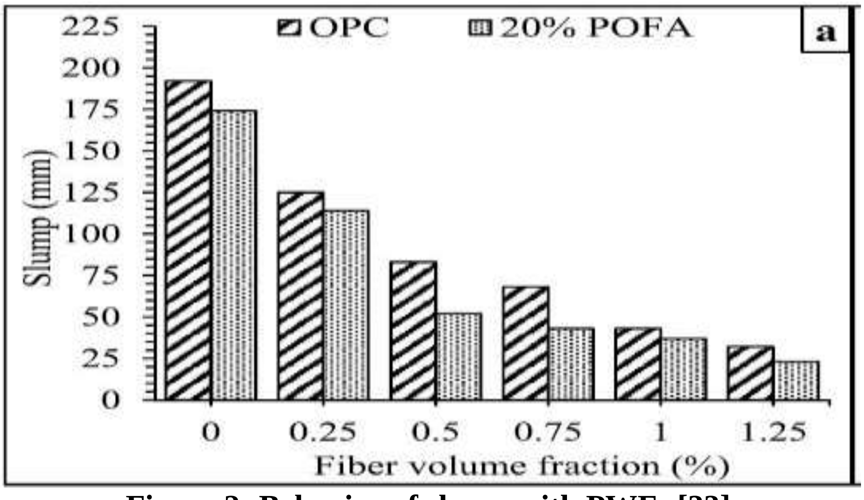

Figure 2: Behavior of slump with PWFs [33]

It is evident that short fibers decrease the workability of concrete less than long fibers. This discusses the reason for further reduction in workability for [33], [32] and [34], which means that they utilized longer fibers. The behavior of utilizing PWFs in the fresh properties of concrete is demonstrated in figure 2.

Table 1: The effect of the workability of plastic waste fibers (PWFs) for several authors.

Sub. type	PWFs %	Reduction in workability %	Authors
Vol. of concrete	0.25 0.5 0.75 1 1.25	36 58 66 79 84	H. Mohammadhosseini, R. Alyousef et al. 2020 [33]
Vol. of concrete	0.5 1 1.5 2	39 43 47 58	Shahidan et al. 2018 [35]
Vol. of mixture	0.5 1 1.5 2	5 8 12 16	Bhogayata et al. 2017 [30]
Vol. of concrete	1	3	Rinu and isah 2017 [36]
Vol. of concrete	0.45 0.75 1.25	45 66 74	Ninoslav et al. 2016 [32]
Vol. of concrete	0.3	90	Daniel et al. 2016 [34]
Vol. of concrete	0.15 0.3 0.45	24 32 53	Afroughs abet et al. 2015 [31]

4. Physical Characteristics

4.1.Density

Density is a feature of the material and represented by mass/unit volume. In fact, the density of any concrete is varying from the other concrete. It is significantly dependent on the design of the mixture and other properties such as the specific gravity (SSD) of the aggregate, etc. An experimental investigation was conducted to determine the potential to improve some characteristics of self-compacting concrete SCC by utilizing PET fibers fabricated from plastic bottles. The investigation included a reference mixture and a concrete containing many different proportions of PET fibers, ranging from 0.25% to 2%. It has been shown that the unit weight of fresh concrete was between (2340 and 2235) kg / m3, when the fibers were utilized in the concrete mixes. This may be due to the minimize SSD of the fibers (1.12) comparing with the SSD of aggregates (2.65) and cement (3.15) [37]. In the same vein, an experimental study has been worked on the behaviors of PET fiber strengthened-mortar by utilizing (0.5, 1, and 1.5) proportions of fibers. It has been concluded that the addition of PET fibers gave a little reduction in concrete unit weight [38]. This behavior is demonstrated in figure 3.

Likewise, an experimental study has been worked on the behaviors of concrete reinforced with PWFs with the utilization of (0, 0.05, 0.1, and 0.2) % volume fraction ratio. The study showed that the density of concrete without fibers were little higher than concrete which reinforced with fibers. It was also showed that, the density reduced when the quantity of fly-ash (FA) and PEFs increased in the concrete mix [39]. From the above-mentioned literature, it could be concluded that there is a decreasing in the value of density for concrete reinforced with waste-plastic fibers (WPFs) compared with traditional concrete. The addition of (0.25, 0.5, 0.75, 1.0, 1.25, 1.5, 1.75, and 2.0) % of waste plastic fibers gave a reducing in the density of fresh concrete by about (1, 2, 3, 3.5, 4, 4.5, and 5) %, respectively, comparing with traditional concrete. [38], and [39] pointed a similar approach, indicating that the lower unit weight of concrete with the high quantity of plastic fibers are due to a lower unit weight of plastic fibers.

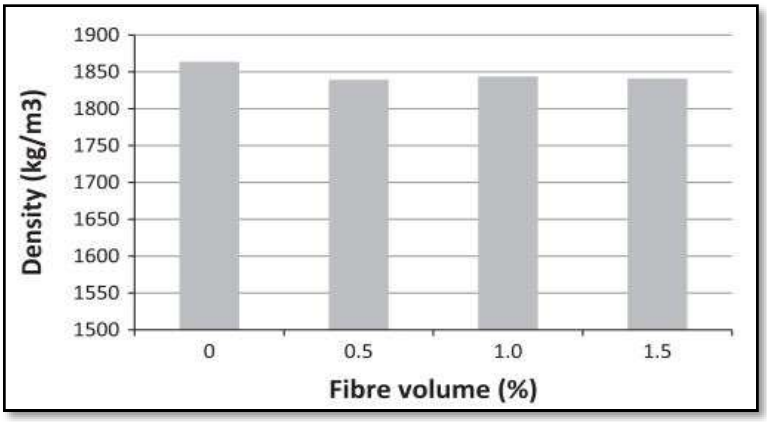

Figure 3: Behavior of slump with PWFs [38].

4.2. Water Absorbency

Water absorbency test is utilized to identify the quantity of water which absorbed with definite conditions. The ability of concrete to absorb is influenced by many factors like materials type, admixtures, temperature, and the duration of exposure. An investigation was conducted on polypropylene plastic fibers that have 12 mm length to identify the durability and mechanical characters of concrete mixed with plastic and steel fibers. The investigation was carried out with different proportions of plastic fibers (0.15, 0.3, and 0.45) %. The results show that plastic fibers have a significant effect on the water absorbency of fiber-reinforced concrete. The results indicate a reduction in water absorbency by (40, 46, and 49) % for (0.15, 0.3, and 0.45) % of plastic fibers, respectively, as shown in figure 4. The reason for the reduction of water absorbency is the restricted pore-connectivity and decreased porosity of concrete. Moreover, based on the classification for water absorbency, all concrete mixtures that provide low water absorbency are indicative of the good quality of concrete [31].

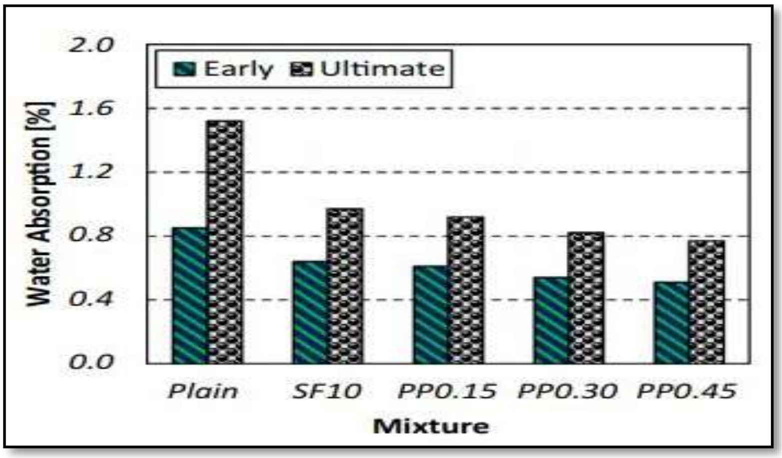

Figure 4: Behavior of Water absorbency with PWFs [31].

In the same vein, an experimental study has been worked on the behaviors of PET fiber strengthened mortar by utilizing (0.5, 1, and 1.5) % proportions of PET fibers. The study demonstrated a reduction in water absorbency by about (48, 55, and 48) for the above proportion of PET fiber, respectively. The reduction in water absorbency may be due to mixing the PET fibers with mortar, which led to a change in the porosity of the mortar around the zone of fibers' contact and decreasing the pores-capillary number [38]. in spite of the limited investigations that have been carried out in this respect, it could be demonstrated from all studies that water absorbency reduces with the increase in the proportions of plastic fibers.

4.3. Compressive Resistance

There are several authors who conducted an experimental study to evaluate the compressibility of concrete. An investigation was carried out to evaluate the thermo-mechanical characteristics of concrete reinforced with PET fibers. The investigation was conducted with three different kinds of 1% PET fibers, the first was straight and its length 40 mm referred to as (PET/a), the second was also straight but its length 52 mm referred to as (PET/b), and the third kind was crimped, its length 52 mm referred to as (PET/c). The investigation outputs demonstrated that the concrete reinforced with the above-mentioned fibers had a significant improvement in compressive resistance than the reference one (without plastic fibers). At the same time, the enhancement for short fibers was greater than long and crimped fibers [40].

Another experimental study was conducted on sustainable concrete containing recycled textile plastic bags (TPB) fibers, PET fibers, and recycled aggregates. This study carried out by utilizing (0.25, 0.5, and 0.75) % of PET and TPB fibers. The utilized PET fibers have a length of (50-60) mm, and a width of (2-3.5) mm. The study outputs demonstrated a reduction in compressive resistance with increase TPB and PET fibers and this reduction was greater for specimens containing TPB fibers than the specimens contain PET fibers. This behavior was different than other investigations, which is due to the adhesion characters between concrete components, the strength of aggregate, and the resistance of cement paste [29].

An experimental study has been conducted on (0.1 and 0.3) % of PET fibers in order to evaluate the performance of concrete reinforced with PET fibers. The outputs of the study concluded that the utilization of 0.1% PET fibers slightly improves the compressive resistance contrasted with the conventional normal concrete. At the same time, the utilization of 0.3% of PET fibers marginally reduced the strength [34]. In the same vein, an experimental study has been performed on the performance of PET fiber reinforced concrete mixtures by utilizing (0.5, 1, 1.5, and 2) % proportions of PET fibers. The outputs are demonstrated in figure 5 (A), which concluded that the compressibility resistance for all mixtures was overridden the targeted compressibility resistance (35 MPa). Also, concrete specimens containing 1% of PET fibers gave significantly the best resistance among the other specimens, while this resistance reduced with the increase of PET fibers proportions and this decrement was larger in long fibers than the short fibers. It could be attributed to the bundling and balling of the fibers through the mixing and casting process, also the weakest part of concrete is the zone among the fiber surface so, initial cracks appeared when applying the compressive load [35].

Another experimental work performed on PET fibers reinforced concrete. It was conducted by utilizing (2, 3, 4, and 5) % proportion of PET fibers, the results demonstrated that the compressibility resistance of concrete increased by utilizing 2% and 3% of PET fibers, and then, when utilizing 4% and 5% of PET fibers, the compressibility was reduced back [41]. In the same vein, an investigation concentrated on the improvement of compressibility of the concrete was performed (figure 5(B)), the investigation reported an improvement in resistance by about (5-1.5) % because of the utilization of plastic fiber with the concrete mixture. This behavior could be attributed to the ability of fibers to prevent cracks from spread, reduce the concentration of stress, convert the direction of cracks, and reduce the growth rate of cracks. [31].

Lastly, an investigation was performed in order to enhance the characteristics of self-compacting concrete reinforced with plastic fibers with proportions of (0.25, 0.5, 0.75, 1, 1.25, 1.5, 1.75, and 2) %. the outputs demonstrated an increment in the resistance of compressibility when the first five proportions mentioned above were used, then, this resistance was decreased back when fiber proportion exceeded 1.5%. [37]. The influence proportion of plastic fibers on compressive resistance are demonstrated in table 2.

Table 2: The influence proportion of plastic waste fibers on compressive resistance.

Sub. type	PWFs %	Reduction in compressibility %	Increment in compressibility %	Authors
Vol. of concrete	0.3 0.5 0.75	23 23 25	- - -	Bui et al., 2018 [29].
Vol. of concrete	0.5 1 1.5	20 - 20	- 22 -	Shahidan et al., 2018 [35].
Vol. of concrete	0.3	90	-	Daniel et al. 2016 [34].
Vol. of concrete	0.1 0.15 0.3 0.45 0.5 1 1.5	- - - - - - -	1 1 2.5 3 4 4 5	Al-hadithi and Hilal, 2016 [37].
Weight of cement	5	-	2	Maqbool and Sood, 2016 [41].
Vol. of concrete	0.15 0.3 0.45	- - -	10 11 13	Afroughsabet and Ozbakkaloglu, 2015 [31].

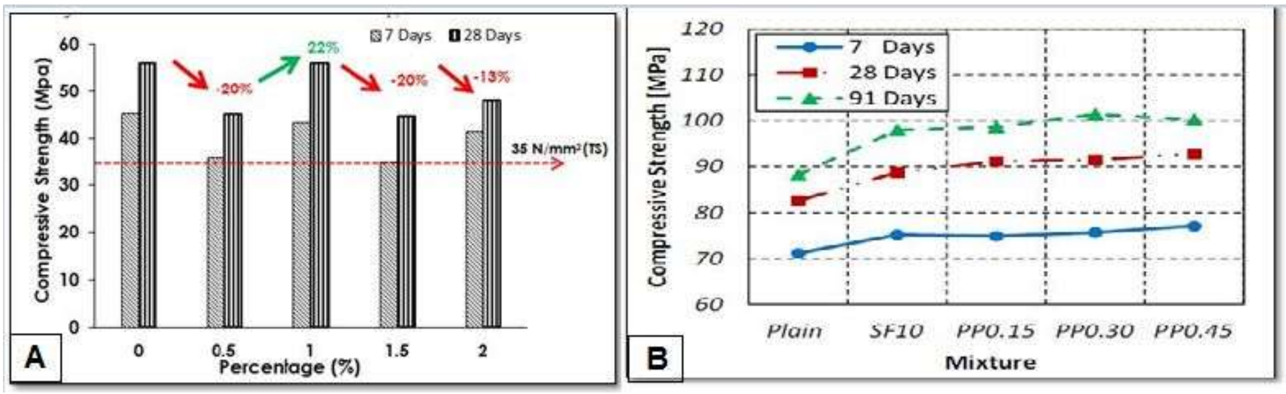

Figure 5: Behavior of compressive resistance with PWFs [35] & [31].

4.4. Splitting Tensile Resistance

One of the main Features of hardened concrete is splitting tensile resistance, therefore, to understand the behavior of tensile resistance, an investigation study has been performed on concrete strengthened with different proportion of PET fibers (0.5, 1, 1.5, and 2) %. The outputs (figure 6 (A)) demonstrated that the values of splitting tensile resistance increase by utilizing 0.5% and 1% of PET fibers, while this tensile resistance was decrease back by utilizing proportions of PET fibers greater than 1%. This is due to the property of the bridging mechanism of these fibers, as this property works to a certain proportion of the fiber, where for higher proportions the strength of bond among the cement paste and fibers was reduced. Further, the concrete tensile stress is transmitted to the fibers, and the latter, in turn, delays the growth and spread of the concrete cracks which help to enhances the splitting tensile resistance. It was mentioning that concrete specimens, which weren't contain any fibers, suddenly failed and split up into two parts, whereas the specimens reinforced with PET fiber were able to maintain their form [35]. An experimental investigation was performed on concrete strengthened with (0.15, 0.3, and 0.45) % of plastic fibers have a length of 12 mm. It was demonstrated that the addition of plastic fibers in concrete mixtures helped the splitting tensile resistance to improve by about (13, 16, and 20) % for the above-mentioned proportions, respectively, as demonstrated in figure 6 (B) [31]. It was demonstrated, from other investigation conducted on concrete strengthened by (0.5, 1, 1.5, and 2) % of PET fibers, that the resistance significantly enhanced by utilizing the first three proportions mentioned above, while the resistance was decreased back when utilizing 2% of PET fibers [42]. Other authors concentrated on PET fibers reinforced concrete since they utilized the PET fibers as a replacement with sand. The outputs demonstrated that the replacement by 10% PET fibers helped slightly to improve the resistance of concrete, while with increase the percentage of replacement by 15 % and 20 %, this improvement started to declined. So, it has been mentioned that the best substitution rate of PET fibers is 10% [43]. Lastly, it has been demonstrated, from an investigation preformed on concrete strengthened with (0.5,1, and 1.5) % of PET fibers, that concrete resistance has been significantly improved. This improvement due to the ability of PET fibers to bridge the cracks and enhance bond characteristics among concrete compounds [44]. The influence proportion of plastic fibers on splitting tensile resistance are demonstrated in table 3.

Table 3: The influence proportion of plastic waste fibers on splitting tensile resistance.

Sub. type	PWFs %	Reduction in splitting tensile resistance %	Increment in splitting tensile resistance %	Authors
Vol. of concrete	0.5 1 1.5	- - 15	2 9 -	Shahidan et al., 2018 [35].
Vol. of concrete	0.5 1 1.5	- - -	2 3 5	Sanjaykumar and Daule, 2017 [42].
Replacement with sand	5 10 15	- - -	4 3 2	Vali and Asadi, 2017 [43].
Vol. of concrete	0.15 0.3 0.45	- - -	13 16 20	Afroughsabet and Ozbakkaloglu, 2015 [31].
Vol. of concrete	0.5 1 1.5	- - -	8 13 19	Irwan et al., 2013 [44].

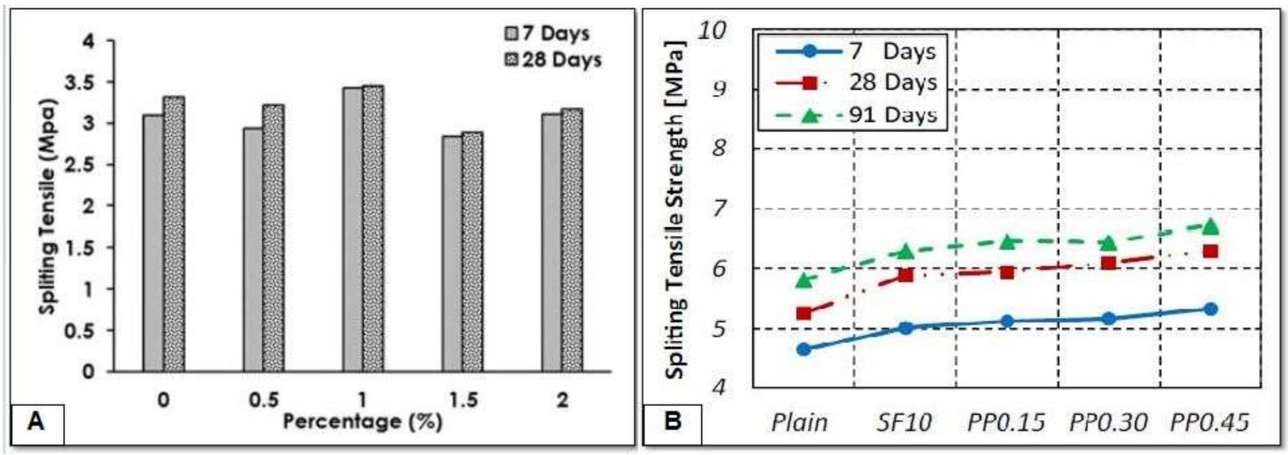

Figure 6: Behavior of splitting tensile resistance with PWFs [35] & [31].

4.5. Bending Resistance

To definite the bending behavior of cementitious materials, an investigation has been conducted on concrete strengthened with (0.1, and 0.3) % of PET fibers. The outputs demonstrated a little reduce in the resistance by about 3% for both proportions (0.1, and 0.3) % of PET fibers [34]. Another investigation has been conducted on concrete strengthened with (0.05, 0.18, and 0.3) % of PET fibers have a length of 20 mm as substitution of volume of concrete. It has been observed an improvement in resistance, toughness, and the ability of absorb energy. It has been also reported that the toughness of concrete was increased with increasing the length of PET fibers. Also, it has been observed an increment in deflection, this indicated an increase in the ductility of the concrete specimens [45]. Other authors concentrated on plastic-fibers reinforced concrete since they utilized (0.15, 0.3, and 0.45) % of plastic fibers having a length of 12 mm. It has been noted an improvement in resistance by about (9, 10, and 13) % for the above-mentioned fiber proportions, respectively, as demonstrated in figure 7. The enhancement ratio based on the proportion of utilized fiber and the age of test. Moreover, while steel fibers have greater elastic modulus and tensile resistance, thus, steel fibers increase concrete bending resistance three times greater than plastic fibers [31].

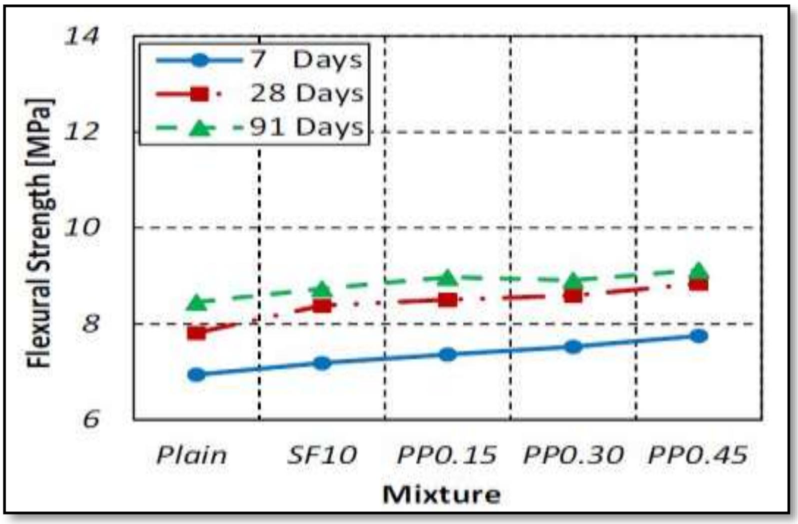

Figure 7: Bending behavior with PWFs [31].

Table 4: The influence proportion of plastic waste fibers on bending resistance.

Sub. type	**PWFs %**	**Reduction in bending resistance %**	**Increment in bending resistance %**	**Authors**
Vol. of concrete	0.5 1 1.5	- - -	16 27 37	Sanjaykumar and Daule, 2017 [42].
Replacement with sand	5 10 15	- - -	22 28 12	Vali and Asadi, 2017 [43].
Vol. of concrete	0.1 0.3	3 3	- -	Daniel et al., 2016 [34].
Vol. of concrete	0.15 0.3 0.45	- - -	9 10 13	Afroughsabet and Ozbakkaloglu, 2015 [31].
Vol. of concrete	0.3	-	16	Fernando et al., 2012 [45].

An investigation has been performed on concrete strengthened with (0.5, 1, 1.5, and 2) % of PET fibers to evaluated the behavior of concrete bending resistance. It has been demonstrated that the bending resistance was improve as the proportion of PET fibers increased, this increment in the resistance was for fiber proportion up to 1.5% and after this proportion, the increase decreased gradually, but remained greater than the reference specimens (specimens without PET fibers), [42]. The evaluation of bending resistance of concrete, which prepared with (5, 10, 15, and 20) % of PET fiber as a substitute of sand weight, has been conducted. It has been noted that the utilization of (5, and 10) % of PET fibers gave gradually enhancement in bending resistance, while by utilize (15, and 20) % of PET fibers, this enhancement was decreased back, but remained greater than the reference conventional specimens. So, it has been reported that the best proportion of replacement is 10% [43]. The influence proportion of plastic fibers on bending resistance are demonstrated in table 4.

4.6. Elastic Modulus

In spite of elastic modulus is one of the main features of concrete, little investigations, in the literature considering such feature of plastic fibers strengthened concrete, are available. An investigation has been performed to evaluate the elastic modulus of sustainable concrete containing TPB and PET fibers. It has been conducted by utilize (0.25, 0.5, and 0.75) % of fibers which having a length of (50, and 60) mm, and width of (2, and 3.5) mm. The outputs (figure 8) demonstrated that the elastic modulus reduced with the increase of TPB and PET fibers comparing with the specimens without PET fibers. The reason could be attributed to the reduction of the elastic modulus of PET fibers than the elastic modulus of cement and aggregates [29].

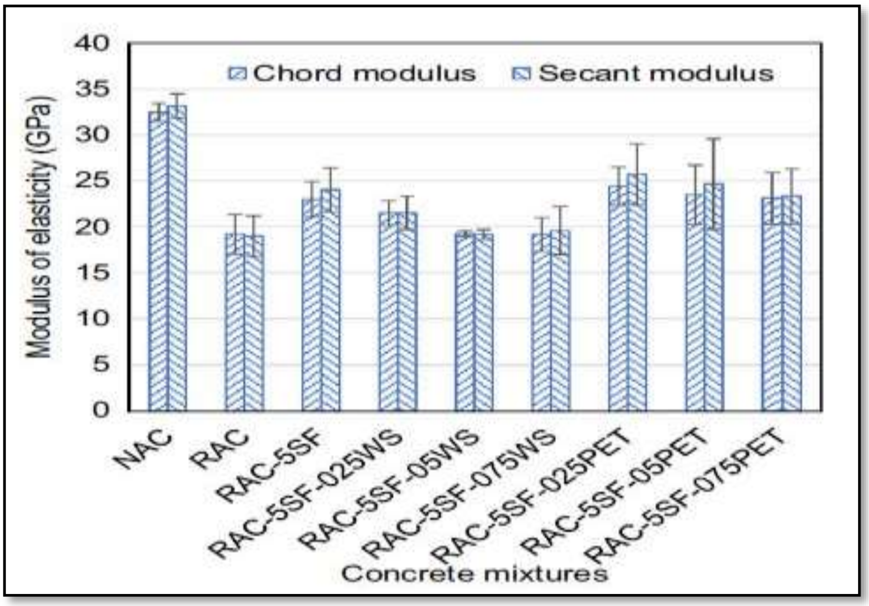

Figure 8: The reduction in the elastic modulus of concrete with increasing PET fibers [29].

Table 5: The effect of the elastic modulus of plastic waste fibers for several authors.

Sub. type	PWFs %	Reduction in elastic modulus %	Increment in elastic modulus %	Authors
Vol. of concrete	0.3 0.5 0.75	20 25 28	- - -	Bui et al., 2018 [29].
Vol. of concrete	0.5 1 1.5	- 8.3 21	8 - -	Irwan et al., 2013 [44].

Other authors studied the response of the elastic modulus by mixing (0.5, 1, and 1.5) % of PET fibers with concrete mixtures. It has been noted that the value of elastic modulus was increase by about 8% with utilize 0.5% of PET fibers, while the utilization of 1% and 1.5% of PET fibers gave a reduction in elastic modulus values by about 8.3% and 21%, respectively [44]. Another study has been performed to evaluated the characteristics of alkaline-cement mortar strengthened by polypropylene fibers, by utilize two proportion (0.5, and 1) % of fiber with three various alkaline mixtures. The first was furnace slag, the second was granulated blast, and the third was 50% fly ash with 50% slag. Comparing with the specimens of cement mortar, the outputs demonstrated a reduction in elastic modulus for all three alkaline mixtures that contained polypropylene fibers [46]. The mechanical properties of plastic-waste fibers reinforced concrete could be summarized as demonstrated in figure 9.

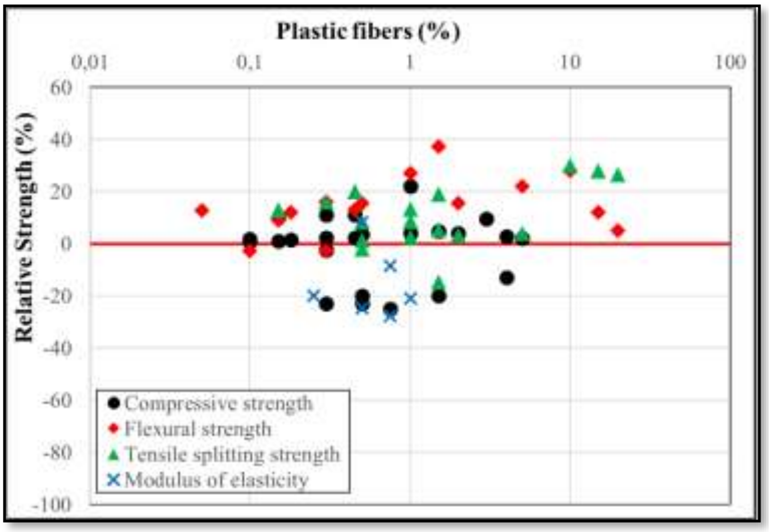

Figure 9: Mechanical properties summery of plastic-waste fibers reinforced concrete

5. Conclusion

From the previous literature, it could be concluding the following facts:

- Adding PWFs to concrete mixtures reduces the workability of concrete mixtures, and at the same time, the utilize of short PWFs decreases the workability less than long PWFs.
- Utilize PWFs in concrete mixtures gives a reduction in concrete density, and with increase the proportion of PWFs, concrete density is reducing and this can be attributed to the low density of PWFs.
- Concrete water absorbency is reducing with add PWFs to concrete mixtures, and by increasing the PWFs proportion, the water absorbency of concrete is reducing.
- Adding PWFs to concrete mixtures helps to improve compressibility resistance, since these fibers help to connect the internal cracks and also prevent the spread and growth of concrete cracks, but at the same time increasing the proportions of added fibers reduces compressibility resistance, this due to a decrease in adhesion between components concrete mixture as well as agglomeration and balling of the fibers during mixing and molding.
- The utilize of PWFs in certain proportions helps to enhance the split tensile resistance of concrete. This could be seen through Figure 9, where all the authors recorded an increase in the tensile resistance of concrete with the exception of a few authors who recorded adverse results and this could be attributed to the type of component materials for the concrete mixture.
- PWFs also help in improving the bending resistance and deflection of concrete specimens. From Figure 9 it could be seen that most of the authors recorded enhancement in bending resistance except few authors that recorded a slight decrease in the bending resistance and this could be attributed to the type and quantity of materials that make up the concrete mixture.
- With regard to the elastic modulus characteristic, despite the small number of investigations that have been conducted on this characteristic, it could be concluded that the use of PWFs reduces the elastic modulus, and this conclusion may change in the future when more researches is performed and concerned in this regard.

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التحسين المستدام للخرسانة باستخدام مخلفات العبوات الغذائية البلاستيكية كألياف اقتصادية وصديقة للبيئة - ورقة مراجعة

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المستخلص

من الحلول الممكنة لبيئة أنظف هو تقليل استخدام المواد غير القابلة للتحلل لتقليل النفايات. تعتبر نفايات البلاستيك الصلب أهم أنواع النفايات في العالم، وذلك بسبب عدم تفسخها وقابليتها للتحلل العضوي المنخفض. لذلك تم توجيه استخدام هذه المخلفات واستخدامها كمواد تقوية للوحدات الخرسانية حيث تم استخدامها كبديل للركام بنسب معينة وكذلك كألياف تقوية للخرسانة. هذه الورقة عبارة عن مراجعة للدراسات البحثية التي ركزت وسلطت الضوء على تحسين الخرسانة عن طريق إعادة تدوير مخلفات العبوات الغذائية البلاستيكية واستخدامها كألياف تقوية لعينات الخرسانة. تم توضيح تأثير الألياف البلاستيكية على قابلية التشغيل، مقاومة الانضغاط، مقاومة الشد الانقسامي، مقاومة الانحناء، ومعامل المرونة. وقد لوحظ أن الخصائص الطازجة للخرسانة تقل عند خلط الألياف البلاستيكية مع الخلطات الخرسانية، بينما يمكن تحسين الخصائص المتصلبة باستخدام نسبة معينة من هذه الألياف.

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