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Influence of Polyethylene Waste on Some Fresh and Mechanical Properties of Self-Compacting Concrete

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Abstract: This experimental research study investigates the results of some fresh and mechanical properties of self-compacted concrete which the sand has been partially substitute with different percentage by volume with crushed fine polyethylene waste. A total of nine SCC mixtures including constant of water/binder ratios, cement content and SP percent with partial replacement of sand with polyethylene waste by (0, 5, 10, 15, 20, 25, 30, 35 and 40%) were designed. Fresh and mechanical properties of SCC that involve time and diameter of slump flow, "V" funnel time, flow time and height ratio of L-box in addition compressive, flexural, tensile strength tests and ultrasonic pulse velocity were measured at 28th day curing ages. The all results were compared and explained the reasons for their differences with the control mix. Tests results showed that it is possible to produce the light weigh SCC by using correct and suitable percent of polyethylene waste substitution with fine aggregate. In addition, their workability improved and ductility increased while the mechanical properties remain within the allowable limits.

Key words: Polyethylene waste, self-compacting concrete, slump flow test, V-funnel test, mechanical properties, workability

INTRODUCTION

The greatest innovation in the world that has recently brought great benefit to human life is plastic materials instead it is serious environmental problem all over the world (Zhou *et al*., 2014; Papong *et al*., 2014). In Iraq it was observed in the last years, significantly increasing plastic waste materials in urbanized areas, especially polyethylene storage boxes waste, importing and producing large numbers of plastic boxes every year. Furthermore, the management and reutilizing plastic waste is not interested. As a result, led to imbalance in waste management. Therefore, finding another process of organizing waste issue by using environment sustainable friend techniques is becoming a major shakedown matter. Re utilize plastic waste in new concrete is considered as the most appropriate application for elimination large amount of wastes (Saikia and De Brito, 2013; Vidales *et al*., 2014; Mahdi *et al*., 2013; Jo *et al*., 2008).

Many previous studies have emphasized on detecting economical and suitable environmentally friendly technique for disposing of plastic waste. A large study was focused on employing of different kinds of plastic waste in cementitious materials and replacement as aggregate such as Akcaozoglu *et al*. (2010, Aldahdooh *et al*. (2018). For example, Choi *et al*. (2005) has provided the employment of PET bottles waste as aggregate, their results indicated that the reduced density and compressive strength compared with traditional concrete were about 2-6% and 33%, respectively (Choi *et al*., 2005). Some investigator, concluded that the flexural strength, strength and split tensile of normal concrete are decreasing in case of increasing the amount of plastic waste embedded in the concrete. The main reason for the loss of strength, flexural and tensile are the decreased bonding between cement paste and smooth surface of plastic grains (Saikia and De Brito, 2013; Kou *et al*., 2009; Hannawi *et al*., 2010; Panyakapo and Panyakapo, 2008; Choi *et al*., 2009; Nabajyoti and Brito 2014; Rahmani *et al*., 2013; Batayneh *et al*., 2007; Saikia and de Brito, 2012; Kilic *et al*., 2003).

In the case of replacement of aggregates in concrete with plastic waste it will give us a light weight concrete which is due to the light weight of plastic particles (Kilic *et al*., 2003). The usage of plastic waste in new concrete is also led to decrease the dead load during structural design, consequently dropping the risk of earthquake on building. As a result, less load transfers to the foundation. During the earthquake, the building made of lightweight material is less damaged, due to lesser inertial force (Akcaozoglu *et al*., 2010; Kilic *et al*.,

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2003). Ali *et al*. (2018) concluded that the compressive strength and density of normal weight concrete decreased when experimental mixes were ready to utilize polyethylene beads as a partial or total substitution of limestone gravel. The values of compressive strength were between of 17-27 MPa while thedensity results were in the range of 1366-1744 kg/m^3 (Ali *et al*., 2018).

Workability in fresh normal concrete tests is clearly reduced if plastic waste is used instead of sand. This due to particles which have non-similar shape and more specific surface area as compared with the fine aggregates. Thus, there will be extra abrasion among the particles leading to minimal workability (Frigione, 2010; Nabajyoti and Brito 2014; Rahmani *et al*., 2013; Batayneh *et al*., 2007; Saikia and de Brito, 2012; Rai *et al*., 2012). Concrete with a higher percentage of plastic waste has a lower UPV because the plastic particles make concrete more permeable (Rahmani *et al*., 2013). It has been noted in previous studies that most of the experiments included the incorporated of plastic waste in the conventional concrete while studies of the replacement of plastic waste with aggregates in SCC is relatively few.

The improvement of SCC has assisted to implementation of concrete structures which have less depend on hand labor quality due to it has high workability and self-consolidating capacities even in narrower corners and hard structural molds without the need for vibration. Moreover, some features should be highlighted: reduction in self-weight of structures and consequently the loads on foundations and the final costs and many advantages (Okamura and Ouchi, 2003; Wu *et al*., 2009; Gesoglu *et al*., 2012).

Yang *et al*. (2015) utilized plasticwaste particles as fine aggregate replacement in SCC. Partial amount of sand was replaced by plastic waste at 10, 15, 20 and 30% by volume. The outcomes demonstrated that the modulus of elasticity and dry density decrease with an increase in fine aggregate replacement. The results also indicated that the slump flow is getting better by increasing the proportion of plastic waste substitution with sand. The viscosity reduced contrary to the results of (compressive strength, splitting and flexural) are improved even the sand substitution percent rise to 15%. After increasing the replacement rate to more than 15%, free water and bleeding starts to appear and reduces the interfacial bonding between cement paste and plastic particles waste. thus weakens of strength of SCC and T500 be longer (Yang *et al*., 2015). Safi *et al*. (2013) agreed Yang *et al*. (2015) in his conclusions when substituted sand with plastic waste at dosages (0, 10, 20, 30 and 50%) by weight in SCC (Safi *et al*., 2013).

The Turkish researchers Gesoglu *et al*. (2017) has replaced the quantities of cement with Plastic Waste Powder (PWP) at varying rates in SCC at 5, 10, 15, 20 and 25% by weight. The results showed that the compressive strength was negatively affected by the use of PWP. However, the highest drop did not pass 24.6% at the level of 25% of PWP replacement (Gesoglu *et al*., 2017).

Sadrmomtazi *et al*. (2016) employed waste PET aggregatesas a fine aggregate with same weight replacement at varying rates in SCC at 5, 10 and 15%. Besides, the replacement proportion of cement with fly ash and silica fume was 30 and 10% by mass, respectively. The outcomes indication that PET waste can be recycled as aggregates in self-compacted concrete. incorporate of PET waste in SCC loosed tensile, compressive and flexural strengths but the waste PET has some advantages like it has no influence on resistance of electrical and reduced the environmental matters, brittle of concrete and dead load of buildings due to its low density (Sadrmomtazi *et al*., 2016).

Many samples of SCC incorporated with Plastic Bag Waste Fiber (PBWF) were prepared by Ghernouti *et al*. (2015) fresh and hardened properties testes of SCC were determined. Experimental results showed that concretes prepared by (PBWF)-length of 2 cm, met the standards of SCC concrete (rated by L-box, slump flow diameter and sieve stability test) in any content of fibers. The involve of this fibers in SCC improving micro cracks in concrete structures. Although, the blended of (PBWF) has not a great impact on the flexural and compressive strengths it has only a significant impacted on the tensile strength at 28th day (Ghernouti *et al*., 2015).

Many trial test has been done to check the influence of blend Waste Plastic Fibers (WPF) on the hardened and fresh properties of SCC concrete, several SCC mixes were prepared at water-to-binder ratio equal to 0.35 for all mixes and 490 kg/m^3 of cementitious amount. The fly ash class F was substituted with cement at 25% by mass and the eighth chosen plastic fiber percent of (0, 0.25, 0.5, 0.75, 1, 1.25, 1.5, 1.75 and 2%) by total volume replaced. Theoutcomes showed that the plastic fibers have inverseinfluence on the fresh characteristic of SCC and enhancement by hardened characteristic (Al-Hadithi and Hilal, 2016; Asokan *et al*., 2010; Correia *et al*., 2014; Ferreira *et al*., 2012; Ismail and Al-Hashmi, 2008; Ruiz-Herrero *et al*., 2016).

This research aims at exploring the possibility and viability of utilizing plastic waste material, polyethylene as fine aggregate in SCC to produce lightweight SCC and environmentally friendly SCC by recycling the waste of the boxes instead of throwing them for application in the field of construction and discussion the influence of incorporate on the workability and mechanical behavior of SCC.

MATERIALS AND METHODS

Mass cement factory Bazyan (OPC) type CEM I 42.5 R used in this study which was stored in a cool and dry place before using. Table 1 and 2, respectively, review the results of laboratory tests for mechanical and chemical properties. Cement was replaced by a fixed ratio with fly ash of type F it had Blaine fineness of (287 m^2/kg) and specific gravity of (2.09 g/cm^3).

Fine aggregate (natural river sand) and (crushed sand) were employed in this study. Fine aggregate was taken from Al-Bokhirbeet quarry. This sand is totally free from all impurity and organic matters. Specific gravities were 2.65 for river sand and 2.43 for crushed sand. The maximum size of gravel used is 10 mm with a specific gravity of 2.71. Sieve analysis of sand and gravel and the limited of IQS: No.: 45: 1984 are shown in Table 3 and 4.

Table 1: Physical properties of cement

Physical properties	Test result	Limits of Iraqi specification No. 5/1984
Setting time (min)		
Initial setting	120	≥45
Final setting	360	≤600
Fineness by Blaine method (m^2/kg)	300	≥230
Auto clave (%)	0.31	≤0.8

Table 2: Chemical properties of cement

Oxide	Weight (%)	Limits of Iraqi specification No. 5/1984
CaO	62.3	-
SiO_2	20.28	-
Al_2O_3	5.55	-
Fe_2O_3	4.20	-
MgO	2.60	<5.0
K_2O	0.75	-
Na_2O	0.4	-
SO_3	204	<2.8
Loss on ignition	1.65	<4.0
Lime saturation factor	0.81	0.66-1.02
Insoluble remains	0.5	<1.5%
FL	0.65	-
Total	99.63	-
Compound		
C_3S	50.05	-
C_2S	20.45	-
C_3A	4.05	-
C_4AF	13.20	-

In this study, the light weight polyethylene waste was used as an alternative to sand in different proportions. All plastic waste passed from sieve number 4.75 mm that is mean it is classified as a sand (Fig. 1). Polyethylene boxes have been collected and grinding into small size by using grinding machine to get fine particles. Specific gravity was calculated using oil because the material is lightweight and floating, the result was 0.94.

Mix proportioning of SCC: The total binder content of 520 kg/m^3 and w/b ratio of 0.36 was constant for all Self Compact Concrete (SCC) mixtures. The 3rd generation of high performance Superplasticizer Sika ViscoCrete 5930 with density 1.095 kg/L was used as a constant dosage equal to 3.6 kg/m^3 in all mixtures to ensure access required workability. Polyethylene plastic waste will be replaced with fine aggregate at eight mixes with percent of 5, 10, 15, 20, 25, 30, 35 and 40% by volume and compared all mixes with control mix.

The mixing procedures proposed by Khayat *et al.* (2000) which illustrates the sequence and duration of mixing have been applied in this study to obtain the same uniformity and homogeneity for all SCC mixes. In accordance with those recommendations, at first, the materials were mixed homogenously for thirty seconds including crushed polyethylene waste, coarse aggregate and two type of sands in an electrical power-driven mixer. After that, half the mixing water was added to the mixture and mixed again for more 1 min. After that, the blended fine and coarse aggregates were left for 1 min to absorb the water well. Then, the cementitious materials including cement and fly ash were added to the mixture for blending another one minute. Finally, the selected superplasticizer with water remaining was poured into the mixture and all the materials were mixed for 3 min and then left for a 2 min break. In the end, the self-compacted concrete was mixed for 2 additional minutes. Concrete tests were conducted for the fresh state like V-funnel and L-box tests. Next the concrete poured, samples were covered by thin plastic sheet and left for 24 h at 20±4°C. After 28 days of water curing, the mechanical tests were performed. Table 5, shows details of the mix proportions of the SCC mixes.

Table 3: Seive analysis of fine aggregate

Seive No.	Accumulated percentage pasing (refrence samples) (%)	Limits of Iraqi specification No. 5/1984	Specimens of group 2 caused by:
4	100	100	Passing used
8	64.57	50-85	Retaining used
16	32.77	25-60	Neglected
50	36.20	30-40	Neglected
100	3.15	2-10	Neglected

Table 4: Grading of coarse aggregate

Seive size (mm)	Passing by weight (%)	IQS: No.45:1984
12.5	100	100
9.5	99	85-100
4.75	20.3	10-30
2.36	4.1	0-10
1.18	0	0-5

Table 5:Mix proportions for self-compacting polyethylene waste concrete (kg/m^3)

Mix destination (%)	Polyethylene waste by volume (%)	Cement (kg/m^3)	Water (kg/m^3)	Fly Ash (kg/m^3)	Fine aggregate (kg/m^3)	Cursed fine aggregate (kg/m^3)	Coarse aggregate (kg/m^3)	SP (kg/m^3)
M-control	0	364	187	156	582	250	832	3.6
M-5	5	364	187	156	558	240	818	3.6
M-10	10	364	187	156	471	221	818	3.6
M-15	15	364	187	156	486	207	818	3.6
M-20	20	364	187	156	458	197	818	3.6
M-25	25	364	187	156	430	184	818	3.6
M-30	30	364	187	156	415	169	818	3.6
M-35	35	364	187	156	400	154	818	3.6
M-40	40	364	187	156	390	137	818	3.6

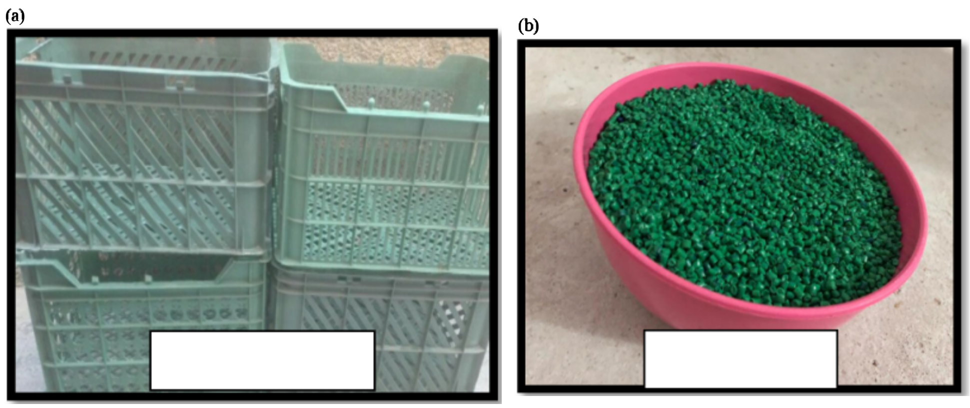

Fig. 1: Polyethylene waste box before and after cutting and grinding; a) Before cutting and b) After cutting

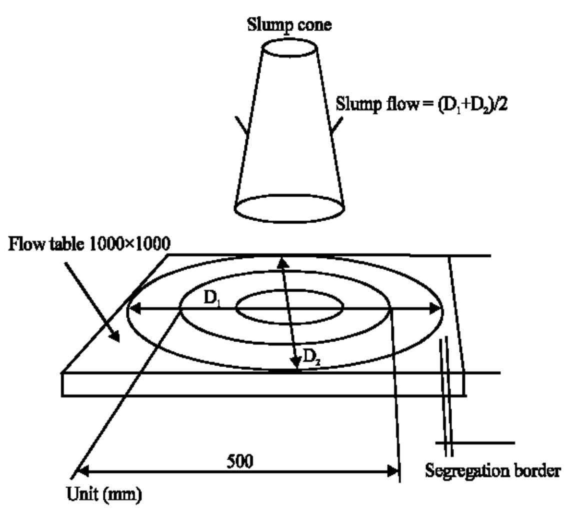

Fig. 2: Slump flow test

Testing procedure

Test on fresh SCC: All fresh self-compacting tests were evaluated according to, recommendations and instructions board in EFNARC (2002). To measure the slump flow, the slump flow cone was filled with SCC without compaction by rod and then flattened surface. After lifting the cone quietly, the average diameter of the concrete spread on the flow table was measured and measured Time (T50) which determines the time taken for the SCC to reach the 50 cm spread circle (Fig. 2) to evaluating mixtures viscosity and ability of filling. The V-funnel test was conducted (Fig. 3). The V-funnel apparatus is fully filled with SCC, then the down gate is opened and the flow time is measured as the time between the opening of the gatetill the funnel is completely emptied.

L-box device is a hollow box in the form of a letter "L". It consists of horizontal and vertical part separated by a gate containing two or three reinforcement bar. After filling the vertical part of the device, the gate is lifted to allow SCC to overpass into the horizontal part. After the flow of concrete has stopped, H_1 and H_2 are measured from the horizontal and vertical parts of the device as shown in Fig. 4. The proportion between H_2 and H_1 represents an indication of passing ability degree of SCC through the tied steel bars. L-box test also gives a visual indicate if the concrete is in a segregation state. Typical acceptance values according to EFNARC (2002) are in the range of 0.8-1.0. Whenever the value nearest to 1, the concrete has more flow ability.

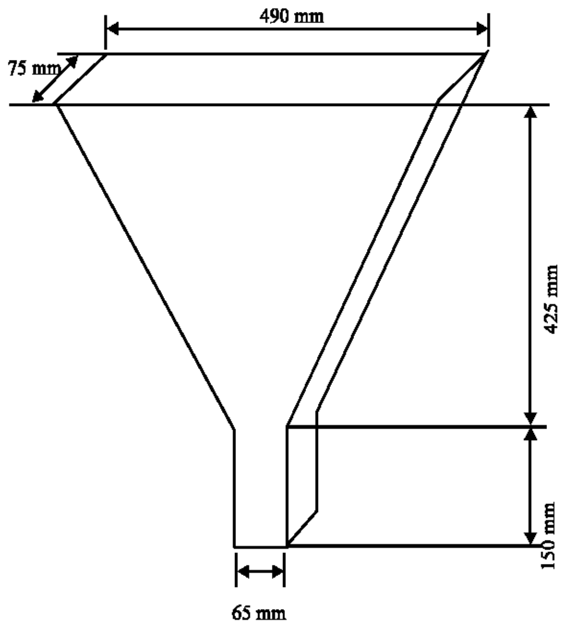

Fig. 3: V-funnel test

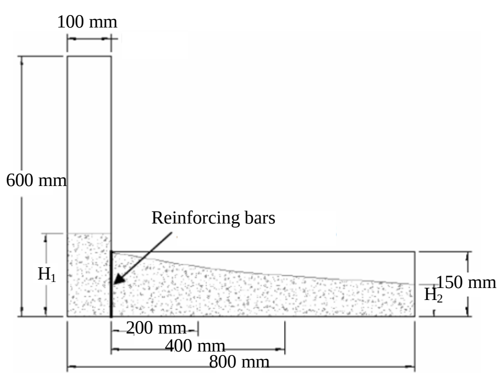

Fig. 4: Photographic view of L-box apparatus and testing procedure

Test on hardened SCC: The compressive strength and tensile strength tests were carried out after 28 days of water curing on SCC using the (cubes samples 150 mm) and (cylindrical samples 100×200 mm) according to ASTM C 39 (ASTM., 2012) and ASTM C496, respectively. In addition, 3 prismatic (10 ×10×150 mm) specimens were tested to find flexural strength values for every mix. PUNDIT system has been utilized to measure Ultrasonic Pulse Velocity (UPV) with a pair of narrow band 54 kHz direct transducers for all cubic samples on the two smooth sides after 28th days.

RESULTS AND DISCUSSION

Fresh properties of self-compacting polyethylene waste concrete: Table 6 shows the measured fresh properties of all SC mixes including slump flow diameter, T50 time of slump flow, time of V-funnel, L-box height ratio, wetdensity and T20 and T40 flow times.

Figure 5 and 6 presented the influence of SCC containing polyethylene waste by different percent with T50 cm slump flow and V-funnel flow times, respectively. T50 cm and V-funnel times were decreased to record minimum values 1.5 and 6.5 sec for (M-P 5%), respectively, compared with control mixture. On the other hand an increase in values was observed for both T50 cm slump flow and V-funnel times from (1.5-10 sec) and from (6.5-20 sec), respectively, after increasing the proportion of polyethylene waste percent in SCC from 5-40% for the (M-P 5%) and (M-P 40%), respectively.

Figure 7, the mix (M-p 5%) is classified as VS1/VF1 while the other mixes (M-P 10-40%) were in the category of VS2/VF2. The results show clearly that all results are within the acceptance criteria of EFNARC (2002) (Table 7) self-compacted concrete that is classified within viscosity class of VS2/VF2 can be used in applications such as columns, shear walls and ramps as well as the SCC having a time of V-funnel flow within 6-12 sec may be highly resistant to possible segregation.

Figure 8 shows the results of wet density versus SCC containing different proportions of polyethylene waste. Our results demonstrated that the unit weight of fresh concrete samples changed between 2100-2371 kg/m^3.

Table 6: Fresh properties of self-compacting polyethylene waste concrete

Mix desiguation (%)	Polyethylene waste by volume (%)	Slump flow (mm)	T50.slump flow time (sec)	V-funnel time (sec)	L-box height ratio	T20 time (sec)	T40 time (sec)	Fresh density (kg/m^3)
M-control	0	750	6	11	0.98	5	9	2420
M-P5	5	800	1.5	6.5	0.95	4	8	2371
M-P10	10	788	2.5	8.1	0.9	3.5	7.5	2299
M-P15	15	780	3	12	0.85	3	7	2250.6
M-P20	20	760	4.2	13	0.8	2.5	6.6	2202.2
M-P25	25	740	5.6	15	0.75	2	6	2183
M-P30	30	720	7	17	0.7	1.5	5	2153
M-P35	35	700	8.5	19	0.65	1	4	2123
M-P40	40	680	10	20	0.6	6	10	2100

Table 7: Limit values proposed by EFNARC (2002) for fresh concrete

Classes		Slump flow diameter (mm)
Slump flow classes		
SF1		550-650
SF2		660-750
SF3		760-850
Class	T50 (sec)	V-funnel time (sec)
Viscosity classes		
VS1/VF1	≤2	≤8
VS2/VF2	>2	9-25
Passing ability classes		
PA1	≥0.8 with 2 rebar	
PA2	≥0.8 with 3 rebar	

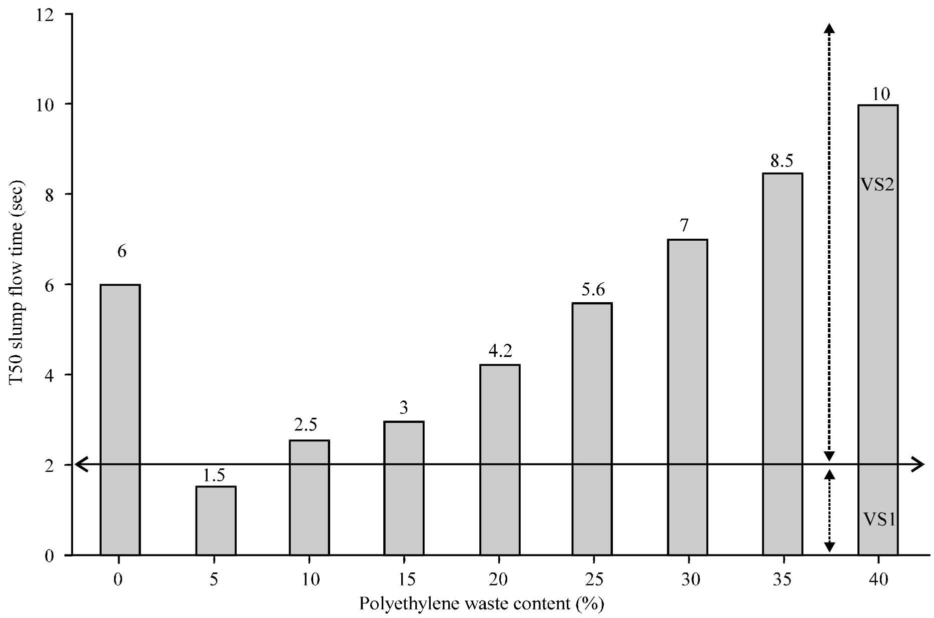

Fig. 5: The T50 slump flow time of the SCCs as a function of polyethylene waste percent

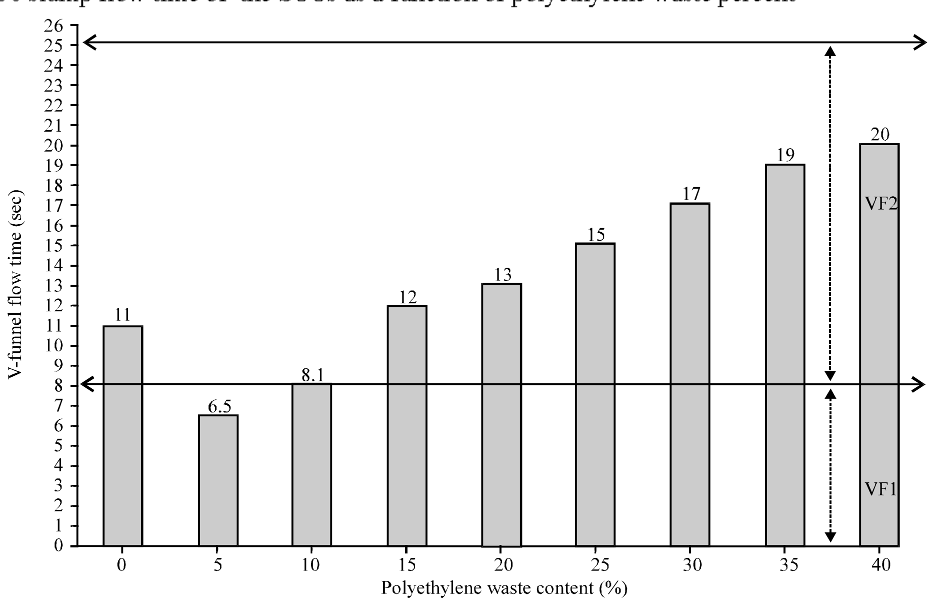

Fig. 6: The V-funnel flow time of the SCCs as a function of polyethylene waste percent

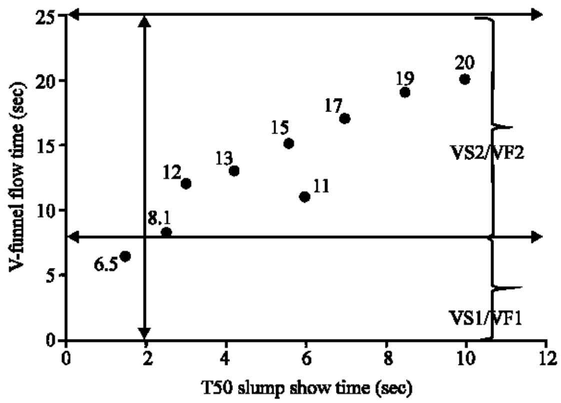

Fig. 7: Variation of V-funnel flow time (s) and viscosity classes

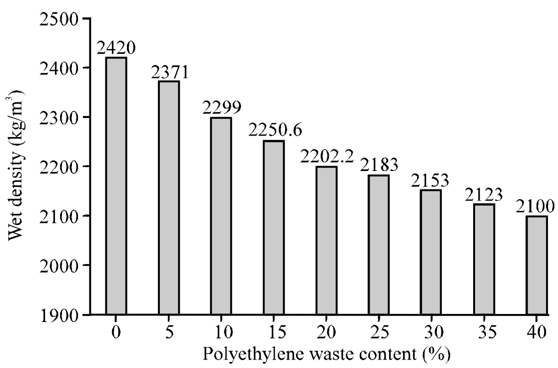

Fig. 8: The wet density of the SCCs as a function of polyethylene waste percent

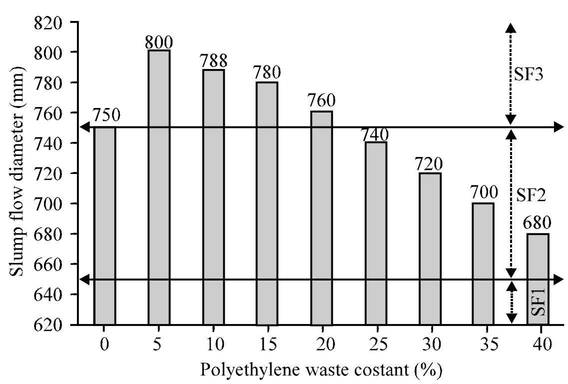

Fig. 9: The slump flow diameter of the SCCs as a function of polytheylene waste percent

The systematic reduction in wet density values was observed with increased of plastic waste ratio in SCC. For example, fresh density of the SCC lowered by up to 2, 9, 13.2% for mixes (M-P5%), (M-P20%) and (M-P40%), respectively, compared with (M-Control) mix. This reduction is attributed to the lower unit weight of polyethylene waste compared to sand.

Figure 9 display the results of the diameter slump flow versus the variation percent of fine aggregate by polyethylene waste content in different replacement level. A control mixture that does not contain any proportion of plastic waste has a slump flow diameter is 750 mm which can be classified as SF2 type. In addition, SCC is having plastic waste particles from 5-20% that satisfies the requirements for SF3. According to, EFNARC SF2 type is suitable for normal uses such as columns and walls while SF3 classis typically used for vertical applications in high reinforcement structures and complex shape structures (EFNARC., 2002). The SCC containing plastic particles from 25-40% are also satisfies the requirements for SF2 type. All results conforming EFNARC recommendations which state lower and upper approval limit of slump flow diameter to be in between 550 and 850 mm, respectively. According to results, the concrete produced in this study can be applied and used in many parts of RC structural members.

As we can conclude from finding these results, thesmallest value of slump flow diameter was calculated for the (M-P40%) mixture using 40% polyethylene waste replacement and (M-P5%) mixture with 5% polyethylene waste replacement has the highest slump flow.

The (M-P5%) mixture has slump flow diameter equal to 800 mm decreased to 740 mm at (M5-P25%) that near value to control mix. For this reason, the SCCs which are made of polyethylene partials waste with replaced percent from 5-25% had best flow property. These results suggest that it is possible to add a small percentage of plastic waste instead of sand till 25% because plastic particles have a soft surface that provides the particles flow together in cement past. On the other hand, the increasing ratio of plastic waste more than 25% substitute with fine aggregate led to bridging action in SCC. Thus, bleeding appears then slump flow behavior is reduced. In this case the water content of the mixture should be modified.

The SCC passing ability from steel reinforcements was determined by means of H_2/H_1 ratio by L-box apparatus. The H_2/H_1 ratio should be equal to or more than 0.8, to confirm that a self-compacting concrete has the good passing ability. Results in this study showed that the values of L-box height ratio gave us results <0.8 in the case of increasing polyethylene waste proportions more than 20%. On the contrary, results obtained for mixtures containing polyethylene waste proportions <20% complied with requirements of EFNARC limitations. The results are described in detail in Fig. 10.

T20 and T40 are the time calculated that mixture must be reaches to 20 and 40 cm distance from the sliding gate of L-box device, respectively. Figure 11 and 12 shows the

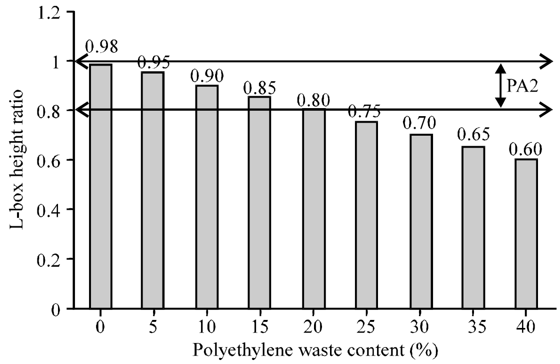

Fig. 10: The L-box height ratio of the SCCs as a function of polyethylene waste percent

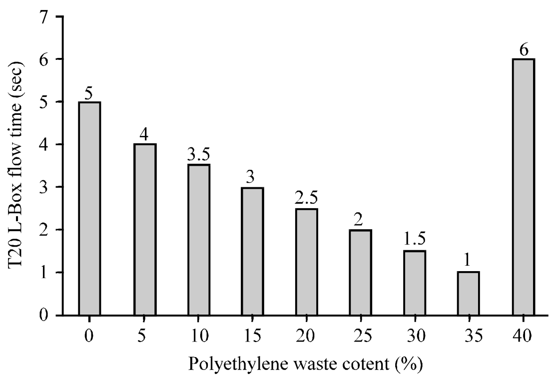

Fig. 11: The T40 L-box flow time of the CSSs as a function of polyethylene waste percent

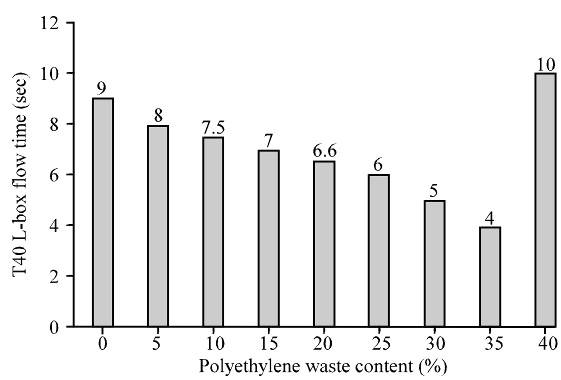

Fig. 12: The T40 L-box flow time of the SCSs as a function of polytheylene waste percent

results of T20 and T40, respectively which grant significant indication of the easy flow of the SCC mixtures. The results explained that replacing the sand with the polyethylene waste reduced the T20 as well as T40 time values except for the last value which recorded a higher value than control mix. T20 values for the mixes containing polyethylene waste from 5-35% were between 4 and 1sec, respectively, at the other end the values of T40 for the mixtures containing polyethylene waste from 5-35% were between 8 and 4 sec, respectively.

Hardened properties of self-compacting polyethylene waste concrete: The summary of test results of mechanical properties of SCC that consist of the different percent of polyethylene waste are given in Table 8.

The compressive strength for mixtures containing different percentage of plastic waste was calculated after 28 day. In this study the maximum and minimum compressive strength values were about 53 and 25 MPa, respectively. By observing the results, we find that the compressive strength values are reduced by increasing the replacement proportion of plastic particles with sand. When compared the results with control mixture at 28th days, the compressive of SCC decreased by 5.6, 11.3, 17, 22.6, 32, 37.7, 43.4 and 52.8% with the replacement polyethylene waste ratio of 5, 10, 15, 20, 25, 30, 35 and 40% continuously. Figure 13 presents the compressive strength of the SCCs as a function of polyethylene waste percent. The R^2 value around 0.97 obtained from this relation indicates that there is a strong relationship between the X and Y axis for all mixes. The gradual decrease in compressive strength values with increasing plastic waste proportions can be attributed to the weak binding force between the surface of the plastic waste and cement paste as well as the plastic particles which it does not absorb water by nature wherever the cement hydration may be inhibited by restricting the water movement (Silva *et al*., 2013; Topu and Uygunoolu, 2010).

The relationship between split tensile strength results with fine plastic particles replacements with sand at 28th day curing ages is shown in Fig. 14. As expected, the results of the splitting tensile strength began a systematic decline when the replacement rates of polyethylene waste increased in concrete. The results indicated that the optimum replacement at 20% was better for tensile strength. The reduction in results is at most due to the powerless binding between the soft surface of plastic waste and cement paste due to the free water remaining on surface of the plastic particles. Figure 15 shows the cylinder sample during failure at the tensile strength test. The percent plastic waste more than 20% exchange levels in the SCC samples led to separating of sample into two parts suddenly, possibly due to the above mentioned reasons in addition to that because of the differences in their load as well as decreasing crushed sand amount in mixes that has a maximum percent of plastic waste.

The results finding of 28th day of flexural strength decreased when the replacement plastic waste with sand content rising as shown in Fig. 16. Net flexural strength of

Table 8: Mechanical proportions for self-compacting polyethylene waste concrete

Mix destination (%)	Polyethylene waste by volume (%)	Compressive strength (MPa)	Splitting tsnsile strength (MPa)	Flexual strength (MPa)	Ultrasonic Pulse Velocity (UPV). (km/sec)
M-control	0	53	3.21	4.25	5.2
M-P5	5	50	2.9	4	4
M-P10	10	47	2.7	3.6	3.8
M-P15	15	44	2.4	3	3.5
M-P20	20	41	2	2.9	3.2
M-P25	25	36	1.9	2.5	3
M-P30	30	33	1.7	2.3	2.7
M-P35	35	30	1.5	2	2.3
M-P40	40	25	1	1.2	2

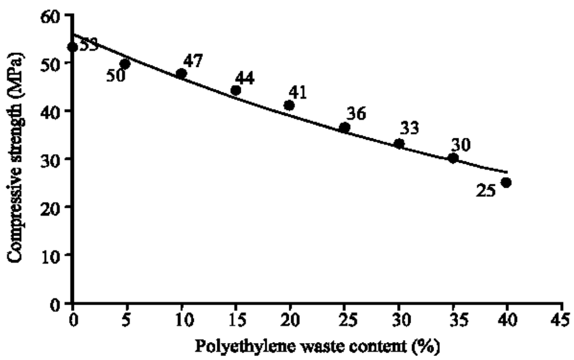

Fig. 13: The compressive strength of the SCCs as a function of polytheylene waste percent; R^2 = 0.9724

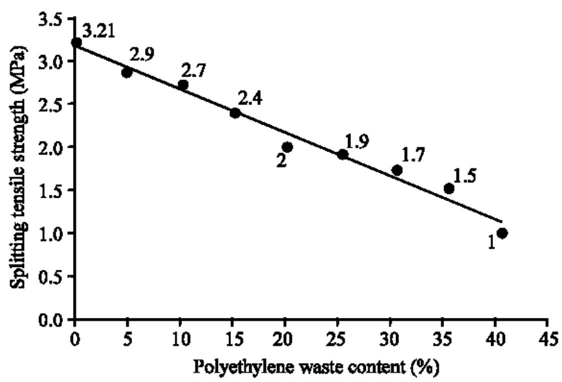

Fig. 14: The splitting tensile strength of the SCCs as a function of polyethylene waste percent

Fig. 15: The speciments after failure during the splitting tensile strength test

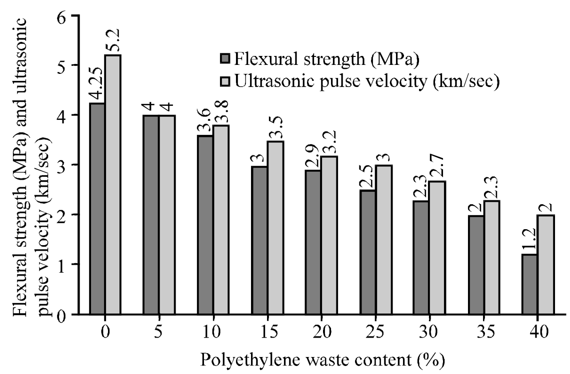

Fig. 16: The flexural strength and UPV of the SCCs as a function of polyethylene waste percent

control mix was 4.25 MPa. The flexural strength of SCC dropped by 6, 15, 29, 31.7, 41, 45.8, 53 and 71.7% with the replacement plastic waste ratio of 5, 10, 15, 20, 25, 30, 35 and 40%, respectively. UPV test is based on the measurement of the passing time of sound velocity in the material. The ultrasonic sound device measures how long the sound wave passes through a distance between the 2 opposing surfaces of the concrete (Fig. 16). The relationship between the calculated wave velocity value and mixes that containing fine plastic waste can be found approximately. In this study, 100×100×400 mm prismatic SCC specimens were used to obtain UPV value of concrete. UPV values were found on prismatic samples at the end of the 28th day before the flexural strength test done. Ultrasonic pulse velocity in concrete significantly decreases with increasing replacement of plastic waste percent with fine aggregate because of porous composition of SCC consisting polyethylene waste. But the results generally good until 20% replacement of plastic waste.

CONCLUSION

Based on findings presented in this research study, the following conclusions can be drawn. Increasing in values was observed for both T50 cm and V-funnel times after increasing the proportion of polyethylene waste percent from 5-40% for the (M-P 5%) and (M-P 40%), respectively. The mix (M-P 5%) is classified as VS1/VF1 while the other mixes (M-P 10-40%) were in the category of VS2/VF2. That is mean the all results are within the acceptance criteria of EFNARC (2002).

The systematic reduction in wet density values was observed with increased of polyethylene waste ratio in self- compacting concrete. The values of L-box height ratio gave us results <0.8 in the case of increasing polyethylene waste proportions more than 20%. On the contrary results obtained for mixtures containing polyethylene waste proportions <20% complied with requirements of EFNARC limitations. T20 and T40 values for the mixes containing polyethylene waste from 5-35% were between 4-1 and 8-4 sec, respectively. By observing the results, we find that the mechanical properties values are reduced by increasing the replacement proportion of plastic particles with sand. But the concrete produced in this study can be applied and used to many parts of RC structural members. UPV values significantly decreased with increasing replacement of plastic waste percent. But the results generally good until 20% replacement of plastic waste. Finally, this labor insures that the recycling of polyethylene waste in SCC gives favorable approaches to protect the environment and non-renewable normal material resources.

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